Annex V Case studies

A summary of the following case studies is contained in Chapter 6 of the main guidance document.

Title: **No: 1**

Selection of **specific pollutants** by using ongoing implementation work of Council Directive 76/464/EEC[1] (Discharge of Dangerous Substances – DSD)

Type of impact:

Increasing loads of chemicals, toxicity, ecotoxicity, accumulation and secondary poisoning

Type of pressure:

Point and diffuse sources of chemicals

Type of analysis or tool:

The Water Framework Directive requires the establishment of measures for against pollution in order to reach the objectives. On one hand, the priority substances (Annex X) are regulated in accordance to Article 16. On the other hand, other specific pollutants need to be identified on a river basin (district) scale (cf. section 3.5 of the guidance).

Council Directive 76/464/EEC already provides for such a mechanism under Article 7 where Member States shall establish pollution reduction programmes for relevant pollutants of list II of that Directive. These so-called "list II substances" must also be selected out of a number of pollutant groups which are similar to the one in Annex VIII WFD.

It is recommended (and to some extent mandatory) to make best use of the implementation of this requirement of 76/464/EEC for the first analysis of pressures and impacts under the Water Framework Directive because, in particular:

- ✓ the transitional provisions (cf. Art. 22 (2) to (6)) require the implementation of 76/464/EEC is required as a minimum requirement and smooth transition must be ensured since the directive requirement will only be repealed in 2013.
- ✓ the rulings of the European Court of Justice which need to be respected.
- ✓ the experience and knowledge available in the Member States and Candidate Countries (which are currently identifying pollution reduction programmes as part of their accession commitment).

Further information on the relation of 76/464/EEC and WFD is available (see references).

Information and data requirements

Depending on the approach used, the following information will be needed, in particular:

- ✓ intrinsic properties (e.g. physico-chemical properties, persistence, (eco-)toxicity, bioaccumulation)
- ✓ emission inventories (e.g. European Pollutants Emission Register (EPER)[2], Article 11 of Directive 76/464)

[1] Council Directive 76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (OJ L 129, 18/05/1976, p. 23).

[2] Commission Decision 2000/479/EC of 17 July 2000 (OJ L 192, p. 36).

- ✓ marketing and use data
- ✓ existing monitoring data (until 2006)
- ✓ surveillance, operational and investigative monitoring data (beyond 2006)
- ✓ Potential sources and emission routes
- ✓ Fate and behaviour models

Brief description including figures

The generic group of pollutants listed in Annex VIII cover a large number of individual substances. It is up to the Member States to establish an appropriate list of "**specific pollutants**" to be assessed for their relevance. However, the methodology for identifying **specific pollutants** is not specified in the Directive.

It is therefore recommended that the identification of **specific pollutants** under the Water Framework Directive should be further developed from the approaches used under Directive 76/464/EEC and the priority setting procedures elaborated for the selection of the priority substances.

It is evident that the 33 (group of) priority substances[3] and the eight list I substances[4] of 76/464/EEC which are not included in the Annex X WFD in the pressure and impact analysis since they will form the "chemical status".

For other **specific pollutants**, the starting point should be the substances identified as list II substances under Article 7 of 76/464/EEC. In addition, a candidate list of pollutants may be established which should be the starting point of a screening and priority setting process involving several steps.

Finally, the prioritisation process developed on European level, the so-called COMMPS[5] process, could be of additional use for the final selection of **specific pollutants** on a river basin scale. Moreover, the output of the Expert Advisory Forum on Priority Substances may also be useful for the pressure and impact analysis for other **specific pollutants**.

Based on the experiences of the implementation of the Directive 76/464/EEC, Member States have applied a wide range of approaches to identify "relevant list II substances".

However, it abstract terms, there are two generic approaches, which could be adopted for identifying potentially relevant pollutants:

- **Top-down approach** – this approach starts with the "universe of chemicals" and relies on all the available knowledge of the substances in order to screen for those substances which are of relevance in a river basin (district);

- **Bottom-up approach** – this focuses on those areas where existing monitoring data (biological and chemical) clearly identifies that the objectives may not be achieved. In addition, a specific, targeted and time-limited screening monitoring may complement the available information.

In most cases, a combination of both approaches is used by Member States.

[3] Decision 2455/2001/EC establishing the list of priority substances (OJ L 331, 15 November 2001, p. 1)

References

"Study on the prioritisation of substances dangerous to the aquatic environment" Office for Official Publications of the European Communities, 1999 (ISBN 92-828-7981-X) [6]

Study report commissioned by the European Commission: "Assessment of programmes under Article 7 of Council Directive 76/464/EEC" (November 2001) [7]

Summary of Workshop on the "Discharge of Dangerous Substances Directive (76/464/EEC) - Lessons Learnt and Transition to the Water Framework Directive' of 1-2 July 2002 in Brussels (available through contact).

Furthermore, an ongoing study project of the European Commission on "Transitional provisions for Council Directive 76/464/EEC and related Directives to the Water Framework Directive 2000/60/EC" will produce specific outputs in relation to the above-mentioned aspects. Moreover, the Expert Advisory Forum on Priority Substances will produce several results which might be useful for the selection of other specific pollutants. These reports and the above-mentioned information is or will become available on the water web site of DG Environment:

www.europa.eu.int/comm/environment/water.

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[4] The eight remaining list I substances are: drins (aldrin, dieldrin, endrin and isodrin), tetrachloroethylene (PER), trichloroethylene (TRI), Carbon tetrachloride, DDT

[5] COmbined Modelling-based and Monitoring-based Priority Setting

[6] http://europa.eu.int/comm/environment/water/water-dangersub/pri_substances.htm

[7] http://europa.eu.int/comm/environment/water/water-dangersub/article7ofdirective77464eec.pdf

Title: **No: 2**

WATER QUALITY PLANS IN FLANDERS (Belgium)

Type of impact:

Status and change of water quality of surface waters.

Type of pressure:

Point and diffuse sources from households, industry and agriculture (and WWTP)

Type of analysis or tool:

Point source – households: number inhabitants x pollution factor (PE)
Point source – industry (only main companies): sampling results of discharges
Point source – agriculture:

- inhabitants is included in households;
- animals: inventories (number of animals x excretion factors)

Point source WWTP: sampling results of discharges
Diffuse source – households: number inhabitants x pollution factor x reduction factor
Diffuse source – agriculture: SENTWA-model (calculation of losses of nutrients)
Load reduction: GWQP-mass balance ; SIMCAT-model (WRc – water quality model)
Status of waterbodies: Biological (Belgian Biotic Index), Physical-chemical (Prati-index)

Information and data requirements

Basic information: map of catchment areas, PE-equivalents, EQS, list of industrial main polluters.

Variables: number of inhabitants, industrial and WWTP discharges, livestock inventories, manure transport, inventories of the actual and planned sanitation projects, water quality data, water flow, load and removal rates of WWTPs, production and removal of WWTP sludge, permitted industrial loads, costs of the sanitation projects.

Brief description including figures

With exception of the driving forces, the approach is an application for water quality of the DPSIR-framework. On catchment level, the pressures (discharges and inflows) and the effect of it on the quality of water bodies are assessed, considering point and diffuse source pollution from households, industry, agriculture and WWTP. The actual status and evolution for the last decade of the water quality of the water bodies is described.

At pressure (discharges and inflow) and status level a series of general physical and chemical pollutants (Q, BOD, COD, N, P, SM, O_2, etc.) (and in some cases also heavy metals) have been reported and loads have been calculated. For 3 parameters (COD, nitrogen, phosphorous) calculation of pollution loads result in 'load balances'. This makes it possible to calculate load reductions (at inflow and discharge level) in order to meet the environmental quality standards (EQS). (see figure).

The policy instruments are described and result in a number of measures that can be used in a scenario or cost analysis (see fig.). A first attempt for scenario analyses has been made and a scenario has been defined for households, industry and agriculture. For that, measures have to be quantified. The result of this excercise reveals if the proposed measures are sufficient to reach the EQS in the future.

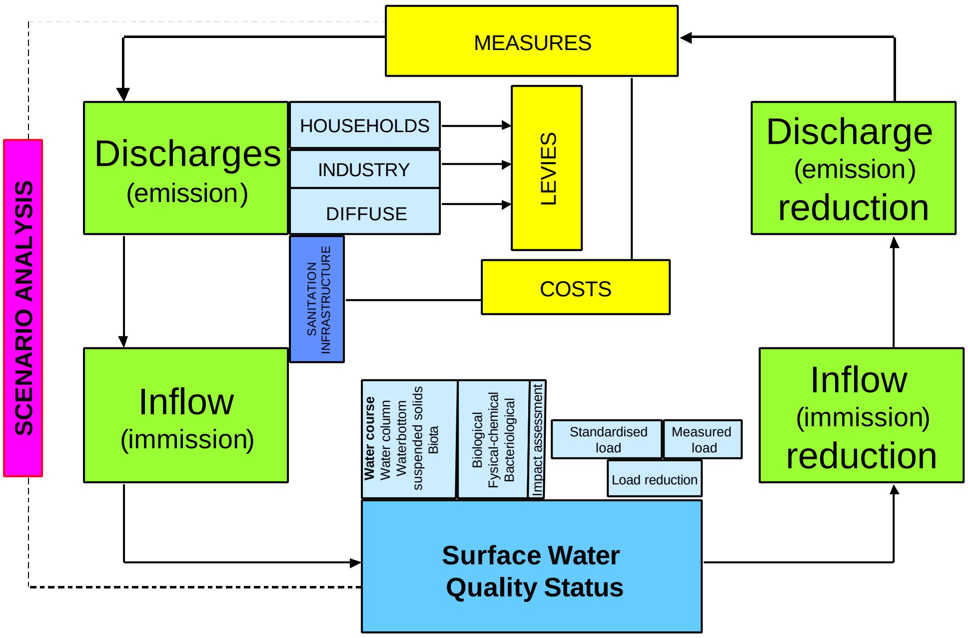
The outcome results in 2 types of reports. A summary report, in which the load balances (and in particular load reductions) are stressed, and an extended technical-scientific document, describing all aspects of water quality considered. This TS-document consists of a manual, describing the framework and all sources and tools used, and the report containing all basic information, results and conclusions. In annex a list of tables and figures is added.

This method is / will be applied to the approx. 260 stream catchments (hydrographical zones) within the 11 distinct river catchments of Flanders. The data collated in 34 tables provides information in a comprehensive way on sampling / monitoring of waste water and water quality, loads and load reductions, as well as a description of the catchments, the functioning of the WWTP-infrastructure, the water uses, etc. in relation to the target groups.

Important and useful are in particular:

- the framework, relating all aspects of water quality (see figure as a flowchart). This framework is dynamic as it allows expansion with new topics e.g. analyses of cost-effectiveness;
- the use of pressure indicators (ratios) which enables to compare results – on the one hand - from the pollution sources on the level of discharges, inflow and after sanitation measures have been completed, and – on the other hand – between the pollution sources (households, industry and agriculture), regardless the surface area covered;
- the availability of information on catchment level, to be totalised on any other higher hydrographic level (e.g. river basin).
- the calculation of load reductions (see figure: inflow reduction), tested against different EQS. Hydrographical zones may be ranked according to the reduction priorities tested against several legal or ecological EQS of COD, N and P. *Example: tested against an EQS of 0.3 mg/l P, load reduction within the river Nete basin must reach 85% or 1.924 kg/d; the contribution of the households to this is about 25% or 481 kg/d; the reduction is specifically high (> 75%) in 10 hydrographical zones.*

<u>Abbreviations:</u> COD: Chemical Oxygen Demand, EQS: Environment Quality Standard, GWQP: (General) Water Quality Plan, N: nitrogen, P: phosphorous, PE: population equivalent, WWTP: waste water treatment plant.



References

VMM, 2001. General Water Quality Plan Nete. 61 p. (Summary Report in English). / VMM, 2000. Plan Général de la qualité de l'Eau de l'Yser. 66p. (Summary Report in French). / (more elaborate versions of the GWQPs are available on cd-rom – only in Dutch).

Water Quality plans in Flanders (Belgium) – Approach and experiences. Note. 25 p. (available on CIRCA).

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Title: **No: 3**

Water Integrated Emissions Inventory (ETC-Water) (France)

Type of impact:

Increasing loads of pollutants, eutrophication

Type of pressure:

Point and diffuse sources of OM, P, and N from households, industry and agriculture.

Type of analysis or tool:

Use and organisation of the already existing national and international statistical sources for the purpose of emission calculations.

Information and data requirements

NB: all data can be considered at a regional and time level and adjusted from monitoring for any actual source or type of source (point/diffuse).

Point source – households: number inhabitants x pollution factor (PE)

Point source WWTP: sampling results of discharges

Point source – industry ((only companies >400 fiscal PE)): Loads by pollution factor and sampling results of discharges

Point source – agriculture: animals: inventories (number of animals x excretion factors), per specie, region.

Diffuse source – households: number inhabitants x pollution factor x reduction factor, impervious urban areas

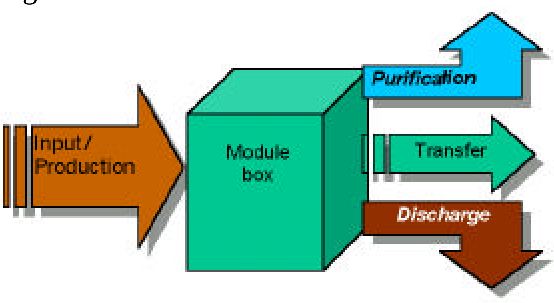
Diffuse source – industry : impervious industrial areas

Diffuse source – agriculture: - Use of fertilisers; model for calculation of losses of nutrients.

Brief description including figures

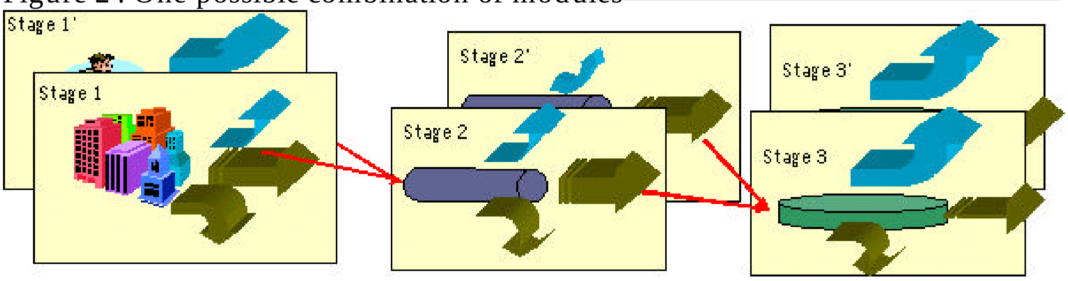
The methodology

Figure 1: The basic module



All emissions are computed as network of elementary modules, to systematise calculations (Fig. 1).
A module receives or produces a certain amount of pollution, purifies a part of it, discharges another part and transfers the remaining quantity to the module downstream (Fig. 2).
This schematisation allows any type of aggregation and presentation of final results (e.g., part of industrial effluents purified in domestic treatment plants.)

Figure 2 : One possible combination of modules



Depending on the organisation of the information system, each country has its own procedures and different data and information are available. This can also be the case at the national or regional level. To overcome these difficulties, the methodology developed in the Loire Bretagne Basin in France proposes to use the best possible data available at the most disaggregated level and coefficients when the data do not exist. The main advantage of this is to have a clear overview of the existing information system. The inventory can be completed and improved when data becomes available or the quality of this data improves and nonetheless to produce information, even if the raw data do not exist in a suitable form.

This of course needs some expert judgement and also a clear presentation of the calculation steps but allows the use of data and information coming from different organisations. This is also economically sound in using the best information and data already available.

Another main idea of the methodology is that the different types of emissions can be described with the same conceptual model. Any emission process is analysed as a combination of modules or steps, thus enabling simple data processing and multi-purpose reporting.

The application

Using this methodology, the project was applied on the so-called „Loire-Bretagne Water Agency“ with the following geographical unit, temporal unit, sources and substances.

The area concerned by the Loire-Bretagne water agency extends over 156,217 km2. At the catchment level, the territory is broken down into 16 catchments, 12 for the Loire river and its tributaries, 3 for Brittany and 1 for Vendée.

At the administrative level, it extends over 10 Regions (NUTS2) and 31 "départements" (NUTS3), both being only partly included in the Water agency area. The 7281 municipalities (NUTS5) are totally included in the aforesaid area and the data were considered at this level.

Agriculture is one of the main activities: two-thirds of French livestock is grown on this area, as well as two-thirds of slaughtering and flesh transformation activity. Half of the national milk production and derivatives also comes from this area.

Measurement habits concerning water in France are based on the mean value of the month of maximal activity and given in tons per day. However, many statistical data are available only yearly, based on the civil year and the data are considered at this level.

The methodology has the ambition to build a unique system and thus to cover all the sources. For the purpose of this exercise, Ifen decided to collect only the data on emissions liable to reach the inland waters quickly. The sources identified were agriculture, industries and domestic.

The three substances studied are organic matter, and the nutrients Phosphorus and Nitrogen.

The data used have many different sources, the main criteria is the potential availability for the whole country with the same organisation.

The main interest of the methodology is to consider all the main sources and all the data available concerning these. It integrates all the available data to provide trends and evaluations of the relative part of each source in the overall pollution. It's easy to change one hypothesis or one set of data and recalculate the results.

Another point to highlight is that all the hypothesis and calculations are transparent and can be adapted to one specific condition or the use of one specific calculation model.

Some results

Figures 3 and 4 show the restitution of the results at an administrative level that is the „departements“ (pink lines and one chart for each). For the administrators of those regions it is important to know the apportionment of emissions or raw pollution between sources and the main source of each substance. In this example the main source of organic matter is domestic. Regarding the quantities assessed, there is a huge difference between the raw and the global pollution: many processes occur along the transfer of the pollutant from its production to its discharge in water. The flexibility of the approach allows the restitution of results at different administrative levels like the region or the „departement“. This is also possible at the hydrographic level: the 16 catchments of the Loire-Bretagne Water Agency.

Finally, it is also possible to aggregate different sources or to focus only on one source to allow the comparison between zones as regards the quantities discharged in waters.

In fact the only limit of these exercises is the original scale of the data: if the original data is available at the regional level, it is not possible to represent the results at a smaller geographical scale like the „commune“ level. It is then very important to use the most disaggregated data to allow the maximum flexibility.

Figure 3: organic matter raw pollution apportionment between departements (BOD5 in kg/day)

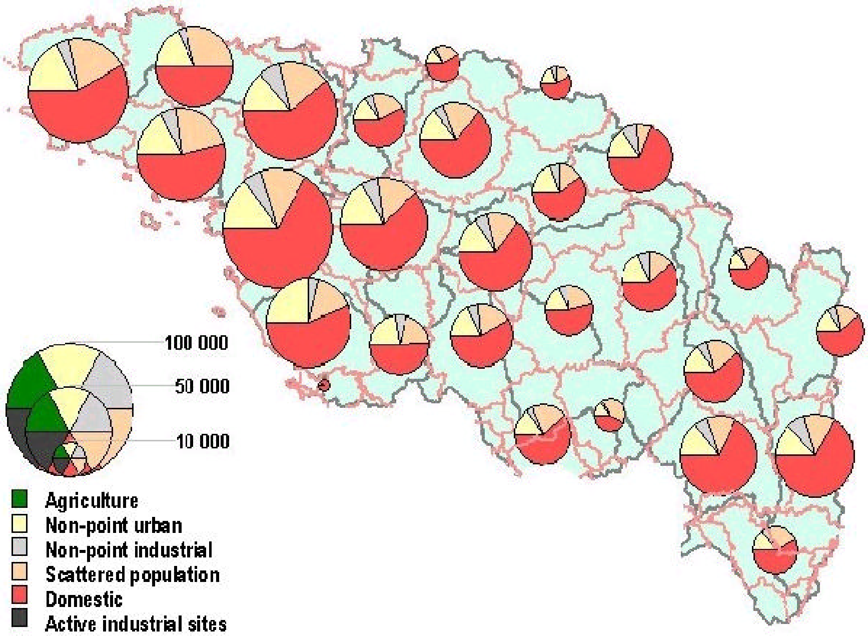
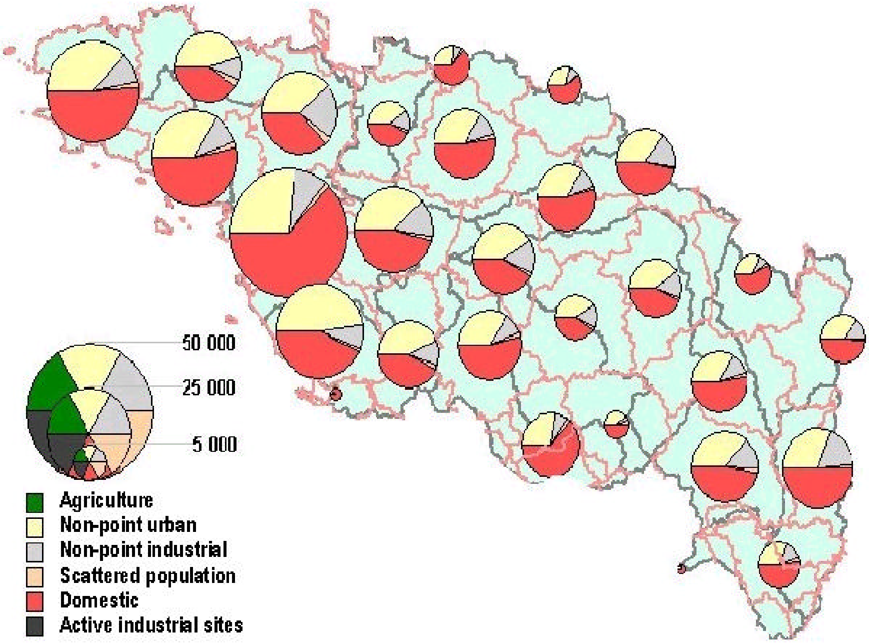


Figure 4: Organic matter global pollution apportionment between departements (BOD5 in kg/day)



References

Fribourg-Blanc, B. 2002. *EUROWATERNET-Emissions A European Inventory of Emissions to Water: Proposed Operational Methodology*, *draft 4*, provisional, Medmenham, European Topic Centre on Inland Waters, p.65, English

Detailed results available on CD-Rom (in French), apply to Philippe Crouzet

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Title: **No: 4**

CARTOGRAPHIC MODELLING OF WATER USE SYSTEM

Type of pressure:

Water abstraction

Type of analysis or tool:

Tools for Water Balance description ("Consumption and Water Management Indexes")

Information and data requirements

Maps of natural water resources, of water demands (urban, industrial, agricultural), of additional water from desalting processes and interbasin water transfers.

Brief description including figures

The objective of this practice is to have a evaluation of the pressure of spatial distribution of water demands on water resources.

A distributed model calculates the risk of water scarcity from the information of natural water resources and water demands. Figure 1 shows the procedure carried out by the model for each cell. The area selected for the cells of the grid used in the model is 1 km2, this gives a total for Spain of 500.000 cells.

The potential water resources available (surface and ground water) are determine from the natural resources (renewable resources generated in Spain). Which are the part of the natural water resources that truly mean the potential offer of water.

The difference between total water resources and potential water resources represent the environmental requirements. These resources cannot be accounted to reach the productivity objectives of the system. Only the rest of water resources (potential water resources) are the ones that can be used in the system and therefore are the only ones included in the water balance (between water offer and demands).

The additional water from desalination processes (Fig.2) should be added to the potential water resources.

Another factor that should be considered are the water transfers at present in operation. These water transfers do not increase the potential water resources at national level but they modify their distribution (Fig.3).

The total demand (water abstraction) is the addition of urban, industrial and agricultural demands. However water returns should be take into account, which come back to the natural water system and may be used downstream in the basin. This is the reason to separate the consumptive and non consumptive fraction of each one of water uses. In this way can be calculated the consumptive and non consumptive water demand for each one of the water uses. The addition of these two fractions gives the total demand (Fig.4).

For each one of the grid cells the water balance is calculated between the potential water resources and the total consumptive water demand. This balance allows to obtain the maps with the spatial distribution of deficit and water surplus (Fig.5 and Fig.6). These maps have only a illustrative character since they are the first approach to the problem. As it is known, the water is not used in each cell in an isolated way.

Therefore a spatial aggregation is needed, which has been based on the water management units defined in the Basin Water Plans. This allow to identify the water deficit and water surplus in the different management units included in each of the basins (Fig.7 and Fig.8). The aggregation of all grid cells of each basin offers the total balance of the basin (Fig.9 and Fig.10).

The processes explained before assume that all the potential water resources generated in the system, plus the possible additional water from desalination processes and / or water transfers are fully used in the system.

Previous statement implies to have available the needed infrastructures to use all water resources and also that the water has the required quality for each use. Therefore the only water supply limits would come only from limitations of the available water resources.

A system will be said that has deficit when cannot supply the part of consumptive use demand although the system has the needed infrastructures and also the water quality required. In the other hand a surplus system does not mean not having any problem of water supply. This problem might exist in case of lack of infrastructures required or in case of lack of water quality required.

To elaborate the water balance with consumptive demands, it is assumed that water reuse in the system is the maximum possible.

This deficit and surplus are of different level and also depends of the size of the systems.

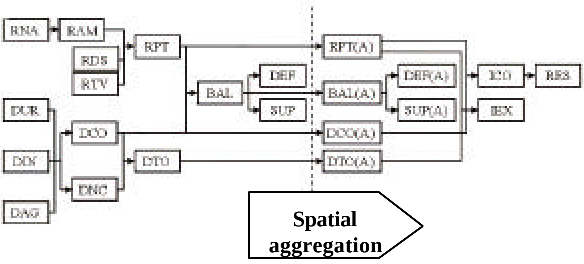
To try to be more clearly having elaborated the water management index and the water consumption index (Introduction à l´économie générale de léau Erhard-Cassegrain and Margat, 1983). This last are used to elaborate a map of water scarcity risk (Fig.11 and Fig.12).

The water management index is the result of dividing the total water demand and the potential water resources. It has to be pointed out that a water management index near or larger than “1” may not mean, in some cases, a water scarcity. This is because if the water abstractions are not too much concentrated in an specific area, part of the water returns might be use downstream.

The water consumption index is obtained by dividing the consumptive demand and the potential water resources. This ratio can also be used as an indicator of scarcity risk. A value greater than 0,5 could indicate “eventual” scarcity, in the other hand if the value is near 1 could mean that the scarcity is “structural”. A low value of water consumption index indicates that water resources have a very low use.

It can be observed that the deficit system have a water scarcity of structural type. In this system the potential water resource is systematically lower than the level of water consumption that is try to reach.

But there are also a number of systems that having water surplus have the risk of suffering an eventual water scarcity. The reason for this is that their levels of water consumption are relatively close to the potential water resources. In these systems a number of successive dry years might produce water supply problems because the lack of enough water resources in those years.



RNA	Natural Resources	RDS	Desalinated Water	DEF	Deficit
DUR	Urban Demand	RTV	Transferred Water	SUP	Surplus
DIN	Industrial Demand	DCO	Consumption Demand	ICO	Consumption Index
DAG	Agricultural Demand	DNC	Non-consumption Demand	IEX	Management Index
RAM	Environmental Requirements	DTO	Total Demand	RES	Risk of scarcity
RPT	Potential Resources	BAL	Balance	(A)	Added

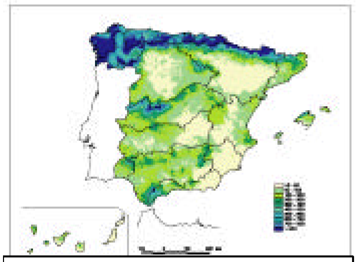


Figure 1. Natural water resources (mm/year)

Figure 2. Desalinated water (Mm³/year)

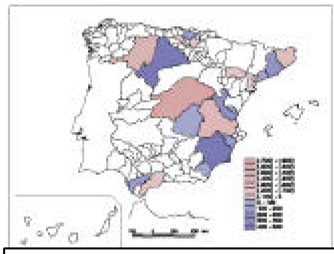


Figure 3. Transferred water (Mm³/year)

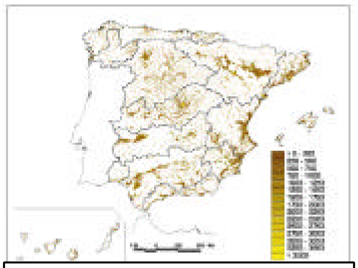


Figure 4. Total demand (mm/year)

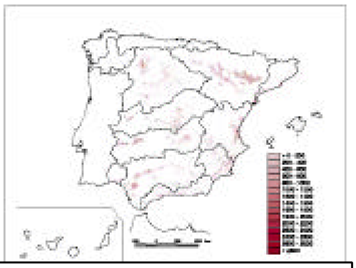


Figure5. Deficit spatial distribution (mm/year)

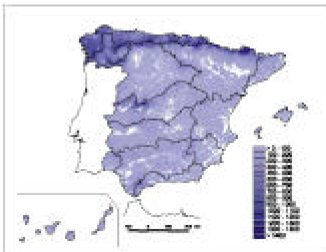


Figure 6. Surplus spatial distribution (mm/year)

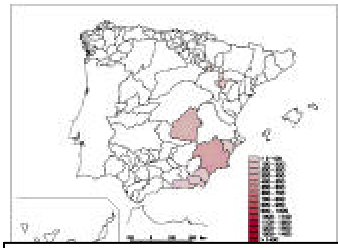


Figure 7. Deficit aggregation in water management units (Mm³/year)

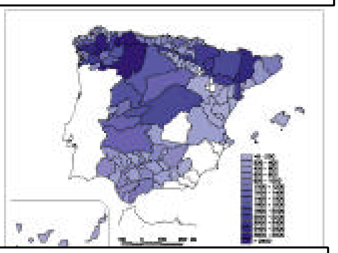


Figure 8. Surplus aggregation in water management units (Mm³/year)

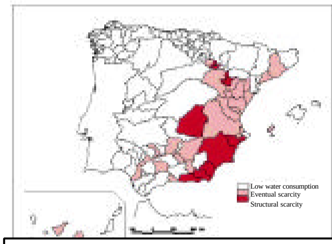


Figure 11. Water scarcity risk in water management units

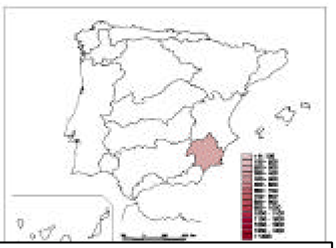


Figure 9. Deficit aggregation in basins (Mm³/year)

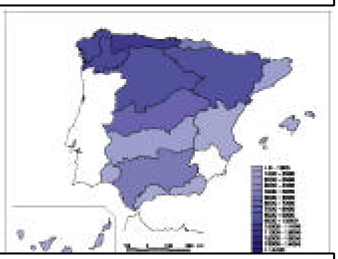


Figure 10. Surplus aggregation basins (Mm³/year)

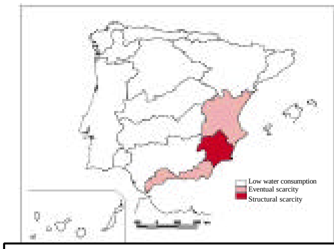


Figure 12. Water scarcity risk in basins

References

MIMAM (2000), Libro Blanco del Agua en España. (Ministry of Environment (2000),White paper on water in Spain) Language: Spanish

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Title: **No: 5**

Diffuse pollution case study: Guadiana river watershed (Portugal)

Type of impact:

Increase of nutrients loads that can lead to eutrophication problems

Type of pressure:

Diffuse sources of P and N based on land use.

Type of analysis or tool:

A simple methodology was developed on a grid-based water quantity and quality model for mean annual values. Integration of Geographical Information Systems (GIS) it is an important tool that will allow characterising the spatial variability of the watershed by using spatial analysis tools.

Information and data requirements

Physical watershed characteristics, land use and topographic, and hydrological characteristics, precipitation / runoff, together with values of nutrients exportation.

Brief description including figures

Methodology

The first step is to create a mean annual runoff grid based on a distributed hydrological model. In this work, the methodology used is described in GOMES (1997), which is based on Temez aggregate model, implemented cell by cell in A.M.L. language in Arc / Info-Grid. The equations of this model, which rule evapotranspiration, water retainance in soil, infiltration and runoff process, are applied to each cell. This model uses precipitation (mm) and potential evapotranspiration (mm) as input variables and has 3 parameters, a flow parameter, a maximum retention of water in soil (mm) and a maximum infiltration rate (mm).

Runoff (mm/year) = f (precipitation, evapotranspiration, parameters)

Pollutant loads need to be assigned to each cell in order to calculate loading of pollutants in a river system. The combination between distributed maps of the watershed characteristics, namely land use and geology, with the exportation coefficients of phosphorus, and will allow estimating nutrient content that reaches to the streamlines (Table I).

Table I Export values of phosphorus E_P and nitrogen E_N (mg m^{-2} $year^{-1}$) (JØrgensen, 1980)

Landuse	Ep Geological classification		En Geological classification	
	Igneous	Sedimentary	Igneous	Sedimentary
Forest				
Range	0.7 - 9.0	7.0 - 18.0	130 - 300	150 - 500
Mean	4.7	11.7	200	340
Forest + pasture				
Range	6.0 - 16.0	11.0 - 37.0	200 - 600	300 - 800
Mean	10.2	23.3	400	600
Agricultural areas				
Citrus	18.0		2240	
Pasture	15.0 - 75.0		100 - 850	
Cropland	22.0 - 100.0		500 - 1200	

The linkage between the coefficients of nutrients to the polygon coverage of land use will be converted to a grid with the same cell size that runoff map and this will be the load map. Using spatial tools of a GIS will allow making operations between the distributed runoff map and the digital terrain model (DTM) of the watershed to obtain the accumulated flow in the streamlines. The same operations are made to the phosphorus load map. This will result in the annual concentration of phosphorus in the streamlines:

Concentration (mg/l) = Load (mg/year) / Flow (dm³/year)

After the calculation of the concentration values it's possible to compare them with nutrients data measured in the water quality sampling stations to validate this methodology. Nevertheless the nutrients measured in each station reflects the total pollution that reach the streamline – point and non-point.

Application

This methodology was applied to the Guadiana river, and only for phosphorus because is the limiting factor, which determines the development of eutrophication. This river is an international basin, with a total area of 66 860 km² and having it's headwaters in Spain, and only 11 600 km² of the area is our national basin.

This river has an important role in the south of Portugal, a region with drought problems. The agricultural activities and animal in pasture have a great impact in this basin as non-point pollution sources, which causes a large amount of nutrients exportation to the water and soil.

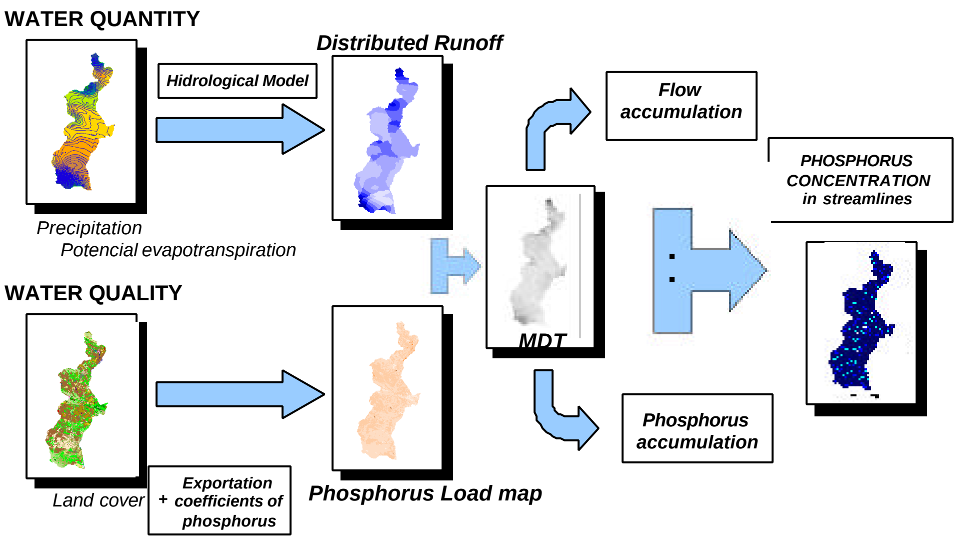

Figure 1 – Methodology application to Guadiana River (Portuguese basin).

Results

For modelling the runoff map it's necessary to have the distributed maps of precipitation and potential evapotranspiration. After calculating the distributed maps of runoff and phosphorus load (Figure 2) it's necessary to accumulate this two variables in the streamlines. The accumulated flow and the accumulated phosphorus load in the streamlines is made by using flow direction map originated from DTM, that shows the direction in each cell that runoff take to reach the streamlines. The concentration values are calculated in mg/l of P by dividing the load values with the flow values.

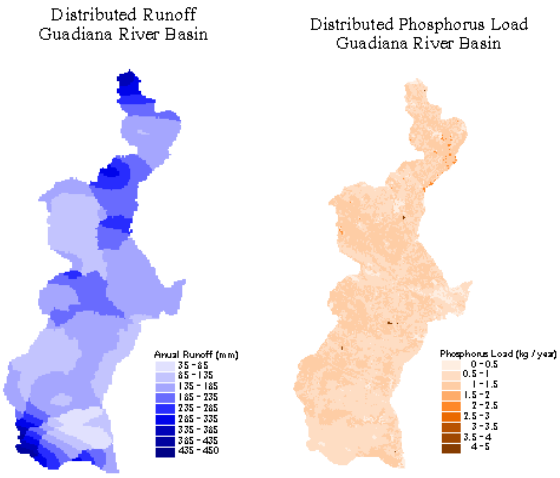

Figure 2 - The input distributed maps to calculation of phosphorus concentration.

A comparison between the estimated values of P and the observed values was made in the water quality sampling stations in the rivers (Figure 3). This Figure also shows the main point sources pollution, industrial and domestic. They are spread all over the basin but more concentrated in the North part.

By comparing these two values (observed versus estimated), we shouldn't forget that estimated value only takes in account the diffuse pollution provoked by land use. It's missing the correspondent impact of animals in pasture and point sources pollution to have the total phosphorus concentration in the rivers.

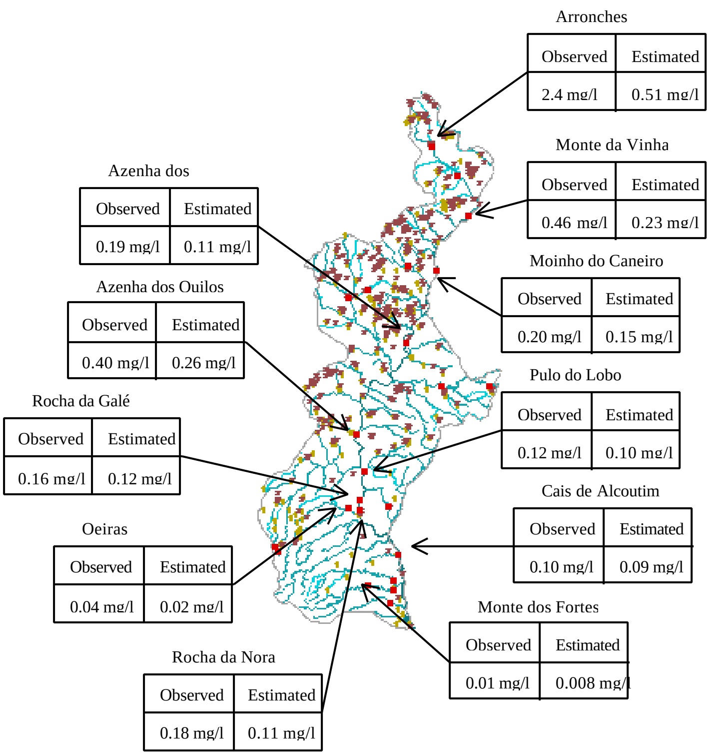

Figure 3 - Comparing the observed values with the estimated in the water quality stations.

In general it can be verified that the higher values of phosphorus concentration are in the North part of the basin and the estimated values are more approximated with the observed ones in the South. This can be explained because there are less point sources in this zone, which reflects the contribution of diffuse pollution.

Regarding sampling data, (Figure 4) it can be concluded that a dilution of the phosphorus concentration is observed as coming to South part of the basin. Also, in terms of percentage, the estimated values related with the observed ones, increase as coming to South part of the basin, which illustrates more contribution of the non-point pollution to the total amount of P.

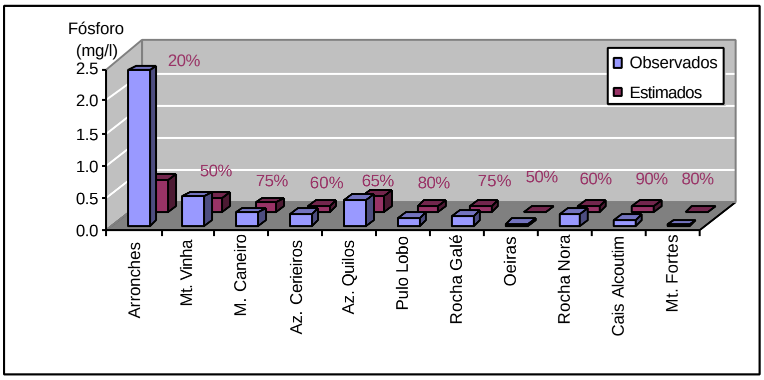

Figure 4 – Comparing phosphorus concentration (observed versus estimated) and their relation in terms of percent.

References

JØrgensen, S.E., (1980), *Lake Management*, Pergamon Press Ltd., UK.

Gomes, F., (1997), Modelação Hidrológica Distribuída: Aplicação à bacia do Guadiana. Universidade Técnica de Lisboa, Instituto Superior Técnico.

Novotny, V., Olem, H., (1994), *Water Quality. Prevention, Identification and Management of Diffuse Pollution.* Van Nostrand Reinhold, New York.

Olivera, F., Maidment, D. R., Charbeneau, R. J., (1996), Spatially Distributed Modelling of Storm Runoff and Non-Point Source Pollution using Geographic Information Systems. University of Texas at Austin.

Quadrado, F., Gomes, F. et al, (1996), Programa de Despoluição da bacia do rio Guadiana. INAG, DSRH.

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Title: **No: 6**

Groundwater Abstractions (Denmark)

Type of pressure:

Lowering of groundwater table, reduction of streamflow

Type of impact:

On groundwater: Alterations in directions of groundwater flow, possibly leading to saline intrusion. Also deterioration of groundwater quality as a result of e.g. upwelling, oxidation in upper layers, increased infiltration.

On surface waters: Reduced dilution of chemical fluxes from e.g. wastewater, modified ecological regimes (resulting from change in a long range of parameters, such as changes in temperature of water in streams as a result of reduced influx of groundwater!).

Type of analysis or tool:

Monitoring: Measurements of changes in both groundwater levels (soundings), and changes in groundwater chemistry (e.g. chloride, sulphate, iron, nickel) to quantify effect of groundwater abstraction.

Model Approach: 2- or 3-dimensional hydrologic models (numeric computer models) used to assess changes in groundwater flow as result of abstraction, and also to calculate water balances. More refined 3-dimensional models can be used-to assess interactions with surface waters and calculate e.g. changes in streamflow.

Information and data requirements

For the application of models often-extensive requirements have to be met for input data. These data are often derived from existing monitoring data and pumping tests of groundwater wells.
For an adequate representation of the hydrological system you need distributed values for a long range of parameters (e.g. hydraulic conductivity and porosity), that are specific for the hydrologic system modelled and also for the geographical setting, to ensure valid results of the model. The more complex and accurate the model, the more comprehensive the data-requirements.

Furthermore, data for both calibration and validation of models must be available in order to test, if the model can precisely reproduce the responses of the hydrological system. These data can often be extracted from monitoring data, so that one part of the monitoring data are used when setting up and calibrating the model, and another part of the data are held back for later validation of the model.

Brief description including figures

Whereas monitoring directly can document failure to achieve good status for both surface and groundwater bodies, especially for groundwater bodies there is often a need to complement the assessment of impacts with models and calculations of the future impacts due to the inherent time delay of pressures on groundwater bodies.

Water balance models can be used on catchment scale. Both as “simple” conceptual models, but also as more elaborate numerical computer models. They can be used to calculate both amounts in cubic meters available for abstraction, and in this relation also be used in quantification of impact on e.g. surface waters, typically on streams.

This is widely recognised in Denmark, where hydrological models are used both in permitting water abstractions under consideration of the risks of saltwater intrusion or damage on associated surface waters / ecosystems. But also when calculating if remediation is necessary for example to ensure acceptable streamflow – and how it is most appropriately done (e.g. if this should be in the form of reduced abstraction or pumping of groundwater to the stream).In the below example, streamflow has been modelled in the County of Roskilde at different stations in order to calibrate the model and determine the hydraulic and other parameters of the system. The model will subsequently be used to assess the maximum groundwater abstraction permissible under consideration of the environmental objectives of the stream. Especially the low discharges are critical in this respect.

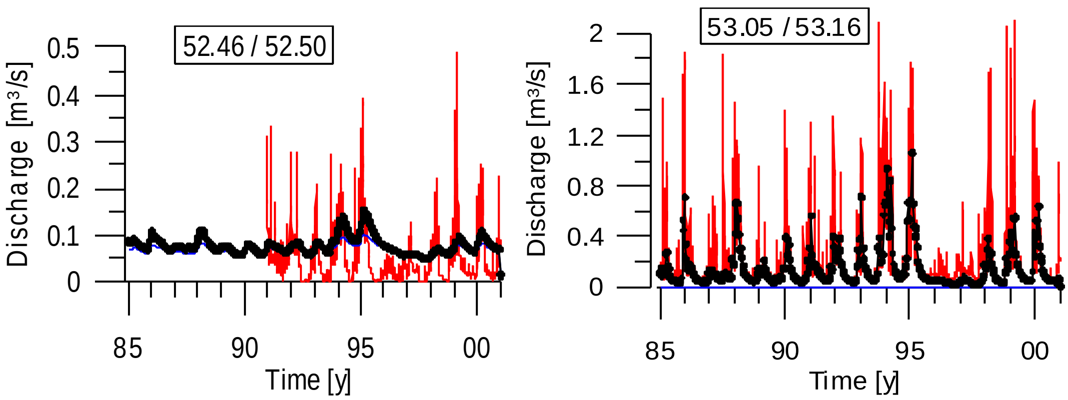

Figure 1: Calibration of hydraulic model on streamflow-data. Thick line: model results. Thin dashed line: recorded discharge. Left a poorly calibrated/determined, and therefore less precise, model. Right a well-calibrated/determined model.

(County of Roskilde (2002): Grundvandsmodel for Roskilde Amt by WaterTech a/s).

Also, the use of computer models makes it possible to make a qualified estimate of travel times for the impact of a given pressure in the form of pollution. This is relevant for assessing the impact on e.g. water supply wells, and also for other cases of groundwater pollution.

Lastly, computer models of hydrologic systems are in relation to groundwater used to delineate groundwater recharge areas. This is highly relevant in tracking the origin of a given impact and thereby the pressure / driving force, and, as a preventive measure, in spatial planning, so as to keep sensitive areas free from polluting activities.

References

County of Roskilde (2002): Grundvandsmodel for Roskilde Amt by WaterTech a / s.

Project report on the state of knowledge of relations and interactions between groundwater and surface waters (including the effects of abstractions). The text is in Danish, but with an abstract in English:

http: / / www.mst.dk / udgiv / Publikationer / 2002 / 87-7972-157-5 / html / default.htm

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Title: **No: 7**

Application of the River System Simulator for optimising environmental flow in the River Maana (Norway)

Type of impact:

Altered flow regime

Type of pressure:

Water flow regulation

Type of analysis or tool:

The models ENMAG, HEC-RAS, QUAL2E, RICE and HABITAT in the River System Simulator (Alfredsen et al 1995) were used in this study.

The modelling approach was to set up and calibrate the model no flow release in the bypass sections of the river, and simulate the impact of releasing 1 m3/s, 2.5 m3/s, 5.0 m3/s and 10 m3/s water as environmental flow.

How the decision was made based on the model

The scientists judged all model results manually, and a common integrated recommended flow was proposed.

In what ways did the application process represent state-of-the-art?

Three well-known and fully documented models (ENMAG, HEC-RAS and QUAL2E) and two newly developed models (RICE and HABITAT) were integrated with a common database and presentation tools in the River System Simulator. The integration represents the state-of-the-art.

Modeller-end-user communication

The end-user for the project, "The Eastern Telemark River Regulation Association", had established a reference group with participation of local and regional authorities, hydropower companies and local politicians. The project reported the progress to this reference group once a year. In the starting face of the project, several meetings between two of the modellers and the end-users were arranged. The end-user had established a reference group. The final output of the project was seven scientific reports and one summary report.

Information and data requirements

The data collection strategy for hydraulic, habitat and fish data was to collect data intensively over shorter periods where water was released back into the river. Other data were collected on a continuous regular (monthly, daily and every 10 minutes) basis. Several of these models require the same input data. The following data were collected:

Technical and hydrological data for the power plants and the reservoirs in the system to run the ENMAG model.

Cross-section and water level data to run HEC-RAS, QUAL2E and RICE models.

River ice cover, water and air temperature data for the RICE model.

Data on the water quality parameters total P, total N, bacterial count, coliform and thermo tolerant coliform bacteria, pH, turbidity and water temperature were collected for the QUAL2E model at twelve sites along the river and at the outlet of several power plants. These data were collected once a month during a period of 14 months as well as during several periods of test water release to the river.

Water depth, current velocity and substrate size were collected for the HABITAT model along 5-12 transects at five fish habitat stations. Fish habitat use data was collected by snorkelling at the same stations during summer situations.

Brief description including figures

The River Maana in the central southern Norway about 150 west of Oslo is regulated with a large dam in the mountains and a total of 5 hydropower plants. The licence for the regulation was due to re-licensing, and this study was done to analyse environmental flow requirements with respect to water-covered area (aesthetics), trout rearing habitats, water quality, ice conditions and power production. The River System Simulator (Alfredsen 1995) was used to simulate and integrate the impacts of a range of 1-10 m3/s environmental flows to be released in the bypass sections of the two most downstream hydropower plants.

The affected bypass sections are of approximately 6 km and 8 km. Fish habitat simulations were done in details at 5 selected representative reaches of 25, 48, 59, 60 and 286 m length. The other subjects were studied on the whole river part of 14 km.

References

The study is reported in several openly available Norwegian reports, also including one summary report:

Harby, A. (ed). (2000) Vassdragssimulatoren for Maana. Hovedrapport. SINTEF, Trondheim, Norway. (in Norwegian).

An article for international publication is submitted to Environmental Modelling and Software. Parts of the study is reported in:

Harby, A. and Alfredsen, K. (1999) Fish habitat simulation models and integrated assessment tools. International Workshop on Sustainable Riverine Fish Habitat, April 21-24, Victoria, B.C., Canada.

References to modelling tools:

Alfredsen K., Bakken T.H. and Killingtveit (eds) (1995) The River System Simulator. User's Manual. SINTEF NHL report 1995.

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Title: **No: 8**

AN APPROACH FOR ASSESSING ALTERATIONS IN THE RIVER WATER FLOWS PRODUCED BY RESERVOIRS

Type of pressure:

Water flow regulation

Type of analysis or tool:

Index for the maximum potential alteration of the natural water regime produced by water flow regulation.

Information and data requirements

- Map of water storage capacity upstream of any point of the hydrological network.
- Map of natural water yields.

Brief description including figures

The objective of this practice is have straightforward index to evaluate the maximum potential alteration that could be produced by the water flow regulation

The map of maximum potential alteration of the natural water regime produced by water flow regulation was made by calculating, using GIS techniques, the ratio between the map of annual water yields and the map of water storage capacity upstream of any point of the hydrological network.

Regulation dams can produce the greatest alteration on the temporal flow regime. Indeed regulation dams are constructed to modify the natural river discharge according to human requirements and such activity alters the natural water regime. The degree of degradation at any point of a river depends on three parameters: the volume regulated upstream of that point, the relative amount of water regulated related to the resources flowing through the river (in other words the storage-to-flow ratio), and the reservoir operational management.

The alterations produced by the management of the reservoir could be null if it reproduces the natural regime, or could make a total alteration of the regime if it stores all the resources and no water is released to the river. This latter case represents the worst effect that a dam can produce to the river flow, and it can be used to quantify the potential alteration of the natural water regime. First, a map of water storage capacity shows the volume of water that can be regulated upstream of each point. Then if the map of annual water yields is divided by the map of water storage capacity, the map of maximum potential alteration of the natural water regime produced by water flow regulation will be obtained.

Figure-1: map of water storage capacity shows the largest volumes exceeding 5.000 Mm^3, which are in the low courses of the large rivers (Guadalquivir, Ebro, Tajo, Duero and Guadiana), while there are some small basins where hardly reach 1.000 Mm^3 (Norte, Sur, C.I. de Cataluña, Galicia Costa and Segura).

Figure-2: shows the map of natural water yields

Figure-3 shows the map of maximum potential alterations by flow regulation. It presents a very different aspect compared to the water storage capacity map. Basins with very high absolute storage capacity, as the Ebro, show little altered regime due to its great natural contribution, while other rivers with also large contribution presents much greater possibilities of alteration (Tajo or Guadalquivir).

Furthermore, it must be recalled that we are referring to a maximum potential alterations, thus real alteration can be much lower than these. If one thinks, for example, in the frequent case of hydropower damming with high storage capacity and also high percentage of water returns, the potential alteration of natural waters regime downstream would be very high, but the real alteration produced would be very small.

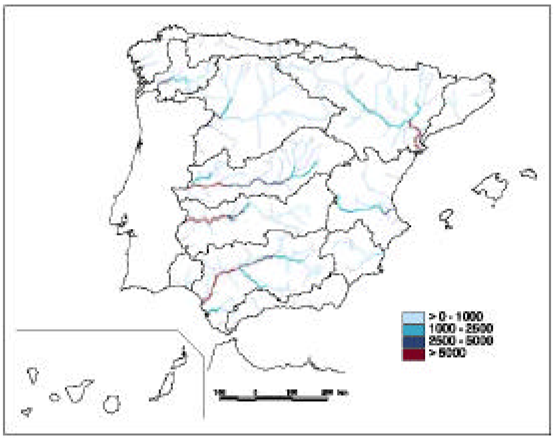

Figure 1: Map of water storage capacity upstream of any point of the hydrological network (Mm^3).

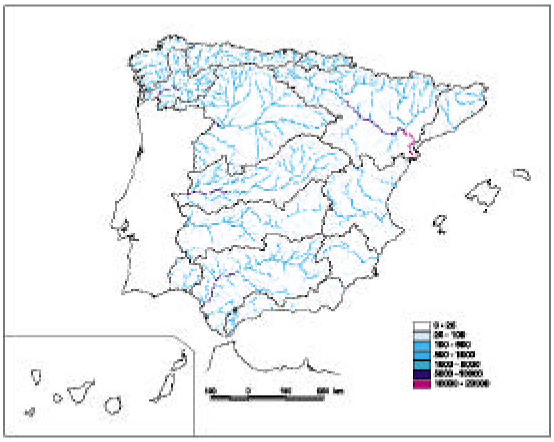

Figure 2: Map of natural water yields (Mm^3/year) Average (1940-1996)

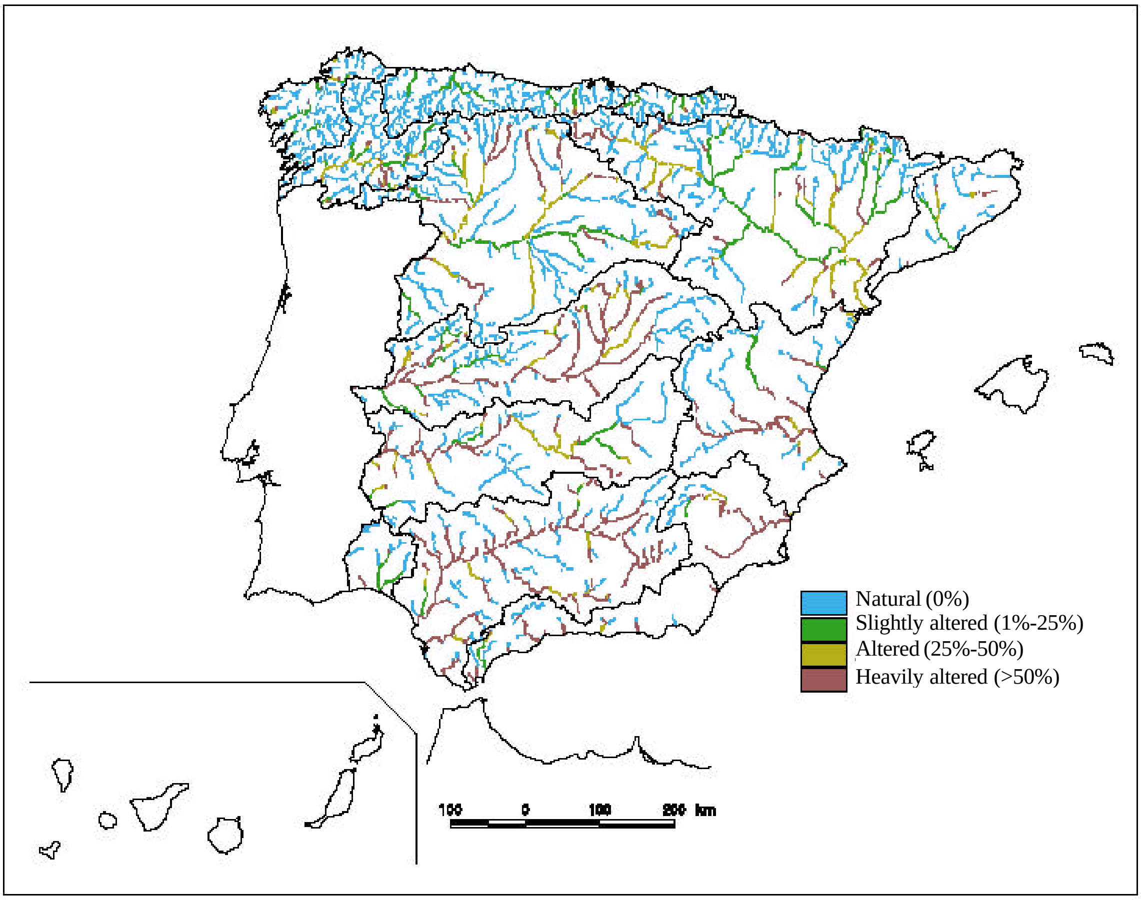

Figure 3: Map of maximum potential alterations by flow regulation.

References

MIMAM (2000), Libro Blanco del Agua en España. (Ministry of Environment(2000), White Paper on Water in Spain)
Language: Spanish

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Title: **No: 9**

How to report on morphological alterations related to human pressures? (Netherlands)

Type of impact:

Altered flow regime results in significant changes of natural dynamics and habitat conditions.

Type of pressure:

Substantial change of estuarian flow characteristics resulting in morphological changes in the estuary

(Driver: Current and future demand for shipping requires deepening and widening of navigation channel in Westerscheldt estuary.)

Type of analysis or tool:

During the analysis there were no uniform criteria or reference conditions available from the HMWB-group or REFCOND for transitional and coastal waters. Therefor a set of objectives and indicators from the Long Term Vision for the Scheldt (TWG Scheldt Commission) is used as a preliminary set of reference conditions.

Information and data requirements

Data on habitat area (GIS), water depth, flow regime, sediment composition and sand transport.

Brief description including figures

The Westerscheldt is the major shipping channel to the ports of Antwerp and Vlissingen. In order to support economical developments the navigation channel has been deepened to grant access to larger ships and reduce dependency of the tidal changes. In the Westerscheldt estuary the continuous dredging and dumping activities related to this deepening have a major effect on the quality status of the system. Important effects are subsequent changes in morphology and habitat composition within the estuary. The Westerscheldt can be characterised as a transitional water and presumably as ‘heavily modified’. This means with respect to the morphological state of the estuary that certain man-made alterations of the system are accepted as irreversible. His certainly reflects to the presence of dikes for safety reasons and also to the navigation channel because of the economical importance. This implicates that the quality objective for this water body is the Good ecological potential, meaning the best possible ecological conditions given within the irreversible changes.

The WFD requires an identification and analysis of the significant human pressures, including man-derived changes on hydromorphology. In order to structure the analysis 5 steps have been taken:

Step 1: system characterisation

The parameters of the most important system characteristics (annex II (par.1.2.3., V (par. 1.1.3. and 1.2.3) of the WFD have been used as a starting point for this description.

Step 2: establishing reference conditions and morphological quality objectives

A reference condition of the morphological status that sufficiently meets the WFD quality objective given by GEP had to be described. Such a reference condition was not sufficiently specified and quantified in the available literature. Since a static (geographical of historical) reference condition is not practical to use in a dynamic estuarine system, the objectives of the ‘Long-term vision of the Scheldt estuary (LTV)‘ are used to derive significant pressures and impacts and to identify criteria to monitor system changes. The LTV focuses on the preservation of essential natural dynamics in a estuary. Two major system objectives are used for this purpose: (1) the multichannel system should be kept intact (2) there should be sufficient space for dynamic sedimentation / erosion processes and changes in habitats.

Step 3: Identification of significant pressures

The assessment whether a pressure on a water body is significant must be based on a general conceptual understanding of the pressures (e.g. water flow) and their impacts on the system (e.g. the related changes in morphology and the ecological functioning and habitats of the system). In the case of the Westerscheldt expert knowledge was used to firstly list all potentially relevant pressures and then in a second step to identify the most significant pressures. Significance only becomes meaningful if determined towards an objective or reference condition. The criterion used for the prioritising was the relevance of the pressure for reaching the system objectives as described in the LTV.

Step 4: Assessment of impacts

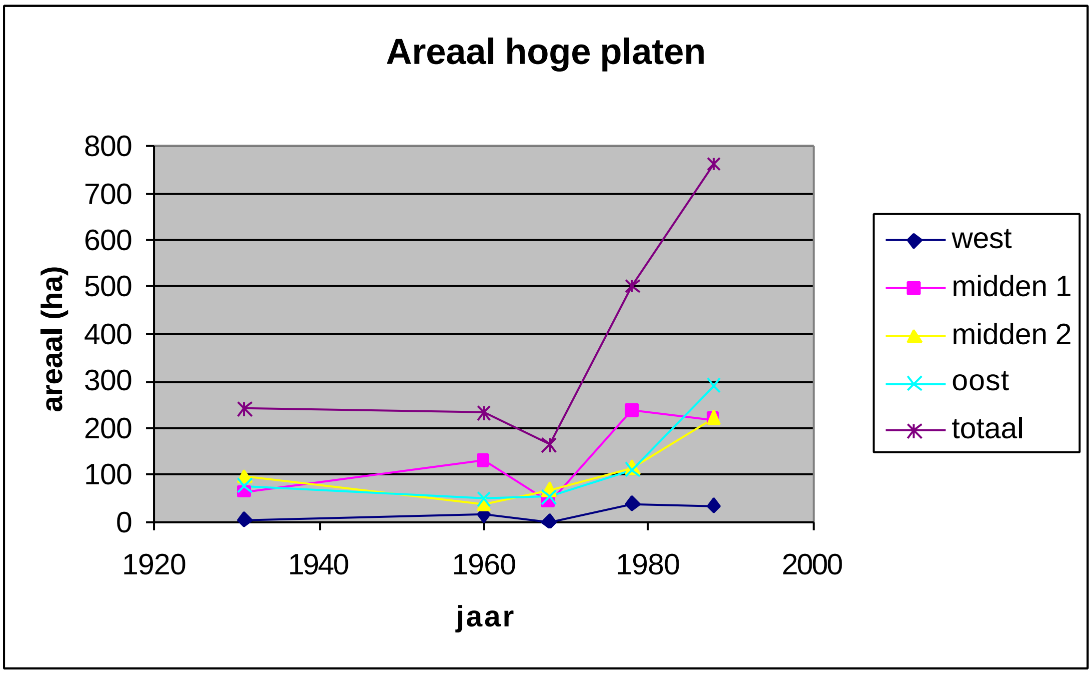
Important goal of the first review in 2004 is to identify the major pressures and their impacts. The pressure with the strongest impact is 'deepening and widening of the navigation channel'. Consequently this activity also has the largest potential to meet or fail the future objectives as formulated in the LTV.

Step 5: Identification of relevant indicators for monitoring impacts

The relationship between pressure and impact has been used to identify relevant indicators to monitor morphological changes. For the multi channel relevant indicators seem to be i.a. shore-length of tidal flats, intertidal area, ebb/flood domination, net sediment-transportation, relation primary channel transport versus secondary channel transport. For the objective of enough space for natural dynamics relevant indicator the height of intertidal flats and lower salt marsh area have been suggested.

Unfortunately the relationship between pressure/ impacts and morphological criteria has not been established thorough enough to be able to derive an operational classification system yet, much depends on expert knowledge. Nevertheless trends away from achieving good ecological status can already clearly be identified for this indicative parameters. (see the graph on increase of area of higher salt marshes which mean that the area of relevant lower salt marsh is strongly reducing). The first review in 2004 is a screening step. It designates the prime aspects that should be treated in the RBMP. For morphology it reveals a number of relevant gaps in knowledge that should be filled in the next steps towards the RBMPs.

Higher salt marsh area



References

- Pilot report on pressures and impacts for the WesternScheldt area – RIZA & Royal Haskoning, in Dutch (English summary included), currently in preparation (finalised in September 2002), report will be made available on : www.waterland.net/eu-water
- Long Term Vision Scheldt Estuary – Resource analysis (RA / 00-445), Januari 2001

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Title: **No: 10**

Screening and impact assessment using EuroWaternet methodology French application (France)

Type of impact:

Organic matter, nutrients, eutrophication, in rivers

Type of pressure:

Point and diffuse sources of OM, P, N, estimated trough their driving forces.

Type of analysis or tool:

Statistical technique to organise use of monitoring data and assess spatial and temporal relationships between pressures and impacts

Information and data requirements

Monitoring stations location and observation raw data,

Catchments structure,

CORINE *land cover*, administrative and catchment limit

Population per NUTS5

Other information can be entered in the stratification system

Brief description including figures

The methodology

Land cover types and population density define the main driving forces that impact river quality. The proportion and combination of land cover types and population density are used to define strata of potential pressures that make it possible to earmark each monitoring station. The stratification process takes into account the sub-catchment and the catchment size as well in order to select stations equally across the whole territory.

The stratification aims at clustering the monitoring stations by groups of identical input discharge. If the strata are well defined, then it is expected that the pollution density (as kg y^{-1} $(km^2)^{-1}$),on the one hand and standard discharge (in m^3 y^{-1} $(km^2)^{-1}$) on the other hand produce concentration data belonging to the same statistical population.

Under these hypotheses, the stratum means and stratum variance can be computed as combinations of point means and variances. Consequently, it becomes possible to compare strata, combinations of strata * catchment and time trends.

The application

Implementation of EuroWaternet in France is now fully operational. A detailed statistical study, using geostatistical processes (multidimensional kriging) demonstrated that 6 strata (dense urban, urban, mixed (urban + intense agricultural), intense agricultural, moderata agricultural, low impact) were sufficient to describe the drivers impacting rivers.

As response to EuroWaternet requirements, 512 sampling stations were selected. For domestic purposes, this selection was extended to ~1500 stations (number is slightly year depending) which are used for representing the water quality issues, **when statistical indicators are involved**.

In a second stage, the methodology is used to define the optimum share of stations as function of pressures on catchments. An optimum network of 2500 stations was defined and is currently under closer examination. This result is not presented here, since being not in line with pressures and impacts. However, it is emphasised that quality of monitoring determines widely accuracy of impact assessment.

Some results

The stratification can be reported as a map of stratum types per elementary catchment (currently 6210). The colour code in each catchment represents the cumulated expected impacts from the upstream part of the catchment.

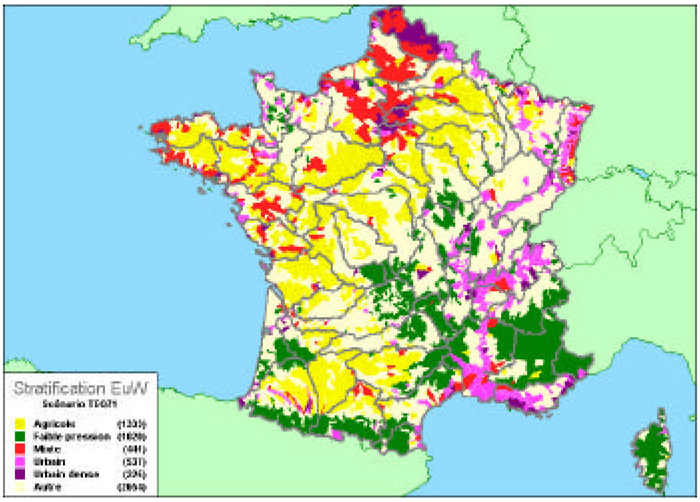
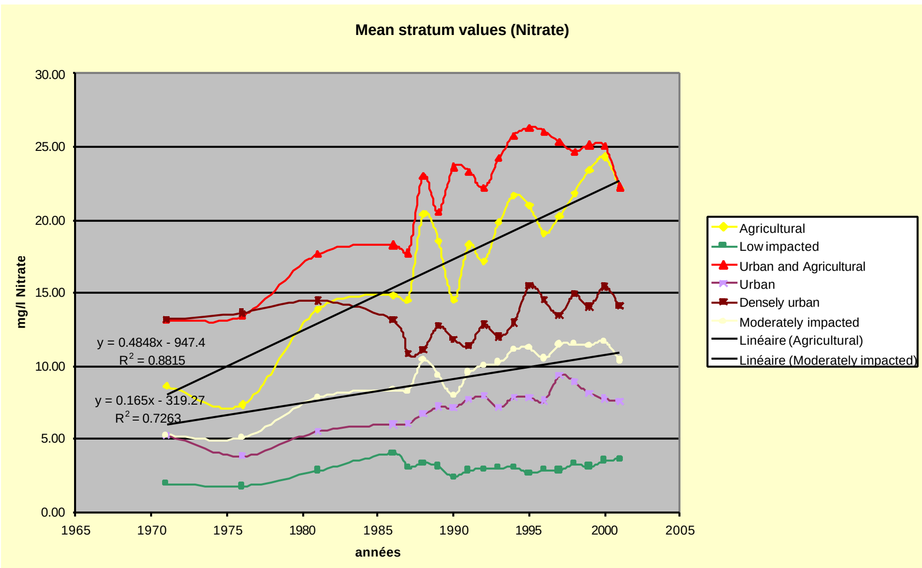
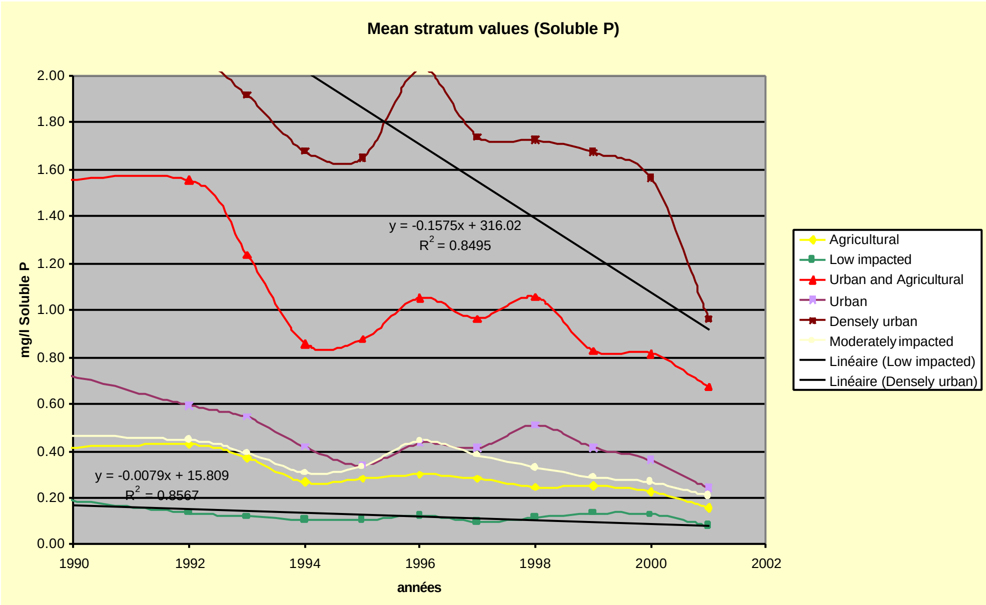


Fig. 1 Current EuroWaternet stratification types used in France.

The stratum type applies to any station situated on the main channel of the river draining any of the 6210 elementary catchments defined. The greyed lines indicate the 55 operational catchments used to force point selection even across metropolitan France.
The foreign part of catchments is considered in the calculations.



In the above example, nitrate per stratum (in this case all French EuroWaternet points are processed) shows clear upwards trends in intense agricultural, mixed and moderately impacted (agricultural) strata. Hydrology effect is not removed from averages, this procedure emphasizes the time trend, supposedly in relation with activities.



In the above example, soluble Phosphorus per stratum (in this case all French EuroWaternet points are processed) shows clear downwards trends in all strata. The improvement is very effective in the most impacted strata, in relation with sewage purification and decrease in detergent P-borne. Hydrology effect is not removed from averages. In this case, the quality of relationship would have been improved, since P averages are very sensitive to dilution.

In both exemplified cases, trends, with baseline scenario, can easily be carried out and indicate which water bodies would be at risk or not of failing objectives.

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Title: **No: 11**

Quantifying impact of pressures and likelihood of meeting objectives by means of the Water Accounts methodology (Eurostat). French application (France)

Type of impact:

Organic matter, nutrients, eutrophication, pesticides, biological status in rivers

Type of pressure:

Point and diffuse sources of OM, P, N, etc estimated either through their driving forces or actual pressures.

Type of analysis or tool:

The Water Accounts methodology apportions the water quality assessments (not raw concentrations) in proportion of the size of water bodies. This methods yields a quantity of quality that can compare with pressures (as loads) or with expenses (as amount of money).

Information and data requirements

Monitoring stations location and observation raw data,

Quality assessment method to compute quality indexes or classes,

Catchments structure and river network structure,

Standard discharges values (average, low flow values) to compute weighting data.

Brief description including figures

The methodology

Water accounts methodology was designed first to build observation systems representative of the river network structure (whereas EuroWaternet yields representative sample of the monitoring network and respond to different objectives).

Several countries, including France, adapted it on behalf of Eurostat. The aim is to allow comparisons of quality state between catchments or NUTS areas and to make it possible to assess the cost of quality improvement.

The heart of the method is very simple: each river segment has a weight, computed as length times the standard discharge. This quantity, named SRU (Standard River Unit / UMEC Unité de Mesure des Eaux Courantes) homologous to local energy content can therefore be added, compared and has a finite value, independent of map accuracy.

In a second step, quality assessed (or extrapolated) for each segment is processed as quantities of quality. Since quality classification schemes refer to classes, it becomes possible to match quality related to nitrate with quality expressed as biological indicator, provided the classification scheme is internally consistent.

The most developed state of methodology is now available, after recent French and EEA developments providing a full chain of production from monitoring data to aggregated indexes (catchment and NUTS) and b) comprehensive set of indicators as well as check trial in four countries (Ireland, UK, Slovenia and France).

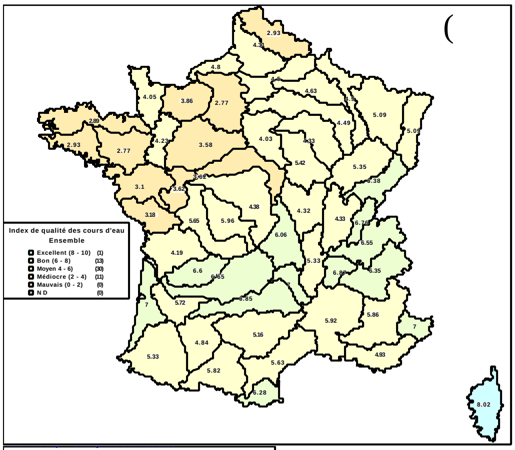
The application

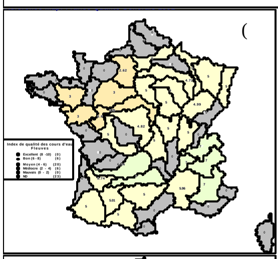
For the time being, the most comprehensive application was carried out in France. However, examples are given for other countries to demonstrate the flexibility of the method.

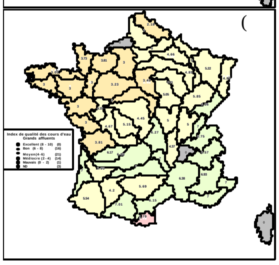
Thanks to the latest developments, the following information is provided by the application of the software available (in France NOPOLU).

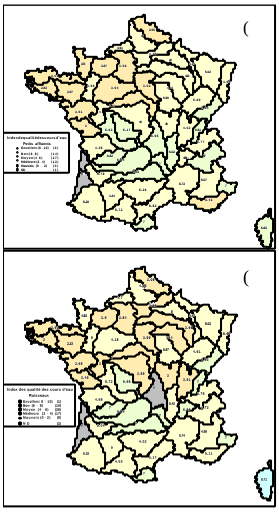
- Quantity of SRU, per quality class, for the different assessment types, if relevant, per river rank, aggregated per catchment (any size type) or NUTS. These quantities directly compare with stock-like units : volume of discharge, amount of money.
- RQGI (River Quality Generalised Index), which is a generalised water quality class encompassing the distribution of quality classes over the aggregation domain (from all river types of a country to a river size class of a catchment),
- Pattern Index, indicating what is the profile of quality problem of the considered domain of aggregation (mediocre everywhere, good with “black spots”, etc.)
- Relative importance index, obtained by comparing the SRU resulting from different quality assessments. For example, comparing nitrate and eutrophication. Quantitative information, for all aggregation units becomes available. Of course, changes in time can be compared as well.

Some results

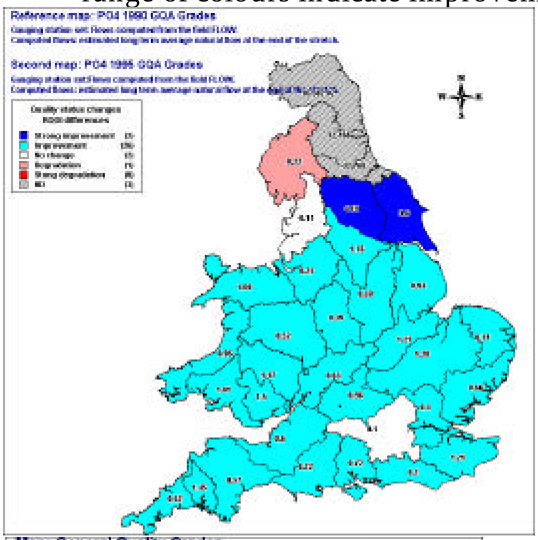


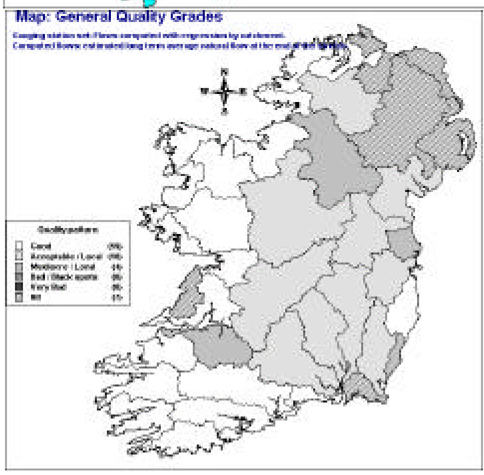






The five maps above (from the 2002 French State of the Environment report) show the aggregated **RQGI**, all rivers (left), for the 55 reporting catchments, and the RQGI broken down in four size classes (left, right, up, down; largest, large, medium and small rivers)
The right bottom map represents the changes in water index in England and Wales, per catchment, with respect to phosphorus contamination of waters. The range of colours indicate improvement (blue) or degradation (red).





The other figure, on the right, shows the pattern of river quality in the Republic of

Ireland, considering biological quality. The patterns suggest that local pollutions are responsible for the observed mismatches with good quality objective. This can facilitate orientation of assessments and further action plans.

References

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Title: **No: 12**

Water quality modelling in Tejo River (Portugal)

Type of impact:

Analysis of water quality in the main river

Type of pressure:

Water quality in tributaries and loads from point sources

Type of analysis or tool:

The water quality model adopted for the simulation of the river was the Enhanced Stream Water Quality Model QUAL2E model (EPA, 1987).

Information and data requirements

Information and data on flows and on water quality were obtained on the Networks Monitoring. Loads from point sources (urban wastewater and main industries).

Brief description including figures

Methodology and Application

Tejo river basin is one of the largest in the Iberian Peninsula, with an area of about 80 629 km^2, being 55 769 km^2 (69%) in Spain, and 24 860 km^2 (31%) in Portugal. This river travels along 230 km in Portugal and discharges to Atlantic Ocean, after crossing Lisbon City.

In the last years the natural regime has changed and the flow from Spain has decreased significantly due to the construction of a large number of reservoirs and the increase of water demands. As a consequence, the water quality characteristics, within the basin, have also been significantly changed during the recent past due to anthropogenic actions.

Concerning the production of drinking water, great Lisbon area and several municipalities in the lower Tejo region, with a population of more than two million people, are supplied by several surface water abstractions. Due to great social, ecological and economic importance, Tejo watershed has been studied with the purpose to identify the relevant point and non-point pollution sources, to characterise water quality and adequacy to the observed and proposed uses. With all this information available it's possible to apply and calibrate models to simulate the evolution of water quality, for different scenarios of hydrologic conditions and pollutant loads.

Several water quality models were evaluated for suitability to Tejo River. The water quality model adopted for the simulation of the river was QUAL2E model (EPA, 1987), which was considered to be more adequate to the program goal and the available data.

The river reach studied is between the boundary section, used has headwater, and the beginning of the estuary (last element in the system), with a length of 150 km. A computational element length of 2 km was chosen as sufficient to describe spatial detail along the river. In the river reach under study there are two dams, Fratel and Belver. Due to their hydraulic characteristics and operational conditions they were treated as a stream segment were the flow is unidimensional and is not affected by stratification. Phisiographic data was based on transversal profiles surveyed in the 1970's. Information and data on flows were obtained on the Freshwater Network Monitoring. Figure 1 shows the reaches and computational elements considered. Also illustrated the 25 point loads considered and localisation of dams.

Figure 1 – Reaches, computational elements and 25 point loads considered, and localisation of the dams.

Currently, there are in the Tejo watershed 50 water quality sampling stations, where sampling is done monthly. Tejo river model input used observations of water quality at stations located at the national border (headwater in the model) and at the last element in the system (beginning of the estuary). QUAL2E can incorporates fixed downstream constituent concentrations into the algorithm. When no direct observations were available, inflows and associated concentrations of water quality were estimated. Estimate values of these flows were made by hydrologic balances of river segments, based on the locations of sampling stations. Nutrient concentrations in flows entering the river were estimated with the available data.

Tejo River model calibration utilised prototype observations of water quality for nine sampling stations. Annual means and summer means were selected to represent two hydrologic and climatologic regimes. Summertime characteristics with low flow conditions were simulated, permitting to analyse the behaviour of the river in the worst conditions of wastewater discharge with increase of pollutant loads to the system. Several calibration data sets corresponding to specific sampling data in summertime were selected to provide a variety of hydrologic conditions.

Results

A geometric representation of the hydraulic characteristics of the stream channel was used. Stream velocities and flows determinate by the model were found to be suitable to represent Tejo River. The two dams present in the first 50 km of the river are responsible for the low velocities observed.

Figures 2 and 3 illustrate the results of the application of QUAL2E to Tejo River for summer conditions. The results are analysed taking in account the field observations, the major uses of the river and compared to water quality objectives set by national and international legislation. Calibration sequence for quality variables was temperature, dissolved oxygen, BOD, phosphates, nitrates and ammonia. Results of calibration were generally good, except for ammonia.

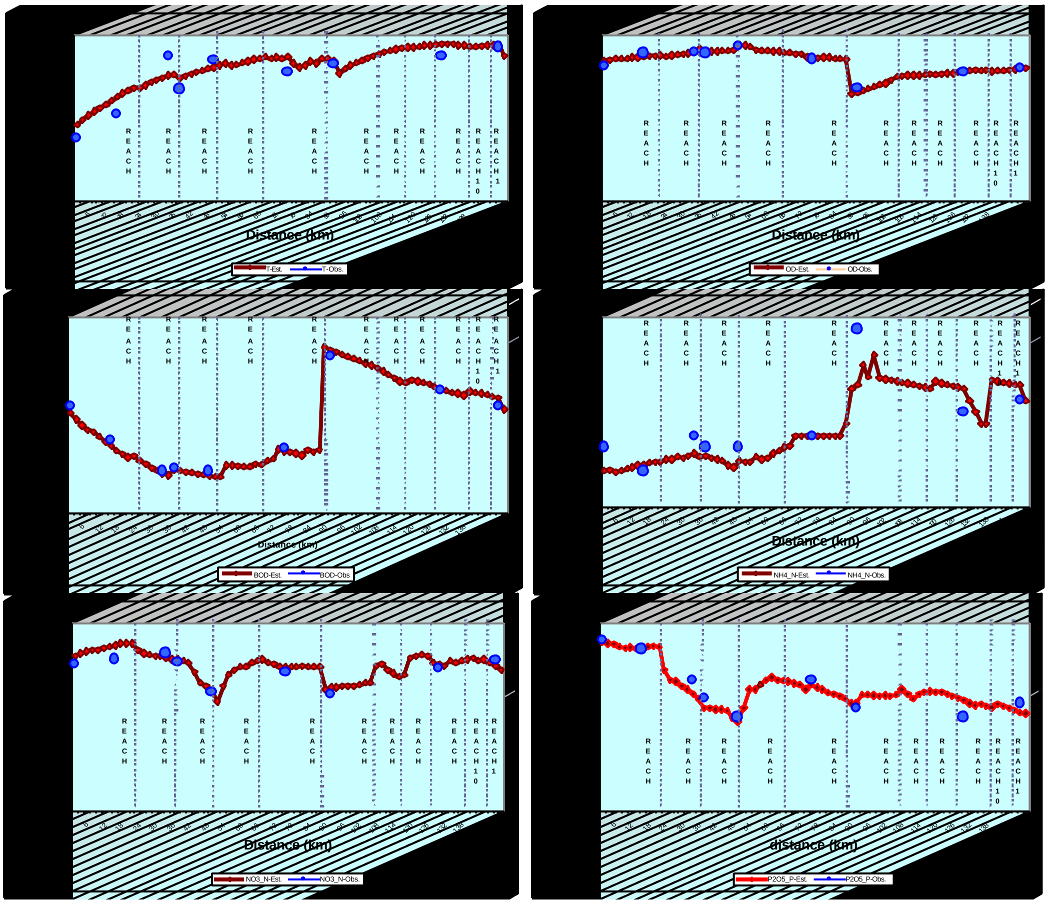

Figure 2 - Comparison between QUAL2E output and observed values in the sampling stations of Tejo.

The profiles obtain for the parameters (Figure 3) represents the actual impact on water quality from the different sources of pollution that affects Tejo River. The big reservoirs in Spain have some effect by reducing BOD, but in terms of nutrients high amounts continues to reach to the border. This will affect the two reservoirs in the national part that have already problems of eutrophication. In other hand, in the national basin there are some problems, specially, after the impact of the paper industry and Zêzere plus Nabão Rivers, which have a representative flow. Also two important tributaries, Almonda and Alviela Rivers represent a significant contribution of pollution that affects Tejo River more downstream.

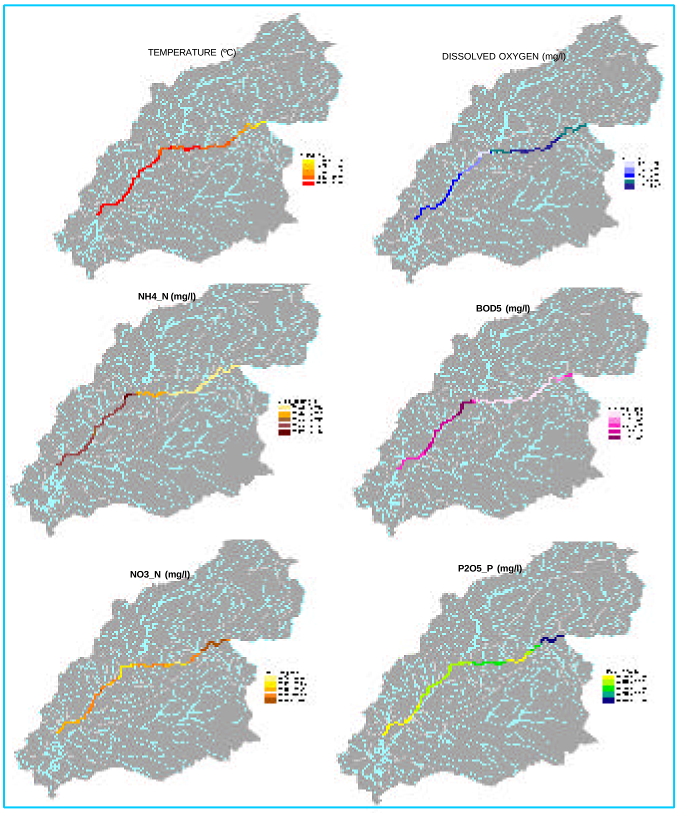

Figure 3 - Profiles of QUAL2E using GIS maps.

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Title: **No: 13**

Criteria for the investigation of significant pressures and evaluation of their impacts for purpose of reporting to the EU Commission; - Strategy paper of the Working Group of the German States on Water (LAWA) – (Germany)

Type of impact:

Status and change of water quality (eutrophic and saprobic status, toxicity, rewarming), changes of habitat, changes of the hydrological regime

Type of pressure:

Point sources, diffuse sources, water flow regulation, morphological alterations, heat input

Type of analysis or tool:

Analysis of existing data on emissions and on the state of a water body, threshold values or balance models for diffuse sources; analysis of impacts based on quality objectives and threshold values, knowledge of experts

Information and data requirements

Data on emissions (communal waste water discharges, industrial waste water discharges) data on land use, data of the state of water body (physicochemical measurements, data on quality of waters and structures of the water body), data about water abstraction

Brief description including figures

For the purpose of investigating significant pressures and evaluating their impacts, a strategy paper was compiled in Germany by the State Working Group on Water (LAWA). The objective is an efficient procedure, agreed on by all states, for compiling the inventory in accordance with Annex II of the Water Framework Directive (WFD) by the end of 2004. For the first description, the strategy paper is oriented on the availability of meaningful and stable data. Should a more extensive description be required, more detailed data will be compiled and, if necessary, collected locally.

Table 1: Data to be collected for different pressures

Pressures	Criteria
Point sources	
• Public sewage-treatment plants >2000 PE (derived from Urban Wastewater Treatment Directive)	Annual volume of water discharge Population (P) and population equivalents (PE) Substance loads according to Annex I of the German Wastewater Directive Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives
• Industrial direct discharge	Statement of systems according to IPPC Directive = pollutants according to EPER Annual loads of plants with obligation to report according to IPPC Directive: consideration of the particular size

Pressures	**Criteria** threshold for the annual load of 26 substances (cf. Table
	1: Size thresholds; EPER) Annual loads of priority substances, substances of the quality objective directive, and river basin-specific substances, insofar as these substances are limited by water directives Food industry facilities >4000 EP
• Storm water / combined wastewater discharges	Discharge of wastewater from an urban area >10 km^2
• Discharges with heat load	Discharges with heat load >10 MW
• Salt discharges	Discharges >1 kg/s chloride
Diffuse sources	Not yet finally defined, coordination with criteria for endangerment of groundwater bodies
Water abstraction	Abstraction without recirculation >50 l/s
Water flow regulation	Procedure for small/medium-sized water bodies: o Parameter "anthropogenic barriers" (Stream habitat survey): ≥6 o Parameter "backwater" = 7 or according to general procedure: o Impassable anthropogenic barriers and backwater
Hydromorphological alterations	Based on the results of river habitat survey or similar investigations: "Water-body bed dynamics" with structural classes 6 und 7

For the purpose of compiling the significant pressures, the WFD indicates which substances and groups of substances are to be considered. In some cases, data that have already been compiled on the basis of other directives (e.g. communal wastewater directives) can be used. Table 1 illustrates what information is to be gathered for the various pressures.
Supplementary to the emissions data, data on the state of a water body available from environmental surveillance should be examined. Primarily data on the state of a water body will be considered to evaluate the impacts of the pressures and will be judged according to quality objectives and aggregation criteria. As a rule in Germany these data are present in the spatial density adjusted for the quality aspects and the site of the impact. If these are insufficient, an assessment or consideration of a model based on established pressures is necessary. An estimation of probability that the good ecological or chemical conditions will not be achieved within a period of observation will be made on the basis of the criteria presented in Table 2.

Table 2: Information necessary for the assessment of impacts

Indicator	**Threshold values**
Saprobic status	30% of stream network > national biological quality level (here: biological quality level II; indicator macrozoobenthos)
Trophic status	➢ 30% of stream network > national quality level (here: trophic

Indicator	Threshold values
	class > II, indicator: chlorophyll a, pH, O2) ➢ also in discussion, but not yet finally defined: assessment by nutrient content/load of the rivers
Physicochemical substances	Exceeding existing quality objectives or quality criteria of EU directive 76/464/EEC and knowledge about entries of priority substances
Warming	According to the EU Fish-Life Directive: - max. annual temperature: >21.5°C (salmonid water body) >28°C (cyprinid water body) - max. winter temperature: >10°C (salmonid water body) >10°C (cyprinid water body) - max. warming up: 1.5 K (salmonid water body) 3.0 K (cyprinid water body)
Salinisation	Median: CI > 400 mg/l
Morphology	- River habitat survey -- overview method: More than 30% of the river distances within the management unit are surveyed with structural quality classes 6 or 7 for the compartment "river bed". - Impairment of river continuity >30% of stream network

The utilisation of the strategy paper has already been tested in the pilot projects “Große Aue” and “Middle-Rhine”. The strategy paper will be continued from case to case in consideration of new developments.

References

"Kriterien zur Erhebung von signifikanten Belastungen und Beurteilung ihrer Auswirkungen und zur termingerechten und aussagekräftigen Berichterstattung an die EU-Kommission", Strategy paper of the Working Group of the German States on Water (LAWA) , 2002; Language: German

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Title: **No: 14**

Case study "Große Aue" – Development of a River Basin Management Plan for the Catchment „Große Aue" within the river basin district Weser

Type of pressure:

Urban discharges, land use, water flow regulation

Type of impact:

Urban discharges, land use: Increasing loads, alteration in saprobic status

Water flow regulation: Morphological alterations, migration barriers

Type of or tool:

Urban discharges, land use: Monitoring of all sewage treatment plants and combined stormwater discharges, evaluation of data from CORINE landcover. Combined assessment of point sources and diffuse sources, for nitrogen and phosphor with a mass balanced model as statistic tool (MOBINEG).

Water flow regulation: Two ways of river habitat survey

Information and data requirements:

Urban discharges: Sources of Data: StUA (environmental authority) Minden (North Rhine-Westphalia); Bezirksregierung (regional gouvernment) Hannover (Lower Saxony):

- Self-control with data-sets depending on the size of sewage water treatment plants
- Officially controlled 4 times a year

Land use: Sources of Data: Federal Statistical Agency, basing on Dates of:

- Landwirtschaftskammer (agricultural administration) North Rhine-Westphalia
- Landwirtschaftskammer (agricultural administration) Lower Saxony

Water flow regulation: River habitat survey

- River habitat survey North Rhine-Westphalia: Operational detailed assessment; basing on „on-location" knowledge; Scale: 100 m
- River habitat survey Lower Saxony: Overview method; basing on maps, aerial view, collected data; Scale: 1000 m

Brief description including figures

Aim of these pilot-project of the implementation of the Water Framework Directive was

- to investigate the driving forces and pressures in the catchment area of the "Große Aue" (northern german low-lands) for surface and ground water bodies
- to exemplify a programm of measures for achieving the good ecological status
- to compile an orientation guide fotr provision, organisation and interpretation of data.

As main-pressures urban discharges (point sources), land use (diffuse sources) and water flow regulation were identified. To assess the influences of point- and diffuse sources on the input of the nutrients nitrogen and phosphor into surface waters a combined mass balanced model, MOBINEG, was used. With this tool effects of sources can be displayed clearly:

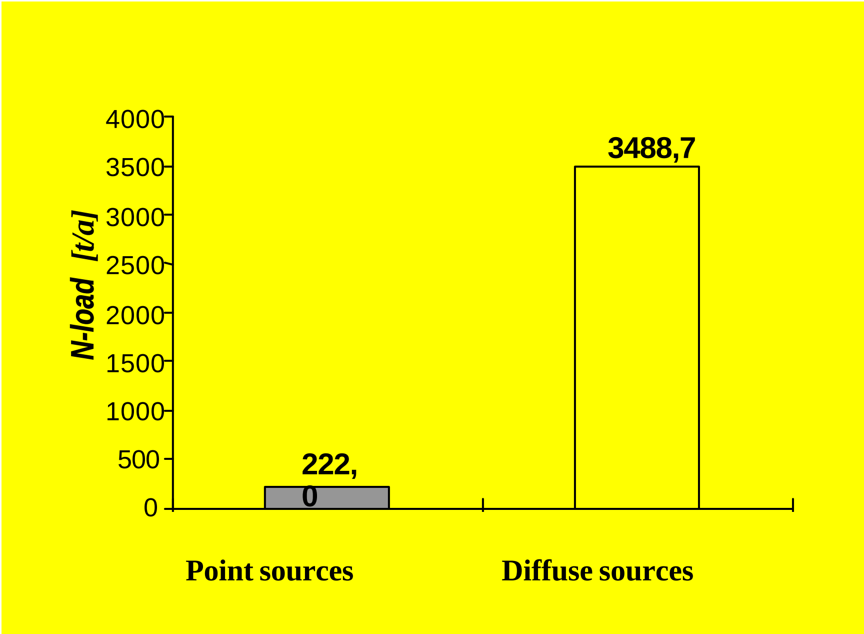


Fig. 1:
N-loads from point- and diffuse sources in the catchment area of the river „Große Aue“

Referring to the diffuse discharges the cultivated areas are the main sources. Nearly 90 % of the diffuse nitrogen discharges to the surface water bodies come from cultivated areas.

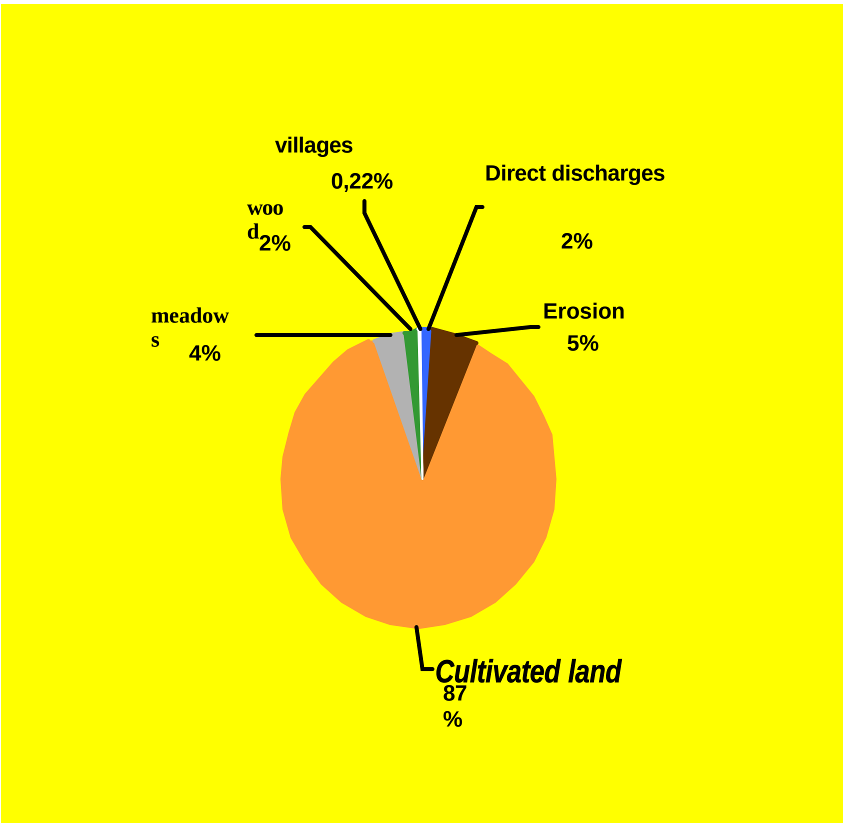
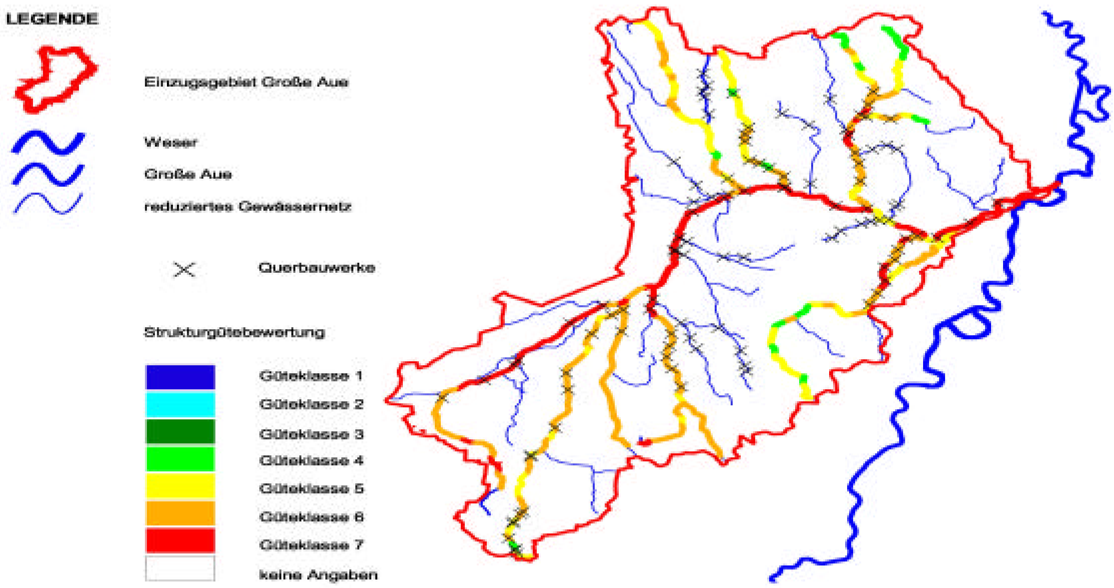


Fig. 2:
Percntage of named diffuse sources concerning the N-loads in the catchment-area of the river „Große Aue“

Within the scope of the case study „Große Aue“ investigations on the flora and fauna of the river „Große Aue“ and several affluents have been carried out. The present composition of species shows some lack in indigenous species and migratory fish, which result from impairment of river continuity as well as hydromorphological alterations (flow regulation, flood protection). The results of the river habitat survey are shown in form of a map which also includes informations about the migration barriers:

Fig. 3: Results of the river habitat survey



In Germany for the reason of investigating significant pressures and assessing their impacts the State Working Group on Water (LAWA) developed a viable strategy paper. The objective is an efficient procedure, agreed on by all states, for compiling the inventory in accordance with Annex II of the WFD by the end of 2004. For the first description, the strategy paper is oriented on the availability of meaningful and robust data. Primarily data of the state of a water body (saprobic status, trophic status, physico-chemical substances, structure of a waterbody) will be used to assess the impacts of the pressures and will be judged according to quality objectives and aggregation criteria. The utilisation of the strategy paper has already been tested in the pilot project “Große Aue”.

Kurzfassung “ **Modellhafte Erstellung eines Bewirtschaftungsplanes am Beispiel des Teileinzugsgebietes Große Aue im Flussgebiet Weser, Febr. 2001, Language: german;**
http://www.bezirksregierung-hannover.de/0,,C40033_N5205_L20,00.html

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Title: **No: 15**

Pilot-Project Middle-Rhine: Development of River Basin Management Plan

Type of impact:

Habitat alterations, modifications of the hydrological regime

Type of pressure:

Diffuse sources, water flow regulation, morphological alterations

Type of analysis or tool:

Analysis of available data of emission and of the state of a water body, balancing models, impact analysis basing on quality objectives and treshold values, expert knowledge

Information and data requirements:

Data of the state of a water body (physico-chemical measurements, water quality and structure of the water body), data about water abstraction, structural state of waters

Brief description including figures:

For purpose of surveying the significant pressures and assessing their impacts the LAWA-group in Germany developed a viable Strategy Paper (see previous example of current practice). With the "Middle-Rhine-Project" of the german federal states Hesse and Rhineland-Palatinate an example, following the LAWA-criteria, concerning the inventory taking according to ANNEX II of the WFD until the end of 2004, is given. Figure 1 shows the surveyed catchment area of the project:

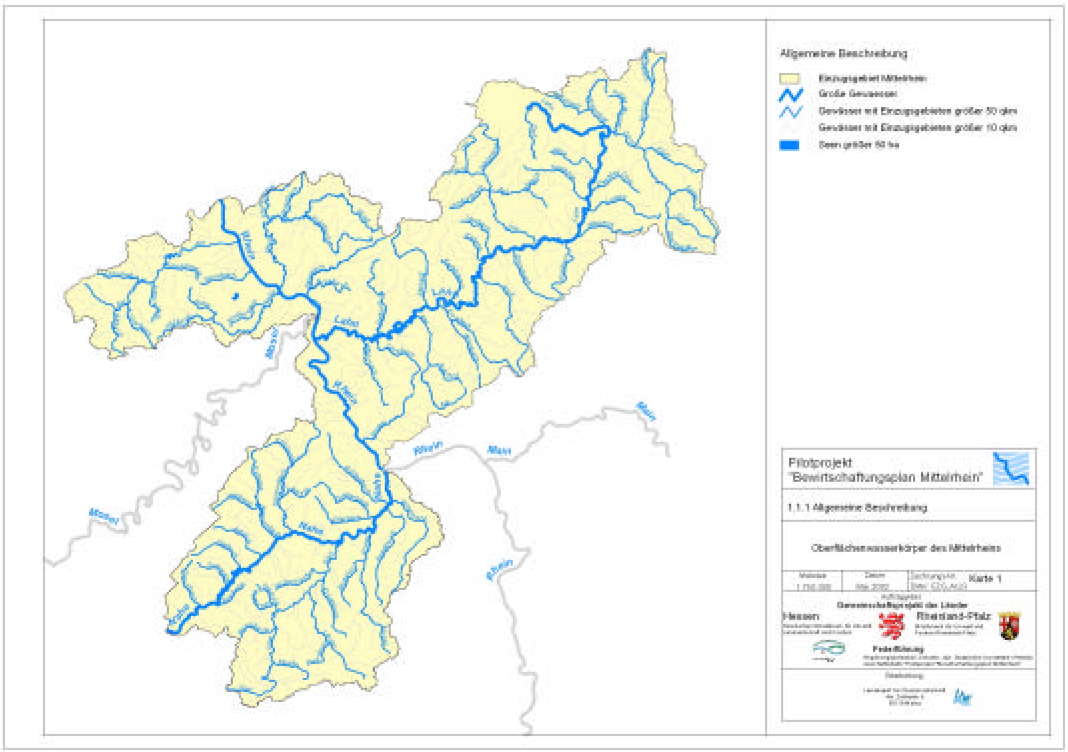

Figure 1: Catchment area of the "Middle-Rhine"

In the project some LAWA-criteria and their combinations concerning point and diffuse sources have been tested on the base of 10 km²-units. As an example the diffuse sources:

- Cultivated land > 50% (current value is still discussed)
- Urban land > 15%
- Special crop land > 5%
- Cultivated land > 50% and urban land > 15%
- Cultivated land > 50% and special crop land > 5%
- Special crop land > 5% and urban land > 15%

have been tested. Figure 2 shows the significant areas:

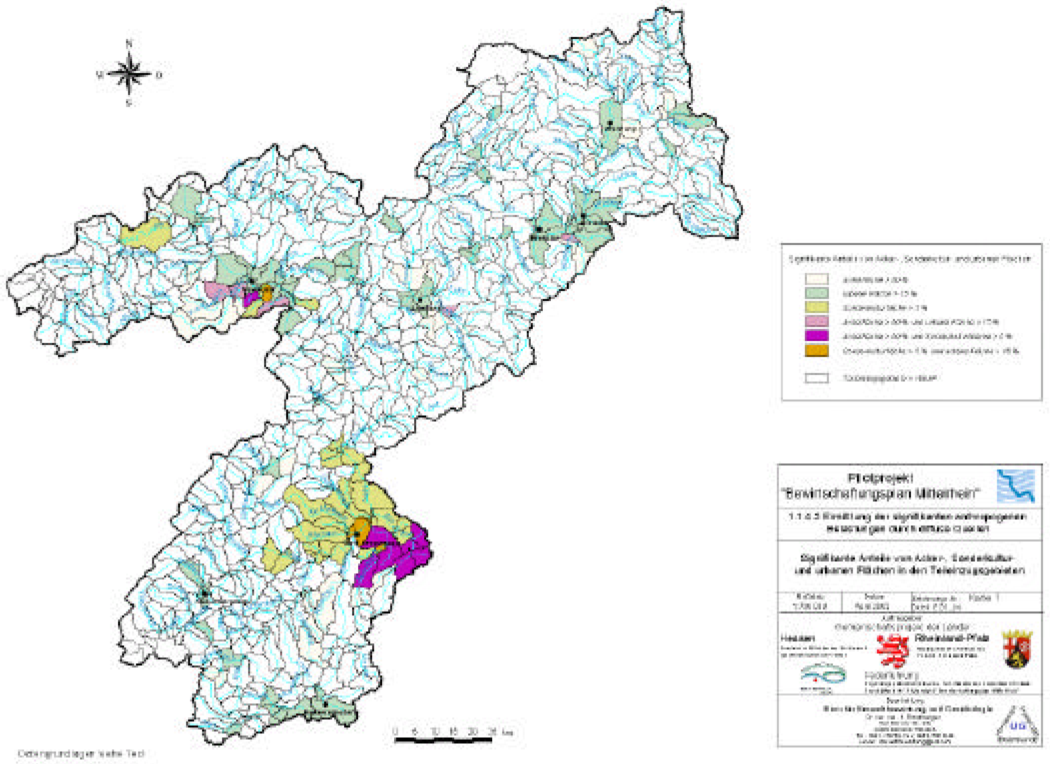

Figure 2: Significant areas concerning diffuse sources in the catchment area of the "Middle-Rhine"

In addition to the data of emission available data of the state of a water body from environmental surveillance have been considered. For the assessment of the impacts primary data of the state of a waterbody have been used. Concerning morphology the former LAWA-criteria regarding the of surveyed river distances (Stream habitat survey - method for little and medium size waters in Germany; LAWA (2000)) with:

- Structural quality class >4 in free landscape (has been adapted from 3 to 4)
- Structural quality class >5 in urban areas

have been tested.

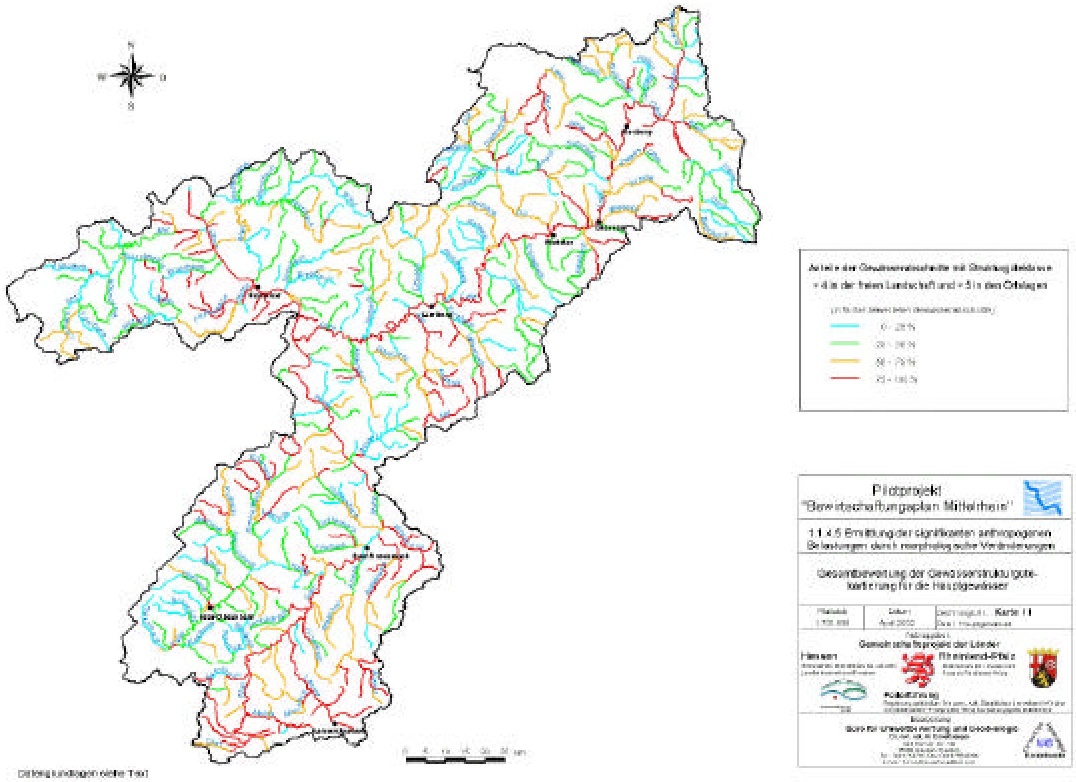

Figure 3: Amount of surveyed river distances with structural quality class >4 in free landscape or structural quality class >5 in urban areas in the catchment area of the "Middle-Rhine"

References

Pilot-Project „River Basin Management Middle-Rhine":Common Project of the german federal states Hesse and Rhineland-Palatinate, report (draft).

Pilotprojekt „Bewirtschaftungsplan Mittelrhein", 2. Statusbericht, Teile A und B, Entwurf vom 30.04.2002. Gemeinschaftsprojekt der Länder Hessen und Rheinland-Pfalz, Federführung: Regierungspräsidium Giessen , Geschäftsstelle Pilotprojekt „Bewirtschaftungsplan Mittelrhein"

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