Observatoire de Terrain en Hydrologie Urbaine
FIELD OBSERVATORY FOR URBAN WATER MANAGEMENT

OTHU'S FINALISED RESEARCH PROGRAM

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FOREWORD

Principles

Glossary of terms

Operational question: a question raised by a management department and referring to a problem encountered during the conduction of one of its missions. The answer to an operational question may be obtained through an ordinary expertise, a training action or may need a specific research program.

Research action: an action limited in time, corresponding to a clearly identified and financed project (training, doctorate thesis, research convention, etc.) and aimed at producing scientific results. To each research action corresponds an action sheet. An action sheet can be subdivided into several project sheets. One research action can contribute to several programs.

Research sub-program: an organised set of research actions aimed at reaching specific scientific objectives on which depends the answer to one or several operational questions. The goals of a research sub-program are defined on both long and middle terms (2 to 4 years). Middle term goals correspond to a commitment within the program's duration, long term objectives exceed the program's limits and are understood in terms of prospects. A research sub-program can be either a specific program (financed within OTHU's framework) or an associated program (not financed within OTHU's framework but led by OTHU's teams and potentially contributing to the resolution of one or several operational questions).

OTHU's scientific program

OTHU's scientific program is constituted by:

- a list of operational questions to be solved in priority,
- a set of research sub-programs, subdivided in a set of research actions.

The scientific program has to be very specific about the links between those elements: the contribution of research actions to the programs and the function of the research programs in the resolution of operational questions.

The content of the research program is usually arranged for four years and is being evaluated every two years by the scientific committee.

The program is developed jointly by the representatives of the end-users who establish the list of operational questions and by the representatives of the research laboratories.

Contents

0 General introduction

The development of OTHU's finalised research program aimed at three major goals:

- Define end-users long term prospects and identify their priority operational goals,
- Make an inventory of the scientific bottlenecks currently preventing those operational goals to be reached,
- Deduce the scientific goals on which OTHU's researchers have to focus and define the research actions liable to reach them.

The development of this program is the outcome of the collaboration between researchers and end-users. The steps that have been taken are described in details in appendix 1.

This program splits up into 7 sub-programs, themselves subdivided into research actions:

- Sub-program n°1: Development of an integrated urban water cycle model
- Sub-program n°2: Improvement of the local knowledge of rain
- Sub-program n°3: Sewer overflow devices management
- Sub-program n°4: Management of peri-urban rivers
- Sub-program n°5: Development of methods of conception, construction and operation of retention/infiltration basins
- Sub-program n°6: Improving the preservation of Lyon's water resources
- Sub-program n°7: Metrology

Each program is led by two persons in charge: a scientific leader from the research world and an operational manager. Their mission is to regularly evaluate the progress of the sub-program, to help organising the research actions (setting up of the financial arrangements and looking for scientific partners to mobilise) and to coordinate the different actions aimed at reaching the set goals.

These research programs are successively being described in the main part of this document.

Each action is described in one or several project sheets. A project sheet represents the elementary basis to which a thesis or a convention is associated. Some project sheets have already started, others have not yet started due to a lack of human or financial resources. Appendix 2 contains the whole set of sheets.

This distribution is obviously formal and actions are all more or less interacting.

A special paragraph is devoted to the presentation of the interactions between the different actions in the form of a general organisational chart.

Lastly, different supporting actions are planned. They are described in the last paragraph of the present document.

1 Sub-program n°1: Development of an integrated urban water cycle model

Scientific leader: Bernard Chocat

Grand Lyon Correspondents: Christophe Rostaing and Emmanuelle Volte

1.1 Operational goals to be reached

1.1.1 Long term prospects

Develop an integrated model able to simulate the evolution and the effects of water and pollutants flows in the sewer system (network, wastewater treatment facilities and plants) and in the natural receiving environments.

This model should be able to simulate different overall strategies of wastewater and rain water management and to predetermine their efficiency by evaluating in a forward-looking way different performance indicators.

1.1.2 Middle term operational goals (3 years)

- Draw a preliminary relevant list of performance indicators of the sewer system. This list will have to include non-technical elements: facilities appropriation, water re-appropriation, communication and development of a "risk culture", limitation of water or pollutant production "at source" (technical alternatives, rain water harvesting, modification of local practices of street sweeping or waste removal, etc.).
- Define the overall structure of the integrated model.
- Create methods enabling to better evaluate and control uncertainties.
- Create experimental tests enabling to better evaluate parasitic waters, exfiltrations and collection rates.
- Create practical rules allowing a better use of the existing parts of the model representing the sewer system in the studies.
- Create efficient processes of data updating concerning town description, sewer system and receiving environments.1

The last two objectives essentially refer to existing expertise and do not require to launch specific research projects.

1.2 Scientific bottlenecks and research actions

1.2.1 Scientific bottlenecks

The fundamental principle is that an overall integrated model will not simply result from a distinctive modelling of the different elements of the hydrologic system.

The main scientific bottlenecks to be resolved in order to reach the operational goals are the following:

- Inadequacy of time steps, space steps and sometimes parameters used in models representing the different elements of the hydrologic system.

[1] This question has in fact multiple aspects: How organise and structure in time the improvements of knowledge about the physical structure? What is the liability of the "automat" allowing to construct the model with SIG and what is the quality of the resulting model? Which is the relevant "time step" for making the "systematic" update of the "small" modifications (more or less continuous evolution of the town for example)?

- Insufficient quality of some models (particularly those concerning production, transfer and evaluation of the pollutants' impacts).
- Lack of knowledge about mechanisms of propagation of uncertainties in the models (uncertainties about data on physical structure of the objects, uncertainties about parameters of the models, …)
- Difficulties in suggesting a relevant operational list of performance indicators.
- Lack of data about the state of the system.

1.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Detailed modelling of the different OTHU sub-watersheds (wastewater, storm water, parasitic water).

The goal of this action is to give the most accurate description of the sub-watersheds physical structure (nature of the urban elements and structure of the sewer network). The main objective is to obtain well instrumented test beds allowing to test the relevance and the performances of the different models as well as the propagation of uncertainties.

See sheet **PR1-1**. – Person in charge: Bernard Chocat

Action 2: Improvement of pollutants production and transfer models by the sub-watersheds

The goals of this action are:

- Contribute to the knowledge of hydraulic and polluting flows produced by urbanised watersheds at different time and space scales
- Study the variability of flows produced at different levels (intra-event, inter-event, inter-annual) and identify relevant explanatory factors which can be applied generally with a view to the modelling of the phenomena at the watershed level.
- Create, test, validate and compare simulation models of polluting flows.
- Create and validate rules, methods and means of measurement.

These models will be tested on OTHU's different sub-watersheds.

See sheet **PR1-2**. – Person in charge: Jean Luc Bertrand-Krajewski

Action 3: Constitution and testing of a provisional list of performance indicators

The purpose of the present research action is to generate performance indicators of the sewer system able to evaluate the quality of the service provided by the sewer system and to help leaders to estimate the relevance of their strategy.

The project is very ambitious and the goal of the action within the three years is merely to define a first indicative list which would remain very provisional. The present action will be initiated by the Grand Lyon in the framework of the reflection about the guiding drainage outline.

See sheet **PR1-3**. – Person in charge: Sylvie Barraud

Action 4: Construction of a coupled model of flooding flows representation

The purpose of the project is to constitute a hydraulic model able to show the interactions between the surface, the underground network and the rivers during floods in urban sectors.

This model should specifically be based on the coupling between CANOE and a software of open channel flows representation (TELEMAC, RUBAR 2D, …). The validation will take place on the site of Oullins.

See sheet **PR1-4** – Person in charge: Bernard Chocat

Action 5: Improvement of the representation models of network inflows/outflows

The purpose of the project is to develop researches led in the framework of the European project APUSS on parasitic waters and exfiltrations measurement.

The objective is to reach a better modelling of these different discharges associated to a methodology of calibration and control. The sub-basin of Ecully, and later all or part of the Yzeron basin, will serve as testing environments.

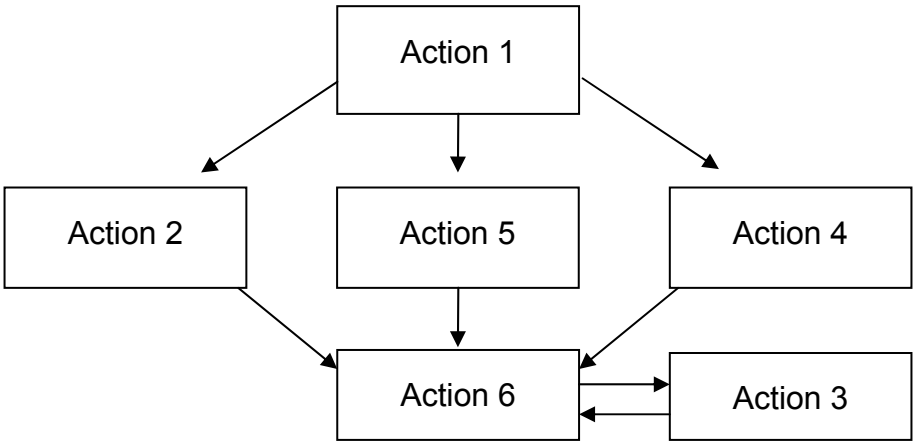
See sheet **PR1-5** – Person in charge: Jean Luc Bertrand-Krajewski

Action 6: Construction of a first version of the integrated model

The objective of this question is to validate the construction principles of the integrated model. The plan is to work on a prototype integrating the different sub-models developed in research actions 2, 4 and 5. The support will be a model representing the sewer network of West Lyon and the drainage network of the Yzeron and its tributaries.

See sheet **PR1-6** – Person in charge: Bernard Chocat

The links between those different actions are represented by the following diagram:



The estimated schedule is the following (actions entirely financed and already started are in black, actions partly financed and ready to start in dark grey and the actions not yet financed in light grey).

	2005	2006	2007	2008
Action 1		Resources to be consolidated		
Action 2		Resources to be consolidated	Resources to be consolidated	
Action 3	Gained resources	Gained resources	Gained resources	
Action 4		Gained resources	Gained resources	
Action 5		Resources to be found	Resources to be found	
Action 6			Resources to be consolidated	Resources to be consolidated

2 Sub-program n°2: Improvement of the local knowledge of rain

Scientific leader: Jacques Comby

Grand Lyon Correspondent: Jean-Marc Didier

2.1 Operational goals to be reached

2.1.1 Long term prospects

Two main objectives have been identified:

- Gather information to supply to the simulation models, more particularly time series of representative rains (see research program n°1).
- Create methods allowing to use the ground and radar data in an optimum way, both on differed time and real time (state of alert declaration, real time management of the sewer system).

Reaching those objectives presupposes the capability of modelling the spatial distribution of the rain over Lyon taking topography, urban influences and aerologic factors into account.

Furthermore, it is crucial to obtain indications of the interannual variability of precipitations, whether or not it is coupled with a trend non-stationarity (hypothesis of climate change) or other.

2.1.2 Middle term operational goals (3 years)

Two operational goals have been set up for the next three years:

- Create tools able to couple ground precipitation measures and radar images.
- Having started the Grand Lyon rainfall data analysis and be in possession of time series of rain rates defined by their spatiotemporal distribution (coupling together if possible radar and ground data).

Further on, the Water Department of the Grand Lyon has to clearly define its goals in real time management as well as the resources it is willing to gather in order to reach them.

2.2 Scientific bottlenecks and research actions

2.2.1 Scientific bottlenecks

The main scientific bottlenecks to be resolved in order to reach the operational goals are the following:

- How couple ground and radar data at best ?
- How take into account meteorological contexts at different levels and use the experience gained through the study of the passed situations ?
- How validate a precipitation input and guarantee its representativeness for a specific type of study ?
- How recognise and define a “risky” climate situation ?

2.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Development of ground data and radar data coupling tools.

The Grand Lyon and OTHU's rain gauges (35 in total) provide local information on the average rainfall intensities within small time steps (a few minutes). Météo France's meteorological radar provides information on instant local averages of altitude reflectivity on meshes of a few kilometres.

The study's objective is to combine these two information in order to build a three-dimensional image of the observed rainfalls (x, y and time) in CANOE format (average intensities by time steps on a regular space networking).

See sheet **PR2 – 1** – Person in charge: Bernard Chocat

Action 2: Characterization of the rain and its dynamic over Lyon and its suburbs

This research will be based on a sharp analysis of the rainfall founded on a thorough knowledge of Lyon's climatic conditions.

Two types of analysis will be carried out:

- Climatic studies using existing data (distribution, spatiotemporal variability),
- Experimental studies using data being collected during the project (sharp knowledge of the processes).

The study of the spatial distribution of rainfalls aims at establishing isohyet charts of the Lyonnaise Region and of Lyon and its suburbs: annual, seasonal, monthly, decadal charts, etc. (rainfall probability maps).

The analysis of noticeable rainfalls will be achieved at every space scales (from continental to urban districts).

See sheet **PR2 – 2** – Person in charge: Jacques Comby

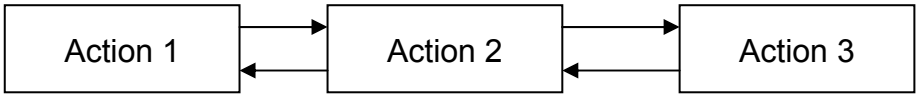
Action 3: Representative rainfall time series construction.

The simulation models of sewer system behaviour use more and more representative rainfall time series with more or less length as inputs (for example a few years for the evaluation of polluting effluents from sewer overflow devices). The process consists of simulating all the rainfalls of the time series, and then realising a statistical study of the resulting hydrological magnitudes (for example the maximum discharge generated at a particular point), in order to be able to associate them to a return period to a given value.

The notion of representativeness presupposes that the rainfalls observed in the past are susceptible to produce effects representative of those observed in the future. This implies to statistically define the properties of the rainfall series used and to study their variability and their stationarity. The properties to be considered can differ according to the type of study taken into account.

See sheet **PR2 –** 3 – Person in charge: Bernard Chocat

The links between the different actions are represented by the following diagram:



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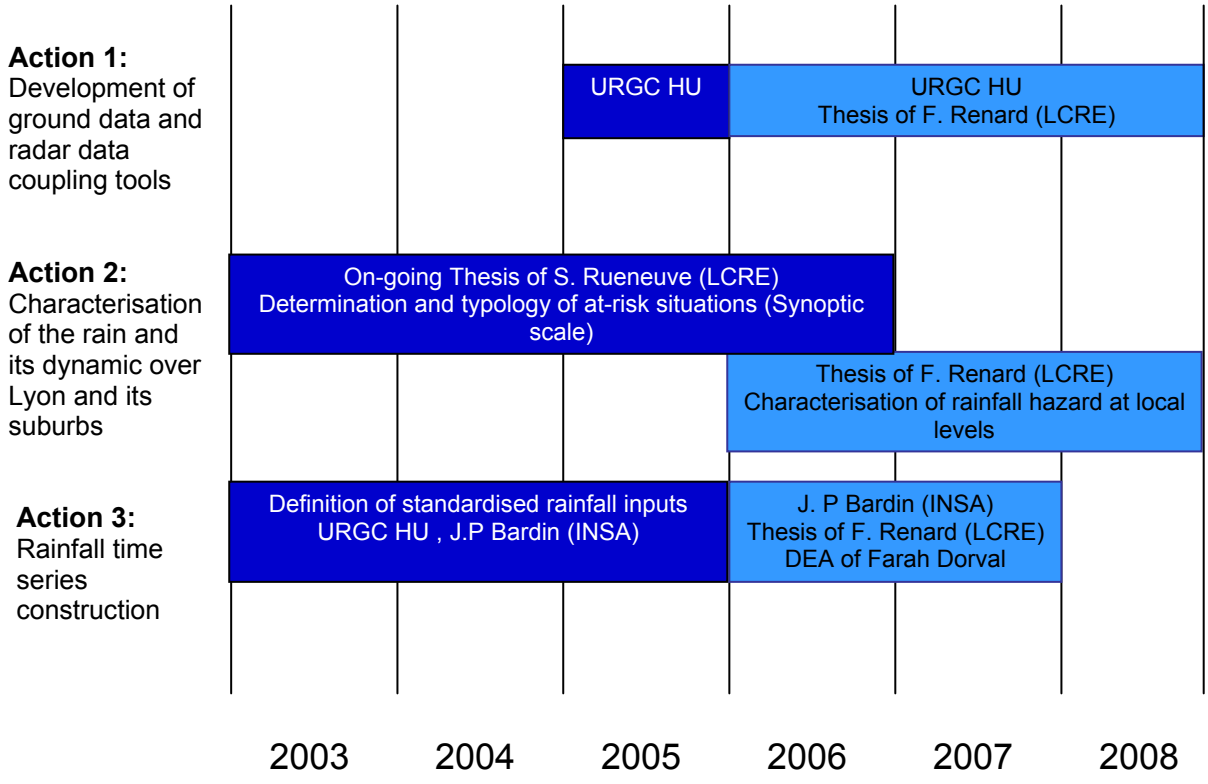


3 Sub-program n°3: Technical elements for management of sewer overflow devices

Scientific leaders: Pascal Breil / Bernard Chocat

Grand Lyon Correspondent: Emmanuelle Volte

3.1 Operational goals to be reached

3.1.1 Long term prospects

The sub-program 3 is dedicated to the elaboration of technical tools that may help to reduce the overall impact of urban wet weather effluents on receiving environments, aquifer and river. It is thereby a support to the self-monitoring principle that every sewer system administrator has to apply.

Therefore, it relies on the diagnosis and comprehension elements of the receiving environments reactions studied in sub-programs 4 and 5.

The two middle term operational goals are:

- Improve the urban effluents management, especially during rainfall periods, in order to limit their impact on the quality of the different receiving environments of the city and its suburbs.
- Develop and validate, in accordance with the State Departments, a rational self-monitoring procedure.

3.1.2 Middle term operational goals (3 years)

- Create a methodology liable to test different urban wet weather effluents management scenarios, at the entire town level (limitation of the number of discharge points, optimisation of the storage capacity in the network and outside the network, etc..), in order to improve the current management practices.
- Start to evaluate at a local level (on one facility) and at an overall level (in the entire urban area) the impact of the different urban effluents (wastewater treatment plants, tributaries and sewer overflow devices) on the Saône. This objective relies on joint research actions with the ZABR (Zone Atelier Bassin du Rhône).
- Create a methodology liable to evaluate the most significant environmental impacts of urban wet weather effluents (especially combined sewer overflows) on small peri-urban streams. This objective appears in this section as a reminder, but is part of sub-program 4.

3.2 Scientific bottlenecks and research actions

3.2.1 Scientific bottlenecks

Concerning the environmental impacts on the peri-urban streams, the main bottlenecks to be resolved in order to reach the operational objectives are the following:

- The knowledge of the physical, chemical and biological mechanisms contributing to the transfer, the storage and the quality degradation of the streams downstream the overflows, as well as the comprehension of the harvesting mechanisms. This is nevertheless crucial in order to suggest management practices in adequacy to the capacities of waters to absorb urban nutrients and toxic substances and also in order to improve this capacity *in situ*. One of the key issues is the comprehension of the exchanges within the hyporheic zone, which requires the development of specific investigation tools. Most of the research actions concerning this aspect are being presented in sub-program 4.
- The evaluation methodology of the scenarios has to be developed and tested. This implies to develop methods of effluents assessment as well as methods of a priori impacts prevision.

As far as the environmental impacts on the Saône and the Rhône are concerned, the research is only starting and the scientific bottlenecks are therefore not yet well known. We suggest to launch during the next three years two prospective studies, one on local impacts and the other on overall impacts. The research on the methodology of scenario tests can be led in a relative independent way (at least as far as the assessment of effluents is concerned), even though it will have to be adjusted as the knowledge about alteration mechanisms evolves.

The necessity of integrating, before the study of impact on the environment, the knowledge via the GESICA data base about the functioning of the drainage facilities along the urban courses of both rivers, justifies that the study of the receiving environment is integrated in sub-program 3 instead of 4.

3.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Create a methodology of evaluation of the main indicators of urban wet weather effluents

The sewer overflow devices reject pollution on a very variable time basis. The aim of this research action is to build structured methods able to evaluate different indicators liable to characterise the wet weather effluents (average annual volume or mass, quantity, …).

The method will have to be applicable on any receiving environment, any size of watershed and any amount of overflow points.

See sheet **PR3-1**. – Person in charge: Bernard Chocat (URGC)

Action 2: Improve the knowledge about the link effluents–ecological state in the case of a small river

The researches conducted through the GEDO project (PR49 of the former research program) have allowed to develop the notion of functional characteristics and functional ecological states of reference and altered.

The goal of the present action is to use these notions in order to analyse the links between pollutants flows from sewer overflow devices and the degradation of the ecological state of the stream.

Sheet **PR3-2** to be created: Persons in charge: P.Breil, M. Lafont, Ph. Namour

Action 3: Improve the knowledge about the link effluents–ecological state in the case of a large river, application to the Saône (ESALY project: Study of the Saône along its urban course through Lyon and its suburbs).

The goal of this action is to study the relations between pollutants flows (CSO, runoffs on waterproof surfaces, industrial and domestic effluents) and the degradation of the ecological quality of a large river along its urban course.

Firstly, it will be needed to make an ecological assessment of the Saône from upstream Neuville to the Mulatière (physico-chemistry, biology), defining the deteriorated sectors and the relatively preserved ones. It will be tried to characterise the most noxious sources of pollution (including sewer overflows). The contribution of the Saône's tributaries (i.e. the Azergues or the Veyle) will also be taken into account (pollution dilution or degradations due to the tributaries). This action will be led in collaboration with the ZABR (M.Persat).

See sheet **PR3-3**: Person in charge: Michel Lafont

Action 4: Create an evaluation methodology of the a priori impacts of wet weather effluents on small rivers.

The goal of the present action is to define an overall methodology aimed at linking in a forward-looking way, different indicators quantifying the urban wet weather effluents, in particular those from the sewer overflow devices, and the quality degradation of the natural receiving environments.

Firstly, it will be needed to compare the characteristics of the effluents (frequency, nature, volume, position, …) and the characteristics of the receiving environments (grade, substratum, profile, …) on one hand to the observed quality of the receiving environments on the other hand. Then it will be tried to draw information out of it. The goal of the study is to determine the flux variables (duration, intensity, frequency, memory) liable to explain the different ecological states observed, in particular on the Chaudanne stream downstream the sewer overflow device.

This approach will be crossed with more clinical ones developed on other matters and will be applied on the whole Yzeron basin.

See sheet **PR3-4**. – Persons in charge: Bernard Chocat / Pascal Breil

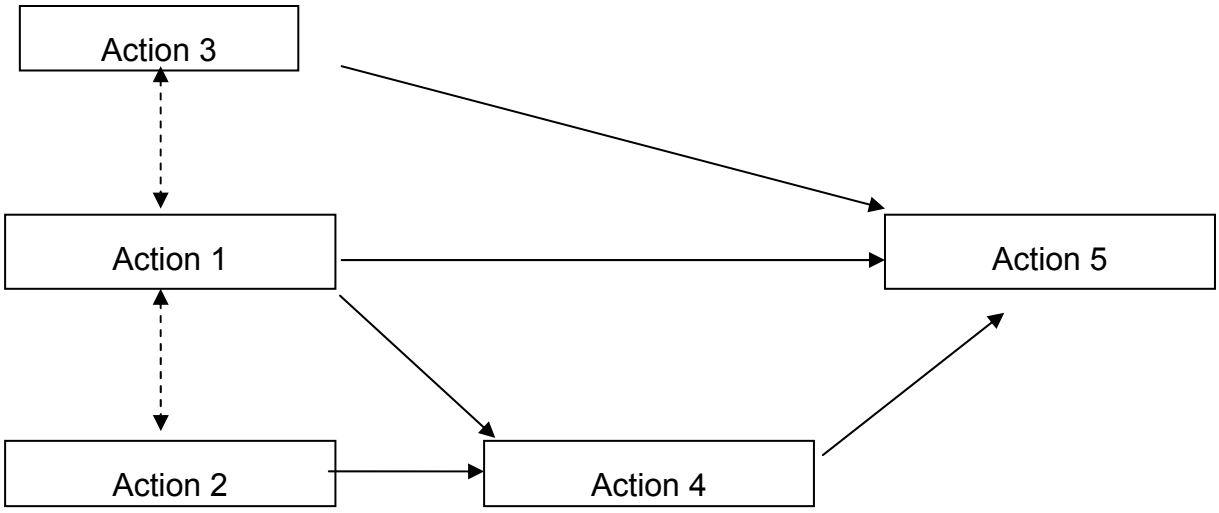
Action 5: Create a testing methodology of effluents reduction scenarios

The above action is about working on the results of research actions 1 and 4 in order to develop a method liable to test a priori the efficiency of the different sewer system managements (removal of sewer overflow devices, increase of storage and/or drainage capacities, …). This efficiency will be measured in terms of reduction of effluents (improvement of the chosen indicators) and if possible in terms of enhancement of the impacts.

A validation will be pursued through the effluents observation by the OTHU as well as through the coupled modelling of urban and rural flows (see SP1).

See sheet **PR3-5**. – Person in charge: Bernard Chocat

The links between the different actions are represented by the following diagram:



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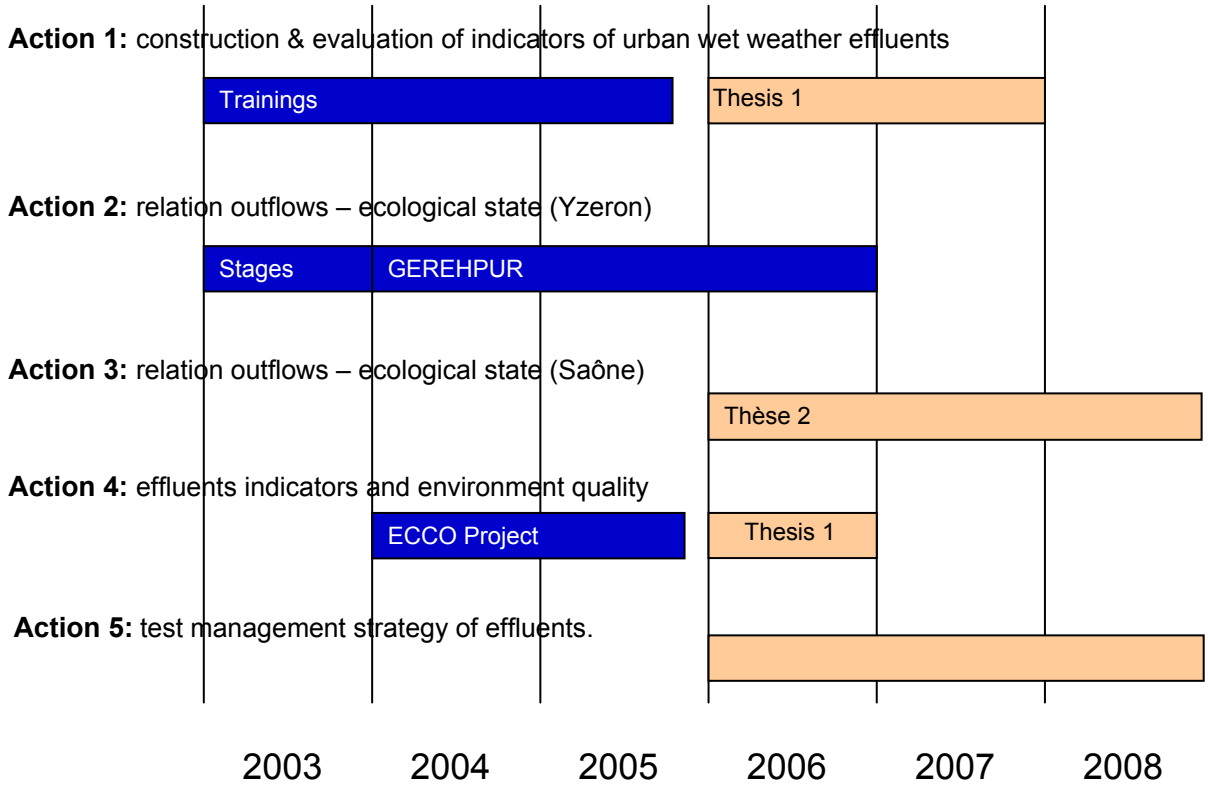


4 Sub-Program n°4: Management of peri-urban rivers in West Lyon

The peri-urban area is often located downstream related urban environments, and offers more free spaces than the dense urban areas. It therefore requires to be handled as a strategic sector in order to preserve the water resource and to reduce the risks linked to the hydrological extreme values. This in order to allow a sustainable development of the urban fabric in its watershed.

Scientific leader: Pascal Breil

Grand Lyon Correspondent: Juliette Pécoraro

4.1 Operational goals to be reached

4.1.1 Long term prospects

Sub-program 4 is aimed at developing analysis and functioning tools of the aquatic environment exposed to urban development. These tools have to be subdivided for the operational departments of the Grand Lyon and the SAGYRC into management principles and decision aid tools liable to respect the natural functioning of rivers and their necessary use by man.

The long term operational goal is to define local indicators of good condition of the urban and peri-urban aquatic environments.

The indicators will have to be complementary to those taken into account within the Water Framework Directive (WFD). They will have to integrate both the ecological aspects (biota and physical habitat), and the economic, social and climate scenario aspects. They will have to allow a functional vision of the environments and be developed in a predictive way (allow to follow the evolution of the environment as the developments go along).

In order to reach these goals, the OTHU focuses its efforts in priority on the description of the environments and on the modelling of the natural water and substance flows in rivers and their perturbation by the urban environment.

4.1.2 Middle term operational goals (3 years)

Four operational goals have been identified for the next three years:

- Achieve the building of a reproducible methodology enabling to combine the effluents indicators (studied in sub-program 3) and the indicators of ecological quality of the environment. The actions concerning this goal will be led in close collaboration with those corresponding to research program n°1 (effluents modelling) and n°3 (self-monitoring of the urban wet weather effluents dump facilities).

  Expected result:

  Inventory and representation method of the usual pressure and natural relaxation factors of one or several Yzeron reaches (principle of eco-dynamic management of the GEREHPUR project).

- Make recommendations concerning the seasons, frequencies and quantities of urban wet weather effluents acceptable for a stream. Both the effects on the biota and on the stability and durability of the habitat will have to be taken into consideration. More specifically the impact on a stream incision and its consequence: the impact on the accretions in the reaches of lesser energy.

  Expected results in the Yzeron basin:

  - Cartography of the Yzeron ecological sensitivity.
  - Management plan of the incised river channels in the Yzeron basin.

- Management plan of the sedimented rivers in the Yzeron basin.

- More precisions about the factors contributing to the evolution of flood hazards in urban areas as well as to the interaction between networks and rivers.

  Expected results:

  - Propagation scenarios of a flood in Oullins
  - Frequency – peak flow - % of urbanisation relationships.

4.2 Scientific bottlenecks and research actions

4.2.1 Scientific bottlenecks

As far as quality is concerned, the bottlenecks are both methodological and associated to the thorough knowledge about local phenomena.

- At the methodological level, it will firstly be needed to improve the tools of streams division into homogeneous geomorphic reaches. This notion is crucial as a similarity of the processes concerning water and substances flows within homogeneous morphologies exposed to the same discharges is expected.
- The concept of functional ecological characteristics defined during the former researches will have to be deepened in order to identify the chemical, physical and biological measurements liable to describe the ecological state of the homogeneous geomorphic reach (definition of the state indicators and the alteration indicators of the ecological functions).
- The natural biogeochemical cycle and the biogeochemical cycle disturbed by human activity along a stream. A thorough comprehension of theirs dynamics is essential in order (i) to adapt the ecological state indicators to a context and (ii) to modify the management principles of the urban wet weather effluents according to the seasons.
- Lastly, as the former researches revealed the preponderant importance for the ecological state of the exchanges alteration in the hyporheic zone, it is crucial to extend researches in priority on this specific matter.

With regard to the flood risks, two scientific bottlenecks have been identified:

- An insufficient comprehension of the modification of the hydrological mechanisms generating floods associated to the modification of the land use.
- An insufficient knowledge about the hydrological mechanisms associated to the propagation of floods in a complex urban area where three potential networks of flows coexist (natural hydrographical network, sewer network and public highway network).

4.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Peri-urban hydric flows

This action aims at better quantifying the contributions of both rural and urban flows to the river floods in the Yzeron area. The action is based on the experimentation (Grézieu, Oullins, …) in typical sub-basins in order to obtain a better description of their specific hydrological characteristics. The process is associated to an isotopic tracing in order to quantify the proportions of the different components (hypodermic flow, aquifer) in a typical environment. This has to lead to a better representation of the naturally diversified peri-urban flows.

The action includes the calibration of a hydrologic model distributed at the Yzeron basin (PR4-1 will be finished in 2006), as well as the coupling with the urban part of CANOE (PR4-2 started in 2005). These 2 action sheets should eventually enable a more realistic simulation of the effect of alternative techniques. Furthermore, a storm basins device has been examined for a short time in Grézieu.

The action also includes the study of the joint network-river (rural/urban) influence on the propagation of a flood in the urban fabric of Oullins (PR43).

See sheets: **PR4-1-1** Persons in charge: R.Gnouma and P.Breil, **PR4-1-2** Person in charge: A.Paquier

Action 2: Indicators of the ecological state of the river as receiving environment

The ecological state has been the object of a functional approach in the GEDO project since 2000. This approach has enabled to define some of the ecological characteristics of the benthic and hyporheic biota of the rivers of West Lyon. The associated classification, which defines more or less degraded states, allows to suggest reasons for the degradation of physical and/or chemical alteration of the investigated environment. Action 2 is now aimed at verifying the transfer ability of this diagnosis tool to a larger river submitted to a series of sewer overflow devices (upstream Yzeron before confluence).

At the same time, the ongoing GEREHPUR project aims at defining an inventory grid of the pressures and the ecological defence ability of a river reach. A graphical representation shows the possibilities or degrees of liberty of the system. The method is merely qualitative but enables to underline the ecological stabilisation or destabilisation factors of a river corridor from one reach to another.

See sheet: **PR4-2,** Person in charge: M.Lafont

Action 3: Consequences of urbanisation on the water flows and associated substances flows

In the peri-urban environment of the Yzeron basin, the natural morphology of the streams is scarcely affected or very locally by the urban development. The aquatic habitat is then essentially disturbed by the modification in quality, rhythm and volume of the passing flows (see action 1). These flows are determinant for the dynamic of the biota of running environments like rivers.

Action 3 aims at identifying and measuring the modifications due to urbanisation on water flows and associated substances flows (nutrients and pollutants). Two levels of approaches are being taken to reach these objectives:

- The level of the local process of exchanges between the water column and the river substrate (PR431) which conditions the development of biota in the substrate. Hereby the hydraulic conditions (hydraulic engine) of these exchanges are being studied in a natural environment and downstream an overflow.
- The level of the stream course (PR432) where in a progressive urbanisation gradient it is tried to evaluate the urban influence (dynamic and quality of wet weather flows) on the dynamics of transfer, accumulation and transformation of vital elements (carbon and nitrogen).

See sheets: **PR4-3-1,** Persons in charge: P.Breil, **PR4-3-1,** Persons in charge: P.Breil & M.Lafont

Action 4: Hydro-geomorphologic diagnosis of the Yzeron tributaries and sub-tributaries and definition of preventive and curative measures.

The action will be aimed at making an exhaustive inventory of the reaches of incised streams in the Yzeron watershed; as well as aimed at looking for and at localising the origin of the perturbations (sewer overflow devices, facilities, …). On each stream of order 1 et 2 (Strahler stream order), which means on a line of more or less 40 km, a longitudinal profile of the bed and the banks will be drawn. The incised zones will appear through the simple comparison of the two longitudinal profiles. The incised channel width, the state of the riparian vegetation and background nature will also be examined. The importance of the width and the depth will enable to estimate the volume of the re-suspended sediments on each incised reaches. The inventory will be integrated in a Geographical Information System (ArcGIS).

On the basis of this inventory, 5 incised reaches will be selected in order to develop the hydro-geomorphologic indicators. This selection will seek to be representative of the various situations on the field. On each reach, 2 cross section profiles will be drawn in order to follow the fluvial adjustments of the incised streams.

This action will also seek to estimate the speed of the fluvial adjustments. Therefore, the date of the facilities installation will be compared with the date of the riparian alders growth rings thinning. The method will be applied to 3 to 4 different reaches of streams in terms of geomorphological changes.

Furthermore, comparisons between the localisation of the incised sectors, the characteristics of the Yzeron basin (lithology, grade, superficial formations, …), the disruptive elements (sewer overflow devices…) and the speeds of fluvial readjustments, will enable to draw a map of the sensitivity to incision.

Lastly, a management plan of the Yzeron basin streams, impacted or sensitive to incision, with preventive and corrective measures, will be suggested.

See sheet **PR4-4**, Person in charge: L. Schmitt

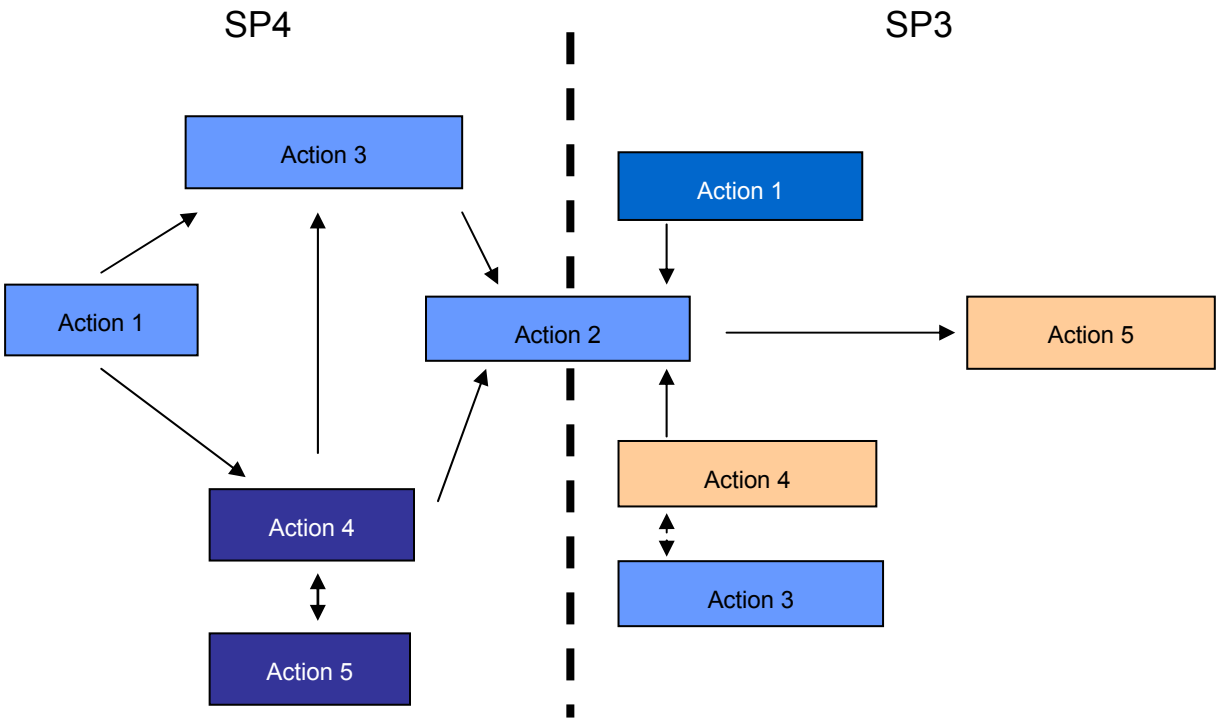
Action 5: Identification of the causes of sand sedimentation of the main streams of the Yzeron hydrographical network and definition of preventive and curative remedies.

This action will aim at drawing a map of the sand sedimentation in the main streams of the hydrographical network (Charbonnières, Yzeron, Ratier...). It will also be needed to determine and to make a cartography of the factors inducing local sand sedimentations (modification of the sediment and/or water discharges, local diminution of the water surface grade line, increase of channel width, hydraulic facilities, …). The cartographic inventory will be accompanied by longitudinal profiles and cross section profiles of representative sedimented zones. This task will then focus on estimating the increase of the sedimentation during the last decades, specifically through investigations among the residents, the managers and the fishing associations.

Lastly, a management plan of the sedimented reaches, including preventive and corrective measures, will be recommended.

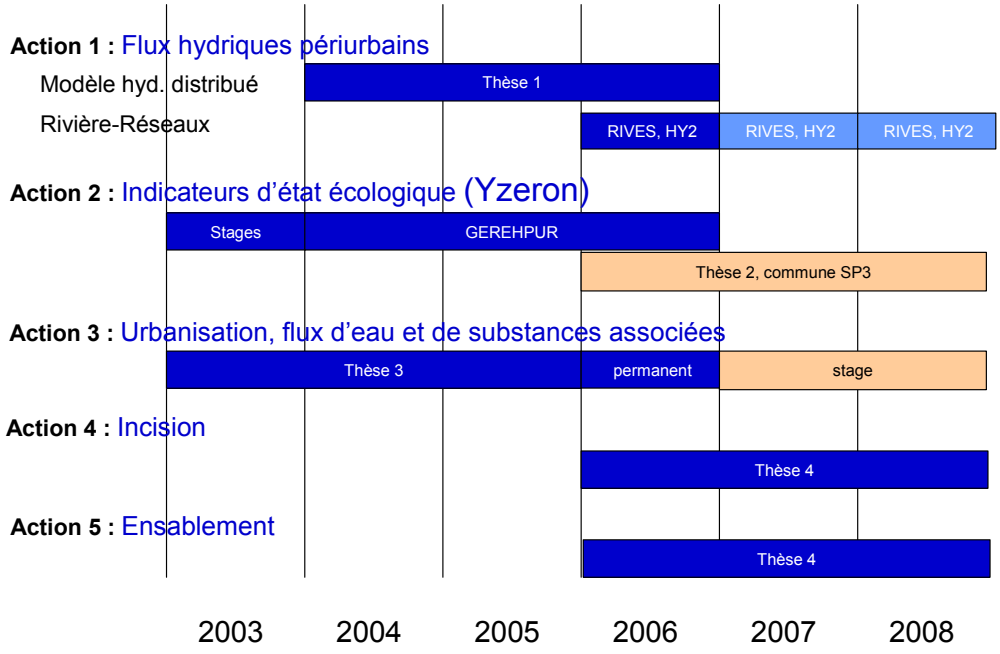
See sheet **PR4-5**, Person in charge: L. Schmitt

The links between the different actions, as well as their relation with sub-program 3, are represented by the following diagram:



The estimated schedule is the following (actions entirely financed and already started are in black, actions partly financed and ready to start in dark grey and the actions not yet financed in light grey).

Sub-program 4: estimated schedule of the actions



5 Sub-program n°5: Development of methods of conception, construction and operation of retention/infiltration basins

Scientific leaders: Yves Perrodin and Sylvie Barraud

Grand Lyon Correspondents: Stéphane Lagoutte and Isabelle Soares

5.1 Operational goals to be reached

5.1.1 Long term prospects

Define methods of conception, construction and operation of the retention/infiltration basins in order to improve the overall features of their durability (environmental, economic and social). The research actions of sub-program 5 are led jointly with those of sub-program 6: Improving the preservation of Lyon's water resources.

5.1.2 Middle term operational goals (3 years)

- Progress in the knowledge of the mechanisms of pollutants transfer and degradation in the soil, and improve the methods of control,
- Create a criteria grid allowing to evaluate the overall performances of a retention/infiltration basin,
- Create sustainable strategies of waste management and possible waste recovery,
- Evaluate the long term efficiency of the infiltration basins in terms of aquifers pollution.

5.2 Scientific bottlenecks and research actions

5.2.1 Scientific bottlenecks

The main scientific bottlenecks to be resolved in order to reach the operational goals are linked to the problems of interaction between the various physical, chemical, biological and hydraulic phenomena coupled with the problems of spatial and temporal scales. They concern more specifically the following issues:

- Methodology insufficiencies concerning inflows on long time series,
- Lack of in situ validation of 3D models of sedimentation in the retention basins,
- Insufficient quality of the models of pollutants transfer in the unsaturated zone,
- Lack of knowledge of the retention, biodegradation and bioturbation mechanisms inside the infiltration basins and of their impact on their functioning,
- Insufficient quality of the models of transfer in the aquifer,
- Difficulty in the overall evaluation of the systems, for instance through the performance indicators.

5.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Study of the temporal physico-chemical variability of the infiltration devices inflows

The infiltration ponds in the storm water management facilities are often preceded by a retention/sedimentation pond. The functioning of the latter conditions the inflows to the infiltration devices. The target is therefore to characterise the efficiency of the retention/sedimentation pond in terms of pollutant trapping. It will also be necessary, after a pluvial event, to characterise the solids and their physical, chemical and biological evolution after sedimentation (grain-size variation, eventual

re-suspension, evolution of some of the pollutants concentrations such as COD, TOC, hydrocarbons, etc.), as those phenomena are susceptible to have a sensible impact on the outflows from the retention basins and the inflows into the infiltration basin. This phase will therefore be aimed at achieving inflow/outflow evaluation through measurements of the hydraulic and pollutants flows, but also through the characterisation of the solids decanted in the pond.

Persons in charge: J.L.Bertrand-Krajewski and S. Barraud, INSA of Lyon- See sheet **PR5-1**

Action 2: In situ study of the evolution of the device/soil interfaces

The superficial zone of the infiltration basins, through the ageing process of the device, is enriched by SS brought by storm waters. They enable a microbial development and make this zone evolutive. More specifically, the supply of anthropogenic chemical compounds by rain waters lead to the formation of microbial and invertebrate communities the most adapted to live in those environmental conditions.
The first target of this subject matter is to characterise physically, chemically and microbiologically the evolution of the substance deposited at the surface of the infiltration zone in order to better understand its pollutants retention and degradation properties, so as to estimate the efficiency of the physically, chemically and biologically active “filter” that this surface constitutes.
Furthermore, the behaviour and the ageing of the device/soil interface may lead to clogging phenomena endangering the functioning of the basin.
The second target of this subject matter is then to quantify the evolution of the spatial spreading of the clogging. These works will enable to improve the diachronic hydrological functioning of the infiltration basins, as well as to produce optimisation tools for the launching of the cleaning campaigns.

Persons in charge: J.P. Bedell (ENTPE), S. Barraud (INSA of Lyon).

See sheets **PR 5-2-1**, **PR 5-2-2**, **PR 5-2-3**

Action 3: Study of the mechanisms influencing the evolution of the pollutants at the device/soil interfaces

The goals of this action are the following:

- define the influence of the physico-chemical characteristics of the soil and the waters on the pollutants transfer,

- quantify the influence of the microbial communities (diversity and activity) on the pollutants evolution and transfer,

- evaluate the impact of the invertebrates (tubificid worms for example) on the physical environment by sedimentary alteration and modification of the hydrodynamism, liable to interact on the clogging process,

- analyse the interactions between invertebrates activity, micro-organisms composition and activity and pollutants flows.

Persons in charge: F. Mermillod-Blondin (University Lyon I), J.-P. BEDELL (ENTPE)

See sheets **PR 5-3-1**, **PR 5-3-2**

Action 4: Study the dynamic of the in situ transfer and retention of the pollutants (soluble pollutants and pollutants associated with colloids) in the unsaturated zone of the soil

The goals of this action are the following:

- Evaluate the hydraulic and geochemical behaviour of rain waters in the unsaturated zone of an infiltration basin (selective study, and then spatially distributed study, of an experimental well),

- Understand and describe the transfer mechanisms of the pollutants adsorbed on colloids in the unsaturated zone of the infiltration basin, according to the chemical and hydrodynamic variations induced by the functioning of the device,
- Evaluate the pollutants flows ejected by the aquifer.

Persons in charge: Cécile Delolme and Thierry Winiarski (ENTPE)

See also sheets **PR 5-4-1**, **PR 5-4-2**, **PR 5-4-**3, **PR 5-4-4**

Action 5: Study of treatability and evolution of trapped sediments (cleaning residues)

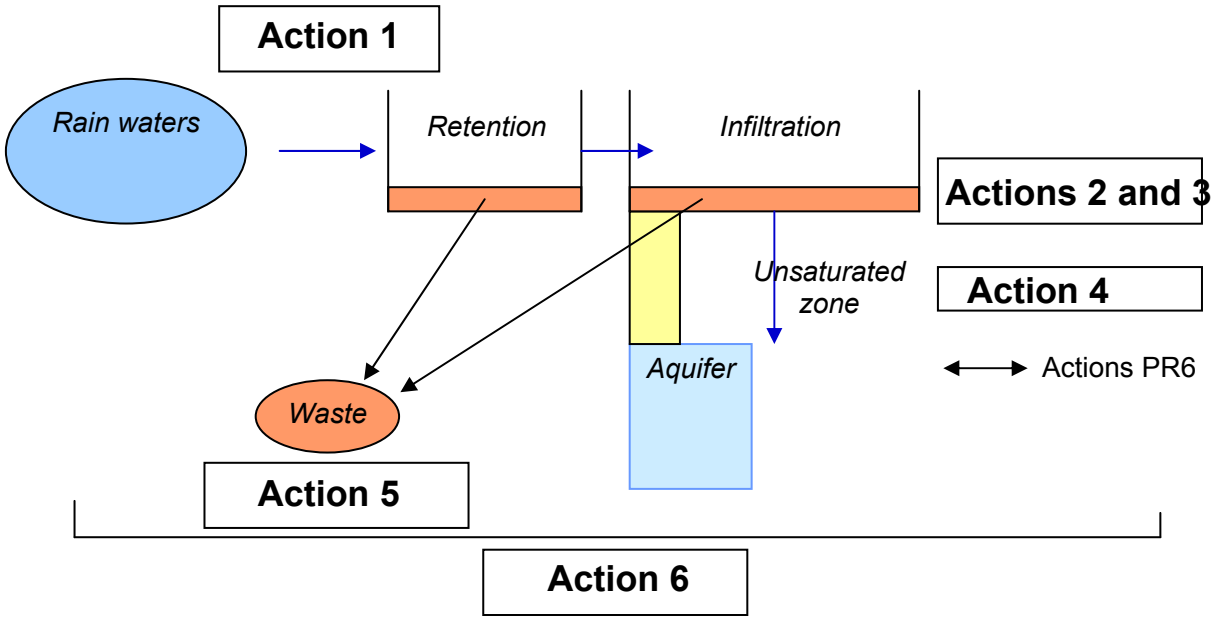
The maintenance of basins or runoff water infiltration devices – essential to guarantee their long term efficiency – necessitates periodic cleaning campaigns of the surface layer. Besides fine particles, this layer concentrates numerous organic and inorganic pollutants, conveyed by runoff water either in the form of particles mechanically retained by the infiltration layer, or in a dissolved form liable to be retained by varied physico-chemical mechanisms. The target of this action is to study conceivable treatment processes of these residues based on the generated flows and the already known characteristics of these substances, then to experimentally determine the treatability of these residues according to the supposedly relevant process(es).
A similar approach has to be taken concerning the sediments trapped on the bottom of the retention/sedimentation basins, adopting joint protocols and methodologies.

Persons in charge: Rémy Gourdon and Blandine Clozel (BRGM) See also sheet **PR 5-5-1**.

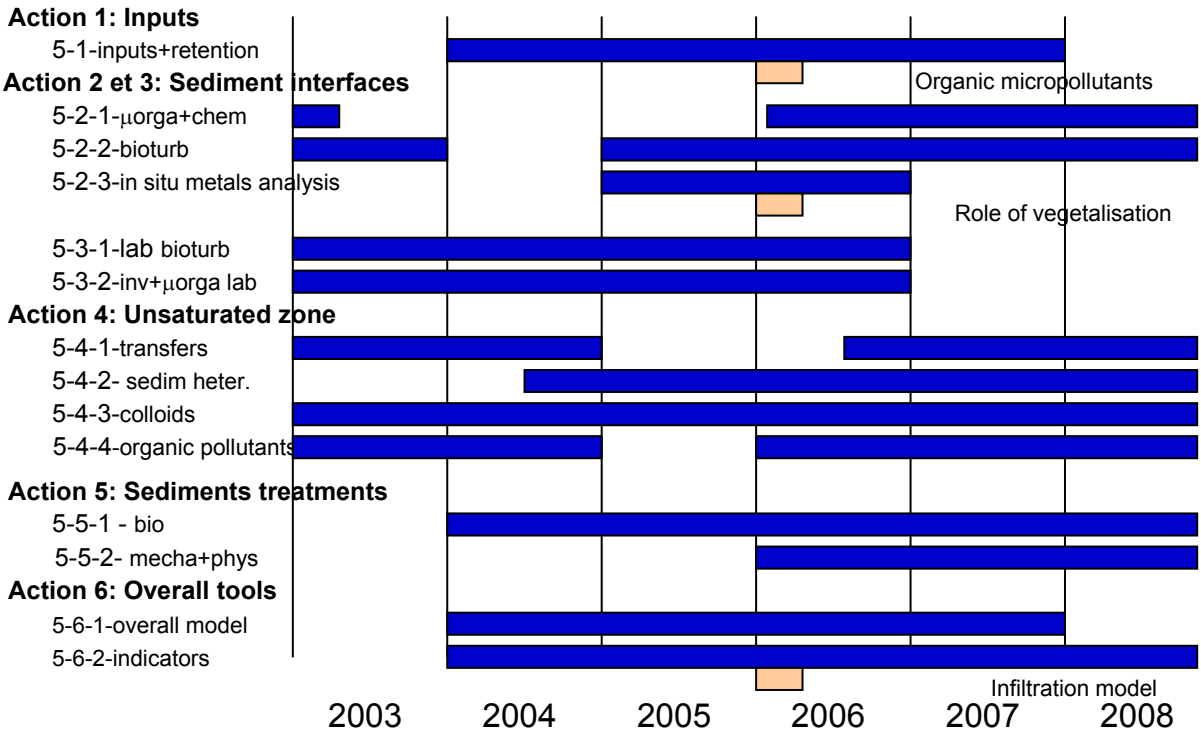
Action 6: Construction of liable tendency indicators and development of multicriteria decision aid methods for the action of conception, management and following of the infiltration technologies

The action consists of carrying on the current work on creating performance indicators for the development of a sustainable infiltration storm drainage. This work has to enable to compare traditional solutions (networks) to infiltration strategies, to compare several infiltration strategies or combined strategies to each other and to intrinsically evaluate a solution. This is a multi-criteria evaluation, which integrates technical, environmental and socio-economical criteria as well as the point of views of the actors intervening in the life of these strategies from the planning until the end of the infrastructures (decision-makers, ideas men and end-users).
Person in charge: Sylvie Barraud. See also sheets **PR 5-6-1**, **PR 5-6-2**.

The links between the different actions are represented by the following diagram:



The estimated schedule is the following (actions entirely financed and already started are in black, actions partly financed and ready to be started in dark grey and the actions not yet financed in light grey).



6 Sub-program n°6: Continue to improve the protection of the water resources of Lyon

Scientific leader: Janine Gibert

Grand Lyon Correspondent: Anne Pérrissin

6.1 Operational goals to be reached

6.1.1 Long term prospects

- Develop a methodology of evaluation and overall hierarchical organisation of the risks associated to the supply of drinkable water to the town.
- Evaluate the specific proportion of urban effluents in comparison to other polluting inputs and evaluate the (negative or positive) impacts of rain water infiltration on the quality of the aquifer of East Lyon.
- Develop tools enabling the reduction of negative impacts.

6.1.2 Middle term operational goals (3 years)

For the next 3 years we suggest to exclusively focus on the problem of the impact of the infiltration storm drainage strategy. Therefore, the research actions of this program are led jointly with those of program 5: Development of methods of conception, construction and operation of retention/infiltration basins.

- Define local health indicators of an aquifer and construct the methodology allowing to reach the zero state.
- Evaluate the long-term efficiency of alternative techniques in terms of aquifer pollution risk, in accordance to program 3.

6.2 Scientific bottlenecks and research actions

6.2.1 Scientific bottlenecks

The main scientific bottlenecks to be resolved in order to reach the operational goals are the following:

- Difficulty in evaluating the aquifers health indicators and thereby the integrity of the groundwater resource,
- Partial knowledge of the transfers in the soil and in the aquifer,
- Insufficient quality of the models of transfers in the aquifer,
- Need of more researches to evaluate the alternative techniques in terms of risk of pollution.

6.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Overall modelling of the East Lyon aquifer

The target is to construct an overall model of the East Lyon aquifer and of its different polluting inputs (diffuse pollutions and concentrated pollutions) in order to be able to test different management hypotheses.

This research action is described in sheet **PR6-1**.

Person in charge: Pierre Thierry (BRGM)

Action 2: Quantification of the impact of the artificial infiltration of runoff water on the biogeochemical functioning (carbon cycle) and the diversity of the invertebrates populations on the surface of the water table

The target of this action is to study the alterations of the microbial activities and the invertebrates populations on the surface of the water table. It will be needed to evaluate the effects of the dissolved organic carbon flows generated by the artificial infiltration of rain waters on the microbial activity, the biogeochemical processes (respiration and denitrification potentials), the wealth and density of the invertebrates populations on the surface of the water table. These modifications allow to estimate the self-purification capacities of the environment. It will also be needed to evaluate the maximum amount of water to be infiltrated by time and space units beyond which the capacities of assimilation of the biological film are exceeded.

This estimation would represent a key decision element to improve the protection of water resources of the Lyonnaise Region.

Persons in charge: Florian Malard, Janine Gibert (University Lyon I). See sheets **PR6-2-1** (ex 3.1.5 modified) and **PR6-2-2** (3.1.6. modified)

Action 3: Characterisation and quantification of groundwater quality upstream infiltration devices

The target is to follow the evolution of the aquifer quality, and more specifically to create a methodology allowing to control the quality under infiltration basins. It will also be needed to improve the efficiency of groundwater quality control devices installed on several East Lyon infiltration basins, in accordance with the physical characteristics of the infiltration fields and the nature of the inputs.

The study will consist of three phases:

- Evaluate the feasibility of the use of control and reference piezometers;
- Define the optimal period to take groundwater samples when rain water is in the aquifer;
- Compare the physico-chemical and biological analyses with those obtained on samples taken earlier.

Person in charge: Florian Malard, University Lyon1.

This research action is described in sheets **PR6-3** (*ex3.1.12)*

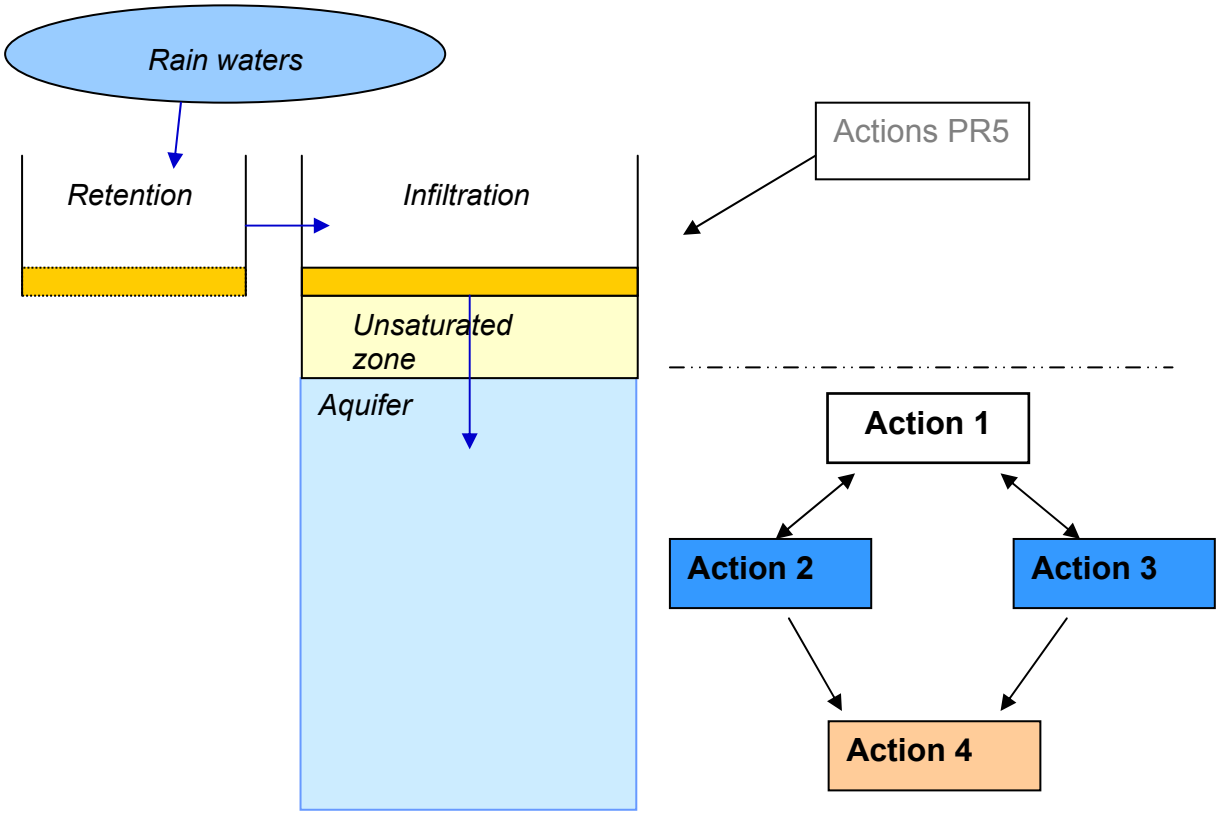
Action 4: Definition of local health indicators of an aquifer and construction of a methodology allowing to reach the zero state

The European Directive on Water for the preservation and the improvement of the quality of the aquatic environments relies on physical, biological and chemical indicators of the environments. They are organised in a description grid of the ecosystems alteration levels. A similar process led to the elaboration of the water quality evaluation system of the Water Agencies (SEQ), but as far as groundwater is concerned only the chemical state is taken into account, and not the ecological state. The main target of action 4 is to evaluate and compare the integrity methods and indicators used with surface waters and which could be applicable or not to groundwater, in order to control their ecological state. Furthermore, it will be needed to define a methodological process allowing to establish a “zero state” of the contaminations and the living organisms and to follow the evolution of the perturbations. The stake is to provide a crucial scientific knowledge to the political and socio-economical decision-makers as well as to the citizens for a better management of aquifers.

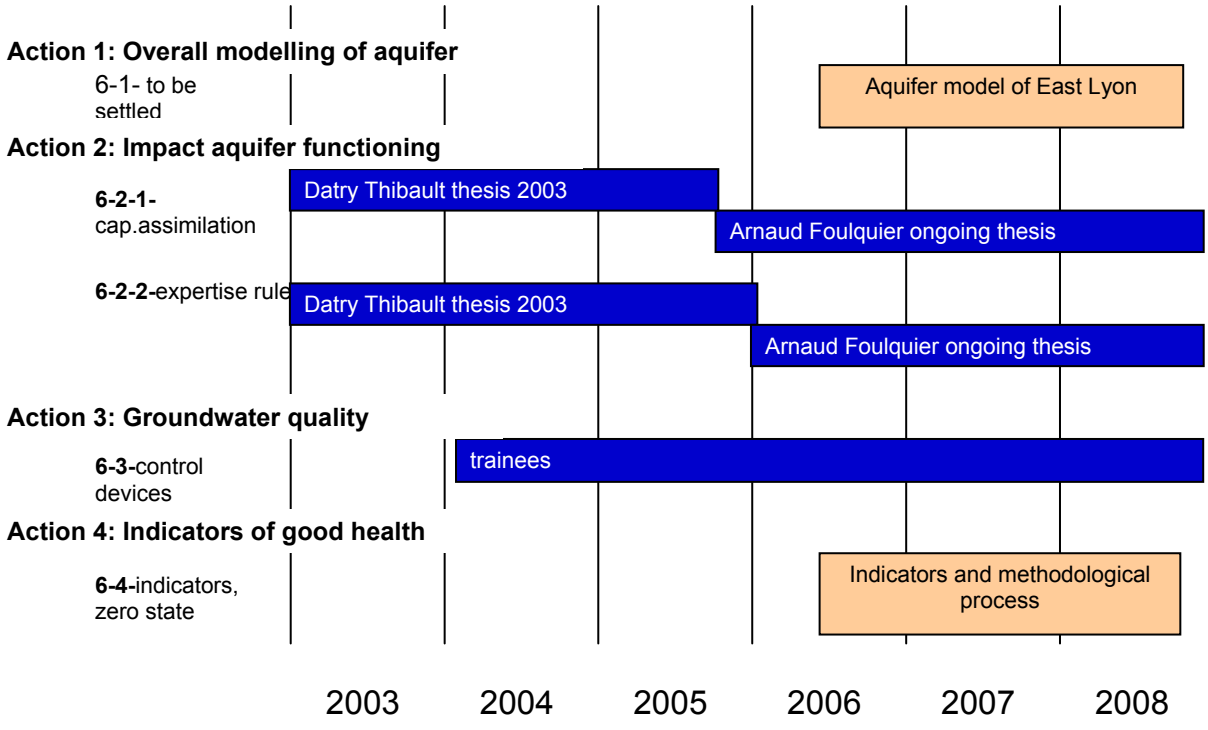
Person in charge: Janine Gibert, University Lyon1.

This research action is described in sheet **PR6-4**

The links between the different actions are represented by the following diagram:



The estimated schedule is the following (actions entirely financed and already started are in black, actions partly financed and ready to start in dark grey and the actions not yet financed in light grey).



7 Sub-program n°7: Metrology

Scientific leaders: J.-L. Bertrand-Krajewski / Ph. Namour

Grand Lyon Correspondent: P. Lucchinacci

7.1 Operational goals to be reached

7.1.1 Long term prospects

Develop procedures, rules and tools allowing to optimise the collection, validation, storage and use of data concerning the functioning of the sewer system and the receiving environments.

7.1.2 Middle term operational goals (3 years)

- Be able to use rationally and to validate the captors of continuous measurement of turbidity (turbidimeters) and of organic matter (COD measurement device, UV-visible mono- and multi-wavelength spectrometers, TOC measurement device, …);
- Validate on the field new types of micro-captors (of nitrates, ammonia, metals and organic matters), adapted to the values of the phenomena studied on the sites of the OTHU;
- Develop a sampling methodology of SS allowing to improve the representativeness of this type of samples;
- Improve the data collection chain of the self-monitoring (development of data validation tools in real time and uncertainties evaluation tools);
- Improve the sampling of sediments on the bottom of basins in order to guarantee their representativeness (geostatistical approach).

7.2 Scientific bottlenecks and research actions

7.2.1 Scientific bottlenecks

The scientific bottlenecks highlighted in this paragraph are linked firstly to the operational goals of this sub-program and secondly to the operational goals of the 6 previous sub-programs.

- Validation and inter-comparison of the captors performances in measuring continuously the SS and the COD, drawing the distinction between dry weather and wet weather;
- Determine the correlations between the signals measured in continuous and different physical magnitudes (turbidity and SS); determine other magnitudes after calibration;
- Conceive captors which would measure new magnitudes never measured before (toxic substances, …);
- Conceive captors adapted to the studied values;
- Sampling strategies and issues about representativeness;
- Improvement of measurement systems in the hyporheic zone;
- Evaluation of uncertainties in self-correlated series.

7.2.2 Research actions crucial to the program's leading, to be launched in priority and to be achieved within three years

Action 1: Measurement in continuous (turbidimetry and UV-visible spectrometry)

The targets of this action are the following:

- Create and validate methods of calibration of the turbidimeters, UV spectrometers and in-situ COD analysers, in order to follow in continuous (dry weather and wet weather) the SS and COD polluting flows produced in the watersheds.
- Accurately evaluate the associated uncertainties for each type of device.

- Transpose and verify the adaptability of these methods to the UV-visible multi-wavelength spectrometers.

This research action is described in sheet PR7-1

Person in charge: Jean-Luc Bertrand-Krajewski, URGC Urban drainage, INSA of Lyon.

Action 2: Sampling methods and representativeness of SS and sediments

The targets of this action are the following:

- Create and validate sampling strategies of SS in the sewer network flows in order to maximise the representativeness of the samples, coupled with an estimation of the associated uncertainties.
- Create and validate sampling strategies of sediments decanted in the retention/sedimentation basins in order to maximise the representativeness of the samples, according to various objectives (evaluation of the sedimented masses, of the average characteristics of sediments, etc.), coupled with an estimation of the associated uncertainties.

This research action is described in sheet PR7-2.

Person in charge: Jean-Luc Bertrand-Krajewski, URGC Urban drainage, INSA of Lyon.

Action 3: Development and test of micro-captors

The targets of this action are the following:

- Conceive and evaluate micro-captors allowing to measure nitrates, ammonia, metals and organic matters in hyporheic environments.
- Develop and validate a procedure of installation and maintenance of the micro-captors on site.

This research action is described in sheet PR 7-3

Persons in charge: N. Jaffrézic, LSA and Ph. Namour, Cemagref of Lyon, QELY

Action 4: Instrumentation in hyporheic zone

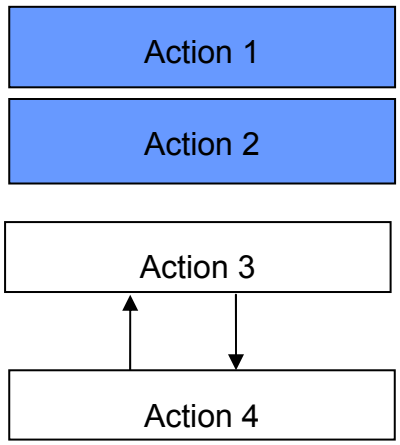
The targets of this action are the following:

- Conceive a system of instrumentation in hyporheic zone
- Draft a practical guide of instrumentation in hyporheic environment

This research action is described in sheet PR 7-4

Person in charge: Ph. Namour, Cemagref of Lyon, QELY.

The links between the different actions are represented by the following diagram:



The estimated schedule is the following (actions entirely financed and already started are in black, actions partly financed and ready to start in dark grey and the actions not yet financed in light grey).

	2005	2006	2007	2008
Action 1		Resources to consolidate	Resources to consolidate	Resources to consolidate
Action 2		Resources to consolidate	Resources to consolidate	Resources to consolidate
Action 3	Gained resources	Resources to consolidate	Resources to find	Resources to find
Action 4	Gained resources	Resources to consolidate	Resources to find	Resources to find

8 Supporting actions

In order to support this research, and besides the traditional valorisation actions led by the GRAIE and organised within OTHU's framework (internet site, OTHU's sheets, technical days), it has been planned to organise **supervising groups**.

These groups will be composed of researchers and end-users. Their mission will be to facilitate the transmission of the expertise in fields where researchers and end-users manipulate the same concepts in different contexts.

There are three planned groups:

- "PLUVIOMETRY" group
- "METROLOGY" group

  The objectives of the latter group are the following:

  Draw up procedures of samples management, from their sampling until their analysis.

  Draw up procedures of maintenance and verification of the captors installed on site.

  Guarantee the homogeneous functioning of the different captors.
- "MODELLING" group

For each group a leader will be designated and be in charge of the regular organisation of meetings.

Furthermore, an **annual assessment meeting** will gather all the sub-programs scientific leaders and operational correspondents in order to discuss with the OTHU's management committee and to sum up the progress of the different sub-programs.

9 Interactions between actions

Appendix 1: Program arrangement process

A- Method of hierarchical organisation of the questions to be treated in priority.

Step 1: Draw up an exhaustive list of the questions raised (note: the questions raised are practical ones aimed at reaching an operational goal, they are not scientific questions), if possible by using the classification recommended on the following page.

Step 2: Classify the practical questions into three categories:

- Questions that can be solved immediately by a research consultancy.
- The more accurate questions requiring to be addressed to a scientific expertise (pluri-disciplinary if needed); those questions correspond to knowledge gained by scientists but which do not have been spread in the professional environment yet.
- Questions requiring the development of scientific researches; clearly identify the scientific questions that have been shelved (i.e. scientific locks).

Step 3: Keep the third category and analyse the scientific questions to be solved and corresponding to each of the practical questions in accordance with the two following criteria:

- Can the question be answered within the allotted time (three years)?
- Is the OTHU organisation adapted (or adaptable) to solve the question ?
- Are the OTHU's current research teams competent and do they have the resources to solve the question?

Step 4: According to the answers to the previous questions and to the end-users priorities, organise into a hierarchy:

- The practical questions which cannot be solved yet but which should be solved within the three years time limit.
- The scientific questions which should be dealt with in priority.

B- List of the selected criteria

End-users interest

- importance of the expected financial benefits (realisable savings, …)
- importance of the expected social benefits (service improvement, reduction of the pollution, diminution of the risks for the employees, …)
- importance of the expected environmental benefits (enhancement of the receiving environment)
- importance of the expected benefits in terms of service organisation
- strategic aspect of the problem (political evaluation)

Scientific interest

- Capacity to produce knowledge
- Capacity to mobilise existing competencies within the OTHU
- Capacity to generate a « valuable » production (thesis, publications)
- Capacity to enable a pluri-disciplinary research

Interest in terms of use of the OTHU organisation

- Continuity of the project (link to ongoing projects)
- Capacity to use and enhance the value of existing data and organisations. If needed, indicate the possible needs of new organisations.
- Specificity of the project (can the project be or not be led on another site or by other teams)
- Possibility to apply the outcomes to other sites
- Capacity to finance the project
- Cost of the project (importance of the resources to gather)
- Possibility to gather internal financial resources (Grand Lyon, Water Agency, …)
- Possibility to gather external financial resources (Region, CNRS, Europe, …)