SOURCE CONTROL OF PRIORITY SUBSTANCES IN EUROPE SOCOPSE

DSS Handbook SOCOPSE

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Preface

The Water Framework Directive

The purpose of the Water Framework Directive (WFD; 2000/60/EC) is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. The WFD aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction and cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances. Therefore the WFD contains a number of directives and guidelines for the future use, release and water quality concerning the priority substances. The WFD defines environmental quality standards as concentrations of pollutants in water, sediment or biota that should not be exceeded in order to protect human health and the environment. The WFD has identified 33 priority substances for which environmental quality standards and emission control measures have to be established (COM(2006)398 final). From this list, a group of 11 substances were identified as priority hazardous. This group of 11 will be subject to cessation or phasing out of discharges.
The WFD requires the identification of pressures to which water bodies are subjected; in particular related to priority substances. Further, the member states are required to assess the likelihood that surface water bodies will fail to meet the environmental quality standards.

About the SOCOPSE project

With the new regulations, new strategies for control of releases of PSs are needed. For decision making and implementation of the WFD, the industrial sector (including agriculture, transport, recreation, water treatment organisations etc.), the local water authorities and the EU policy makers need guidelines for introduction of cost-effective measures. The project Source Control of Priority Substances, SOCOPSE, is a research project focussed on development of tools for the implementation of the WFD with regards to PSs. Within the project a Decision Support System (DSS) is developed for management of PSs in order to assess the effectiveness and (possibly secondary) impacts of various measures or combinations of measures and to make the right selection of measures. These measures include water treatment technologies, management options, and substitution as well as strategies for follow-up and monitoring and frameworks for communication and dissemination of progress.

All annexes of this handbook can be found at the web-based version of the DSS. Please visit www.socopse.eu

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1 Introduction

1.1 About the SOCOPSE decision support system

Support decision process
The SOCOPSE decision support system (DSS) is primarily intended to support water authorities to make plans and make decisions for the control of PSs at both European and national or river basin level (Article 11. sub 3k of the WFD). The plans are a part of the river basin management plans (RBMPs) which the water authorities have to produce in final version in 2009. Also in the future (2015), when the plans have to be updated, the DSS will be helpful.
The DSS focuses on the chemical status of river basins.
The DSS is also suitable for other stakeholders to assess the effectiveness of various management options.

Also applicable on other substances than PSs
Of course PSs are only one of the aspects of a RBMP. Although the DSS is developed for the control of PSs it is applicable to any chemical substance where a limit value in the form of a concentration has been set.

What is it?
The developed system fits in the framework suggested by the EC to implement the WFD and to compile the RBMPs. It provides a format by which information, needed to prepare and to make the decisions, can be gathered, stored, updated and evaluated. Therefore the DSS serves as a structure to collect the inputs and as a structure to produce output in the form of information needed for decisions. The DSS is not a software tool.

What is in it?
The DSS handbook includes descriptions of useful tools that allow the evaluation and selection of alternative (clusters of) measures which are needed to lower the release of PSs and/or the concentrations of PSs and to eliminate these from the surface waters. Within the SOCOPSE project 11 PSs were examined: mercury, cadmium, hexachlorobenzene, tributyltin, DEHP, atrazine, isoproturon, nonylphenol, polycyclic aromatic hydrocarbons, anthracene and polybrominated diphenyl ethers.
Just as the DSS itself, these tools are proven and based on sound science. Eventually (sets of) measures should be tuned to (all) other measures which are foreseen in the river basin management plan and to the human activities in the area. For that, a social-economic analysis (SEA) is a helpful tool.

About this handbook
The DSS handbook aims to support drafters of river basin management plans and policy makers, at local, national and/or EU level and at (transboundary) river basin level. With this handbook they can select measures to prevent or reduce PSs in river basins. Therefore policy information and available reference data on substances and measures are brought together in this document in a structured way.

Web-based version of the DSS
In addition to the paper version a web-based version of the DSS handbook is available at the project website www.socopse.eu. The web-based version contains all annexes (over 250 pages) with information on substances, measures, and additional tools and relevant methodologies such as environmental fate models, economic evaluation methods. The web-based version of the DSS also contains further information on the handling of uncertainties, the role of priority substances in the WFD, environmental quality standards, phased-out priority substances, mass flow analysis schemes for PSs in Europe et cetera.

Reader's guide for this document
This chapter gives a general introduction. Chapter 2 describes the general structure of the DSS and subsequently in chapter 3 each step of the DSS is described in more detail.

1.2 Related DSS's

In the framework of the SOCOPSE DSS other existing instruments should be mentioned:

- **WFD-Explorer**
  The WFD-Explorer (www.krwverkenner.nl) is a planning kit for the WFD for assessment of the effectiveness of measures to improve the ecological quality of a water bodies in a river system. The tool was developed by Deltares/Delft Hydraulics, The Netherlands.
  The WFD-Explorer supports water managers in making decisions on various strategies to improve the ecological quality (of phytoplankton, macrophytes, macro fauna and fishes). With the WFD-Explorer one can select a measure and show in real-time its impact on the realization of ecological objectives and its costs. WFD-Explorer was applied to a number of other pilot-areas in The Netherlands.
  Compared to the SOCOPSE DSS the WFD-Explorer is more focused on the ecological status of a water body in stead of on the chemical status. The available measures are aimed at improving ecological quality at local scale.

- **Basic Principles for selecting the most cost-effective combinations of measures for inclusion in the program of measures as described in Article 11 of the Water Framework Directive – Handbook**
  Issued by the Federal Environment Agency of Germany. In this project, a methodology for selecting the most cost-effective sets of measures as part of the river basin management plans to be set up for each river basin by 2009 according to article 11 of the Water Framework Directive (WFD) has been developed. Based on a description of the relevant national and European guidelines for the implementation of the WFD and a case study analysis of the prevailing pressures on German water bodies, an exemplary catalogue of applicable measures and instruments was compiled. The included measures and instruments are described in greater detail in data sheets contained in the annex. The study differentiates between concrete technical measures and administrative, economic and informational instruments, which facilitate and support the implementation of the measures. Starting point for the methodology developed in this project is the analysis of pressures and impacts according to the WFD until December 2004. Based on an inventory of the prevailing pressures and sources, potentially relevant

sets of measures and supporting instruments are selected. In the ensuing multi-step evaluation process taking into consideration the ecological effectiveness of these sets, the probability of reaching the WFD-objectives until 2015, the time frame necessary for their implementation and a prioritization with respect to the direct and indirect costs involved, the most cost-effective combination is identified. While the derived method constitutes a preliminary recommendation to decision-makers in water management, a further development and specification as well as an adjustment of the proposed method to local conditions and experiences is mandated. In addition to the practice-oriented handbook, a more extensive study, featuring additional background material, has been prepared.

- **River Basin Manager's Toolbox**
  River Basin Manager's Toolbox (www.rbm-toolbox.net) provides information and tools needed in the implementation of the Water Framework Directive (WFD) and will assist the River Basin managers in various steps of the WFD implementation process. Then River Basin manager's Toolbox has been developed by three different research projects:
    - Benchmark Models for the Water Framework Directive: BMW;
    - Relationship between ecological and chemical status of surface waters: REBECCA, and;
    - Tools and systems to extend and harmonise spatial planning on water courses in the Baltic Sea Region – WATERSKETCH.

  Compared to the SOCOPSE DSS the River Basin Manager’s toolbox is indeed a toolbox with various tools with a main focus on assessment and modelling of substances and hydrology. The tools are not connected to a systematic approach such as in the SOCOPSE DSS of REACH and the tools don’t include measures and an assessment of the effects of measures. Some of the tools (e.g. the Public Hearing Database from Watersketch) lack a translation to English. Nevertheless some of the tools can be helpful.

- **Rule-based Decision Support System for the Morphological Rehabilitation of Watercourses**
  In their article Sewilam *et al*(2007) describe a rule-based decision support system that has been developed to assist decision makers in preparing the EU program of measures. The DSS aims at rehabilitation of morphological structures of small and medium-sized watercourses in Germany. Due to the lack of quantitative data and knowledge on hydromorphology modelling the DSS manipulates the decision making process in a qualitative way, based on the knowledge of experts. Compared to the SOCOPSE DSS this DSS is focused on the hydromorphology of watercourses (in stead of an entire river basin).

2 General structure of the DSS

Seven steps to solutions
The basic structure of SOCOPSE DSS contains seven sequential steps (see Figure 1).

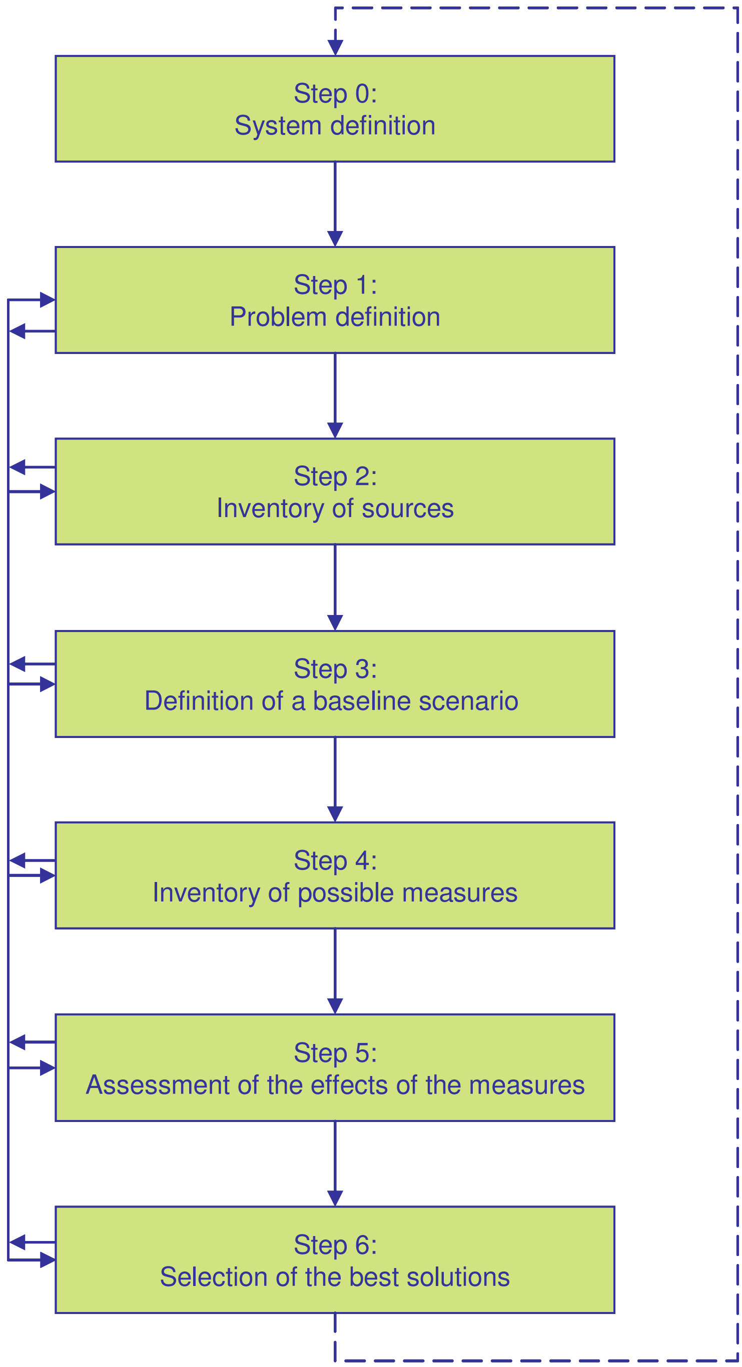


Figure 1: Overview of the decision support system

Why do we suggest this general structure of the DSS?

The structure of the DSS is based on long standing international experiences with the application of Economic Evaluation Methods in policy and decision making, notably in the field of environment- and water management issues. The methodology that is used as a general structure is referred to as Societal Cost Benefit Analysis (SCBA, see Socopse website for more information). The proposed methodology is presently applied in the EC program REACH [1].

Step 0: System definition
In the System definition step the boundaries of the studied system are set and the geographical, physical, chemical, biological and societal characteristics of the system are described. The system definition is the background for all further assessments and thus as detailed information as possible is desired.

Step 1: Problem definition
In Step 1 the problem around PS and WFD are envisaged. The WFD requires a 'good status' for all waters by 2015. PS concentrations may not exceed the environmental quality standards and they may not increase in time. The need is to comply with this requirement and therefore non-compliance can be defined as problem. The result of this step is a table or map with the areas of exceedance: locations where a good chemical status is not met.

Step 2: Inventory of sources
In Step 2 an inventory of sources with effect on PS concentrations at river basin scale is derived from the areas of exceedance table (result of Step 1), from a database with an EU wide inventory of possible sources and from area specific information (e.g. from permits, emission registration data etc.). Step 2 results in a list (table or map) with actual areas of exceedance and their possible sources.

Step 3: Definition of a baseline scenario
In Step 3 a baseline scenario is defined. The step outlines an answer to the following questions: 'To what extent additional measures are necessary to improve the water quality?' and 'Is there reason to assume that the present situation with respect to the water quality will change of will be different in the future? If so why? Will the problem definition change?'
In some cases the main sources of pollution have been eliminated already and the system is recovering towards good chemical status. In these cases it is important to identify the possible threats to recovery, but there's no need to take any action except monitoring. Step 3 results in a list (table or map) with future areas of exceedance and their possible sources.

Step 4: Inventory of possible measures
Step 4 is concerned with creating an inventory of possible management options for the PSs. These management options include e.g. process-oriented options, end-of-pipe techniques, product substitution (phase out) and other options e.g. at Community level. First a scan on the need for measures to solve the actual and future areas of exceedance

[1] Registration, Evaluation, Authorization of Chemical Substances: see http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

and sources is performed. For each situation where 'no action' is not an option the possible and for the area relevant measures are listed from the measure database. Since measures could be applicable for more than one PS a check is performed on whether measures can be combined. The result of Step 4 is a list of possible measures per substance.

Step 5: Assessment of the effects of the measures
In Step 5 an assessment of the effects of the possible management options/measures takes place. Once the possible alternative measures have been defined (the result of Step 4), it is necessary to determine which categories of effects need to be taken into account in order to decide on the most appropriate selection method (Step 6). The assessment of the effects is at least a calculation/estimation of the Costs of Compliance and of the performance of the measure: primarily the reduction in PS concentration, but also the effect on other substances can be regarded.

Step 6: Selection of the best solutions
In Step 6 the selection of the best solution (sets of measures) takes place. In dialogue with the main stakeholder groups (pointed out in Step 0; System definition) the most applicable selection method is chosen based on the expected effects of the measure (sets). With this method the measures and their effects are weighed (and ranked). For those cases where only costs and concentration reduction are important Cost Effectiveness Analysis (CEA) has to be performed. If besides costs and concentration reduction also other effects are relevant a Societal Cost Benefit Analysis (SCBA) or a Multi-criteria Analysis (MCA) has to be performed. From the result of these analyses the best solutions are selected in dialogue with/or advice from the main stakeholder groups.

For the steps 2-6 there is a feedback loop to the preceding one in case completion of the step requires new or other input from the previous step.

3 Description of the steps

The steps of the DSS are described in more detail in the next paragraphs.

3.1 Step 0: System definition

3.1.1 Framework of the step

The aim with this step is to set the physical boundaries of the studied system as well as to characterise it with respect to geographical, physical, chemical, biological and societal conditions, and to identify the key stakeholders, who are or should be involved in the decision-making process. It should be mentioned that situations between countries and/or scale levels can be different. The system definition is the background for all further assessments and thus as detailed information as possible is desired.

3.1.2 Instructions how to do it

The WFD requires each member state to characterize each body of surface water with respect to category (river, lake, transfer zone or coastal water), type (system A or B – see WFD) and geographical location. The information that has to be gathered and the way how it should be presented is specified in Annex II to the WFD. If the system is known to be polluted by certain PS's or other chemical substances, this should be given here, as well as possible known pollution sources. In the ideal case, this information has already been compiled and structured by the user, and will then work as system definition in the DSS. If not, the information should be sought from national/regional/local data sources depending on the nature of the system. The system definition is best presented with a GIS-map (required by the WFD) and complemented with information on population, main activities and a list of stakeholders. The list of stakeholders is required by the WFD in the form of authorities (Annex I), including information on names, addresses, responsibilities and legal status, memberships of associated authorities, geographical coverage (adapted for GIS implementation) of the drainage basin, and international, institutional connections. This list should be filled up with additional stakeholders, such as NGO's or local industry representatives. The information should be compiled in a format according to the user's choice, i.e. in table format or in text format.

3.1.3 Sources of information

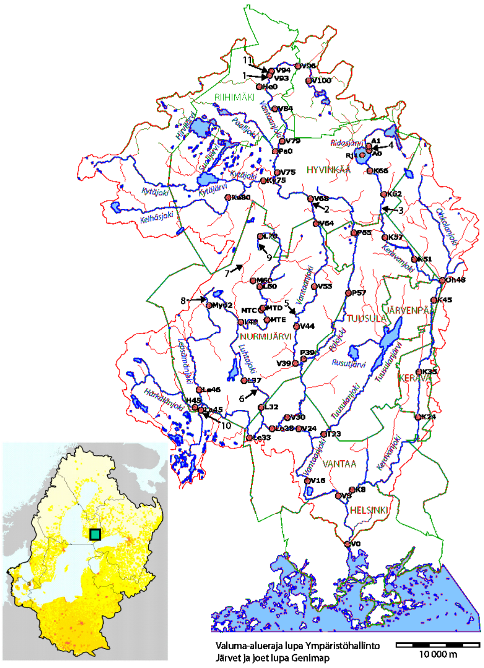
The information required for system definition is specified in the Annex I, II and III to the WFD. This information is best collected at local water management boards, where the area specific knowledge is compiled. Information sources on pollution status could be national, regional databases on monitoring data, if such exist.

3.1.4 Result of the step

The result of this step is primarily a detailed map of the water system to be studied, with additional information on water flows, known pollution status, population density, industrial and agricultural activities, and aquatic parameters such as sediment quality, particle and organic carbon contents, temperature profile. A separate list of stakeholders should also be part of the result. Figure 2 shows a simplified example of a system definition of the river Vantaa in the Helsinki area. This example does not include the more detailed information on stakeholders, pollution status and aquatic parameters.

Finland

Vantaa River



Catchment area 1 686 km^2
Population of 1 milj. inhabitants
Agriculture (24 % cultivated)
Industry (dairy, food, metal, paint, detergent)
Drinking water source (emergency) to
Helsinki Metropolitan area
Irrigation source
Recreation object
Cultural scenery and objects

Figure 2: Simplified system definition of Vantaa River in the Helsinki area

3.2 Step 1: Problem Definition

3.2.1 Framework of the step

In Step 1 the Problem definition is set. The WFD requires a 'good status' for all waters by 2015 and phase out of PSs by 2020. PS concentrations may not exceed the EQSs and they may not increase in time. The need is to comply with this requirement and therefore non-compliance is can be defined as problem. The result of this step is a table or map with areas where PSs cause problems.

3.2.2 Instructions how to do it

Basically the work to be done in Step 1 follows Figure 3.

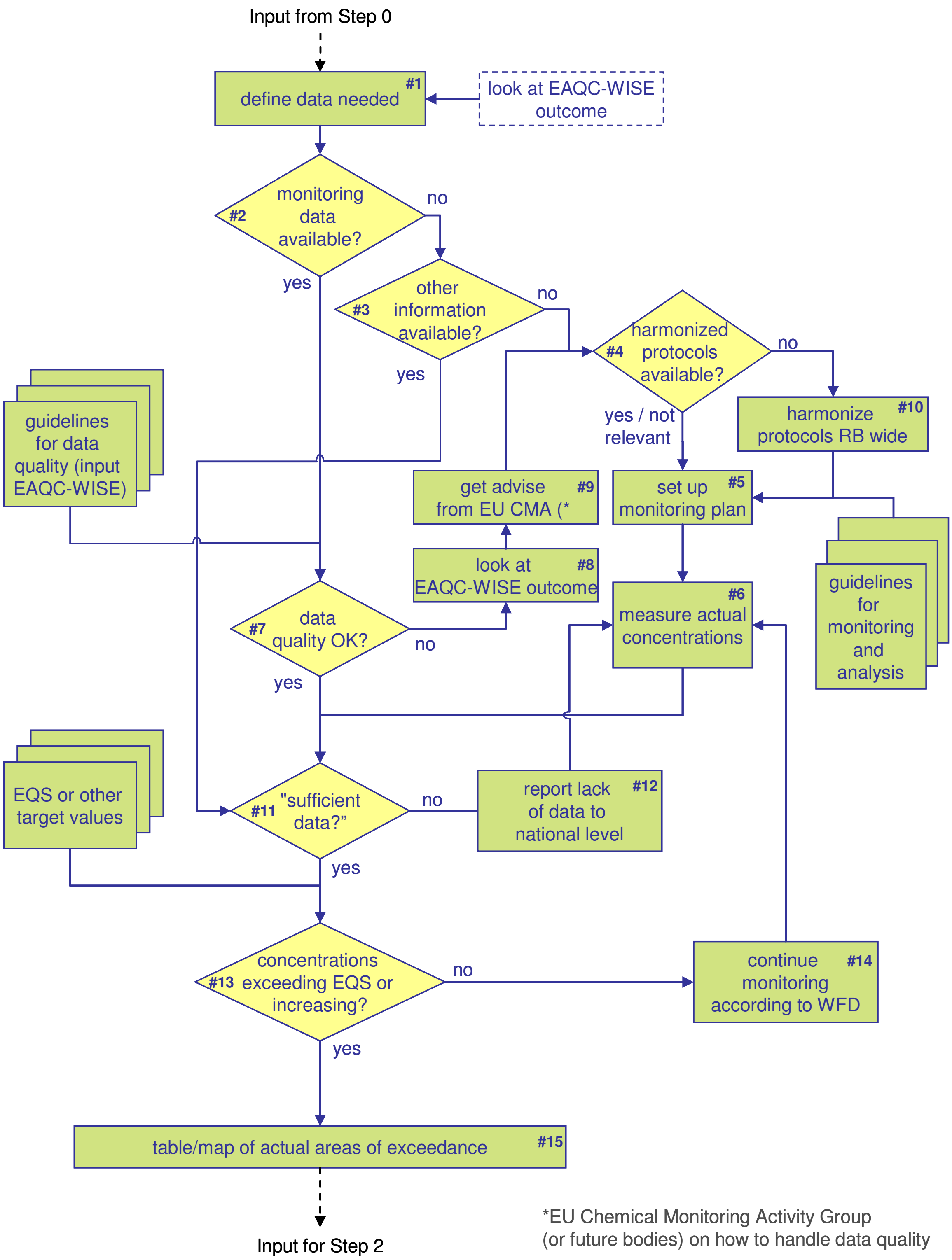


Figure 3: Step 1: Problem definition scheme

The sub-steps/parts in Figure 3 are numbered and described below:

1. **Define data needed [#1]**
   Based on the system definition (i.e. the input from Step 0) the needed data are defined. Common questions for the data definition are:
   - which PSs and other substances throughout the river basin should be assessed?
   - how and when are they supposed to be measured (time trends, protocols)?
   - how are the results of these measurements calculated?
   - how about the data reliability?

   Since measuring an entire river basin is a very time consuming and expensive activity measurement priorities have to be set. These can be based on the presence of economic activities, flow patterns, river characteristics, etc. The outcome of EAQC-WISE project[2] could provide useful additional information.

2. **Monitoring data available [#2]**
   This decision checks the availability of monitoring data as defined in sub-step #1. Decisions on data quality and data quantity are subsequently made in sub-steps #7 and #11. If monitoring data is not available the water manager can decide to use other information in sub-step #3 as an alternative data source.

3. **Other information available [#3]**
   This decision checks (only) *if* other information is available. This 'other information' can be qualified as data which is not defined in sub-step #1 but which can be of possible use and are allowed as an alternative. When no 'other information' is present the process of gaining new data starts following sub-steps #4-6.

4. **Harmonized protocols available [#4]**
   Gaining new monitoring data starts with a decision on the availability of harmonized protocols for sampling and measuring. This is relevant for transboundary river basins.

5. **Set up monitoring plan [#5]**
   When either monitoring data (sub-step #2) and other information (sub-step #3) are not available a monitoring plan should be set up. For large, remote areas the water manager can decide to measure reference areas. The monitoring plan should capture data quality requirements. See WFD-CIS Guidance Document no. 7 Monitoring for further information (http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/guidance_documents/).

6. **Measure actual concentrations [#6]**
   In this activity the actions as described in the monitoring plan are carried out. The results are measurements of actual concentrations.

7. **Data quality OK? [#7]**
   This decision checks whether the provided monitoring data are adequate; it should corresponds with the data quality as defined in the sub-step #1. Data with poor quality cannot be trusted and should not be used. In that case new data is needed.

[2] EAQC-WISE: FP6 project on European Analytical Quality Control in support of the Water Framework Directive via the Water Information System for Europe. See: www.eaqc-wise.net

8. **Look at EAQC-WISE outcome [#8]**
   The outcome of the EAQC-WISE project on data quality could be helpful in cases where problems with data quality appear. More information can be found at www.eaqc-wise.net

9. **Get advise from EU CMA [#9]**
   In addition to sub-step #8 the water manager can gain advice on data quality issues from the EU Chemical Monitoring Advise group or its successors. More information can be found at

10. **Harmonize protocols RB wide [#10]**
    River basin wide harmonized protocols (measuring and sampling methods) can be a condition for setting up a monitoring plan. The harmonizing process can be a rather time consuming activity.

11. **Sufficient data [#11]**
    This decision checks if monitoring data quantity are as sufficient as defined in sub-step #1.

12. **Report lack of data to national level [#12]**
    Inform (and consult) the national level in case of lack of data. Subsequently the measure the measurements of actual concentrations should be continued until the sufficient data level is reached (sub-step #6).

13. **Concentrations exceeding EQS or increasing? [#13]**
    The measurements of actual concentrations are mapped and compared to the EQS of the PS for the specific type of water (see list of EQSs at the Socopse website). In general, data are sufficient if they point out that there is or will be a persistent problem with the PSs. The precautionary principle should be considered, there may be situations where it cannot fully be stated that concentrations are increasing e.g. they may be increasing in one matrix (fish), but decreasing in another (water) or vice versa. At this moment standards are available for inland waters and other surface waters only. For hexachlorobenzene, hexachlorobutadien and mercury EQS for biota still needs to be specified. EQSs for PS in sediments are not available (see footnote 3, page 8).

14. **Continue monitoring according to WFD [#14]**
    Continue monitoring according to the monitoring plan to acquire more data.

15. **Table/map of actual areas of exceedance [#15]**
    The sub-steps above lead to a table or map of the areas of exceedance at river basin level: at those locations the PS concentration is exceeding EQS and/or is increasing in time over the past years.
    Depending on the size of the pollution situation the results can be presented in one or more tables or maps for each PS alone or grouped. If an area of exceedance is related to another WFD problem (e.g. hydromorphological) then add this to the table as a remark.

3.2.3 Sources of information

- For monitoring data: national/regional data bases (ICPDR for the Danube; Naturvårdsverket.se and regional County Administrative Boards for Sweden); scientific literature.
- Models for prediction of trends – see Socopse website for more information.
- EQS: Eur-Lex

3.2.4 Result of the step

The result of Step 1 is a tables or map for each PS indicating the areas where EQS's are exceeded and/or where concentrations increase in time. An example table is given below.

Table 1: Example of (partly filled-in) table of exceeding EQSs or changing concentrations per location

		Locations			
		1	**2**	**3**	**…**
Substances	1	No problem			
	2	Increasing concentrations			
	3	Decreasing concentrations			
	…	X% higher than EQS			

3.3 Step 2: Inventory of sources

3.3.1 Framework of the step

In Step 2 an inventory of sources with effect on PS concentrations at river basin scale is derived from the problem location table (result of Step 1), the EU wide inventory of possible sources and location specific information (e.g. from permits, emission registration data etc.). Step 2 results in a list (table or map) with actual areas of exceedance and their possible sources.

The EU wide inventory was obtained from information on major sources of emissions of PSs to the atmosphere, water and soil, which affect PS concentrations in various aquatic ecosystems. This information was needed in order to assess the importance of:

- Emissions of PSs from individual sectors of economy and waste disposal to the total emissions, in order to propose mitigation measures;
- Emissions of PSs directly to the aquatic ecosystems compared to indirect releases of PSs to these ecosystems through emissions to the atmosphere and then atmospheric deposition and/ or emissions to the terrestrial ecosystems and then leaching/ re-suspension processes to aquatic ecosystems, and;
- Aquatic ecosystems as a source of contamination of the atmosphere and terrestrial ecosystems.

3.3.2 Instructions how to do it

The key questions for the MFA to solve is the assessment of the PSs which are related to the major pathways of PSs from their production and / or generation until release to the natural compartments, in addition to what the direct and indirect (through atmosphere and terrestrial ecosystems) contributions of PS releases to the aquatic ecosystems are in Europe. This shall relieve the main emission sources affecting the concentrations of PSs in aquatic ecosystems in Europe and the main emission amounts of PSs from these sources. For instance, it has been found that atmospheric deposition is a major pathway for some of the studied HMs and PAHs, while application of pesticides makes land as their important pathway to the aquatic environment.

Step 2 follows Figure 4 where the table or map of actual areas of exceedance is the starting point.

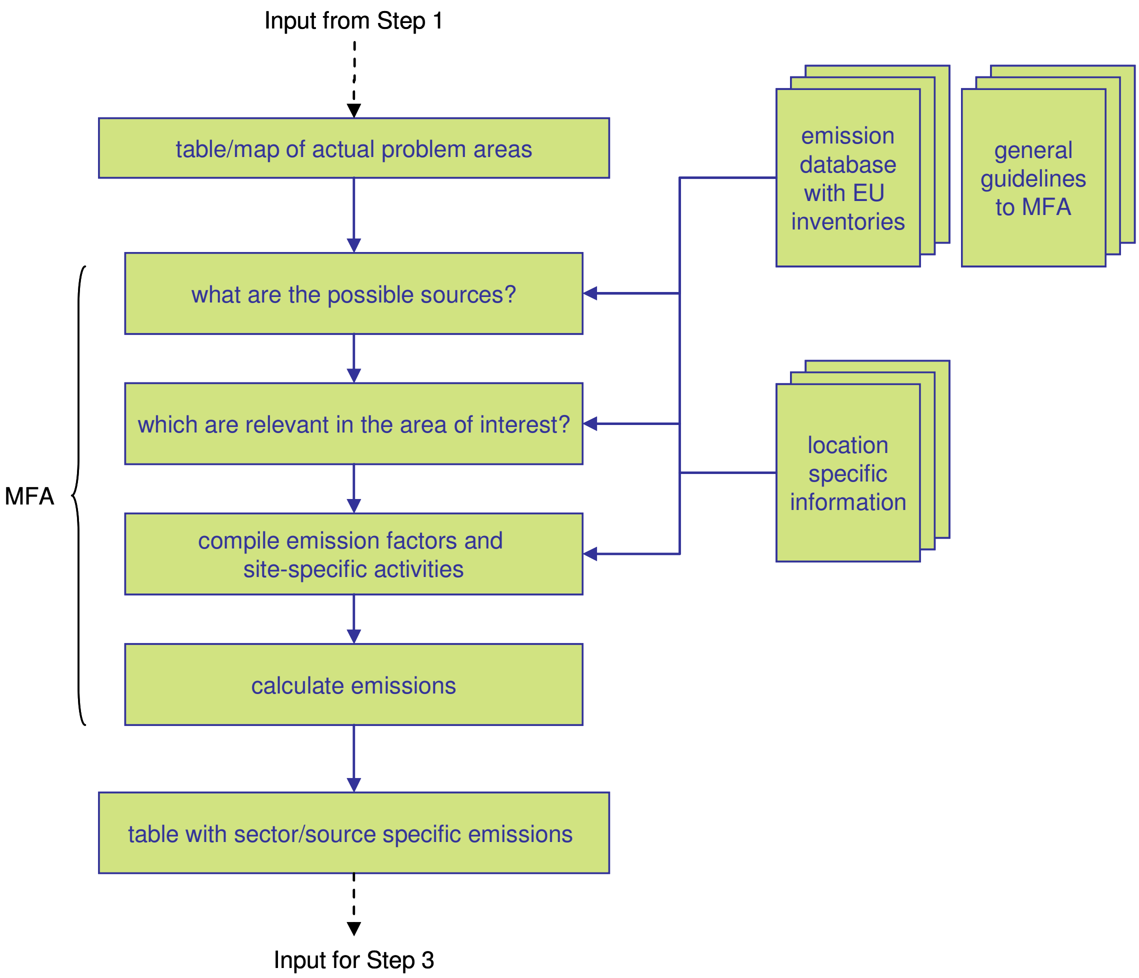


Figure 4: Step 2: Inventory of sources scheme

The sub-steps are:

1. **What are possible sources?**
   The areas of exceedance at river basin scale (from Step 1) are matched with possible sources for the emission database with EU inventories. This database

contains for each PS a quantitative overview of the main sources, along with a scheme of Mass Flow Analysis at European level (see web-based version of the DSS: www.socopse.eu).
Please note that focussing at only the main sources can be tricky since small but relevant emissions at local scale can be overlooked easily.

2. **Which are relevant in the area of interest?**
Together with area specific information such as the presence of certain industrial activity in the area from permits, emission registration data etc. Here potential role of contaminated sites and sediments as emission buffers should not be neglected.
3. **Compile emission factors and site-specific activities**
Emission factors are compiled for the relevant sources in the areas of interest.
4. **Calculate emissions**
From the emission factors emissions are calculated.
5. **Table with sector/source specific emissions**
Relevant sources, i.e. sources that cause problems in the river basin, are collected in a table/map of locations and their main possible sources.

3.3.3 Sources of information

In order to find or calculate the needed information, this may require:

- Establishment of emission inventories, such as emission factors/rates for individual PSs and different source categories;
- Establish an inventory of goods and the PS concentration in these various goods;
- An understanding of the partitioning of materials through processes as well as statistical information on various uses of PSs in different economic sectors;
- The content of PSs in raw materials in the case of PSs being by-products of industrial and agriculture goods production;
- See web-based version of DSS (www.socopse.eu) for more sources of information

3.3.4 Result of the step

The result of Step 2 is a with sector/source specific emissions. An example table is given below.

Table 2: Example of (partly filled-in) table of exceeding EQSs or changing concentrations per location

Substance	Locations	Source	Remark
Mercury	1	Power plant	
Mercury	1 +2	Diffuse air	
Tributyltin	1, 2, 3, 4	Historical, ships	
Cadmium	1, 3	…	

3.4 Step 3: Definition of the baseline scenario

3.4.1 Framework of the step

This step outlines an answer to the following questions:

- To what extent additional measures are necessary to improve the water quality taking into account the measures already taken (autonomous development)?
- Is there reason to assume that the present situation with respect to the water quality will change or will be different in the future? If so why? Will the problem definition change?

In some cases the main sources of pollution have been eliminated already or will be eliminated in the near future and the system is recovering towards good chemical status. In these cases it is important to identify the possible threats to recovery, but there's no need to take any action except monitoring.

A key issue in answering the previous question is the definition of *autonomous development*, which can be considered as development which is beyond our control. This can include diverse things, such as:

- Changes in industry (new plants under construction, others closing down);
- Economic development (increase in consumption or production output);
- Human population increase or decrease in the catchment area;
- Development in agriculture, technology, legislation, etc.;
- Environmental change (i.e. rainfall, flooding, temperature, eutrophication);
- Policies.

Baseline scenarios will have to be developed anyway in the WFD.

It is important to identify that also environmental change can affect the behaviour and levels of priority substances. For example, eutrophication can have a significant effect through processes of sediment deposition, burial, advection of particles and changes in the food web (see Koelmans *et al.* 2001 for a review). Another example would be the effect of climate change on the annual rain pattern and subsequently on the sedimentation-resuspension cycle of hydrophobic chemicals.

In order to interpret the importance of these human induced and environmental "drivers of change", some kind of *simulation* of their potential effects is necessary. Usually this means making emission scenarios on future loading, defining the current state of the water body and simulating future concentration levels based on the scenarios. Environmental fate models (EFMs) can easily be applied to the simulation stage and their use is reviewed in the web-baes version of the DSS (www.socopse.eu). The environmental fate models are computer programs for simulating the concentrations, persistence, levels and transport of chemicals in a model environment. They can be adjusted to local conditions to predict the effects that changes in emissions will have on concentrations and to identify the importance of various environmental processes in transporting the PSs. Because of environmental variation, the behaviour of a given PS will depend on the local conditions (sediment organic carbon, sedimentation,), which should be taken into account in planning management options. The environmental fate models were developed for taking into account the simultaneous and complex processes which together determine the residence times and concentration/emission response of organic substances. Because environmental fate models were developed for organic substances, their application to metallic pollutants is a more complex issue. The web-based version of the DSS provides an overview on environmental fate modelling for water managers as well as examples of application and further references on environmental modelling.

It should be clear that there is considerable uncertainty included in the process of identifying future drivers, creating emission scenarios and simulating the load-effect relationship. In order to make good decisions in spite of uncertainty, uncertainty and sensitivity analysis should be performed while depicting the autonomous development scenarios. There are several techniques for performing an uncertainty analysis, information of some of them can be found on www.socopse.eu.

3.4.2 Instructions how to do it

The process of defining a baseline scenario has been described as a flowchart in Figure 5.

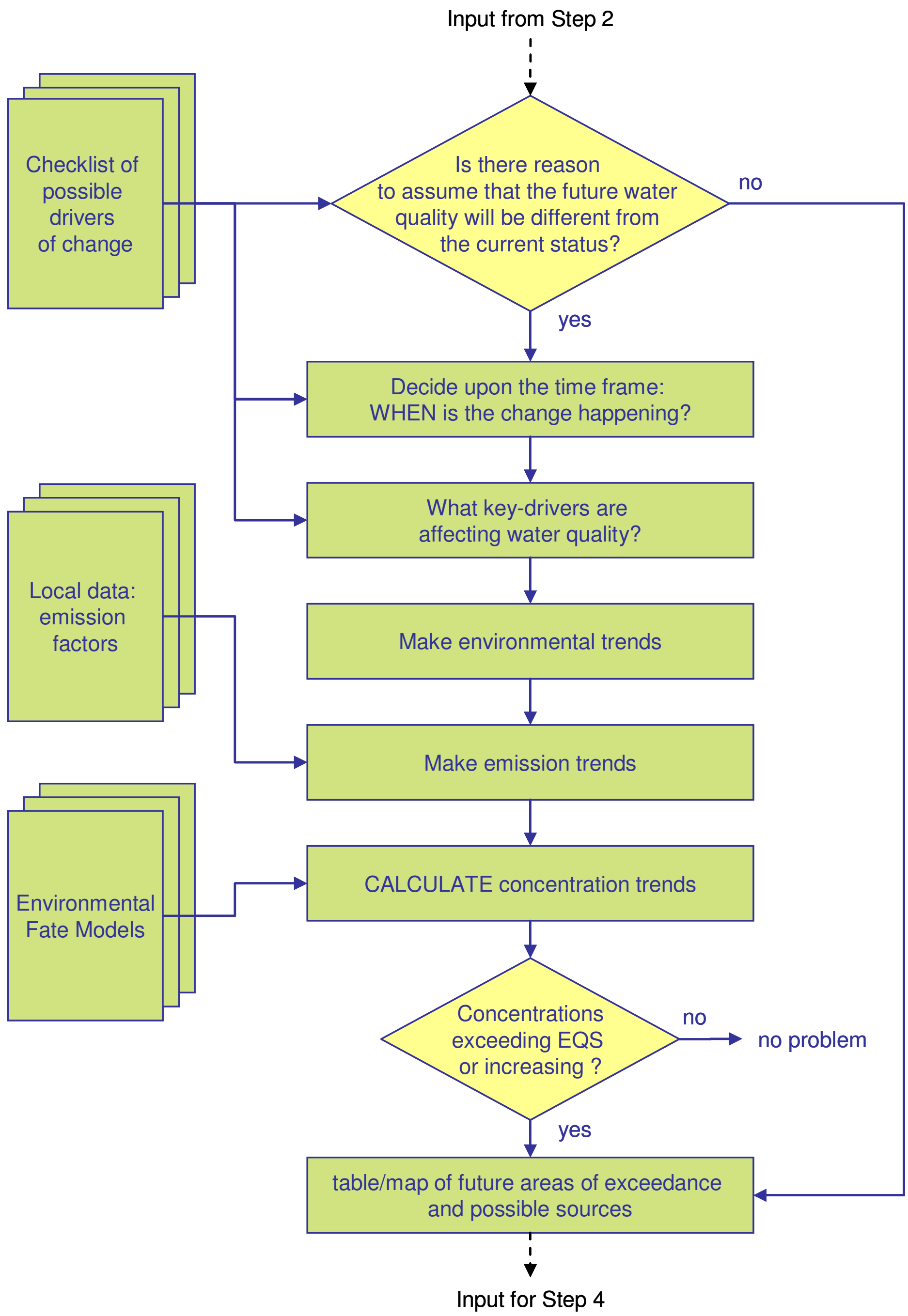


Figure 5: **Step 3: Definition of the baseline scenario scheme**

The sub-steps are:

1. **Is there reason to presume that the future water quality will be different from the current status?**
   This question needs to be answered first. The answer to this question can be found by comparing the current knowledge on the water system and emission sources to a checklist of possible drivers of change (industry, economy, population increase, environmental change). In the later stages this DSS will include checklists for the major PHSs analysed in the case studies, but in the current state the user has to make

her own checklists based on the results of the material flow assessment and common sense (i.e. increase in the amount of fluorescent light bulbs will increase mercury emissions from waste treatment of these products). If the current status is presumed to be stable (answer = no), then the further stages of this step can be omitted and the result delivered to Step 4 will be the same areas of exceedance that are present now. However, if change is presumed (answer = yes), the next stages need to be performed: decide the time frame, identify the drivers of change, make trends of emission level and environmental change, calculate concentration trends and identify future areas of exceedance.

2. **Decide upon the time frame: WHEN is the change happening?**
   Concerning the time frame, the WFD sets out years 2015, 2021 and 2027 as periods for the review of the achievement of objects as laid down in Article 4. These years can be a good starting point for the analysis.

3. **What are key-drivers that influence water quality?**
   The next task is to identify what are the key drivers of change for the levels of the studied PSs. In this stage the results from the MFA-analysis and from environmental fate modelling come to use. MFA can be used to identify possible emission sources and EFMs can be used to identify, which environmental processes are the most relevant for each priority substance. The results of grouping of PSs according to their sensitivity to environmental processes are presented in the web-based version of the DSS (see www.socopse.eu).

4. **Make environmental trends, make emission trends, calculate concentration trends, compare them to EQSs**
   After the decisions about the time-frame and the identification of key processes have been made, the rest of this stage is straightforward. First emission scenarios are made based on the predicted changes of key drivers. Then scenarios of environmental change are assembled from literature and from international scenarios. This data is used in environmental fate models to predict the concentration levels and trends that can be expected in the chosen time frame, and finally these trends are compared to the EQSs.

5. **Tabel/map of future areas of exceedance and possible sources**
   The final outcome of this step is a description of the potential areas of exceedance that can be expected in the near future.

3.4.3 Sources of information

- See www.socopse.eu

Other sources of information are:

- Economic development scenarios (regional economic input-output tables)
- Environmental permits for opening factors
- Existing decisions (phase out, etc.)
- Environmental monitoring (universities, institutes)
- IPPC, HELCOM …
- Previous round Roof reports

- Article-5 reports

3.4.4 Result of the step

Table 3 can be used as a format for presenting the future areas of exceedance and substances.

Table 3: Example of (empty) table of possible future areas of exceedance per substance

		Possible areas of exceedance 2015			
		1	**2**	**3**	**…**
Substance	TBT	x			
	DEHP				
	Atrazine		x	x	
	…				
		Possible areas of exceedance 2021			
		1	**2**	**3**	**…**
Substance	TBT				
	DEHP	x	x		
	Atrazine				
	…				
		Possible areas of exceedance 2027			
		1	**2**	**3**	**…**
Substance	1				
	2	x			
	3				
	…				

3.5 Step 4: Identification of possible measures

3.5.1 Framework of the step

Step 4 concerns the identification of all relevant and possible management options for the priority substances for actual (Step 2) and future (Step 3) areas of exceedance. In the future, this step could be expanded to cover also management options for contaminated sediments[3]. In this step no further selection of measures is made; this will take place in Step 5.

In general the management options can be divided in[4]:

[3] **Management options for contaminated sediments**
At present, due to the lack of reliable information on concentrations of priority substances in sediments and biota at a Community level, EQS for the priority substances have only been set for surface waters (see Annexes, 5.4). It is therefore up to Member States to set EQS for sediments or biota where necessary and appropriate, to complement the surface water EQS set up on Community level. However, to assess long-term impacts and trends, Member States should ensure that existing levels of contamination in biota and sediments do not increase.

[4] See also: Reference Document on Economics and Cross-Media Effects (EC 2006), chapter 2

- *Measures for polluters:*
    - *Process-oriented options*
      Available source control options in processes (both production of substance and use in other processes), including product recovery, process modification (e.g. use cleaner fuels or cleaner raw materials, better maintenance), new processes, closed-circuit operation, use of other components.
    - *End-of-pipe techniques*
      Techniques which can be used to remove the selected priority substances from process water and wastewater of industrial sites and wastewater of municipal wastewater treatment plants.

- *Policy instruments for government:*
    - *Substitution of product (phase out)*
      Available other products (alternatives) which can be used (in products, in applications, consumers, agriculture, etc.).
    - *Options for other (diffuse) sources (Community level options)*
      Management options focussed on measures which could be taken at the community level, for example sewage sludge treatment, waste disposal, sediment or soil removal and treatment, etc.

The step will produce an overview of relevant fact sheets and summary tables of possible measures per source-substance combination (see available Fact sheets in the download section of www.socopse.eu). More detailed information on the listed control options can be found in section 5 of the Substance Reports`(available at www.socopse.eu). Information on measures at regulatory level is given in section 3.3 of these reports.

3.5.2 Instructions how to do it

Basically the steps to be taken in Step 4 follow Figure 6.

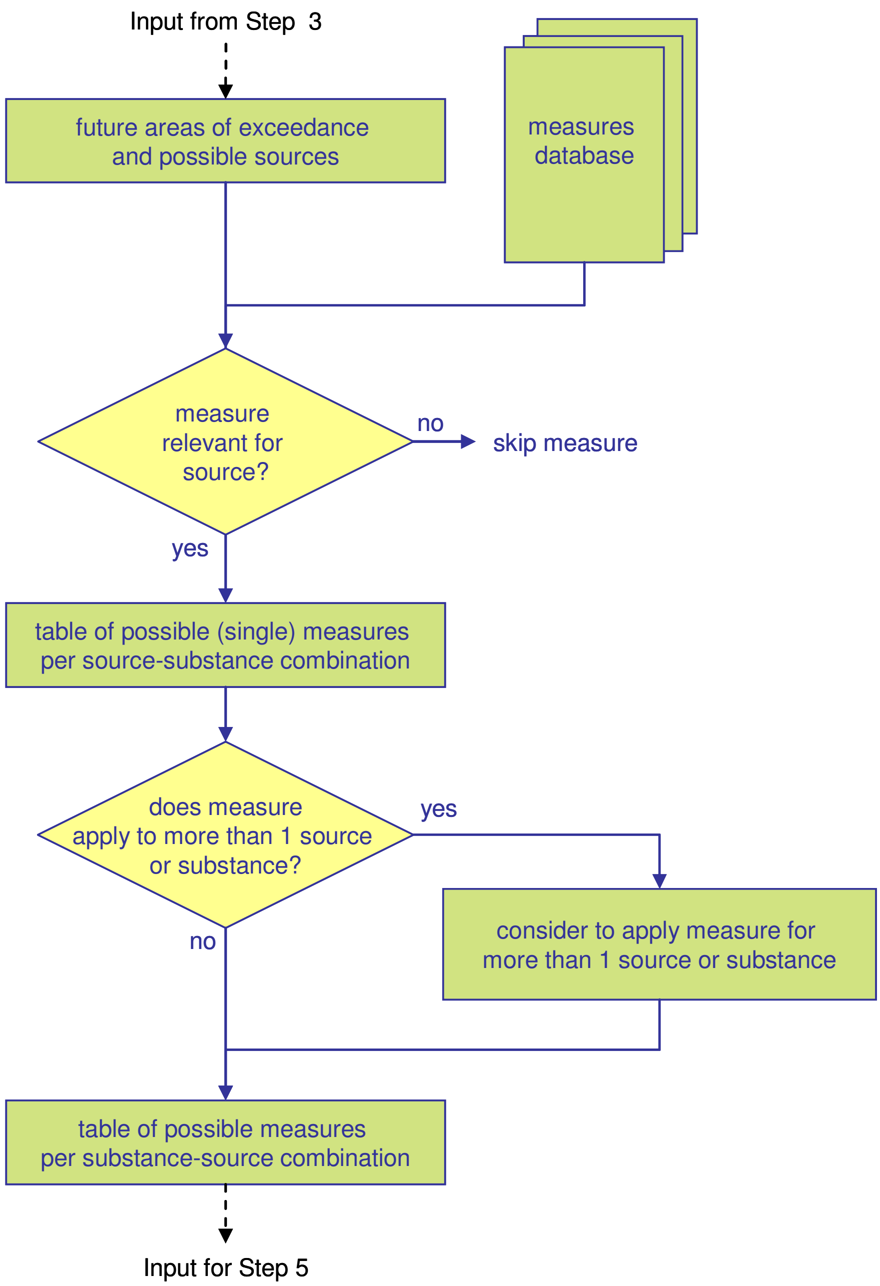


Figure 6: **Step 4: Inventory of possible measures scheme**

The sub-steps are:

1. Based on the actual areas of exceedance and sources (result of Step 2) and the future areas of exceedance and sources (result of Step 3) the necessity of taking measures is checked: are measures really necessary?

2. For those locations where measures are necessary, the sources are matched with the measures database (see available Fact sheets in the download section of www.socopse.eu). This database contains a collection of fact sheets on possible measures per substance with as much as possible detailed information on:

- *Technical feasibility*
  For end-of-pipe techniques, information is provided on the type of pollution and typical concentration range encountered the conditions (matrix, pH, co-contaminants – if available), limits and restrictions. For measures other than end-of-pipe techniques, impacts on the total process, impacts in the total factory and complexity are considered.
- *Performance / Environmental impact*
  This criterion takes into account the achievable reduction in contaminant concentration/load (removal efficiency for the priority pollutant), the ability of the technique to remove other (priority) substances, cross-media effects, energy consumption (per kg removed substance), and wastes generation (sludge, concentrates).[5]
- *Costs*
  Fixed investment costs as well as variable operational costs (labour, energy consumption, chemicals, environmental rates, etc.) per unit are considered, where possible[6]. However, it should be noted that due to a general scarcity of cost data and large variations depending on plant size and location, the given information is usually site-specific and serves as an example.
- *State of the art*
  This criterion distinguishes between BAT technologies, other existing technologies and emerging technologies.

Due to a general shortage of detailed quantitative information, different measures may not be readily comparable. For this reason, a qualitative score is assigned for each criterion, ranging from – – to ++.
Summary fact sheets are produced for each measure/source combination and available in the download section of www.socopse.eu.
This sub-step results in a list or table of possible (single) measures which are relevant for the problem causing sources.

3. The next sub-step involves a check on whether single measures can control more than one substance, or whether the measure is applicable for more than one source or substance-source combination (synergy check). A first quick selection can be made based on common understanding.
   For this purpose there is a simple quick scan selection tool available at the SOCOPSE website.

[5] See also: Reference Document on Economics and Cross-Media Effects (EC 2006)
[6] Please note that calculation of the Cost of Compliance takes place in Step 5, Assessment of the effects of the measures. Cost information in the fact sheets in Step 4 is indicative.

3.5.3 Sources of information

The main sources of information for this step are the 10 Substance Reports[7] produced in WP 3 of the SOCOPSE project. These Substance Reports are summarized in the factsheets in (available in the download section of www.socopse.eu). The factsheets can be used for the first selection of measures. For additional information one can use the complete Substance reports. The Substance Reports for atrazine, cadmium (Cd), di(2-ethylhexyl)phthalate (DEHP), hexachlorobenzene (HCB), isoproturon, mercury (Hg), nonylphenol, polycyclic aromatic hydrocarbons (PAH), polybrominated diphenyl ethers (PBDE), and tributyltin (TBT) are available at www.socopse.eu. The information in the Substance Reports was to a large extent compiled from reference documents and other guidance on Best Available Techniques (BAT), as well as from additional sources such as technical reports and published scientific literature.
BAT Reference documents (BREFs) are available from the European Integrated Pollution Prevention and Control Bureau (EIPPCB). These reference documents are subject to periodic revision. The current documents are available on the EIPPCB website (http://eippcb.jrc.es). Additional sources of information on a wider range of substances could be e.g. the central database developed by the European Chemicals Agency (ECHA) in Helsinki under the REACH Regulation (http://echa.europa.eu/home_en.html).

3.5.4 Result of the step

The ultimate output from Step 4 is a table of possible measures per substance and source, as illustrated below.

Table 4: Example of a table of possible measures per substance and source

Substance		Possible measures			
		1	**2**	**3**	**…**
Source	1		●		
	2	●		○	
	3		○	●	○
	…				

Legend: ● Available measure
○ Emerging measure

Depending on the extent of synergies between different substances and/or sources, some of these tables may then be combined in a subsequent step.

3.6 Step 5: Assessment of the effects of the measures

3.6.1 Framework of the step

In Step 5 an assessment of the effects of the possible management options/measures takes place. Once the possible alternative measures have been defined (the result of Step 4), it is necessary to determine which categories of effects need to be taken into account in

[7] In the future substance reports and factsheets for all PS should be available.

order to decide on the most appropriate selection method (Step 6). The assessment of the effects is at least a calculation/estimation of the Costs of Reduction and of the performance of the measure: the reduction in PS concentration.

3.6.2 Instructions how to do it

Step 5 basically follows the figure below.

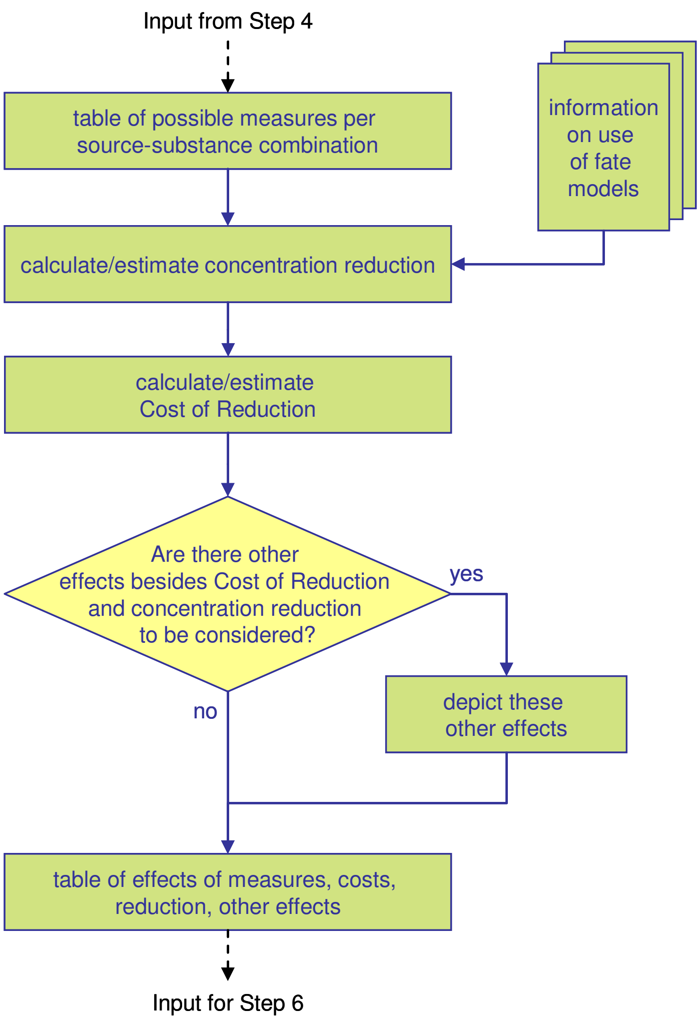


Figure 7: Step 5: Assessment of the effects of measures

The sub-steps within the assessment of the effects of measures are:

1. **Calculate/estimate concentration reduction**
   Form the measures per source-substance combination (the result of Step 4) the concentration reduction is calculated/estimated: what reduction in concentration will be reached when applying a measure? One can make use of environmental fate models.

2. **Calculate/estimate concentration reduction**
   Subsequently, the Cost of Reduction are calculated/estimated expressed in total

(fixed and variable) costs as well as these costs per stakeholder group – the 'costs for whom'. See tools section of web-based version of the DSS (www.socopse.eu) for more information.

3. **Are there other effects besides Cost of Reduction and concentration reduction to be considered?**
   If there are (in)direct economic or societal effects or effects not yet considered those effects should be depicted.

   Possible other effects are:
   - Toxicity of substitute towards the environment;
   - Increase of CO_2 release due to higher energy consumption;
   - More costs due to higher use or use of other of raw materials;
   - Additional concentration reduction of other problem substances (e.g. phosphates, nitrates, copper);
   - Production of more final waste;
   - Effect on regional employment due to industry or agriculture restrictions;
   - Increase of recreational values.

4. **Table of effects of measures**
   The result of Step 5 is a table or list of the effect of measures, costs, concentration reduction and (if applicable) other effects.

3.6.3 Sources of information

- Reference Document on Economics and Cross-Media Effects (EC 2006)

3.6.4 Result of the step

An example of a table of effects of measures, costs, reduction and other effects is provided in the tools section of the web-based DSS (www.socopse.eu).

3.7 Step 6: Selection of the best solutions

It is important to realize that water managers cannot demand management options from the polluters. They have no force to require the *means* to reach a certain targets; they can only demand the *targets* themselves: the EQSs to be reached. Therefore the selection of best management options is an advice to apply by the polluters.

3.7.1 Framework of the step

In Step 6 tools and guidelines will be given to come to the selection of the best solution (sets of measures). In dialogue with the main stakeholder groups (pointed out in Step 0; System definition) the most applicable selection method is chosen based on the effects of the measure (sets). This stakeholder involvement is very important as they have to agree on the starting points the applied methods, weighing factors etc. (see www.socopse.eu: Decision Support System > Tools > Stakeholder Involvement).
For those cases where only costs and concentration reduction are considered to be relevant Cost Effectiveness Analysis (CEA) has to be performed. If besides costs and

reduction of concentration also other effects are relevant a quick scan Societal Cost Benefit Analysis (SCBA) or Multi-criteria Analysis (MCA) has to be performed. With this method the measures and their effects are weighed.
From the result of these analyses the best solutions are selected in dialogue with/with advice from the main stakeholder groups.

3.7.2 Instructions how to do it

Basically Step 6 is carried out as depicted in Figure 8.

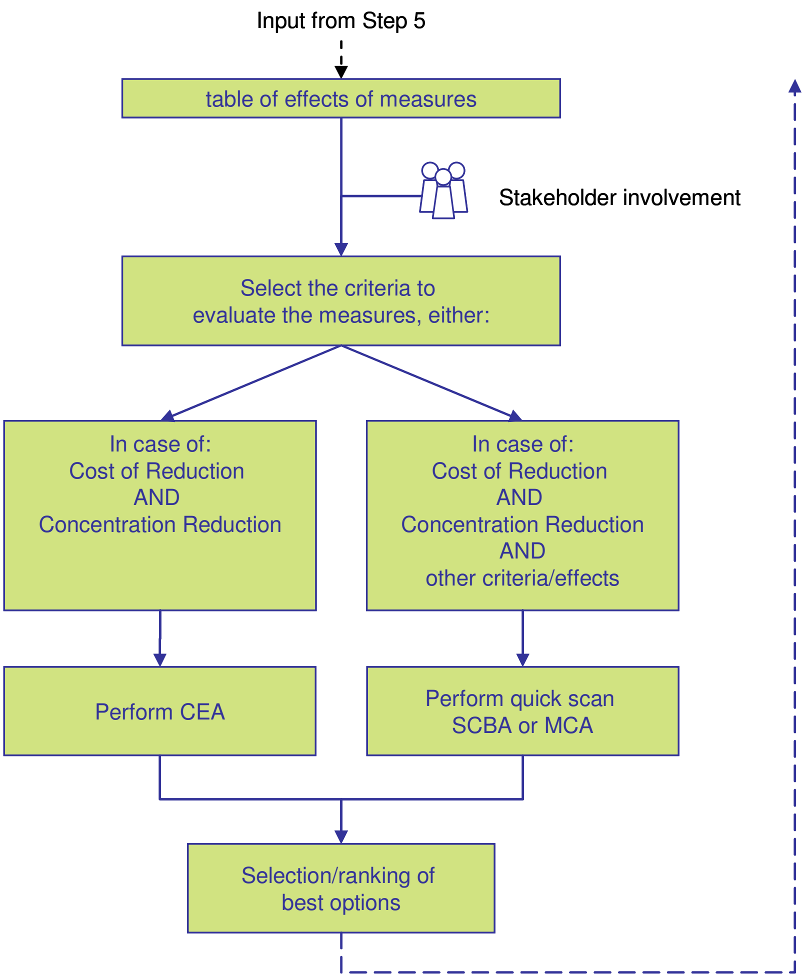


Figure 8: Step 6: Selection of the best measure options

Once the alternative options are determined a decision has to be made which ones to choose. Selection methods are applicable but will of course only be useful if a selection has to be made between alternatives. So there must be more than one "solution" and the measures must in principle be feasible in a technical, social, economic and juridical way.

The following situations may occur (Figure 8):

1. the option with the highest risk reduction (% reduction of concentration) per Euro spent will be chosen: CEA is applicable (see www.socopse.eu for a brief description)
2. it has been determined that there are other relevant effects besides the costs of compliance and the reduction of the pollutant that have to be taken into account when selecting the most attractive options: SCBA or MCA may be relevant selection tools (see www.socopse.eu for more information)

In whatever situation as a minimum requirement the reduction of concentrations and /or the Costs of reduction have to be calculated / estimated.

The ***definition*** of costs and benefits may be different for economists, engineers, policy makers and other stakeholders. In the further development and application of the DSS we will try to develop a common vocabulary. Use will be made of earlier experiences, or experiences else where (e.g. REACH etc).

The minimum that is needed are the costs of compliance: a private enterprise (e.g. a manufacturer) will have to comply with standards, norms, regulations etc. In order to comply, the enterprise will have to take measures and to make costs:

A. Fixed costs (e.g. investment costs: how much, how long will these last, etc.);
B. Variable costs: costs that are dependent on the throughput (e.g. cost of substitution of one agent by another in the production process).

There may be several sources of information. For a number of substances (Cd) this has already been investigated. For other substances there may be handbooks or cost figures (REACH) available.

Note that the Cost of compliance may also include the administrative costs. These may be perceived as quite high in some instances (e.g. REACH).

The costs of compliance are needed when judging the cost effectiveness of alternative measures to comply. If these costs are very low there should be not problem in implementing the solutions no real choice will have to be made. If however there are different paths leading to Rome and all of them may be expensive, it makes sense to choose the most cost efficient way.

However: there may also be effects other than the reduction in the release in priority substances, e.g. closure of the factory, change of one toxic agent by another, effects on the costs of central / collective water cleaning agencies. In these cases we will have to look for ways of trying to quantify these effects as they will have to be taken into account in either an SCBA or an MCA (see www.socopse.eu for a brief description).

3.7.3 Sources of information

The Web-based DSS provides information on economic evaluation methods and cost calculations.

3.7.4 Result of the step

Based on the results of the analysis with the applicable selection method the best solutions (measure option or sets of measures options) are selected in dialogue with/with advice from the main stakeholder groups.