

In pursuit of optimal measure packages

Dutch handbook on costeffectiveness analyses for
the EU Water Framework Directive

21 september 2005

Ministerie van Verkeer en Waterstaat

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Colophon

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Status of this handbook

This handbook offers frameworks for implementing the cost-effectiveness analysis. The analyses themselves should be implemented by the regions. Uniformity of basic assumptions and methods is safeguarded by ensuring that all regions use the same handbook. This makes it possible to compare the results of the regions and it also simplifies analyses on a greater scale, at the level of the (inter)national Rhine river basin, for example.

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1 Introduction

1.1 Introduction

This manual describes the Dutch approach towards the selection of cost-effective packages of measures to realise the objectives of the European Water Framework Directive (the 'cost-effectiveness analysis'). This approach can be broken down into three parts. First, a list will have to be drawn up with measures that can contribute to the attainment of the objectives. Next, in step 2, these measures will be prioritised according to their degree of cost-effectiveness. Finally, in step 3, a package will be composed on the basis of this list, through which the objectives will be attained at the lowest possible costs. This report aims to aid the implementation of each of these three steps.

In this manual, *measures* are only meant to refer to technical measures. These are the physical interventions that lead to the (desired) effects. (Economic) *instruments* may be applied to actually implement the package of measures eventually selected. The purpose of these instruments is to change the behaviour of the various causal parties, as a result of which they will carry out the required measures. Since it will not be certain in advance that the use of a certain instrument will lead to the implementation of a given measure with certain desired effects, it will not be easy (and therefore largely pointless) to perform a cost-effectiveness analysis in which the use of instruments is coupled with the attainment of objectives. Obviously, it is important to assess which instruments can be best employed for which type of measures. However, this is considered to be the next step after the cost-effectiveness analysis and will be described in a separate report.

The most important requirement for the approach is transparency. In the Water Framework Directive, this transparency is particularly important to make public participation possible. For this reason, simple approach is used, which can be followed easily and directly by anyone. This means that preference is given to making use of available knowledge in a pragmatic way, as a result of which the most interesting course can be identified in broad outline, as opposed to a less transparent model, which is more likely to identify a solution which is theoretically optimal.

1.2 The place and role of the cost-effectiveness analysis in the EU WFD

The Water Framework Directive provides that member states must have achieved a good ecological and chemical status of surface and ground waters by 2015. To achieve this, the member states must carry out a number of steps. The first reports had to be completed in 2004 (see Figure 1). In the Netherlands, a national interdepartmental Economy and Finance working group has performed the economic analyses to meet the reporting obligations for 2004 under the EU Water Framework Directive. These involved an economic description of water consumption, the estimation of trends up to and including 2015, and the assessment of cost-recovery percentages. The results of these

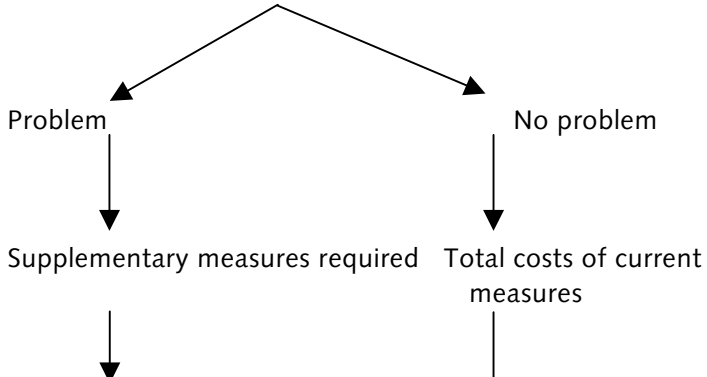
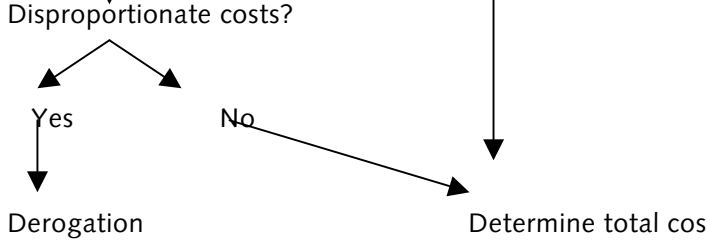
analyses have been discussed with representatives of regional water managers, such as regional directorates, water boards and provinces. It was decided to carry out these analyses at a national level partly to ensure their uniformity (the same approach for all river basins) and partly for pragmatic reasons (most of the information is available in national information databases).

The foregoing indicates that the member states gave a description in their 2004 reports of the current economic situation in the various (sub) basins (i.e. an economic description of water consumption). An estimate of expected economic developments was made at the same time in order to discover whether there will be a good ecological and chemical status in 2015. By linking economic developments with technical knowledge of the burdening of the water system by economic sectors, a picture is created of the expected ecological and chemical status in 2015 ('baseline scenario'). By comparing this status with the objectives that apply in the various waterbodies, it becomes clear where objectives will be attained and which waterbodies risk failing to meet their objectives on time (risk analysis; step 2, "Identification of water management issues" in Figure 1).¹ Apart from a forecast of expected economic developments until 2015, the risk analysis requires that a number of matters will have to be known, such as the definitions of the water bodies, the significant emissions and sources. This information is indispensable for the cost-effectiveness analysis, and means that the risk analyses in the regions will have to be completed in time before being able to begin with the cost-effectiveness analyses.

Once it has been determined to what extent the situation in 2015 will deviate from the desired situation, it will then be possible to assess by means of the cost-effectiveness analysis how the remaining shortfall can be made up at the lowest possible cost. In fact, cost-effectiveness analyses are the optimal tool to find the cheapest allocation of technical measures to be implemented to attain a certain objective. It is for this reason, therefore, that the EU Water Framework Directive requires explicitly that cost-effectiveness analyses be performed at river-basin level (see Text box 1).

¹ It could also become evident from such an analysis that, as a result of current policies, the problem is already being solved. In that case, no additional measures will have to be taken, even if the current situation would deviate from the desired situation.

Figure 1. Schedule of the economic analyses and the place of the cost-effectiveness analysis (Wateco, 2002)

Objective	Step	Time schedule
Characterising river basins	Step 1: Economic description of river basins Trends till 2015 Current level of cost recovery	Before 2004
Identification of water management issues	Step 2: Problem identification to achieve an effective water status (risk analysis) 	Before 2006
Identification of cost-effective package of measures	Cost-effectiveness analysis 	Before 2008 Before 2009
Determining cost recovery and price incentives		Before 2010

As becomes evident from Text box 1, the provisions of the EU WFD imply that economic considerations will also have to be taken into account for water management purposes. However, the text of the EU WFD occasionally allows for more than one interpretation. Due to the absence of frames of reference, for instance, these provisions create problems in the interpretation and conversion of the requirements involved. This also applies to the choice of the most cost-effective combination of measures. To provide some clarity, this manual elaborates on the cost-effectiveness analysis in the Netherlands. Although the analyses themselves will have to be performed only at a later stage (see Figure 1), a number of regions have already started to investigate certain issues. This manual, which can be employed by the region authorities, has been drawn up to ensure that the methods and details in the various regions link up well and to enable comparison between those regions. In this way, the manual contributes, on the

one hand, to the development of a uniform approach, which will make it possible to carry out supraregional analyses more easily, while, on the other hand, the regional managers are supported in the fulfilment of their obligations as laid down by the EU Water Framework Directive.

Text box 1: Cost-effectiveness analyses in the EU Water Framework Directive (European Community, 2000)

Articles 5 and 11 of the EU Water Framework Directive contain references to the analyses described in appendix III of the EU Water Framework Directive. Reference to the cost effectiveness analysis is mentioned in this appendix:

Appendix III

Economic analysis

The economic analysis shall contain enough information in sufficient detail (taking account of the costs associated with collection of the relevant data) in order to:

- b) make judgements about the most **cost-effective** combination of measures in respect of water uses to be included in the programme of measures under Article 11, based on estimates of the potential costs of such measures.

Article 11 mentioned above suggests that programmes of measures should not lead to a deterioration of the water status, and that such programmes should contain at least the basic efforts required to comply with current legislation and implement any measures indicated (time limit for adoption, regular review and possible adjustments).

1.2.1 Link between CEA – CBA: Measuring (dis-) proportionate costs

In Annex III, the WFD makes explicit mention of an opinion on the most cost-effective combination of measures. The Cost Benefit Analysis (CBA), on the other hand, is not mentioned explicitly, but seems to offer a useful structure for making the effects of measures more transparent. The relationship between the cost-effectiveness analysis described in this manual and the Cost Benefit Analysis (CBA) means that the cost-effectiveness analysis is used to make a selection of a cost-effective package of measures as referred to in Article 11 and Annex III of the WFD. This cost-effective package of measures enables the attainment of the objectives at least costs. The CBA subsequently describes the broader social consequences – referring to both the monetary and non-monetary effects – of this package of measures. Based on this information, it is subsequently possible to substantiate any adjustments of the objectives (phasing, reduction). In turn, these adjusted objectives will form the new starting-point for a cost-effectiveness analysis. The search for the optimum set of measures can therefore be seen as an iterative process, in which both of these economic-analysis methods can play an important part in the drafting of feasible and affordable objectives and their associated packages of measures.

The measuring of proportionality means requires that it is possible to compare the economic consequences and financial implications of, on the one hand, the means to be used (e.g. the supplementary measures to improve the water quality of one or several water bodies) and, on the other hand, the objective to be attained (to achieve and maintain a GES or GEP for the same water bodies). On the basis of the calculated net discounted value (NDV) and/or cost-benefit ratio (CBR), a cost benefit analysis makes it possible to assess, firstly, whether and to what extent there are any welfare gains (benefits>costs) or welfare losses (costs>benefits) as a result of the supplementary measures to be implemented.² If this analysis is based on the cost-effective package of measures, the WFD objectives are already being realised at the lowest possible costs by means of the supplementary measures that have to be assessed in the cost benefit analysis. The economic cost benefit analysis will then deal specifically with the question of what the attainment of environmental targets GES or GEP will be worth, in other words, what the relating benefits will be and whether (and to what extent) the calculated or estimated benefits will exceed the calculated lowest costs involved to attain the objectives. If the costs exceed the benefits, the question will remain open to what extent these costs will have to exceed the benefits in order for them to be considered disproportionate. This will be a political decision.

Figure 1 shows that the decision to consider the costs to be disproportionate is a decision that will be taken after the cost-effectiveness analysis has been carried out. Consequently, the cost-effective package of measures is initially drawn up, after which this package will be evaluated as to whether it is too expensive (or might produce any other undesirable effects). If the description of the social cost benefit analysis takes account of the entire process, from the description of the current situation (the phase before the risk analysis in Figure 1), then it is logical that it will largely describe the same steps as those to be taken in the cost-effectiveness analysis. In this case, the cost-effectiveness analysis could be seen as a part of the social cost benefit analysis (this corresponds to the approach proposed by the CPB (Central Planning Bureau), in which the cost-effectiveness analysis is embedded in the Social Cost Benefit Analysis).

1.3 Measures

1.3.1 Measures in this manual

In this manual, technical measures are understood to mean those interventions that result in a physical effect, e.g. reduction of emissions, such as adjustments to sewage treatment plants, for

² As a rule, if there is a positive NDV or the CBR is higher than 1, then there is evidence of an improvement in economic prosperity, and the additional measures to be taken can therefore be justified on economic grounds. If the NDV is negative or the CBR is lower than 1, there is evidence of a situation in which the taking of additional measures will result in reduced prosperity, and it will be advised not to take the additional measures on the basis of economic considerations.

example. These are interventions, in other words, that lead directly to an improvement in the status of the water body, e.g. through reduction of emissions. In the case of reducing/preventing discharges, this will comprise both end-of-the-pipe and process-integrated measures.

This manual makes an explicit distinction between measures and instruments. As described above, measures are technical interventions (physically perceptible change in behaviour or technical adjustment). Instruments are all kinds of activities that can be carried out in an attempt to realise this change in behaviour (or technical adjustment). Instruments may consist of price incentives (subsidies, levies/taxes), orders and prohibitions (including regulations), but also cover education and public information.³

The most important reason why the distinction between instruments and measures is so vital is that a cost-effectiveness analysis will seek the cheapest allocation of (technical) measures, but the measures are subsequently implemented through the use of instruments. The selection of the type of instrument is to a large extent a political consideration. A cost-effectiveness analysis of instruments alone cannot be performed easily. The object of a cost-effectiveness analysis is to find that particular allocation of measures that will realise the given objectives at the lowest possible costs. The issuing of an instruction will not by definition contribute to the realisation of the objectives. Only at the moment that the (technical) measures are implemented will the effect be produced and will the target be approached. That is why a cost-effectiveness analysis only covers the (technical) measures.

1.3.2 Measures in the EU WFD

As becomes apparent from the text in the Text Box, Annex III of the WFD makes the provision that the economic analysis must contain sufficient information to form an opinion on the most cost-effective combination of measures in the field of water consumption, which must be included in the package of measures in accordance with Article 11. According to the same article, the ultimate package of measures will in any case have to include the 'basic measures' and, where necessary, also 'supplementary measures'.

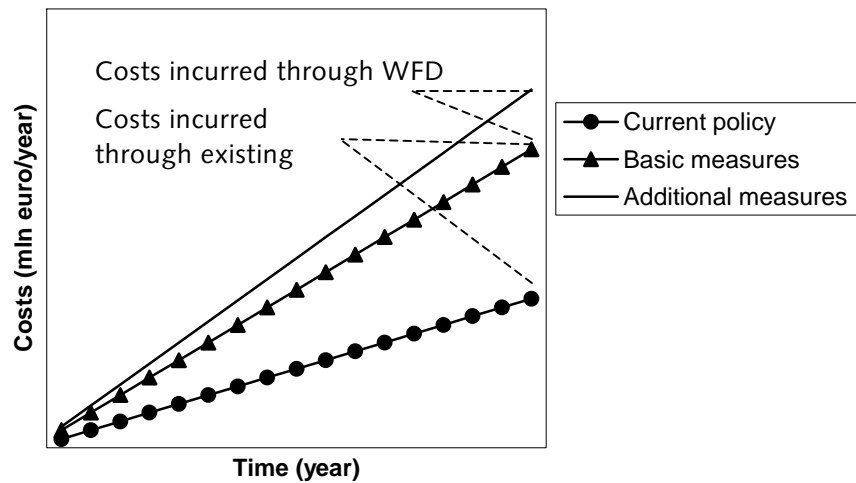
³ For instance, a public information campaign may be a useful instrument under certain circumstances to bring about a certain change in behaviour, such as a reduction in nitrogen emissions as a result of the implementation of an extra purification step. To bring about the same change in behaviour, various instruments could be used; besides public information campaigns, one might think of price incentives (subsidies, levies), orders or prohibitions. The emission reductions realised are not then the consequence of the public information campaign, but of the extra purification step. It is then more accurate to include only the purification step in the cost-effectiveness analysis. One could then analyse how this can best be carried out. For the latter, one could also perform a cost-effectiveness analysis, but in this case it would be to assess which instrument would have the best chances of realising a certain change in behaviour (implementation of a desired measure) at the lowest possible costs.

The **basic measures** refer to the minimum requirements that must be met in any case. A complete summary of these measures is given in paragraph 3 of Article 11 of the WFD, which mentions, amongst other things, measures required for the application of the Community Legislation for water protection (including measures required by virtue of Article 10 and section A of Annex VI of the aforesaid legislation), measures that are considered necessary for the purposes of Article 9 (cost recovery) and measures to promote sustainable and efficient water consumption in order to ensure the (environmental) objectives mentioned in Article 4 are attained. The **supplementary measures** include those measures that the member states are permitted to define within each river-basin district as part of their package of measures. Annex VI, section b of the WFD contains a non-limitative list of this type of measures, including legislative, economic and fiscal instruments, codes of conduct, emission and extraction control measures and construction projects (see Annex 4 for a summary of the basic measures and supplementary measures).

The fact that, according to Article 11, the package of measures ought to include at least the 'basic measures' means that a summary must be incorporated into the river-basin management plans of both the basic measures to be taken (and partly already taken) and the supplementary measures. It will therefore be necessary for each river-basin district to take stock of the basic measures that are necessary to meet the requirements (minimum requirements) by virtue of legislation and regulations apart from the WFD. These basic measures will form an integrated part of the package of measures. Secondly, the effects of these measures on the environmental objectives will have to be assessed, whilst the consequences for the realisation (on time) of the environmental objectives must be charted (estimate of current policy). Only insofar as the implementation of the basic measures would have insufficient effect (and 2015 would therefore nevertheless show a discrepancy between the water status as targeted on the basis of the WFD and the expected water status), will it be necessary to formulate and carry out supplementary measures.

The foregoing could imply that the scope of the cost-effectiveness analysis for the EU WFD should be limited only to those measures that are to be taken over and above the basic measures to realise the EU WFD objectives. However, many of the basic measures mentioned in the WFD are not worked out further into technical measures. For a part of these basic measures, it would be possible to seek the cheapest possible implementation of these basic measures by means of a cost-effectiveness analysis as described in this manual. What is then actually at issue here is the search for the cheapest possible method to implement the current policy. Seen strictly formally, these are therefore not the costs that arise directly from the implementation of the Water Framework Directive, but from the implementation of current policies. The costs of the Water Framework Directive arise from the supplementary measures that are to be implemented over and above the current policy in order to realise the WFD's objectives. The method

of the cost-effectiveness analysis described in this manual may assist in defining the least cost program of measures.



1.4 Costs

In this manual, the costs of a measure are understood to mean all the costs that are directly related to the implementation of a measure. These include both the costs of the purchase of machines, buildings, etc. (investments) and the costs of labour, energy, purchase of raw materials, etc. (operation and maintenance).

To be able to compare the measures on the basis of their cost-effectiveness, all costs are expressed in annual costs. The costs of operation and maintenance are usually represented annually, but not investments. This means that the investments sums will have to be converted into annual amounts. This can be done by applying a period of depreciation and a depreciation percentage. To make the cost details transparent and comparable, the analysis must always mention the investment amount as well as the depreciation period and interest percentage used.

1.5 Scope of this manual

As shown in Figure 1, a cost-effectiveness analysis will only have to be carried out if the risk analysis shows that the water body to be analysed is expected to create problems in attaining the objectives relating to the good water status. The point of departure of the analyses described in this manual is therefore that a risk analysis has been carried out and that the problems and their causers are therefore already known. This means that this manual will not detail the manner in which the current situation must be described, how the developments in the water status until 2015 – the projection year for the EU WFD – must be described (including a description of the consequences of current policies) and how, by making a comparison between the current situation and the objectives, an estimate must be made of the risks of certain objectives not being attained. These steps normally form part of a cost-effectiveness analysis, but because these steps have already been worked out in other reports, a description of

these steps is not included in this manual. This handbook takes the results of these risk analyses as starting point for the cost-effectiveness analyses

This manual describes how a selection can be made, based on the description of the problems as formulated in the risk analysis, from a long list of possible technical measures in order to ultimately arrive at a selection of the most cost-effective combination of measures. This will be done in three steps, which are described in detail in this manual:

1. Firstly, a selection of all the relevant measures will be made from a long list of all kinds of measures. Next, based on this list of theoretically relevant measures, a number of measures will be dropped as a result of regional knowledge. What remains is a list of practical and relevant measures.
2. Secondly, the possible measures are prioritised on the basis of their cost-effectiveness.
3. Thirdly, by consolidating the cost-effective measures into packages of measures, the objectives will ultimately be attained at least costs.

The end result of the cost-effectiveness analysis is an allocation of technical measures among regions and sectors with which the objectives can be realised at least costs.

Once it is known with which package of measures the formulated objectives can be attained and at what costs, it may turn out that these objectives can only be attained at unreasonably high cost ('disproportionate costs'). If this is the case, the WFD offers the possibility of an exemption being made (postponement or phasing of objectives). This manual does not describe how such exemptions can be substantiated and what information will have to be submitted (this will be described in other reports). However, as soon as the packages of measures are analysed, the possible consequences of the measures will have to be clearly described, not only in terms of their costs and contribution to the realisation of the objectives, but also in terms of loss of employment and possible indirect effects.

Other items that are not explicitly dealt with in this manual are the implementation of technical measures and the apportionment of the costs (burden sharing).

After the cost-effective package of technical measures has been defined, it will have to be analysed how this program of measures can be implemented and which instruments will have to be used to bring about the required changes in behaviour. The instruments may involve levies, subsidies, orders, prohibitions as well as education and public information. An analysis of the usability of instruments will take place after the analysis of the cost-effective program of measures. The use of instruments will be described in a separate report.

An important aspect of the interpretation of the results of the cost-effectiveness analysis is that such an analysis aims to find a particular allocation of measures in which the defined objectives are attained at the lowest possible costs. The cost-effectiveness analysis does not

indicate who should actually be bearing the costs. If it becomes clear from a cost-effectiveness analysis that certain measures must be implemented in the region upstream, then this means nothing more or less than that it will be cheaper to implement them upstream than to have every region implement (for instance) a proportion of the measures. In fact, any allocation of measures other than the cost-effective allocation will result in higher costs.

A cost-effective allocation of measures often means that one sector will have to make a more than proportionate effort, whereas another sector will have to make less of an effort. To realise such an allocation of measures, a system can be developed according to which the sectors that are required to make less of an effort will contribute to the costs incurred by the other sectors which are making a greater effort. Such a system, in which compensation payments are made, requires a decision in favour of a certain desired apportionment of costs arising from the implementation of measures. This is a political decision, which is related to the implementation of measures. The cost-effectiveness analysis described in this report is aimed solely at the allocation of the measures (allocation), rather than on their implementation.

1.6 Overall approach

1.6.1 From coarse to fine

In the search for measures, any available information will have to be used as much as possible. This information will not always be complete and correct, but, if supplemented with *expert judgement*, it will be possible to make an initial analysis of the most important problems and possible measures. This rough analysis will show which missing information will have to be further investigated. This method helps to prevent too much energy being spent on improving information that is not used afterwards, such as investigating the costs of purification techniques for zinc in a given region, when it only suffers from hydromorphology problems.

1.6.2 Integrated perspective

The purpose of the Water Framework Directive is to improve the ecosystems. This is a huge task, which cannot be solved by a single sector on its own. This means that, when carrying out the cost-effectiveness analysis, not only should the problems that can be solved or the measures that the regional water boards are able to take be considered by, for instance, the regional water boards, but that the analysis must cover all the sectors of Dutch society. This means that representatives of these sectors will also have to be involved in the performance of the cost-effectiveness analysis (the Water Framework Directive emphasises the importance of public participation).

1.6.3 Early start

To be able to complete the definitive package of measures on time, it is vitally important to make an early start. It is therefore advisable to begin in 2005 with an initial rough analysis (quick-scan), going through all the various steps from risk analysis and the search for

relevant measures to, ultimately, a possibly interesting package of measures. In this manner, it will soon become clear what the most important problems are that will need to be solved, and what information will possibly still have to be collected in order to be able to carry out the definitive analysis in 2006/2007.

1.7 The set-up of this manual

The next Chapter describes the method through which the relevant measures can be selected from a long list of possible measures. Subsequently, Chapter 3 contains a description of how the measures can be prioritised according to their cost-effectiveness in accordance with the criterion of cost-effectiveness = costs/effect. This description begins with a simple example of one business with a limited number of measures, which are worked out in ever greater detail (increasing degree of complexity), with several substances simultaneously, up to the level of entire catchment basins. This Chapter also deals with the problems concerning uncertainties and how to handle the time factor. The composition of cost-effective programs of measures is described in Chapter 4. In Chapter 5 a case study is presented, in which the method has been worked out for hydromorphological interventions in the river Meuse. Finally, Chapter 6, presents a case study on emission reduction in one of the sub riverbasins.

2 Selection of relevant measures

2.1 Method for arriving at a list of relevant measures

Measure schedules are employed to realise a list of relevant measures. By offering a clear structure and using the available expertise – particularly from the risk analysis – in a swift and appropriate way, these schedules aid the selection from a long list of possible measures of measures which may contribute to solving the problems described in the risk analysis. This first step is largely similar to the approach in the German handbook on cost-effectiveness analyses (Interwies et al, 2004).

The basis structure can be summarized in the following steps:

- | | |
|---------------|---|
| Dit Hoofdstuk | <ol style="list-style-type: none">1. Problem field: Description of problem type.2. Source: Description of the cause of the problem3. Deficient policy: Description of the environmental parameter requiring improvement4. Combination of the three components above leads to possibly interesting measure types/sorts5. Theoretically relevant individual measures may be derived from this list of possibly interesting types of measures6. This is followed by a test of the practical relevance of the theoretical measures deduced |
| Hoofdstuk 3 | <ol style="list-style-type: none">7. The most cost-effective measures are then evaluated from within this set of relevant individual measures |
| Hoofdstuk 4 | <ol style="list-style-type: none">8. Finally, the selected measures are then comparatively appraised, resulting in an optimum package of measures |

2.2 Structure of measures sheets

Measures sheets are arranged according to a tree diagram / funnel system, through which the user is guided to the necessary measures sheet. The system is as follows:

Problem field => source => deficient policy (deficiency parameter for which goals must be achieved) => measure sort => theoretically relevant measure => practically relevant measure

The idea behind these measures sheets is to employ a relatively simple and shrewd method, based on the expertise already gleaned from the risk analysis to arrive at a limited list of relevant measures deduced from a rough list of potential measures. The Knowledgesystem Measures largely follows this structure (see also Section 3.3 and Appendix 4).

2.2.1 Step 1: Description of problem type: Problem field

A distinction is made in the problem fields between different types of pollution and different types of hydromorphological problems.

Pollution:

-
- A Specific sources
 - B Diffuse sources
- Hydromorphological problems:
- C Water abstractions (municipalities, households, locks)
 - D Regulation of flow through
 - E Hydromorphological changes

2.2.2 Step 2: Description of the cause of the load: Source

A distinction is made in sources between different types of point sources and diffuse sources.

Point sources:

1. Sewage treatment plants (point discharges by municipalities/households)
2. Industry

Diffuse sources:

3. Agriculture
4. Recreation, shipping
5. Corrosion of construction materials
6. Traffic and other atmospheric deposition

2.2.3 Step 3: Description of the environmental parameter requiring improvement: Defective policy

Each problem field and source is subdivided into deficient policy and measures. This is elaborated below for one example (further elaboration follows in the Measures Knowledge system).

Problem field

A Point sources

Source

A.3 Industrial and private institutions

A.3.2 Waste water discharges by sewage treatment plants (STPs; private institutions)

Defective policy/water initiative

A.3.2.1 – A.3.2.2 COC, BOC₅

2.2.4 Step 4: Identification of potentially interesting types of measures: Type of measure:

Combination of three components above leads to delineation of possibly interesting measure types/sorts. In this case, to the measure types:

A.3.2.1.3 – A.3.2.2.3 Reduction of particulate emissions through end-of-pipe solutions, possibly with reuse of raw materials

2.2.5 Step 5: Identification of theoretically relevant individual measures

The following theoretically relevant individual measures may be derived from this list of possibly interesting types of measures:

Measure:

Anaerobic purification, and retro-fitted purification of residue

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The same problem field, the same load source, but different deficient policy/water initiative leads to other measures, such as suggested below:

Deficient policy/water initiative:

A.3.2.3 Nutrients: nitrogen (N)

Type of measure:

A.3.2.3.3 Reduction of particulate emissions through end-of-pipe solutions, possibly with reuse of raw materials

Measures:

Optimisation of the purification plant for:

- *NH₄-N (aqueous nitrogen)*
- *N_{total} (total nitrogen)*

Methanol levels

Effluent filtration and iron levels

Anaerobic purification, and retro-fitted purification of residue

Optimisation of active-silt process

Combination of measures

2.2.6 Step 6: From theoretically relevant measures to practically relevant measures

After a definitive selection of theoretically relevant measures has been made, based on the measures schedules. These theoretically relevant measures then have to be assessed on their practical relevance. This requires knowledge of the area and the local situation. This prevents measures which are impractical, though they theoretically might present a solution to the observed problems, from being included in the final package of measures. Removing groynes, for example, is a theoretically interesting measure to increase water flow, but if where there are no groynes, this measure becomes practically irrelevant.

3 Prioritisation of measures

3.1 Introduction

After having defined which measures are relevant (previous Chapter), these measures will have to be prioritised (this Chapter), before they can be consolidated into packages of measures (Chapter 4) and implemented). This Chapter therefore deals with step 7 as described in section 2.1.

The simplest way to prioritise measures according to their cost-effectiveness is by dividing their costs by their effects.

$$\text{Cost-effectiveness} = \frac{\text{Annual costs}}{\text{Annual effects}}$$

Measures with lower costs per unit of effect are then more cost-effective than measures with higher costs per unit of effect. Or, on the other hand, you can say that the measures with the greatest effect per Euro are the most interesting (*'the biggest bang for the buck'*). This approach is described below for various levels of scale. First, we take a look at an application at the level of one individual source (e.g. an individual company). After that, we describe a situation in which there are several similar sources within a single area. Next, we show how various types of sources can be taken into account within a single area. After that, we describe how an analysis can be made covering several areas.

An approach in which cost-effectiveness is determined on the basis of the criterion of the lowest costs per effect is particularly useful if the effect can be described unambiguously. For example, by how many kilograms the phosphate discharge into a certain point will be reduced (e.g. a blue node, or another point for which objectives are to be attained). However, in order to limit eutrophication, not only P, but also N is important. By using 'eutrophication equivalents' the emission reductions for N and P can be lumped together, as a result of which it will be possible again to search for the lowest costs per effect. In the same way, it is possible to carry out an analysis by means of so-called 'dispersion coefficients' for measures that have effects on various heavy metals simultaneously.

Before going into the method to be used for the cost-effectiveness analysis, we will briefly deal with the description of the effects of measures.

3.2 Description of effects

A cost-effectiveness analysis is aimed at finding that particular allocation of technical measures that attains predefined objectives at least costs.

The Water Framework Directive includes two types of objectives. Firstly, objectives for many substances are formulated in terms of

maximal concentrations. These are supplemented with ecological objectives, which set requirements, depending on water type and the possible presence of irreversible hydromorphological changes, for e.g. diversity and numbers of fish, waterplants and macrofauna. Because the cost-effectiveness analysis focuses on the attainment of the objectives, the contributions of individual measures to the realisation of the objectives must be clear.

For many measures, it is not easy to describe their effects on the ecosystem in general terms. For instance, it is difficult to indicate what the effect is of 1 kilogram of zinc on the biodiversity for macrofauna or fish. Even for hydromorphological measures, the effects on the ecosystem can only be described by means of very rough assumptions (see learning experiences in the project about hydromorphological measures in Chapter 5). However, it is of vital importance for a cost-effectiveness analysis to have estimates of the effectiveness of available measures. That it is difficult to predict the effects of measures on ecosystems accurately, because every ecosystem is different, must not result in ultimately making no prediction at all about the possible tendency of the effects of the measures. It is therefore essential to at least describe the effects general terms (through bandwidths; if necessary, qualitatively).

The foregoing shows that it is clearly necessary, for the purposes of the cost-effectiveness analysis, to seek co-operation with experts who are able to supply more information about the effectiveness of measures, also at a regional level. Especially because there may be great differences from one region to another, regional knowledge will have to be used in particular to obtain estimates of the contributions that measures can make to the realisation of the objectives. In terms of costs, there may also be regional differences. For instance, if earth has to be excavated in order to implement a measure, the one region may turn out to have more polluted soil than the other region. This can have a major impact on the total costs of the measure. When describing the costs and effects of measures, it is of vital importance to indicate explicitly what could possibly cause such regional differences in costs and effects. This will help to improve transparency of the analyses and thereby the comparability and the basis of the analysis.

For the description of the cost-effectiveness analysis in the rest of this Chapter, it has been decided to describe the effects in terms of reductions in the discharge into the surface water. This assumes that it is known by how much the discharge into the surface water will have to be reduced in order to fulfil the objectives. However, as stated earlier, the objectives are often formulated in terms of maximal concentrations. Because there is often an unambiguous relation between discharges and concentrations, this can be simply converted on the basis of regional knowledge and/or models.

The most important reason for using emission reductions consistently as the frame of reference in this manual, rather than reductions in concentrations, is that the information about costs and effects of

measures is usually also described in terms of emission reductions, rather than reductions in concentrations. The same principle is used in the Knowledgesystem Measures, which appeared on internet page <http://www.kaderrichtlijnwater.nl> in the summer of 2005 (see also the description in the following subsection).

To be able to describe the effects of measures in terms of reductions in concentrations, the emission reductions must be linked up with regional water quality models (or on the basis of expert knowledge). The description of these models falls beyond the scope of this economic manual.

Apart from objectives relating to concentrations of substances, the WFD has explicitly formulated objectives for the functioning of the ecosystem, e.g. relating to the biodiversity and the numbers within the species. This applies to macrofauna, fish and waterplants. These objectives can partly be realised only through the implementation of effect-oriented measures. For instance, removing weirs and thereby creating currents in the rivers can stimulate the presence of current-loving species of fish. Emission-reducing measures do not play a role in this. This may be different for other ecological objectives. For instance, to prevent the eutrophication of a certain lake, effect-oriented measures can be used, such as active biological management, but source-oriented measures can be introduced as well (such as reducing excess manure in agriculture or advanced purification in sewage treatment and in the manufacturing industry). The section below contains a description of how the pros and cons of various source-oriented measures can be weighed. Likewise, Chapter 5 shows how hydromorphological measures can be consolidated into sets of measures. By comparing the costs of the package of source-oriented measures to the costs of the effect-oriented approach it is possible to determine in what way the ecological objectives can be attained at the lowest possible costs. Since in particular the effects of the measures to be taken into consideration are often determined to some considerable extent by the local situation, regional knowledge is of great importance if one intends to make a thorough analysis.

3.3 Information about cost effects of measures: The Knowledgesystem Measures

This manual describes the method used for the cost-effectiveness analysis. To be able to use this method, information is required about the costs and effects of measures. This information can be found in the Knowledgesystem Measures. This system will become the central information system with details about costs and effects of all kinds of possible measures. These details will then be available to all those involved in the enforcement of the WFD who need or wish to see these details. The most important objects of this system are to disclose, share and align this information efficiently.

The system was developed in the summer of 2005. Since then, it is possible to consult it to use it for additions via <http://www.kaderrichtlijnwater.nl> (however, in the first half on 2006,

it will be hosted at www.paict.com). This system is only available in Dutch (see also Appendix 5).

Users will be able to enter their own data. As a result of this, for instance, a regional water board that has specific know-how of and experience with a certain measure can enter the costs and effects of this measure or add comments to any measures that are already available. This information will then also become available elsewhere in the country. For practical private analyses of (sets of) measures, it is possible to download data in Excel files.

In this way, an interactive platform is created at which information about measures can be exchanged effectively and efficiently. Quality assurance is provided through workshops with various experts.

This system is set up to include generic information about costs and effects of measures, rather than calculations of effects at the level of individual waterbodies. This will have to be done by regional water managers for their specific situations.

3.4 Analysis at the level of a single individual source⁴

If a Sewage Treatment Plant (STP), which discharges 114 thousand kilograms of P a year, has to push back its P emissions, then one must first analyse the possible measures that this STP can take. Let us assume that there are two options: expansion of the activated sludge process or effluent filtration with iron dosing. The possible costs and effects are shown in the table below. It becomes evident that the costs per kilogram of P reduction are the lowest if the activated sludge process is expanded. This measure is therefore the most cost-effective. If the STP must reduce its emissions by 30%, this measure will suffice. It is only if a further reduction in emissions is required that effluent filtration will become interesting as an additional measure.

Source	Measure	Costs	Emission reduction	Costs of emission reduction
		€	kg P per year	€ per kg phosphate to be removed
STP 1	Expansion of active-sludge process	7,475,000	38,264	195
	Effluent filtration and iron levels	4,721,100	21,683	218

3.5 Analysis of two similar sources in one area

If several sources are present in one and the same area, the cost-effectiveness of measures at the various sources will have to be analysed, in order to find the cheapest set of measures with which objectives relating to e.g. the improvement of the water quality can be realised.

⁴ The figures mentioned here are notional and are only used for the purpose of illustration.

Let us assume that there is another STP in the same area, which has the same possibilities for reducing P emissions, but because its situation is slightly different, it has to invest more to make effluent filtration possible. On the other hand, the costs of expanding its activated sludge process are clearly lower. See the table below.

Source	Measure	Costs	Emission reduction	Costs of emission reduction
		€	kg P per year	€ per kg phosphate to be removed
STP 2	Expansion of active-sludge process	715,000	6,623	108
	Effluent filtration and iron levels	1,977,100	3,753	527

It is now the most cost-effective to start with an expansion of the activated sludge process at STP 2, followed by the activated sludge process at STP 1. Should this still fail to improve the water quality of the receptive water sufficiently, it will be interesting to apply effluent filtration to STP 1, whilst effluent filtration at STP 2 will only be effective as a last resort.

3.6 Analysis of two different sources in one area

3.6.1 Point sources vs diffuse sources

An important distinction that is made between sources is the difference between point sources and diffuse sources. STPs are an example of point sources. Waste water is often directly discharged into the surface water through a pipe. Since this constitutes a direct discharge, an emission reduction by 1 kilogram of P at the source will also result in a reduction by 1 kilogram of P in the surface water.

With diffuse sources this is different, as the discharge is much less manifest, because emissions end up in the surface water indirectly through the soil or the air.

If, for instance, farmers distribute more manure absorbed by their crops, a part of this surplus will eventually, after transport through the soil, end up in surface water. However, since part of the substances is either fixed in the soil (as with phosphate) or converted into gases (as with nitrogen), in agriculture, an emission reduction by 1 kilogram of P at farm level does not automatically lead to a reduction in the P emissions into the surface water by 1 kilogram.

To understand the effectiveness of measures taken in agriculture, it will have to be known how much of the substances is fixed in the soil and what part ultimately ends up in the surface water. At point sources, it is always the entire amount of the emission that will end up in the surface water.

Let us assume that a pig farmer has four options to reduce P emissions; a limited adjustment of the feed composition, a significant adjustment of the feed composition (which may cause damage to health), stepping up manure removal and a restriction of production.

Source	Measure	Costs	Emission reduction	Costs of emission reduction
		€	kg P per year	€ per kg phosphate to be removed
Pig farm	Limited adaptation of feed composition	132	23	6
	Significant adaptation of feed composition	1,992	141	14
	Increase removal of slurry	6,910	803	9
	Limit production	9,000	932	96

With these measures it must be borne in mind that certain measures cannot be implemented when combined with other ones and the costs and effects can therefore not simply be added as was done above for the STPs. The significant adjustment of the feed composition, for instance, consists of the same adjustments described under the measure of a limited adjustment of the feed composition with an additional restriction on the feeding schedule, based on minimum requirements. These measures can therefore not be taken in combination with each other, but a decision will have to be taken in favour of either the one or the other measure. The same goes for the production restriction measure. If implemented to its full extent, the farm will be closed, thereby ruling out the possibility of carrying out any of the other measures.

The costs and effects of the various measures at business level are presented in the table below.

Source	Measure	Costs of emission reduction	Effect on surface water	Costs of load reduction
		€ per kg phosphate to be removed from source	Kg reduction required from source per kg reduction in surface water	€ per kg phosphate to be removed from surface water
Pig farm	Limited adaptation of feed composition	6	20	120
	Significant adaptation of feed composition	14	20	280
	Increase removal of slurry	9	20	180
	Limit production	96	20	1920

The costs mentioned above are the costs and effects that apply to the farm. However, because a large part of the phosphate is fixed in the soil, e.g. 95% (Note: This percentage may depend on the distance from the farm to the surface water. This information must be supplied by experts in the region), a reduction in emissions by 1 kilogram of P

at the pig farm will only result in a much smaller reduction in the emissions into the surface water, viz. by 50 grams. In other words, to reduce the emission of P into the surface water by one kilogram, the pig farmer will have to cut back 20 kilograms of P at his farm.

In this example, emission-reducing measures at pig farms are cheaper, expressed in costs per kilogram of P reduction, than measures at the STPs. This applies to the cost-effectiveness of measures implemented at the source. However, if we consider the effect of the emission reduction on the water quality, we must take into account the fact that a large part of the phosphate is fixed in the soil. This makes the measures in the farming industry much less cost-effective.

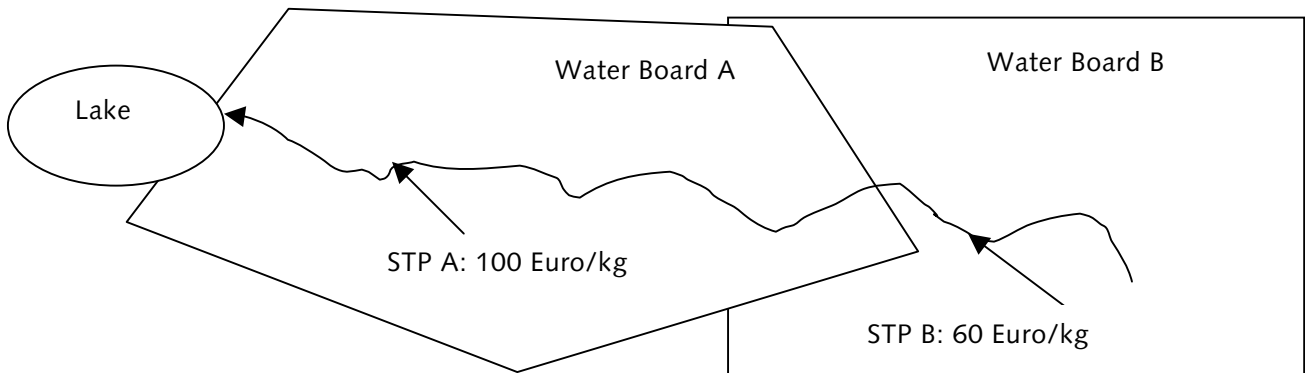
It will then become apparent that the expansion of the activated sludge process at STP 2 is the most cost-effective measure, followed by the measures of limited adjustment of the feed composition and increased manure removal at the pig farm. After the possibilities for reducing emissions at STP 1 have been exhausted, it will become interesting to implement a significant adjustment of the feed composition rather than a limited adjustment. Only after effluent filtration is also applied at STP 2, and therefore all other possible measures have been exhausted, the restriction on production levels will become an interesting option.

3.7 Analysis of various sources in an (inter-) national river basin

When carrying out a cost-effectiveness analysis at river basin level, it is important to know what objectives are to be attained. If the objective has been formulated for a certain discharge point, such as a lake or sea situated downstream, it will have to be known not only what the costs are per kilogram of emission reduction, but it will also have to be clear what the impact is of an emission reduction at sources in the various areas on the water quality in the lake or sea downstream. The distinction between the effectiveness of the measures in the various regions can be included in the analyses in the same manner as described earlier for the distinction between point sources and diffuse sources. This means that in order to find the most cost-effective allocation of measures, first an estimate will have to be made of how many kilograms of emission reduction will be required at the source to realise a reduction in the discharge into the lake by 1 kilogram. Next, the costs per measure to realise one kilogram of reduction in the discharge can be analysed. The cheapest measure should then be implemented first. This is illustrated in the example below.

Let us assume that there are two STPs in two different regions (e.g. water boards A and B) along a river, which are both discharging the same quantities of substances, but whose abatement costs are different (see Figure 1). If the effect of one kilogram of emission reduction at STP A on the discharge into the lake is equal to the effect of one kilogram of emission reduction at STP B, it will be necessary for STP B to reduce more than STP A in order to reduce the discharge into the lake at the lowest possible costs.

Figure 2. Illustration of an analysis with several sources in one river basin



Source	Costs of emission reduction	Effect on surface water	Costs of emission reduction
	€ per kg phosphate to be removed	Kg reduction required from source per kg reduction in surface water	€ per kg phosphate to be removed from surface water
STP A	100	2	200
STP B	60	4	240

However, due to biochemical and other processes, the impact of emission reductions in the upstream section of the river is usually less significant than the impact of emission reductions downstream. Let us assume that due to biochemical reactions STP A needs to realise 2 kilograms of emission reduction to reduce the discharge into the lake by 1 kilogram, whereas 4 kilograms of emission reduction is required from STP B to realise the same reduction in discharge into the lake (Note: this information must be supplied by experts in the region). The costs of reducing the discharge into the lake by 1 kilogram will then amount to EUR 200 for STP A and to EUR 240 for STP B. This then means that to reduce the discharge into the lake by 1 kilogram, it will be more cost-effective to deal with the emissions at STP A, even if the costs of STP B per kilogram of emission reduction (at the source) are lower. This is comparable to the analysis described earlier of emission reductions at farms and at STPs (see van der Veeren (2002) for an example of a cost-effectiveness analysis on nutrient abatement in the Rhine basin, including 7 economic sectors in 13 different regions)

If the objective would be to improve the water quality in the section between the points at which the STPs are discharging into this river, then only the measures taken at STP 1 in region B will be relevant. A cost-effectiveness analysis which takes account of the difference in effectiveness between the regions is then not necessary. It will be sufficient to carry out an analysis at the level of the individual source. In other words, a supraregional analysis is only interesting if co-operation between the regions is relevant and interesting. In fact, this example shows clearly how regional analyses can be coupled in order to perform a supraregional analysis in this way. This

requires, however, an unambiguous and uniform approach. By taking the same approach in the various regions, this can be achieved.

Supraregional analyses can show whether the same objectives (in this case for a lake situated downstream) can be realised at lower costs for the river basin as a whole than if each source would apply the same emission reductions (uniform policy). These analyses do not dictate that the party which would have to realise most emissions in accordance with the cost-effective allocation of measures would also have to bear most of the costs.

For the river basin as a whole it is cheaper to allocate the measures cost-effectively and therefore have one region (or one source) reduce slightly more than another, than if all parties would reduce emissions equally. As a result of this, it is possible for those who have to make less of an effort (and therefore save costs) to compensate those who have to make more of an effort for these extra efforts. And even after these compensation payments there is still a part of the 'profits' left. How the compensatory payments are to take place and how the balance of the profits is to be distributed is a (political) implementation matter, upon which the cost-effectiveness analysis is unable to pronounce.

3.8 Analysis of various eutrophic substances simultaneously

Eutrophication is a major water quality problem against which the necessary measures must be taken, also within the framework of the WFD. Eutrophication can be prevented by reducing N and P loads. In the approach of the cost-effectiveness analysis mentioned above, the costs per unit of effect are analysed. This makes it difficult to analyse various substances at the same time. In fact, if a measure has simultaneous effects on N and on P (e.g. manure processing), how should the costs be attributed to the various substances?

One method to do this is by using eutrophication equivalents. This is an internationally recognised approach, in which the effect of N can be added to the effect of P, by expressing it in terms of the contribution that the substance in question makes to the eutrophication problem. Since phosphate is much more important to eutrophication than nitrogen, 1 kilogram of P is considered to be just as harmful to the environment as 10 kilograms of N (source: Van der Veeren et al (2004); consult regional ecologists about this to fine-tune regional analyses).

By attaching emission reductions of P ten times as much weight as the emission reductions of N, it is possible to determine the costs per effect on the reduction in eutrophication. This is illustrated in the table below.

This table shows that by using eutrophication equivalents it is possible to carry out a cost-effectiveness analysis for several substances simultaneously.

Table 2: Analysis of various eutrophic substances simultaneously (values for eutrophication equivalents from Van der Veeren et al (2004))

Source	Measure	Costs	Emission reduction kg N	Emission reduction kg P	Effect on surface water	Effect on surface water	Effect on eutrophication	Costs per eutrophication equivalent	Ranking order
		At source	At source	At source	Kg N reduction required from source per kg N reduction in surface water	Kg P reduction required from source per kg P reduction in surface water	Eutrophication equivalents (= kg P reduction in load + 0,1*kg N reduction in load)		1 = cheapest
STP 1	Expansion of active-silt process	7,475,000	0	38,263	1	1	38,263	195	6
	Addition of methanol	175,000	198,971	0	1	1	$0.1 * 198,971 = 19,897$	9	1
	Effluent filtration and iron levels	4.721.100	0	21.683	1	1	21.683	218	7
STP 2	Expansion of active-silt process	715,000	0	5,641	1	1	5,641	1,268	9
	Addition of methanol	100,000	17,601	0	1	1	$0.1 * 17,601 = 1,760$	57	4
	Effluent filtration and iron levels	1,977,100	0	1,918	1	1	1,918	1,031	
Pig farm	Limited adaptation of feed composition	132	197	23	5	20	$23/20 + 0.1 * 197/5 = 5$	26	2
	Significant adaptation of feed composition	434	409	23	5	20	$23/20 + 0.1 * 409/5 = 9$	48	3
	Increase removal of slurry	6,910	1,195	803	5	20	$803/20 + 0.1 * 1,195/5 = 64$	108	5
	Limit production	90,000	2,381	932	5	20	$932/20 + 0.1 * 2,381/5 = 94$	957	8

3.9 Analysis of various heavy metals simultaneously

The same method as is used for the water problem of 'eutrophication' can be used for the problem of 'spreading of heavy metals', i.e. using weighing factors with which the emissions of heavy metals can be added on the basis of the impact that these substances have on the environment. Possible values for these weighing factors (dispersion coefficients) are given in the table below (source: Van der Veeren et al (2004); consult regional ecologists about this to fine-tune regional analyses).

Table 2: Values of dispersion coefficients for heavy metals (source: Van der Veeren et al (2004))

Substance	Dispersion coefficient	Expressed in
Cadmium	0.0049	Kg
Mercury	0.0331	Kg
Arsenic	0.0001	Kg
Chromium	0.0406	1000 kg
Copper	0.3337	1000 kg
Lead	0.0417	1000 kg
Nickel	0.0000	1000 kg
Zinc	0.0332	1000 kg

The analysis can be performed in the same way as described above for eutrophication equivalents.

However, such an analysis is especially interesting for the prioritisation of measures if there are measures that have an effect on various substances simultaneously, whilst certain objectives also have to be attained for various substances simultaneously.

If in a certain region the maximum concentration is being exceeded for only one substance, it will be sufficient to follow the costs-divided-by-effect approach as presented in the preceding sections.

3.10 Analysis of various substances simultaneously

Another method to include measures in the cost-effectiveness analysis that will have effects on various substances (e.g. eutrophication and heavy metals) simultaneously is by taking the following steps (see van der Veeren (1999) for an example on nutrient abatement in the Rhine basin):

- First define the substance that is causing the most serious problem,
- Carry out the cost-effectiveness analysis for this substance,

-
- Next, determine to what extent the set of measures produced by this analysis will simultaneously fulfil the objectives for the other substances.
 - If not, the analysis can be repeated with the remaining measures for the substance that will then cause the most problems in attaining the objectives.
 - (and repeat the same steps subsequently for the remaining substances, until all objectives are attained).

However, it is possible at the end of the analysis that for the last substance the emissions will be pushed back more than is necessary. In that case, one could consider implementing the last measure included in the package of measures only partly, as a result of which the objectives set for the last substance would be fulfilled exactly.

It is also possible that at the start of the analysis measures are included in the package that have become superfluous, because measures that were given lower priority in the package will also reduce the emissions of the substances analysed first. It is advisable to pay attention to this (see also the learning experiences mentioned in Chapter 6, where a summary can be found of the report entitled "Kosteneffectiviteitanalyse Kaderrichtlijn Water Deelstroomgebied Rijn-Oost; Koploperproject" (*Water Framework Directive cost-effectiveness analysis in the East Rhine Sub-basin; Trendsetter Project* (Morselt et al. (2005)), in Dutch).

In the example below, the discharges of two substances have to be reduced. Substance 1 by 150 kilograms, substance 2 by 100 kilograms. Let us assume that measure A is the most cost-effective for reducing substance 1. The effect is a reduction by 150 kilograms. The objective for this substance is therefore fully attained. However, this measure has no impact on the reduction in substance 2. That is why a measure is sought that will be cost-effective for substance 2. The cheapest measure realises too little reduction in substance 2 and therefore it is attempted to achieve something for substance 2 by using the second measure on the list of affordable measures. This turns out to be measure C. This measure will reduce the discharge of substance 1 by a maximum of 320 kilograms and substance 2 by 80 kilograms. By implementing only half of this measure, the objective will already be fulfilled. However, it now turns out that measure A has become superfluous. This measure can therefore be eliminated from the package. The ultimate cost-effective package of measures will therefore consist of measure B and half of measure C (this analysis was actually

carried out in the pilot project Rhine East; see Chapter 6 for more details).

Measure	Reduction of substance 1	Reduction of substance 2
Objective	150	100
A	150	0
B	0	60
C (max red 320/80)	160	40

3.11 Analysis of hydromorphological measures

The example above has been worked out for emissions and water quality, but it also applies to water quantity and hydromorphological interventions. Chapter 5 gives a description of a pilot study, in which this analysis has been performed in detail for a section of the river Meuse.

3.12 Comparative assessment between emission-oriented measures and restoration and construction measures

In the previous sections we described how emission-reducing measures in particular can be prioritised according to the cost-effectiveness of the relevant measures. Chapter 5 will show that this method can also be used to prioritise hydromorphological/ecological measures according to their cost-effectiveness. Where emission-reducing measures are often focused on realising water quality targets (e.g. concentrations of zinc in the water), hydromorphological/ecological interventions are usually aimed at achieving an ecological effect (e.g. adjusting sluices so fish can pass through, or the construction of spawning areas). In these situations, various measures of one particular type can be compared relatively simply in terms of their costs and the contribution they make to attaining the objectives.

If both hydromorphological/ecological and emission-reducing measures can be implemented to realise a certain objective, such as limiting the eutrophication process, it should be known how much each of the types of measures will contribute to solving the problem. As soon as this is known, the pros and cons of the two types of measures can be weighed relatively simply again by dividing their costs by their effects and by assessing which measure will score best.

3.13 Time

Some measures will only have an effect after a longer period of time. This may be due to time-lags (agricultural emissions from farm lands will not decrease immediately when emissions are reduced at farm level, but only after a certain period of time), but could also be caused by phasing-out (if the use of a certain substance is banned today, this substance will still be found in the environment for a certain period of time). Measures that only have an effect after a longer period of time will therefore have a limited value for the realisation of the objectives of the EU WFD for 2015. This also applies to measures that are very expensive if implemented at short notice, but the costs of which will decrease sharply if the measures are implemented in phases. For instance, for many process-integrated measures, the costs of implementing these measures 'overnight' will be extremely high, because all machinery must be switched off. If it would be possible to wait with the implementation of the same measures until regular major maintenance is carried out, for which the machinery would have to be switched off in any case, the same measures could turn out to be much less expensive. For this reason it could be interesting to carry out the cost-effectiveness analysis not only for the situation in which the objectives are realised in 2015, but also for the situation in which the objectives are attained in 2021 or in 2027 (phasing periods mentioned in the EU WFD). In this way, the cost-effectiveness analysis could supply important information for substantiating a possible phasing of the realisation of objectives.

3.14 Uncertainty about costs and effects

For many measures, it is impossible to represent the costs and effects in a single number with 100% certainty. In many cases, estimates of the size of scale will be involved, in which a bandwidth can be represented in the shape of a lower and upper limit. Since uncertainty with regard to costs and effects of measures may differ from measure to measure, the bandwidths may also differ from measure to measure. For example, for measures that are already being implemented regularly it will be possible to make a relatively reliable estimate of their costs and effects. However, for measures that are reasonably experimental, with which hardly any experience has been gained, it will be more uncertain what the expected costs and effects will amount to exactly. For such, more experimental measures, the bandwidths will tend to be relatively wide.

One way of dealing with these uncertainties is by carrying out several cost-effectiveness analyses. For example, an analysis could be carried out once using the lower limits, and once using the upper limits. If this has any influence on the prioritisation of the cost-effectiveness of the measures and the measures included in the package of measures, this uncertainty will have to be stated explicitly, complete with a summary of the possible consequences for the realisation of the objectives and the costs to be incurred. In the ultimate decision-making process the pros and cons will have to be weighed on the basis of this information.

Moreover, one could decide to conduct further research into the costs and effects of the measures involved, in an attempt to reduce the bandwidths. This emphasises the need to start well on time with the initial, rough analysis, so that it will soon become clear where extra (research) efforts would be required, in order to be able to eventually draft a thoroughly substantiated package of measures (from rough to accurate).

3.15 Indirect effects

Apart from an effect in terms of their contribution to the realisation of objectives, measures often have other consequences as well. E.g. employment, or the supplying and processing industries (indirect effects). If analyses are carried out on a limited scale, these effects will often be limited in their scope and therefore mostly negligible.

However, as the scale of the analysis and the scale of the measure increase, the importance of these indirect effects will also escalate. If, for instance, a cost-effectiveness analysis is performed for a small creek, it may become clear that it would be cost-effective to stimulate the limited number of pig farmers to close their business. The effect of this measure would be felt mainly by families on the farms involved, but the effect on the rest of the economy in the region would be moderate, let alone on the Netherlands as a whole. This would change if the same measure were applied to the entire basin of the river Meuse. In that case, cattle feed businesses and cattle hauliers, for instance, would also be faced with a significant drop in their turnover.

It is important to be able to take account of the indirect effects, both in the analyses on a local/regional level and the analyses on a supraregional/national level. On a regional level, this will take place mainly qualitatively. However, on a national level there may be a need to represent these indirect effects quantitatively, because the scope of these indirect effects may play a role in discussions about disproportionality of costs. This is being researched in the project entitled 'The Water Economy of the Netherlands'.

3.16 Instruments in a cost-effectiveness analysis

In Chapter 1 it was stated that the cost-effectiveness analysis is limited to the allocation of measures and is unable to pronounce upon the implementation of measures, because political preferences play an important part in this. For this reason, only the technical measures are included in the cost-effectiveness analysis and not the instruments. In principle, it is possible to use the method presented here also for the analysis of the cost-effective use of instruments. For a brief description, please see Appendix 5.

3.17 Cost-effectiveness analysis vs flows of substances

As becomes evident from the description of the method given above, a cost-effectiveness analysis looks for the least cost allocation of measures to realise a certain objective, covering various sectors. Within this context, the measure with the least costs per effect will score highest. This may mean that a sector that contributes only moderately to the creation of a problem will have to take measures to solve the problem in the cheapest possible way for the entire river basin. In other words, the cost-effectiveness analysis does not pay attention to the extent to which the various sectors contribute to the problem. This extent is only relevant if one intends to assess how much effect the measure involved will have and whether any measures apart from the cheapest one will have to be taken.

Let us assume that there is a eutrophication problem in a certain region. An analysis of the flows of substances shows that agriculture is the largest source of nutrient emissions, followed first by the STPs and next by the manufacturing industry. The cost-effectiveness analysis could then show that the manufacturing industry would be able to take a certain measure which would be relatively economical and would result in a clear reduction in the nutrient emissions. If this measure would be the cheapest per eutrophication equivalent compared to possible measures on the farms and at STPs, this measure would be given top priority in the cost-effectiveness analysis. If this measure would be sufficient to solve the eutrophication problems in the region, then this would therefore mean that the largest source (in this example, agriculture) would not need to take any nutrient-abatement measures.

If this would be considered unfair, the cost-effectiveness analysis could be carried out again, focusing only on agricultural measures. However, this would lead (by definition) to a more expensive set of measures. Seen from the point of view of society as a whole, the question can

then be asked of whether it is fair to demand more money from society than strictly necessary for solving the same problems.

For that matter, it would be possible to ensure, in order to relieve the sense of unfairness, that sectors that are not required to take measures would nevertheless bear a part of the costs, for instance by means of levies. As a result of this, the sector that takes the measures would not by definition be the one that bears the costs. However, this is an implementation matter in which political motives clearly play a part. This goes beyond the scope of this manual.

3.18 Cost-effectiveness and transfer

Section 3.7 described how a cost-effectiveness analysis can be performed covering various regions. This showed that, depending on the costs of the measures at the source and the effect of measures taken at the source on the lake situated downstream, it would be cheaper to take measures downstream or, conversely, upstream. In any case, it is unlikely that such an analysis would prove that both regions would have to make equal efforts. However, in the Netherlands, the principle is generally accepted that water managers are not allowed to transfer problems to each other, which means that the regions upstream will have to ensure that the pollution of the water they pass on to the regions downstream remains within reasonable limits. This means that if it would become evident from a cost-effectiveness analysis that it would be cheapest to make less of an effort in the region upstream than in the region downstream, this would not be feasible from a political point of view.

What is politically feasible, on the other hand, is to analyse how every region would be able to solve its own problems and what would be the costs of this. The outcome could subsequently be compared to various scenarios of actions taken upstream. A very relevant question would be, for instance, what would happen if the region upstream would achieve the same emission reductions as us? This means that the influx of substances from the region upstream will decrease. What else would we then have to do to fulfil the objectives? Possibly less. A similar analysis was carried out in the pilot project in Rhine East, of which a summary can be found in Chapter 6.

3.19 Comparative assessment between objectives

A cost-effectiveness analysis will show with which set of measures objectives can be attained at the lowest possible costs. For the cost-effectiveness analysis, the objectives are a given fact. This therefore also means that the objectives must have been defined in order to be able to perform a worthwhile cost-effectiveness analysis.

If a choice has to be made from various objectives, such as reducing the concentrations of copper or constructing fish ladders, the cost-effectiveness analysis will not be able to provide any answers. There are other economic analysis methods available for this, such as, in particular, the cost-benefit analyses and multi-criteria analyses. The latter type is especially practical if several aspects cannot be expressed in terms of money, but their pros and cons must be weighed in various units. For example, the costs expressed in terms of money versus aspects such as qualitative statements about public support, indicator values for environmental quality and qualitative scores on solidarity. Based on the application of these multi-criteria analyses, it would be possible to decide which objectives are to be considered more important than other ones. This method requires the use of weights, which are to be supplied by politicians (see van der Veeren (2002) for an application on nutrient abatement policies in the Rhine basin).

4 Compiling a cost effective package of measures

4.1 Compiling packages

Once it is known which measures are relevant, and once their cost-effectiveness has been estimated, an assessment must be made of which measures could together lead to realising the objectives. This is achieved by compiling packages of measures (step 8 in the schedule of section 2.1). E.g. once it is known what the load target levels should be in kilograms to a discharge point, a package of measures is selected which is considered capable of reducing the load to the required level at least cost. A package of measures is compiled by first including in the package a measure for which the costs per unit of intended effect are the lowest. This is the measure which should have the lowest costs for reducing the load to the discharge point by one kilogram (this is not necessarily also the source for which the costs are the cheapest per kilogram emission reduction to the source; see Chapter 3). It can then be assessed whether the objective might be realised by this cheapest measure. If this is indeed the case, then the package of measures consists of only this one measure (a cost effective package of measures therefore does not necessarily have to include multiple measures). However, if it is not possible to realise the objective, then a measure will have to be considered which ranks second on cost-effectiveness. It can then be assessed whether the objectives can be realised now with a package of measures consisting of a combination of both the cheapest and second cheapest measures. If the answer to this is yes, then the optimum package has been found. If not, then the third scoring measure will also have to be included in the package, etc.

4.2 About the existence of half-measures

It is possible when compiling packages of measures that, in order to achieve a certain objective, it is not necessary to implement a given measure entirely, but rather to employ it only partially. It may be unnecessary in many cases to implement the measures over the whole area and instead, for example, only to apply it to a limited number of hectares, companies, etc. Instead of implementing half-measures, it may be pertinent to apply a measure to a limited number of companies. In this way, half-measures can be taken account of when compiling packages of measures (or broadly

speaking; with measures not fully implemented in the cost-effectiveness package of measures). This approach mainly works for analyses on a larger scale. If an individual farmer faces the decision of having to adapt his cowshed, he is unlikely to benefit from adapting just a quarter of his cowshed in order to realise the objectives. He would simply have to decide whether to adapt the cowshed or not. In such situations, it may be more interesting to choose a measure which may be more expensive per kilogram of reduction, but is easier to sub-divide. Since such problems are less of an issue on a regional level, it may be assumed that just a quarter of cowsheds would need to be adapted (there is more potential for sub-dividing measures on a larger scale).

4.3 1 + 1 is not always 2

There are many measures which do not show any mutual coherence. When such measures are included together in a package of measures, total costs and total effect can be determined simply by adding the costs and effects of the two measures together. For example, in order to determine the costs and effectiveness of a package of measures consisting of agricultural feed alterations and greater purification at STPs, one simply has to consider the sum of both measures. However, measures are often mutually dependent on each other. In that case, it is no longer possible just to add the costs and effectiveness of the individual measures to determine the total costs and effectiveness of the package of measures.

For example, a cattle farmer might feed his cattle less protein to reduce fertilizer nitrogen emissions. Suppose this offers a 50% reduction in nitrogen emissions relative to the current situation. Another measure might be to spread less manure. Suppose this also offers a 50% reduction in nitrogen emissions relative to the current situation. It is obvious that, were both measures to be implemented by the farmer, this will offer a less than 100% reduction in emissions. The effects can apparently not simply be added together, although costs probably can.

By indicating explicitly whether measures might interact, it becomes clear which costs and which effects can be added together and which cannot be added together.

Combinations of measures for which the costs and effects cannot simply be added together, may be included as separate measures. A decision has to be made when compiling packages of measures between individual measures or combinations of measures.

4.4 Information for assessing packages of measures for feasibility and affordability

After the relevant measures have been combined into packages of measures, it is possible that objectives cannot be realised technically, even when all possible and relevant measures have been engaged. This may for example be due to loading of the bed in the past which, due to the long-term consequences of past leaching, prevents comprehensive emissions reductions and standards from being realised. The objectives are then not technically feasible.

As already mentioned, a cost-effectiveness analysis indicates which package of measures can be used to achieve the objectives for the lowest possible costs. However, policymakers may be of the opinion that (even) the costs of the cheapest packages of measures could be too high (disproportional). For example, if – in an extreme situation – an amount greater than the total national budget for the Netherlands would need to be invested to clean up one drainage ditch, then it is pretty unlikely that the government is going to permit this.

Furthermore, implementing the cheapest package of measures may create undesirable side-effects, such as a sharp rise in unemployment, effects on suppliers and/or their customers, etc. The policymaker might decide that this type of side effects are important reasons to deviate from the previously posed objectives.

Technical feasibility and financial affordability therefore constitute reasons for adapting the objectives, by phasing or adapting in austerity (see also Appendix 2).

When describing packages of measures, information required to justify adapting objectives should already be explicitly included. To subsequently evaluate packages of measures on their feasibility and affordability, more information is probably required than just the costs and the contribution of the measure to the realisation of the objective. The inclusion in the cost-effectiveness analysis of demand for information concerning such considerations as feasibility and affordability, offers far better support to policy makers and the appraisal processes they are required to employ. This includes relevant information for discussions regarding:

- Cost-benefits analysis
- Effects on other sectors and total economy
- Employment
- Time

The importance of such considerations is described briefly below. The way in which these considerations will ultimately be dealt with in the Netherlands will be described in other

reports. However, some preliminary work can be carried out by also compiling relevant information during the cost-effectiveness analyses.

An assessment of the possible disproportionality of the costs can be substantiated not only by considering total costs of the package of measures, but also by weighing the potential benefits. If, when analysing the package of measures, it becomes clear that benefits can be expected (whether or not expressed in monetary terms), these can already be indicated. This includes an important interface with the Cost Benefit Analysis (CBA).

To be able to substantiate exceptions (postponement or alteration of the objectives), the consequences of packages of measures on the total economy need to be demonstrated. So besides describing direct effects, attention also needs to be given to indirect effects.⁵

The scope of indirect effects is mainly dependent on scale. The closure of a single pig farm will have little effect on the total economy in a certain sub-basin. This would be a different story if it concerned the removal of all pig farms in the Meuse sub-basin. This could have significant consequences, not only for the pig farmers themselves, but also suppliers and the processing industry may suffer.

Effects on the economy will not only be measured monetary, but may also include changes in employment. The cost-effectiveness analysis may indicate that the cheapest option is to close a certain company, causing the employment opportunities of an entire region to disappear. This is important information, since it may lead to a decision to re-evaluate the package of measures.

Moreover, it will have to become clearer whether objectives that are currently not feasible (technically or financially) may become so when the realisation date of the objectives is postponed. For this reason, the cost-effectiveness analysis should be carried out on various projection years; 2015, 2021 and 2027 (projection years mentioned in the Water Framework Directive). Carrying out analyses on multiple years clarifies whether objectives that may be unaffordable in the short term may in fact be affordable over the longer term (based on phased implementation).

⁵ Direct effects are the effects felt by the sectors implementing the measures; indirect effects are the effects felt by others.

5 Case study 1: Hydromorphological measures in the Meuse

5.1 Introduction

As its subtitle suggests, the report '*Over maatlatten, monitoring en maatregelen; een verkenning naar de ontwikkeling van maatregelenpakketten voor de Kaderrichtlijn Water*' [About points of reference, monitoring and measures; an exploration of the development of packages of measures for the Water Framework Directive (in Dutch)] (Rommelzwaal, 2005) concerns an exploration into the drawing up of packages of measures. This is done for hydromorphological measures in the main channels of the IJssel, the diked Meuse, and the tidal Meuse/dammed Meuse. Moreover, the whole analysis which has to be carried out for the Water Framework Directive was tested, with special attention to problems encountered in such an analysis. The formulation of these learning experiences was the most important goal of this study.

The analyses for the diked Meuse is presented below, together with a few learning experiences. More information is available in the RIZA working document mentioned above (in Dutch).

5.2 General description of the study area

5.2.1 Hydromorphology

The Meuse is a pluvial river, about 935 km in length. The diked Meuse covers the course from the Maas-Waal canal junction (between Cuijk and Grave) to Lith. This section represents the water body defined and typified as R7: slowly flowing river/secondary channel over sand/clay.

The diked Meuse is by nature a strongly meandering river course with a deep summer bed between levee systems. The first part of the diked Meuse flows from Cuijk through the Pleistocene river terraces of the Rhine. Throughout the rest of the river's course it is surrounded by large-scale backland areas, in which Pleistocene river dunes surface here and there. Vertical or horizontal accretion of sandbanks and flood plains occurred on a small scale in the convex bends of the meanders. The breadth-depth ratio, however, was too limited to create banks and islands in the river.



The meanders of the diked Meuse formed in the Middle Ages. In the first half of the 14th century, continuous dikes were constructed on the levees. Since then, the meanders have hardly moved. The raised flood plain lobes were gradually covered and levelled out, due to which few channels and oxbow lakes remain.

The dikes were the first interventions in the river's course. Over the centuries they were followed by levee strengthening, large-scale bend cut-offs and the construction of weirs at Grave and Lith. The weirs are only opened during very high discharges, which means that water-levels hardly vary in this section of the Meuse. The largest water-level variations occur directly downstream of the weir at Grave. The level of the flood plains, which lack summerdikes, is higher than that of the weir, so they only flood in extremely rare circumstances. The high-lying flood plains are therefore exceptionally suitable for farming: they are largely used as pastures and for arable farming. A few brooks discharge into the first section of the river's course. Further downstream, various watercourses discharge their water into the Meuse via pumping stations.

5.2.2 Human impacts

The general description of the diked Meuse in the previous section already gives quite a good picture of the significant degree to which hydromorphology has been influenced by human activity. The weirs have a dominant effect in this. Table 1 sums up both the hydromorphological changes in the system, and the human intervention that has influenced the hydrology or the morphology.

Table 5.1 Hydromorphological impacts on the diked Meuse.

Influence	Effect on hydrology and morphology
Primary dikes	Limited flooded area.
Normalisation (levee strengthening)	Increased flow rate with peak discharges, loss of shallow water zones.
Bend cut-off	Increased flow rate with peak discharges
Weirs	Mainly static water-levels, slow-flowing, interruption of continuity.
Closure of Haringvliet	Interruption of continuity.
Interruption of links with regional waters.	Interruption of continuity.
Accelerated water discharge in river basin.	Higher peak discharges.
Lith hydro-electric power station.	Interruption of continuity.
Shipping	Wave erosion.
Mineral extraction in flood plains.	Creation of pools and pits.
Levelling of flood plains.	Loss of natural relief.
Agrarian exploitation of flood plains.	Loss of natural vegetation.

The river's course has two weirs: Grave and Lith. A fish ladder has been constructed at Lith; a fish ladder is also planned for Grave. A hydro-electric power station is located near the Lith weir.

The influences on hydromorphology are reflected in the ecological quality parameters. The following section describes the degree to which this happens.

Further projects are being planned for this section of river in the coming years. Concerning the Zandmaasproject, this covers the following issues:

- Deepening of the summerbed between Grave and Ravenstein: 3 metres.
- Deepening of the summerbed between Gennep and Grave: 1.5 to 3 metres.
- Water-level scheme in the Grave weir reaches: 50 cm.
- Construction of Keersluis (floodgate) Heumen (mouth of Maas-Waal canal)

There are sand-reclamation works in the Loonse waard. Ecologically-friendly banks will be constructed along the sections destined for deepening, and near the Loonse Waard. Possibilities for the construction of ecologically-

friendly banks at other locations are also being investigated. Conservation projects are planned for various flood plains.

5.3 Risk analysis

The risk analysis relevant for this study consisted of an ecological assessment in which the ecological status of the diked Meuse was evaluated using the three relevant ecological points of reference from the WFD, for fish, aquatic flora and macrofauna. Until now, there were only two reference points for natural waters and none for heavily modified water bodies such as the main channel of the Meuse. For that reason, the reference situation for natural waters was used.

5.3.1 Fish

In the risk analysis, fish stocks in the diked Meuse are recorded in the risk analysis as being "inadequate", though it also indicates that this refers to an estimate. This is because there are few data available for the diked Meuse. The RIVO (The Netherlands Institute for Fisheries Research) has compiled and analysed the available data. This concerns trawl catch data from 1992-1996, supplemented with trap registrations from one location. An electric fishing net has been used to take samples along the banks. Table 2 gives a summary of these data. Due to the limited dataset, it is not possible to make clear distinctions between sub-sections of the river's course. However, the diked Meuse is reasonably homogenous, so there are not expected to be any great differences between the sub-sections of the river's course.

Table 5.2 Score of the diked Meuse on sub-divided points of reference for fish.

Aspect	Score	Assessment
Number of species of diadromous fish	10	good
Number of species of rheophile a/b	20	very good
Number of species of limnophile fish	4	good
Relative abundance of rheophile species	0-4%	poor
Relative abundance of limnophile species	0-1%	poor ¹
Relative abundance of 0+ rheophile	-	-

¹ May be incorrect due to lack of catches along the banks.

The general picture is: there is not much wrong with the variation in the diadrome (migrating), rheophile (favouring fast-flowing currents) and limnophile (favouring waterplants) fish species, but numbers are too low. The picture may therefore be somewhat distorted due to the lack

of catches with an electric net along the river banks. However, since the diked Meuse also mainly has strengthened levees, it is unlikely that catches there would have provided a vastly different picture. It is striking that White Bream numbers are relatively low but those of Bream are quite high. This is probably caused by the weirs in the river's course, since this means the river is static through much of the year. White Bream is a species that thrives in permanently flowing habitats, while Bream prefers stagnant water.

The age make-up has not been calculated since an electronic fishing net was not used.

The lack of suitable habitats is thought to be an important reason for the low density of sensitive species. Furthermore, the weirs also play an important role. For one thing, there is the lack of a suitable bypass facility. The Grave weir still does not have a fish ladder. The Lith weir does have one, but it is not known how effective it is. Moreover, the weirs ensure that the water hardly flows through much of the year and exert a strong influence on water-level dynamics.

5.3.2 Waterplants

The risk analysis indicates that the waterplant situation of the diked Meuse is inadequate. Data are available for two locations, over a chronological number of years. Table 3 gives a summary of the different years. The locations have not been sub-divided since no systematic difference exists between them.

Table 5.3 Scores on waterplants

Year	Abundance	Species-composition	Total
1996	0.00 (poor)	0.00 (poor)	0.00 (poor)
1997	0.00 (poor)	0.00 (poor)	0.00 (poor)
1998	0.27 (inadequate)	0.39 (inadequate)	0.33 (inadequate)
1999	0.31 (inadequate)	0.42 (moderate)	0.37 (inadequate)
2000	0.25 (inadequate)	0.42 (moderate)	0.34 (inadequate)
2002	0.48 (moderate)	0.42 (moderate)	0.45 (moderate)

The table indicates that both abundance and diversity are insufficient. Over the years, there does appear to be evidence of a slight improvement in the situation.

This unfavourable situation is caused by a lack of shallow water, a lack of locations sheltered from the flow, the presence of waves from shipping, the lack of sludgy substrate and unnaturally strong water-level fluctuations as a result of the dikes. Furthermore, the water in the diked Meuse is almost stagnant throughout much of the year. This promotes the development of a few species of waterplants, but does not lead to a rich diversity of species. Another problem is the poor water quality, which encourages algae growth (which in turn restricts the development of waterplants).

5.3.3 Macrofauna

The risk analysis describes the macrofauna situation of the diked Meuse as inadequate. Table 4 gives a summary of samples from a slightly longer section of the Meuse's course (but which is included in its entirety in type R7). Not only are the numbers of dominant positive and typical species low, but there is also some evidence of high densities of dominant negative species. The reasons for this are the lack of shallow water, the limited presence of vegetation and wood, little variation in the composition of the bed and the waves from shipping. In addition, few fish that prefer fast-flowing currents can be found in the weir reaches.

Table 5.4 Score of the diked Meuse on macrofauna.

Year	Number of samples	Score dominant negative species	Score typical species	Score dominant positive & typical species	Total score
1996	3	0.1	0.1	0.1	0.3 (poor)
1997	3	0.1	0.2	0.2	0.5 (inadequate)
1998	4	0.2	0.2	0.1	0.5 (inadequate)
2000	8	0.1	0.2	0.2	0.5 (inadequate)
2001	4	0	0.1	0.2	0.3 (poor)

5.4 In pursuit of optimum packages of measures

5.4.1 Method

The starting point for the pursuit of optimum packages of measures are the results of the risk analysis presented above. This risk analysis includes information concerning potential loads, the development of these loads up to 2015 (the projection year for the EU WFD), and the expected water status in 2015. Since it is not only the expected situation that is described, but also the objectives for the various water bodies, the problems that require relevant measures are also known. In this way, the risk analysis offers information about the causal parties. Consideration of which measures might be applied to these causal parties (at least theoretically) then creates a long list of theoretically potential measures. This list can then be shortened using regional knowledge to arrive at a shorter list of practically potential measures⁶. These measures can then be combined into a package of measures.

The method employed can be summarized in a number of steps, where each step removes a number of possible measures:

1. Problem field
2. Load source
3. Deficient policy
4. Type of measure
5. Theoretically possible individual measure
6. Practically possible individual measure
7. Ranking of cost effective measures
8. Assessment and compilation of packages of measures

After the problem has been identified, the theoretically possible measures can be determined using measures schedules. These measures schedules can help to logically reduce the number of measures being considered by leaving out irrelevant measures. In this way, the measures sheets help to focus on the measures that are relevant for the problem at hand.

The steps mentioned above are further elaborated below for the current case study.

Step 1: Identification of the problem field

What is the problem field? As described earlier, a distinction is made in the problem fields between different types of

⁶ Theoretically, removing groynes is one way to stimulate better flow, but if an area has no groynes, then it is not a practical measure.

emissions (pollution) and different types of hydromorphological changes.

- Point sources
- Diffuse sources
- Water abstractions
- Regulation of flow through
- Hydromorphological changes

As a result of this first step, the measures which have anything to do with point sources, diffuse sources or water abstractions are excluded.

Step 2: Emission source

This concerns the question who is responsible for regulation of flow through and hydromorphological changes. A distinction is made between different types of point sources and diffuse sources.

- Municipalities/households
- Industry
- Agriculture
- Other sources

The causal parties of the problems currently under consideration do not include municipalities/households, industry or agriculture. Other sources are the causal parties.

Step 3: Deficient policy

What is the deficient policy which must now be considered? In other words, what is the problem? The options are:

- Abundance of fish
- Diversity of fish
- Abundance of waterplants
- Diversity of waterplants
- Abundance of macrofauna
- Diversity of macrofauna

It appears that all parameters are relevant. Only the diversity of fish scores high enough not to be considered a problem.

Step 4: Identification of type of measures

The above-mentioned specified combination of problem field (regulation of flow through and hydromorphological changes), sources (other sources) and the policy deficiencies described above result in the following types of theoretically possible measures:

- Improvement of possibilities for the migration of fish

- Improvement of habitats along the banks
- Restoration of water flow

The basic assumption here is that dikes, normalisation and the current management of the weirs belong to the heavily modified character of the diked Meuse and that shipping remains a user function.

Table 5.5 Outline of the types of measures that can improve the ecological status of the diked Meuse. An x indicates where a positive effect can be expected.

	fish	waterplants	macrofauna
Improving fish migration possibilities	x		
Improving habitats along the banks	x	x	x
Restoration of water flow	x	x	x

Step 5: Identification of theoretically possible measures

As far as the diked Meuse is concerned, the restoration of fish migration possibilities can be realised by means of the construction and improvement of fish passages adjacent to the weirs, and reduction of the damaging effects of the hydro-electric power station at Lith. Also, better migration possibilities are important between the Meuse and the regional waters that feed it.

Restoration of a natural flood pattern in the flood plains, a measure which might prove very suitable for application in the IJssel, seems less suitable in this case since there are no summer dikes. The high levels of the areas outside the dikes, however, mean that flooding only occurs with peak discharges.

Improvement of the habitats along the banks does not just concern restoration of the bank itself.⁷ Due to its generally very low flow rates, the diked Meuse offers the potential for developing bank areas in the main channel itself. Moreover, connected pools and oxbow lakes also offer various possibilities. Due to the function of the weirs, there is little potential for jointly flowing secondary channels (except for a special variant near the weirs).

⁷ Habitats along the banks concerns natural banks, with a variety of slowly flowing water and nearly stagnant water, between sandy and silty beds, between bare and plantless area, with locally occurring dead wood. Furthermore, waterplant fields are also included.

In the diked Meuse, the lack of permanently flowing water leads to the limited presence of organisms which favour a stronger current. Measures to restore permanently flowing water would advance the recovery of these organisms. The possibilities here are limited, assuming that the weirs retain their current function (i.e. shipping purposes). Banks with protective revetments might, to a certain extent, create a flowing character directly downstream of the Grave weir. There are also possibilities for using the water-level difference over the weirs by constructing a jointly flowing secondary channel that begins above the weir and rejoins the river downstream of the weir.

Table 6 gives an overview of the actually potential measures in the diked Meuse. This summary is partly based on the analysis from the ecological evaluation, and partly based on the overview of hydromorphological intervention that has taken place in the Meuse. The table demonstrates the effects of the measures according to expert judgement.

Many comments can be given on such a summary of measures. Much depends on the specific circumstances at the location itself, the way in which a given measure is implemented and to what degree measures are combined. The proposed flood prevention projects for this section of the river will also have an effect on its ecology. The ecologically-friendly river banks should be seen as projects aimed specifically at complying with the WFD targets: they will certainly have a significant impact. Conservation projects in the flood plains can be of particular use when constructing new waters which adjoin the river. Though deepening of the summer bed and a water-level scheme can be expected to have a negative effect, this may, however, be compensated by implementing the proposed ecologically-friendly river banks (when they are wide enough).

Step 6: Identification of practically possible measures

For this study it was assumed that the dikes, normalisation, dams and shipping will remain and that the stagnant character of this river is the irreparable consequence of all the significant changes implemented in the past. This means that the only measure aimed at *restoring the water flow* is not given priority, and the measure *flowing channel beside the weir* can be excluded from subsequent analyses. As far as the measures aimed at *improvement of fish migration possibilities* is concerned, 'Optimisation of fish ladder/fish bypasses' and 'Disengage hydro-electric power station during peak downstream migration' appear to be the most relevant from a practical point of view.

As regards measures to *improve river-bank habitats*, 'Ecologically-friendly river banks with protective revetments', 'Connected oxbows/pools (recently dug)' and 'connected oxbows/pools (linking isolated waters)' are practically the most relevant. For this reason, these measures are considered in greater detail.

Table 5.6: Summary of possible measures to improve the ecological status of the diked Meuse and the anticipated effects (+++ = significant positive effect, 0= no effect, --- = significant negative effect)

	Fish	Waterplants	Macro-fauna
<i>Improving fish migration possibilities</i>			
Optimisation of fish ladders/fish bypasses	++		
Disengage hydro-electric power station during peak downstream migration	+		
Fish-friendly lock management at weirs	+	0	0
Leaving Haringvliet ajar	+	0	0
Fish ladders/crossings to regional waters	+	0	0
<i>Improving habitats along the banks</i>			
Removal of levee reinforcement	+	+	++
Ecologically friendly banks with protective revetments	++	++	++
Connected oxbows/pools (recently dug)	++	++	++
Connected oxbows/pools (linking isolated water)	+	0	+
Expansion of river-bank vegetation management	+	0	++
Introduction of dead wood in water	0/+	0	++
Regulation of shipping (speed, bulk)	0/+	+	+
<i>Restoration of water flow</i>			
Flowing channel along weir	++	0	++

Step 7: Ranking of cost effective measures

Table 7 gives a total overview with a rough estimate of the costs per measure. An important basic assumption in relation to this is that a standard length of 3 kilometres has been supposed. The estimates are made to enable the cost-effectiveness analyses to be carried out, and to clarify which issues and problems might arise. However, the data are insufficient to actually apply the results of the analyses in practice.

A number of problems arise when carrying out the analyses:

- The effectiveness of the measures is only indicated qualitatively (with plus and minus signs).
- One plus does not necessarily equate to another. For instance, wood in the water has positive effects for a

totally different group of macrofauna than the recovery of the water flow in the Meuse.

- Far from all the measures can be employed at every location.
- Certain measures are best implemented in combination with others.
- Measures are not very interchangeable.

To be able to employ the selected measures further, certain suppositions have to be made, which creates great uncertainties. The analysis is therefore no more than an illustration of the type of results that are possible when further, more detailed information becomes available.

The following suppositions have been made:

- Measures mentioned per water body within the category 'recovery of river-bank habitats' are interchangeable.
- The effectiveness of these measures varies. It has been assumed that 1 km unreinforced levee would have the same effect as 750 metres ecologically-friendly river banks or 500 m in-line dams (all these measures apply to one side of the river only). For the same effect, a channel or oxbow of 250 m would be required.
- To achieve a good ecological status, it is necessary that (one bank of) the river has either 100% non-reinforced levees, or 75% ecologically-friendly river-banks, or 50% in-line dams, or 25% secondary channels/oxbows. A combination of these measures is of course also possible.
- It has been assumed that half the issues described in section 3 are already present or will be realised in the framework of other projects (for example, the *Room for the River* programme, or improvements relating to shipping). So only half need to be constructed for the benefit of the WFD.
- Finally, it has been assumed that flood plains need to be lowered in 25% of the flood plain area to arrive at a good ecological status.

It has been assumed that in-line dams will always be combined with non-reinforced banks, and that non-reinforced banks, ecologically-friendly banks, lowering of flood plains, secondary channels and oxbows are always combined with extensive river-bank vegetation management. Finally, due to the significant uncertainties relating to the costs of management and maintenance, only the costs of construction have been included in the considerations.

Ecologically targeted measures	effect on point of reference				Costs (Cash Value in EUR 1000)			Comments / Negative consequences
	fish	waterplants	macro fauna	Bird and Habitat directive	Investments	Management and maintenance	Total	
Cut through/remove summer dike	+	-	+	o	160	0	160	Possibly at the cost of low-dynamic ecotopes in the flood plain: selective application
Lowering of flood plains	++	+	++	+	5,160	0	5,160	Score in combination with cutting through summer dikes and design with water and gradual land-water transition, assuming that no valuable ecotopes are lost.
Removal of levee reinforcement	+	+	++	+	60	0	60	Danger of significant erosion.
Ecologically-friendly banks with protective revetments	++	++	++	o	600-900	50	650 - 950	Cost depends on size; large waters cost more than small waters
Jointly flowing secondary channel: recently dug	+++	+	++	+	60,000	1,000	61,000	
Jointly flowing secondary channel: existing isolated water linked	++	-	+	o	24,000	1,000	25,000	
Channel along weir	++	o	++	n/a	24,000	0	24,000	Sections of permanent flowing water in almost stagnant system
Connected oxbow/pool: recently dug	++	++	++	o	40,000	0	45,000	
Connected oxbow/pool: existing isolated water linked	+	-	+	-	18,000	0	18,000	
Widening of summer bed	+	+	+	+	1,500	0	1,500	When the space created is used for ecological river-bank layouts
In-line dams	++	+	++	+	6,000	0	6,000	When combined with ecological river-bank layouts
Expand river-bank vegetation management	+	o	++	o	360	0	360	In combination with ecological river-banks
Introduce wood into the river	o/+	o	++	o	10	0	10	Good score does not concern all macrofauna, but specific species. Not for application in main channel.
Regulation of shipping (speed/bulk)	o/+	+	+	+	pm	0	Pm	In combination with ecological river-bank layouts.
Disengage hydro-electric power stations during downstream peak migration of fish	+	o	o	n/a	21,000	0	21,000	
Improve fish ladders/fish bypasses	++	o	o	n/a	15,000	0	15,000	
Fish-friendly lock management	+	o	o	o	0	0	0	At weirs and sea-defence dams.
improve link to regional waters	++	o	o	o/+	2,000	0	2,000	

Ranking of various measures on the basis of cost-effectiveness only becomes interesting when different measures need to be weighed against each other to determine which are potentially useful for inclusion in the package of measures.

An assessment is not required for measures designed to improve fish migration possibilities since they are only effective when all the relevant measures have been employed. The analysis is mainly intended to determine total costs (important for the discussion about the feasibility and affordability of packages of measures).

The costs for improving the two fish ladders already installed are estimated to be €15 million each, i.e. €30 million in total. The costs for temporarily disengaging the hydro-electric power station at Lith (during peaks downstream fish migration) are not known.

There are two possible alternatives for improving the river-bank habitats. The construction of ecologically-friendly river banks and oxbows.

- It costs € 63,000 – 990,000 per 3 km to construct ecologically-friendly river banks. The costs of extensive vegetation management must be added to this (€ 7.2 million per 3 km). A section of 13.5 km (required 75% of 36 km, of which half is planned or already exists) brings the total costs to €32.7 – €36.8 million.
- Oxbows are required over 9 km. Assuming that €50 of the required river-bank layout is planned or has already been constructed, 4.5 km of oxbows is still to be created. And assuming that half of these are new structures and the other half are to be realised by linking existing waters, the average costs amount €18.5 million per 3 km section. The total costs for construction therefore amount to €27.8 million. A further €10.8 million must be added to this for the expansion of vegetation management, which brings the total costs to €38.6 million.

Construction of oxbows appears to be slightly less cost effective than the construction of ecologically-friendly river banks.

Step 8: Compiling a package of measures

The package of measures is compiled by assuming that all fish migration measures have been employed, and that it has been decided to employ ecologically-friendly river banks

when restoring the river-bank habitats, but that it is accepted that nothing is done to improve water flow.

For this package of measures, the total costs for realising the ecological targets amounts to around €100 million (assuming the targets for ecological waters).

5.5 Some learning experiences

This project was designed to gather learning experiences of different aspects of the WFD analyses. A summary of this regarding the cost-effectiveness analysis is included below.

- To be able to carry out a CEA, it must be clear on what scale measures should be implemented: The current analyses include a number of assumptions. For instance, it has been assumed that 1 kilometre of non-reinforced bank has the same effect as 750 metres of ecologically-friendly river bank, 500 metre in-line dams, or a 250 metre long secondary channel. The degree to which these assumptions are realistic is debatable.
- The effects of measures can only be estimated qualitatively (based on expert judgement). This makes it difficult to compare measures on their effectiveness. Moreover, "one plus is not necessarily the same as another". Positive effects can differ strongly in character for each measure. Moreover, it is also not clear whether (and ultimately how) effects can be added.
- The qualitative estimation of what effects measures might have sometimes seems more like the identification of opportunities and threats than the evaluation of effects which will definitely occur at a certain point in time. However, the latter of these is required in the framework of the WFD costs effectiveness analysis. But nature only allows itself to be controlled to a limited degree, and the desired effects can sometimes arise in a distant future.
- The costs of measures are often very much location specific. Such costs are especially influenced by land prices, the presence of buildings and the possible necessity for purifying polluted soil.
- Furthermore, the fact that on the one hand far from all measures are applicable in practice (which limits the number of options), and that on the other hand measures can be mutually reinforcing or excluding, also plays a role. So, in reality, the CEA is far more concerned with searching for various possibilities, baring in mind information regarding costs and

effectiveness, than it is concerned with simply determining those measures that will achieve objectives in time at least costs possible.

5.6 Conclusion

There is a great need for both ecologists and economists who dare to make rough estimates concerning the potential costs and effects of measures. Only then can an initial estimate be made of possibly interesting measures and packages of measures. If we leave the analysis of possible packages of measures until all details are known, the objectives will never be realised in time.

6 Case study 2: Reducing emissions in the East Rhine sub-basin

6.1 Introduction

In the report entitled "Kosteneffectiviteitanalyse Kaderrichtlijn Water Deelstroomgebied Rijn-Oost; Koploperproject" (*Water Framework Directive cost-effectiveness analysis in the East Rhine Sub-basin; Trendsetter Project* (Morselt et al. (2005)), in Dutch), the method described in this manual was tested in a casestudy on emissions of five substances in the East Rhine Sub-basin.⁸ The substances total-N, total-P, Cu, Zn and Ni were chosen, since these are the substances that are regionally expected to create most of the problems in the attempt to realise the objectives of the Water Framework Directive, as indicated in the Article 5 report for this sub basin.

The purpose of this project was primarily to gain experience with the method and, also, to find out to what extent currently available information would be sufficient to carry out such an analysis. In other words, this project was aimed at identifying gaps in method and knowledge.

The various steps of the cost-effectiveness analysis were carried out in this project, from the description of the current situation, a forecast for the future situation, a risk analysis (= comparison between the expected situation and the objectives for the various regions), the search for possibly relevant measures, up to and including the prioritisation of measures and the composition of packages of measures, including an estimate of the total costs of these packages. In addition to this, the project included a qualitative description of the possible instruments that could be used for the implementation of the measures, with a brief description of the possible apportionment of costs that would be related to this.

The analysis was carried out for situations with and without transfer. The situation without transfer refers to the situation in which every region attempts to attain the objectives defined for the region concerned by implementing only those measures that can be taken within the region

⁸ This project, also known under the name of *Koploper Rijn Oost*, was carried out by Teun Morselt and Rutger te Grotenhuis of the RebelGroup and Ton Schomaker of Royal Haskoning under the authority of RIZA.

concerned. The discharges from regions situated upstream are considered to remain constant at their current levels. The alternative analysis – which takes account of transfer – is based on the assumption that the regions situated upstream also have to attain objectives. By initially considering whether and how the regions situated upstream would be able to attain their objectives, the discharge into the region situated downstream will decrease, as a result of which the region downstream will have to make less of an effort to attain the objectives defined for that region. These two analysis variants can be typified as ‘every region for itself’ (without transfer) or, conversely, ‘interaction’ (with transfer). Because the situation without transfer does not take account of the fact that emissions will also be reduced in the other regions, downstream water quality will ultimately improve more than is needed to attain the objectives. This means, at the same time, that the costs will be higher than strictly necessary in order to fulfil the objectives.

6.2 General description of the East Rhine Sub-basin

The East Rhine Sub-basin covers an area of about 6,773 km², and comprises the two basins of Vecht-Zwarte Water and Achterhoek-Liemers. This region has a population of over 1.9 million, with concentrations in the bigger towns such as Zwolle and Deventer and the towns in Twente (Enschede, Hengelo and Almelo). Part of Arnhem also forms part of the East Rhine Sub-basin. The most important form of land use in this sub-basin is farming, with land-related cattle farming as the most important subsector. In addition to this, the region comprises nature reserves, such as the Wieden and the Weerribben, the land of the Dinkel, the shorelands along the Zwartewater, the floodplains along the IJssel and the brooks in the Achterhoek.

In terms of landscape, a few large units can be distinguished in the East-Rhine region. To the north of the Vecht, there is the low-level fenland area in the north of Overijssel as well as the slightly hilly cover sand areas in the south of Drenthe, intersected by brooks such as the Vledder and Wapserveense Aa. To the south of the Vecht, we find Salland and Twente: the eastern sands to the east of the fluvial clay of the Gelderse IJssel and the Oude IJssel are characterised by a sharply fractured relief with, at short distances, considerable differences in altitude, soil types and water management.

The eastern sandy area (Salland and Twente) drains in a northwesterly direction into the IJssel. Only the area around Almelo and Tubbergen drains in a northerly direction, flowing out via the Regge and the Dinkel into the Vecht. Further down to the south are the Achterhoek and the Liemers. The Achterhoek consists primarily of sands. The brooks contribute substantially to the ecological value of the scenery here, especially around Winterswijk. The Liemers is mainly a clay area. The eastern part turns into a sandy area with concentrations of intensive cattle farming and the Montferland nature reserve.

To the west, the East Rhine area is bordered by the IJssel. The boundary runs along its left bank. This means that the river and its floodplains still form part of the East Rhine sub-basin.

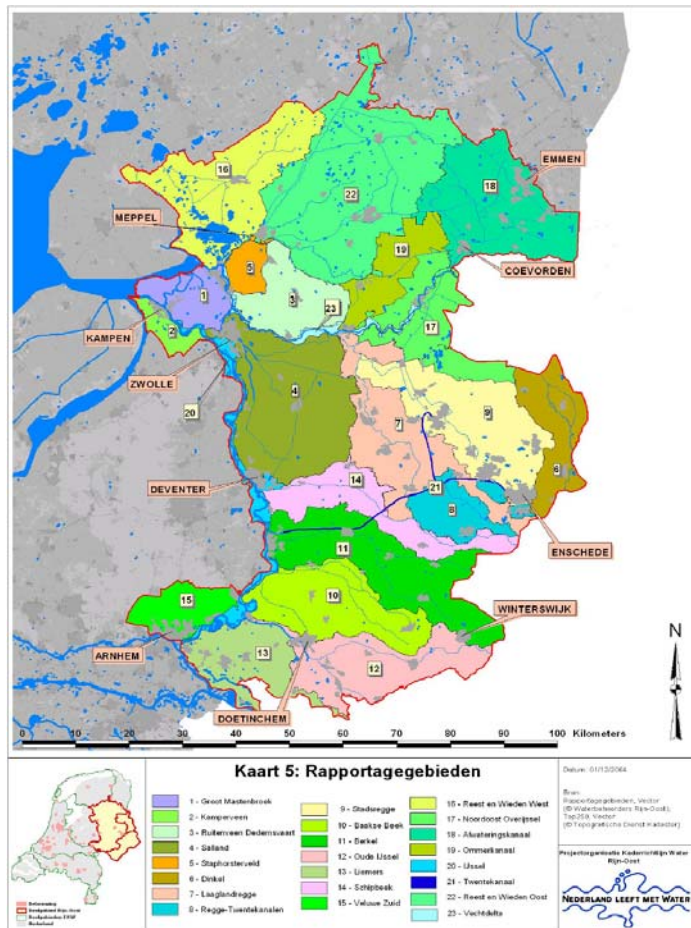


Figure 6.1. Simplified map of the East Rhine sub-basin with its 23 reporting areas (Source: Arcadis (2004): Water Framework Directive, Background Document Characterisation of East Rhine Sub-basin)

The East Rhine Sub-basin has been divided into 23 reporting units for the purpose of the analyses (see Figure 6.1).

6.3 The various steps of the analysis

In this project, the following steps were carried out:

1. Description of the current situation in each region and identification of water quality objectives.
2. Description and quantification of autonomous developments and prevailing policies, converted, at the same time, into water pressures up to and including 2015.
3. Risk analysis; comparison between the expected situation in 2015 and the objectives for each region.
4. Identification of potential measures.
5. Estimate of effects and effectiveness of measures.
6. Estimate of direct and indirect costs of measures.
7. Performance of the cost-effectiveness analysis, including analysis of consequences of the use of possible instruments.
8. Uncertainty analysis based on (1) 'baseline scenario' and (2) the estimate of costs and effects of possible measures.

Step 1 Description of the current situation for each region

The outcome of step 1 was a quantitative description of the reporting areas, consisting of a summary of the current emission sources and their burdening of the surface waters as well as substance balances for all water bodies for N, P, Cu, Ni and Zn. The Stradif model, developed by and for the region, was used for this. Finally, the description of the current situation comprised a summary of the existing emission-reducing measures.

Sources	Nitrogen		Phosphorous		Copper		Nickel		Zinc
	(ton/year)	(%)	(ton/year)	(%)	(kg/year)	(%)	(kg/ year)	(%)	(kg/ year)
Sewage treatment	3.902	7%	501	50%	2.554	25%	1.779	16%	23.731
Industry	35	0%	5	1%	223	2%	17	0%	197
Diffuse sources	13.066	23%	216	22%	2.680	26%	1.372	12%	28.765
Import from Germany	40.727	71%	272	27%	4.903	47%	7.944	71%	27.310
Total	57.730	100%	993	100%	10.360	100%	11.112	100%	80.004

Table 6.1 Summary of the share of the most important loads of the East Rhine sub-basin in 2000 (Arcadis (2004); Water Framework Directive, Background document Characterisation of East Rhine Sub-basin).

Step2 Description and quantification of autonomous developments and prevailing policies

In step 2, a description was given of the autonomous developments and prevailing policies in the East Rhine sub-basin and the regions covered by this region. Items that were analysed were e.g. the demographic developments and the use of space, the socio-economic developments and a brief description of the prevailing policies. The information used came predominantly from the 2004 report on the East Rhine (including Table 6.2).⁹

Table 6.2 Expected autonomous socio-economic developments in the East Rhine until 2015.

River basin Rhine East	Unit ¹	Present situation	Autonomous trends
		Absolute value in 2002	Index 2015 (2002=100)
Production volume economic sectors			
<i>Agriculture</i>			
Arable farming	Nge	53.377	93
Green houses	Nge	70.579	161
Horticulture	Nge	42.979	291
Animal husbandry	Nge	740.661	83
Intensive livestock	Nge	166.501	84
Combination farms	Nge	108.644	66
<i>Fisheries</i>			
Fisheries	Mln Euro	1	70
<i>Mining</i>			
Mining	Mln Euro	741	117
<i>Manufacturing</i>			
Food and processing industry	Mln Euro	6.588	93
Chemical industry	Mln Euro	3.339	80
Metal industry	Mln Euro	5.052	96
Energy- and watercompanies	Mln Euro	2.439	117
<i>Services</i>			
Envrironmental services	Mln Euro	877	157
Transport over water and through air	Mln Euro	94	146

¹ Nge is an economic dimension used in Agricultural measurements, and stands for Nederlandse grootte-eenheden (Dutch size units). These are units of gross standard

⁹ For the agricultural sector, however, the information used came from the LEI (Agricultural Economic Institute). This deviated on various points from the information in the article 5 report. Since the detailed level of the information from the LEI better reflected the wish to make information available at the level of individual regions rather than regionalised national data, it was decided to use the information from the LEI.

balance (total yield expressed monetary minus certain related specific costs) which are corrected for the price development of the balance in the Netherlands.

Finally, a forecast was made for the effects of the autonomous developments and prevailing policies on the water status in 2015. However, because the forecast was based on results of Stradif (which assumes a 5% growth for all sectors), it was not possible to include these figures for autonomous developments.

Table 6.3 gives an estimate of the measures that are (or will be) taken under current policies. These will not be included as part of the packages of measures.

Table 6.3: Specific emission sources and current emission-reducing measures for the five substances under review in the East Rhine Sub-basin.

Emission sector	Emission source	Current measure
Sewage treatment plants (STPs)	STP	3 purification steps (suspended solids, CZV BZV, N and P)
	Overflows	Storage/settling basin, basic effort (50% reduction in waste disposal)
	Rainwater drain	Local treatment whether or not with disconnection ¹
Households	Rural residential development	Individual treatment of waste water (ITWW) ¹
	Corrosion of steel constructions	Replacement, coating
	Fireworks	None
Residential housing	Corrosion of dwellings	Replacement, coating ¹
	Corr. roofs in commercial and industrial buildings	Replacement, coating ¹
Industry	Industrial point dischargers	Permits more stringent
Traffic	Leakage of engine oil	Oil separation facilities (carparks)
	Wear of road surface	Improvement of road surface, treatment of road run-off water
	Wear of tyres	Treatment of road run-off water
	Railway tracks	Replacement of wooden sleepers by concrete ones ¹
Shipping	Motorised recreation and commercial shipping	Collection and removal of bilge water
	Anti-fouling recreation and commercial shipping	Replacement of anti-fouling facilities ¹
Agriculture	Flushing	Buffer strips, active boundary management
	Fertilisation	Buffer strips, active boundary management
	Greenhouse horticulture flushing	Optimising fertiliser usage
	Rural flushing	Reduction of phosphate levels in cattle feed, removal of fertilisers, more accurate fertilisation
Other	Atmospheric deposition	Cleaning up largest sources of emissions to the atmosphere
	Corrosion in other applications	Replacement, coating
	Other sources	Various

¹ Measures still in the starting phase

Step 3 Risk analysis

Because the final EU WFD standards for the various substances were not yet available (at the time when the analyses were performed), the risk analysis, which was carried out in step 3, was based on MPR values¹⁰. In the risk analysis, the scope of the quantities of substances to be reduced in each sample was defined by comparing the maximum permissible load, given a certain objective, with the expected loads. It became evident that autonomous developments and current policies would only have a moderately positive effect on internal loads of the five substances. Moreover, it became clear that the good chemical status in 2015 is not expected to be attainable in about half of the reporting areas without supplementary measures (see also Table 6.4).

Table 6.4 shows that the emission reductions, necessary to meet the MPR standards (as provisional WFD objectives) for a good chemical status in 2015, may differ considerably from substance to substance and from one reporting area to another:¹¹

- The total-N load will have to be reduced sharply in particular in the Laaglandregge, Stadsregge, Berkel, Oude IJssel, and Reest and Wieden Oost, whereas the load of Groot Mastenbroek, Kamperveen, Staphorsterveld, Zuid Veluwe, IJssel and Twenthekanalen will already be in compliance with the standards in 2015 if current policies are continued.
- The total-P load will have to be reduced in particular in the regions of the Laaglandregge and Stadsregge. In 16 of the 23 regions, total-P load will already be below the MPR norm in 2015 as a result of present policies.
- In order to meet the MPR norm for copper in 2015, it will be necessary to reduce loads, especially in the regions Regge-Twenthekanalen, Stadsregge and Reest and Wieden Oost. In 11 regions, the copper load will need to be reduced to a lesser degree. The other nine regions would already meet MPR norms in 2015, as a result of current policies.

¹⁰ MPR = Maximum Permissible Risk. These are water quality objectives according to Dutch environmental policies

¹¹ For a detailed description of the emission reductions to be realised in each reporting area, reference is made to the report entitled "Characterisation of the East Rhine sub-basin" (Arcadis, 2004). Water Framework Directive, Characterisation of the East Rhine sub-basin (Main report).

Table 6.4: Assessment of the water quality in the reporting areas in 2000 according to NW4 (Source: Arcadis (2004). Water Framework Directive, Background Document Characterisation of East Rhine Sub-basin; De Straat Milieuadviseurs (2004). The water quality in the Vecht/Zwarte Water river basin. Final report).

Water system	Code measurement location (blue node)	Total nitrogen	Total phosphate	Copper	Nickel	Zinc
		(mg/l)	(mg/l)	(µ/l)	(µ/l)	(µ/l)
	MPR	2.2 ¹	0.15 ¹	3.8	6.3	40
1 Groot Mastenbroek	Target value (NR)	1.0 ¹	0.05 ¹	1.1	4.1	12
	qvl79	2.0	0.11	1.60	1.9	17
	qbw99	1.6	0.11	5.00	6.9	24
	qht99	3.3	0.17	2.80	1.1	29
2 Kamperveen	obr00	2.1	0.32	11.66	4.2	111
3 Ruiten Dedemsvaart	kdv08	3.0	0.16	4.20	3.9	24
4 Salland	uzw01	2.7	0.23	3.30	3.5	21
	mw86	2.4	0.16	6.40	3.4	29
5 Staphorsterveld	ikl62	2.2	0.12	1.70	1.1	18
	iks98	2.6	0.14	1.70	1.7	15
6 Dinkel	30.001	6.1	0.19	6.40	5.7	31
	33.001	6.0	0.17	6.00	11.0	33
7 Laaglandregge	01.500	5.5	0.52	12.30	11.6	87
	01.002	3.5	0.15			
8 Regge Twenthekanalen	20.01Hagmolenbeek	7.5	0.13	10.67	12.6	53
	20.012Usselerstroom	2.7	0.11	8.15	13.0	99
9 Stadsregge	07.500	5.5	0.46	7.90	10.2	57
10 Baakse Beek	BAB03	2.6	0.11	4.83	6.8	10
	GRB02	2.5	0.06	3.33	4.6	10
11 Berkel	BER04	6.2	0.15	5.83	7.5	29
12 Oude IJssel	OIJ03	5.5	0.12	6.67	7.9	40
13 Liemers	ODR01	1.5	0.14	1.67	4.6	10
	ZWA01	1.0	0.07	2.50	4.6	15
	DIW02	4.5	0.13	3.25	4.6	10
14 Schipbeek	SBK90	4.1	0.09	6.63	8.5	31
15 South Veluwe	ROB01	1.5	0.06	4.17	4.6	15
16 Reest and West Wieden	3ETTK9RO	1.5	0.10	2.60	1.7	12
	4KSTE1RO	2.2	0.20	5.90	3.0	24
	1WAPA6RO	1.3	0.13	5.80	4.4	26
17 North-east Overijssel	okah05	4.1	0.12	7.00	8.7	34
	05.001	3.5	0.23	11.50	11.6	95
	irwb65	3.4	0.12	5.30	13.4	28
	hmgh86	3.1	0.24	3.70	9.3	30
18 Drainage canal	gkcv99	3.0	0.17	5.60	5.6	27
	gafk55	2.8	0.21	7.50	4.6	70

19	koko92	3.1	0.23	10.00	6.0	46
Ommerkanaal						
20 IJssel	KAMPEN	2.7	0.13	5.97	2.9	29
21 Twenthekanalen	EEFDE	4.4	0.17	7.29	7.3	33
	WIENE	5.5	0.09	9.18	9.0	40
	ENSCHEDE	2.8	0.26	11.36	8.3	38
22 Reest and East Wieden	2MEPD4RO	2.0	0.16	3.70	3.7	18
23 Vechtdelta	mvec00	3.5	0.14	5.70	6.8	41
	lve92	4.6	0.17	8.00	7.1	54
	lve85	4.9	0.18	5.00	6.3	32
	GENMDN	3.6	0.18	4.30	4.3	21

Legend

1) Summer average value for eutrophication-sensitive, stagnant waters

	\leq target value (NR) = CIW class 1
	target value - \leq MPR = CIW class 2
	MPR - \leq 2 x MPR = CIW class 3
	2 x MPR - \leq 5 x MPR = CIW class 4
	$>$ 5 x MPR = CIW class 5
	no data known

-
- A reduction in the nickel load will need to be achieved especially in the regions of Regge-Twenthekanalen, Stadsregge and Berkel.¹² As a result of present policies, 16 regions will already meet the MPR norm for nickel in 2015.
 - The zinc load will have to be reduced substantially, in the regions Laaglandregge, Regge-Twenthekanalen and Stadsregge.

Steps 4, 5 and 6 Identification of potential measures including costs and effects

Steps 4, 5 and 6 resulted in an extensive summary of potential measures (more than 50 in total), including both farming measures (information coming from the LEI) and measures in other sectors (information coming from previous studies carried out by RIZA). The effects were estimated for each measure, as well as the direct and indirect costs. The direct costs were calculated on the basis of information relating to the annual operation and maintenance costs as well as investment costs (calculated on the basis of investments, economic life expectancy (depreciation period) and interest). It was possible to represent the information about the direct costs largely quantitatively, whereas the indirect costs were sometimes known quantitatively but most often qualitatively. To maintain the option of comparing details with each other, it was decided to classify the information about indirect effects into a qualitative scale: 0, +, ++, +++.

The calculation of costs was based on the total annual costs. These consist of the annual costs for operation and maintenance and the investment costs, converted into annual costs.

The costs were converted from costs per hectare into costs per sub-basin region by multiplying the costs per hectare by the number of hectares (per causer category or emission source). However, it was not known for all sources how large the share of a certain type was exactly. For this reason, a 'specification factor' was introduced. This factor takes account of the fact that arable farming may well be considered farming, but not all farming is arable farming.

¹² The exceedingly high nickel load in Berkel is caused by the extremely high negative closing entry in the nickel balance. The negative balancing entries have been attributed for all substances and regions to the internal loads of the water bodies in that region. The Rijn & IJssel Water Board has assigned the high negative balancing entry for Berkel as a "new" source attributable to delayed discharge from the soil as a result of pyrite oxidation.

The cost-effectiveness of each measure was calculated as costs divided by effects, as described in the other chapters of this manual:

$$\text{Cost-effectiveness} = \frac{\text{Total annual costs}}{\text{Kg of substance reduced per year}}$$

By determining this for each measure, it is possible to prioritise measures according to their costs per reduced ton of substances in each water body.

Step 7 Performance of the cost-effectiveness analysis

In step 7, the ultimate cost-effectiveness analysis was carried out for two situations: with transfer and without transfer. The following definitions were used in the analysis:

Without transfer:

Each region attempts to meet its own objectives. Especially for regions in which a large share of the total load comes from upstream it is extremely difficult to attain the objectives. On balance, these regions will be reducing more than required to attain the objectives downstream.

With transfer:

This calculation is based on the assumption that the upstream region meets the standards prevailing there. This means that the influx of substances from regions situated upstream is less than it is now and the attempts to achieve reductions in the downstream region can be relaxed. The objectives downstream are realised exactly.

In most regions, various substances have to be reduced simultaneously. The general approach taken here is:

1. The substance for which the required emission reduction is the highest is dealt with first (in kg/year).
2. For this substance, the costs per effect are analysed (kilograms of emission reduction per year).
3. The measures with the lowest costs per effect are accumulated, until the required emission reduction objective for the substance involved is attained.
4. Then it was determined how much of the other substances is being reduced "in the process" through the implementation of the selected measures.

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5. This leads to the substance for which the required emission reduction is the highest (see 1).
 6. Repeat steps 1 up to and including 4, until all objectives are realised.

Example:

In a certain region, the loads of total-N, total-P and copper have to be reduced (nickel and zinc are expected to meet the MPR standards in 2015 if present policies are continued). The highest reduction will have to be realised for nitrogen: 20.7 tons/year. This means that all the measures will first be prioritised according to their cost-effectiveness with respect to the reduction in nitrogen. At the same time, it is recorded how much of the other substances is already reduced in the process. It becomes apparent that, as a result of the implementation of the first measure (reducing fertiliser toxins), 67.2 tons of nitrogen is already being reduced. The objective is therefore attained. Next, the following substance is selected: copper. After having implemented the measures that were aimed in the first instance at nitrogen, 14.4 tons/year of copper will have to be reduced. A new prioritisation of measures, this time aimed at copper, shows that two extra measures are needed to realise the required 14.4 tons, viz. 'information on prevention of copper-bearing anti-fouling' (this is in principle an instrument, rather than a measure!) and 'halophyte filter behind the STP'. After these measures, emissions will be reduced by 16.9 tons. Next, those measures that are able to reduce the emissions of P-total are selected. By optimising the fertiliser toxins and subsequently scooping out watercourses and removing plants, the objectives for P-total are finally also attained.

In this way, it becomes clear that all objectives can be attained by using a package of the following five measures: reducing fertiliser toxins (mainly aimed at N), public information on prevention of copper-bearing anti-fouling (mainly aimed at copper), halophyte filter behind the STP (implemented in the first instance because of copper reduction, but also reduces a part of the other substances), optimising fertiliser toxins, dredging water courses and removing plants (the two measures chosen last are mainly chosen because of their effect on P, but also result in less N).

Table 6.5 Fragment of the cost-effectiveness analysis in a random water body

MATERIAL BALANCE	Total-N (ton/pa)	Total-P (ton/pa)	Copper (kg/pa)	Nickel (kg/pa)	Zinc (kg/pa)
Supply	2587	138	6815	9327	34394
Internal load	186	9	224	93	1923
Total supply	2773	147	7039	9420	36317
Discharge	2773	147	7039	7945	29749
Closing entry	0	0	0	1475	6568
Transport factor	1.00	1.00	1.00	0.84	0.82
Net reduction required	20.73	7.20	14.42	0.00	0.00

	% encountered	Cumulative costs	Cumulative reductions				
Measure	Measure	(€/year)	Nitrogen Reduction (ton/pa)	Phosphate Reduction (ton/pa)	Copper Reduction (kg/pa)	Nickel Reduction (kg/pa)	Zinc Reduction (kg/pa)
Reduction of fertilizer toxicity	100%	0	67.2	2.0	0.0	0.0	0.0
No measure (concerns Stradif conclusion), very limited	100%	0	67.2	2.0	0.0	0.0	0.0
Advice to prevent use of copper-bearing anti-fouling	100%	7,334	67.2	2.0	13.4	0.0	0.0
Retro-fit helophyte filter to STP	100%	11,198	68.1	2.1	16.9	1.3	22.7
Optimise fertilizer toxicity	100%	11,198	81.5	2.5	16.9	1.3	22.7
Eliminate dredging and plants	100%	421,152	100.0	7.2	16.9	1.3	22.7
Reduce surface run-off	100%	1,316,468	155.1	9.7	16.9	1.3	22.7
Dry buffer zones (impoverished)	100%	1,755,744	175.8	10.5	16.9	1.3	22.7
4 th stage by STP	100%	1,865,313	179.3	10.7	20.8	2.7	59.5

An important question that arises when packages of measures are being defined is to what extent measures are divisible. After all, it becomes evident in many cases that if the measure selected last is implemented in full, emissions will be reduced to a greater extent than necessary according to the objectives. If the measure selected last would not need to be implemented in full, this could result in a considerable cost saving. Conversely, it is possible that the indivisibility of measures, which will lead to higher reductions than those that are strictly necessary, may be an argument in favour of choosing a measure that may well cost slightly more per effect, but which will achieve a more accurate attainment of the reduction objective. Let us assume that two measures are possible: one with which 200 kilograms can be reduced at 1 euro per kilogram and one with which 10 kilograms can be reduced at 2 euros per kilogram. If the objective is to reduce the substance by 5 kilograms and both measures are indivisible, it will be possible to realise the objective at the lowest cost by choosing the measure mentioned last, through which 10 kilograms will be reduced at 20 euros, rather than choosing a measure through which 200 kilograms are reduced at 200 euros.

Another issue that arises from the example above is that measures can sometimes have several effects. A consequence of this is that measures that are included in the top of the package of measures and are only aimed at the substance analysed first could well be eliminated from the package of measures again at a later stage.

One should also bear in mind that the effect of certain measures may depend on other measures that affect the same source. In the example above, it seems likely that if the fertiliser toxins are reduced, the optimisation of the fertiliser toxins will have less of an effect than if the fertiliser toxins had not been reduced.

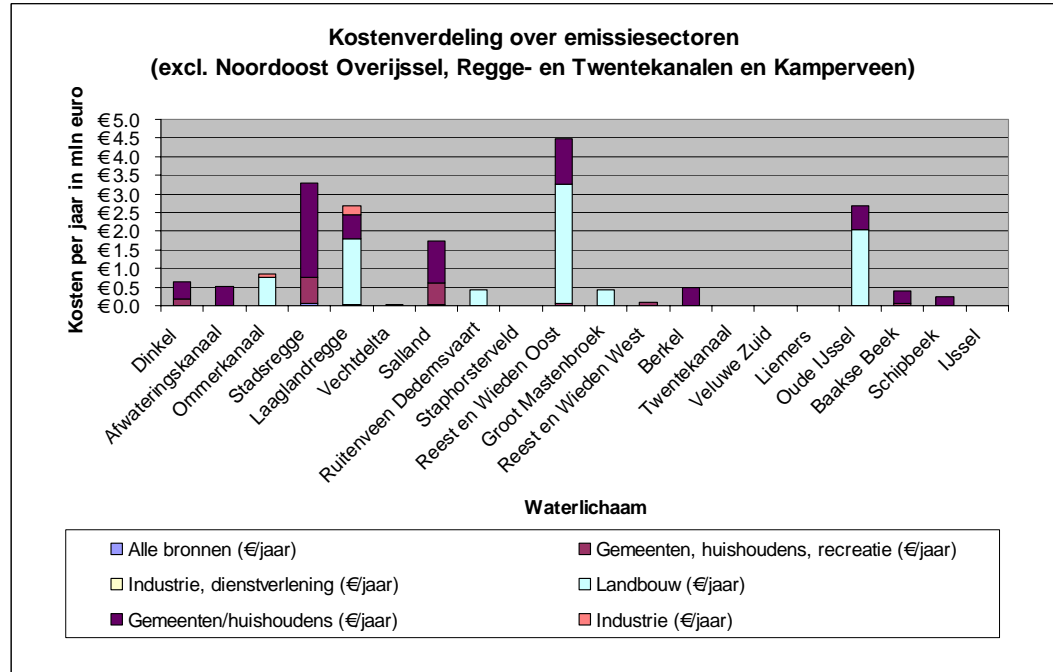
6.3.1 Results without transfer

The total costs of the cost-effective package of measures *without transfer* amount to 84 million euros per year. The value of this figure is limited, because of the large number of assumptions that have been made to carry out the analyses (bandwidth 100%; due to which the costs will vary from 0 to 170 million euros per year).

Reasonably rough assumptions were made, for instance, in respect of the scope of the various sectors in the various regions. By making more use of regional knowledge, it might be possible to improve the specification factors used.

The figure below shows the costs per region. In this figure, Northeast Overijssel, Regge and Twentekanalen and Kamperveen are not included, because the costs of these

regions (32, 27 and 8 million euros per year, respectively) are so much higher that they would render the results of the other regions invisible.



Distribution of costs over emissions sectors (excl. North-east Overijssel, Regge and Twente canals and Kamperveen)

Annual costs in million euros

Water body

All sources (€/year)

Industry, services (€/year)

Municipalities/households (€/year)

Municipalities, households, recreation (€/year)

Agriculture (€/year)

Industry (€/year)

Figure 6.2 Cost apportionment among emission sectors and regions without transfer

Measures that turned up frequently were (i) halophyte filter behind the STP, (ii) reducing excess manure and (iii) a fourth stage behind the STP (see Table 6.6). It became apparent that the farming sector would be faced with most of the costs (76%). However, to a large extent (60 out of 64 million euros) this was caused by an extremely expensive measure that had to be taken in two regions, viz. the excavation of farming land. This is a relatively expensive measure, but in the absence of alternatives in these regions it was the only possibility to attain the objectives. This emphasises the need to check whether the list of measures

used was in fact complete. After all, it seems likely that if alternative measures had been available, these would have been cheaper than the measures chosen in this case.

Table 6.6: Summary of measures to be taken and the number of regions in which they would have to be implemented

Measure code	Measure	# application
30	Retro-fit helophyte filter to STP	15
4	Reduction of fertilizer use	14
29	4 th stage by RWZI	12
24	IBA 3	9
2	Reduce volume of concentrates	6
28	Application of wadis	6
5	Optimise fertilizer use	5
21	Helophyte filter	4
37	Make permit regulations more stringent	4
49	Advice on limiting the setting off of fireworks	4
51	Retention of run-off water	4
7	Reduce surface run-off	3
8	Remove topsoil	3
31	Transfer purification	3
36	Advice to prevent use of copper-bearing anti-fouling	3
41	Coat galvanised steel and lead plating	3
43	Membrane filtration	3
23	Eliminate dredging and plants	2
32	Complete storage/settling basin	2
45	Hunting ban	2
48	Reduce metal/fuel content	2
42	Tackle diffuse emissions to the atmosphere	1
53	Cover rubbish tips	1
Total		111

Despite the use of various packages of measures, it proved to be impossible to meet the MPR standards for all the substances in all the regions (see also Table 6.7).

Table 6.7: Summary of non-realised standards during analysis without transfer

Region	Total-N	Total-P	Copper	Nickel	Zinc
Dinkel			X	X	
Stadsregge			X	X	
Laaglandregge				X	X
Regge- Twentekanal			X	X	X
Berkel				X	
Twentekanaal		X			
Oude IJssel				X	
Baakse Beek				X	
Schipbeek				X	
Kamperveen			X		X

Table 6.8 gives a summary of the costs per sector. To put these costs into a better perspective, the costs are converted per unit in Table 6.9. This shows that the bill for households would increase by about 21 euros per year, while the farming industry would have to spend over 3,000 euros per farm on measures that they would have to take (as mentioned earlier, however, the amount is closely related to the costs of the measure of 'excavating farming land').

Table 6.8: Summary of the apportionment of the total costs among the defined causer categories in the situation without transfer (* 1000 Euro/year)

Total	All sources	Municipalities, households, recreation	Industry, services	Agriculture	Municipalities/ households	Industry
84,352	1,398	4,333	1,018	63,751	13,280	571
% of total	1.7%	5.1%	1.2%	75.6%	15.7%	0.7%

Table 6.9: Summary of costs per unit in the emission sectors in the analysis without transfer.

Category	unit	Costs per unit [€]	% of production in East Rhine [%]	Costs per produced euro [€/€]
Households	Households	€ 21	-	
Industry	Factories	€ 58	45.5%	25.1E-6
Services	Offices	€ 50	50.1%	17.31E-6
Agriculture	Farms	€ 3.355	3.5%	796.41E-6

The results of the cost-effectiveness analysis offer some handles to water managers to make adjustments in the package of measures based on a calculation of the costs for the various causer categories.

Let us assume that a certain category, agriculture for instance, is hit disproportionately hard and the water manager intends to find measures that are to be charged to other causer categories. In the summary of cost-effective

measures, the water manager will then be able to switch simply to the next, only slightly less cost-effective measure (one line down). As a result of this, the total costs may rise, but this may nevertheless be desirable in order to be more reasonable and fair. Another route that can be taken is that of compensation. In this case, the cost-effective measure mentioned in this example is actually implemented in the farming sector, but the costs are not or not entirely borne by the farming sector. Other sectors also pay for this measure. This will lead to lower costs and could therefore be preferred (although one should take account of possible transaction costs).

6.3.2 Results with transfer

As mentioned earlier, the most important difference with the analysis without transfer lies in the fact that it is assumed that the objectives are attained upstream (instead of assuming that the regions situated upstream continue their current emission levels). This therefore means that, in the analyses with transfer, the influx from upstream regions is clearly less than in the analysis without transfer. In certain cases, e.g. Twentekanalen, this means that extra measures are no longer needed in order to be able to attain the objectives.

Table 6.10 contains an example of material balances of the Twentekanalen with transfer. Upstream of the Twentekanalen lie the water bodies called the Regge-Twentekanalen and the Berkel. If the reducible copper content in the Twentekanalen is considered, for example, this amounts to 8.68 kilos per annum. However, because copper reduction has already taken place in the upstream water bodies due to the required measures, an upstream reduction of 26.78 kilos/pa has already been achieved. As a result, the influx of copper in the Twentekanalen is 26.78 kilos/pa less than in the starting situation – more than is required to be reduced in the water body itself. The example below illustrates this by showing how the chemical composition of the Twentekanalen does not require a single measure in order to realise the chemical objectives.

Figure 6.10: Material balance of the Twentekanalen in the situation with transfer

MATERIAL BALANCE	Total-N	Total-P	Copper	Nickel	Zinc
	(ton/pa)	(ton/pa)	(kg/pa)	(kg/pa)	(kg/pa)
Supply	642	16	1463	5711	6780
Internal load	5	1	29	8	80
Total supply	647	17	1492	5719	6860
Discharge	383	8	1324	1294	3406
Closing entry	264	9	168	4425	3454
Transport factor	0.59	0.46	0.89	0.23	0.50
Gross reduction required	2.09	0.74	8.68	0.46	0.00
from Regge Twenthekanalen	1.63	0.15	26.78	1.24	67.30
From Berkel (80%)	0.00	0.00	0.00	0.00	0.00
<i>TOTAL from upstream</i>	1.63	0.15	26.78	1.24	67.30
Net reduction required	0.46	0.59	0.00	0.00	0.00

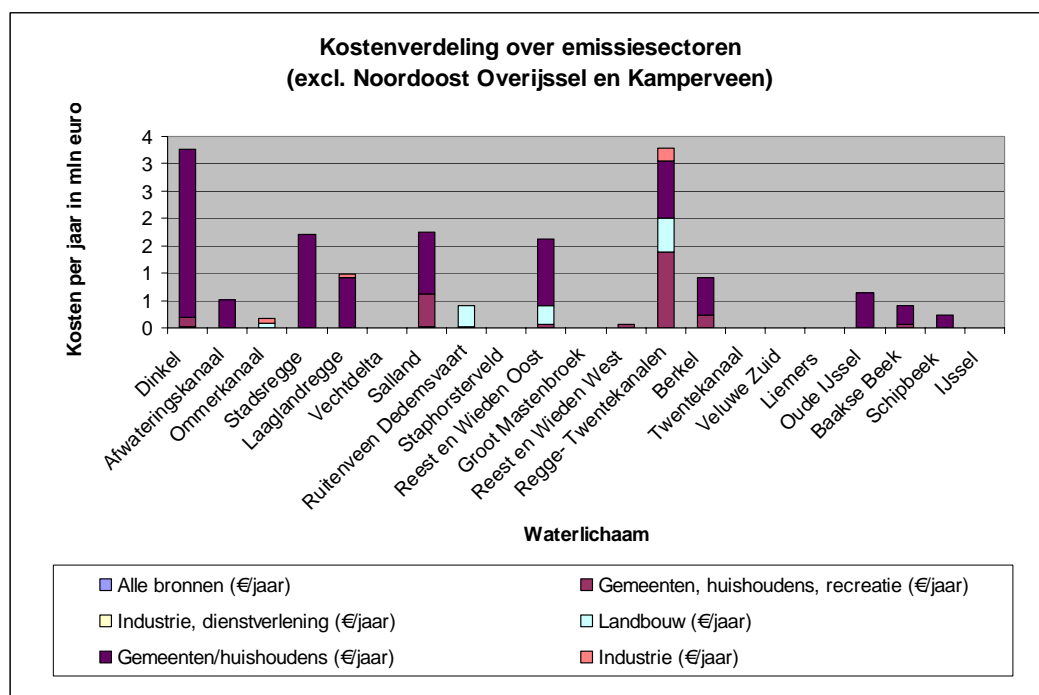
For the analyses, nutrient abatement objectives per water body were dropped and replaced by simply one objective for the water body located most downstream. After all, nutrient concentrations are more relevant to the ecological objectives in the downstream lake, than to the waters that flow into it. The chemical objectives, however, were upheld for each region (in fact, the WFD imposes strict requirements on chemical concentrations).

The reductions achieved by regions situated upstream were carried forward to regions situated downstream by means of transport coefficients. As a result of this, it often is no longer necessary to realise reductions downstream. Measures that cause nitrogen and phosphate levels to decrease will no longer be relevant in such an analysis (these are included in the realisation of objectives for the other substances). This also becomes evident from the following summary of measures that still had to be entered in the analysis without transfer, but no longer needed to be included in the analysis with transfer.

Table 6.11: Summary of measures that are 'dropped' from the packages of measures in the performance of the cost-effectiveness analysis with transfer.

Measure	# times	Average reduction percentages				
		N	P	Cu	Ni	Zn
Reduction of fertilizer use	14	30%	20%	0%	0%	0%
Make permits more stringent	6	50%	50%	50%	25%	50%
Optimise fertilizer use	5	6%	6%	0%	0%	0%
Reduce surface run-off	3	40%	40%	10%	0%	0%

It turned out that hardly any measures had to be taken in the regions situated further downstream. This goes in particular for the regions Vechtdelta, Staphorsterveld, Groot Mastenbroek, Twenthekanaal, South Veluwe, Liemers and IJssel. In these cases, the standard is already met without any supplementary measures.



Distribution of costs over emissions sectors (excl. North-east Overijssel and Kamperveen)

Annual costs in million euros

Body of water

All sources (€/year)

Industry, services (€/year)

Municipalities/households (€/year)

Municipalities, households, recreation (€/year)

Agriculture (€/year)

Industry (€/year)

Figure 6.3 Cost distribution among emission sectors and regions without transfer

The total costs of the cost-effective package of measures would decrease to 55 million/year¹³. This is 30 million less than without transfer. Moreover, if the chemical standards per water body were dropped, the difference could even be greater.

¹³ In this analysis, the same bandwidth of about 100% applies due to the large number of assumptions.

It also became evident that it was impossible in the situation with transfer to attain the objectives in all the regions. Of all unattainable standards, only the problem with total-P for Twentekanaal has become solvable relative to the analysis without transfer.

Tables 6.12 provides some insight into the distribution of the costs. What stands out is that the farming sector would still be faced with most of the costs, whereas industry and services were charged to a much lesser extent, or not at all. The changes in relation to the analysis without transfer are shown in Table 6.13.

Table 6.12: Distribution of the total costs among the causal categories in the situation with transfer (* 1000 Euros/year)

Total	All sources	Municipalities, households, recreation	Industry, services	Agriculture	Municipalities/ households	Industry
55,254	1,314	2,899	0	36,987	13,696	357
% of total	2.4%	5.2%	0.0%	66.9%	24.8%	0.6%

Table 6.13 The costs per unit in the analysis with transfer, and as a percentage of the costs per unit in the analysis without transfer

Category	cost analysis with transfer	cost analysis without transfer	% of costs without transfer
Total costs	€ 55,254,635	€ 84,352,421	66%
Households	€ 20	€ 21	94%
Industry	€ 5	€ 58	9%
Services	€ 0	€ 50	0%
Agriculture	€ 1,947	€ 3,355	58%

This last table shows clearly that industry and services in particular and, to a lesser extent, the agricultural sector, will benefit from the problems being solved upstream. For households, it does not make much difference. Many of the measures that they would have to take in a situation without transfer would also have to be taken in a situation with transfer. This refers especially to the adjustments at the STPs (halophyte filter, 4th stage and IBAs).

Step 8: Uncertainty analysis

For the uncertainty analysis, Groot Mastebroek was selected as a representative region. In this region, it was checked what the effect would be of a change by 10% in the value used for a series of assumptions on the total costs and the sequence of measures.

Assumptions	Explanation
Explanation of the internal load per water body	In a few cases, parts of the internal load could not be explained and were put down to certain sources of emissions and sectors. The moment that the internal load is not entirely explained, it becomes more difficult to select adequate measures which contribute to the cost effectiveness analysis.
Cost specification factor	Specific features in land-use (and ideally also differences between water bodies) make it necessary to use a specification factor when estimating the costs of a measure in a water body. The factor is built-in as an 'adjustment knob', with the aim of arriving at realistic cost estimations. Improvement of these estimates is possible using region specific expertise. Changes to the specification factor directly influence the cost effectiveness of measures.
Balance of materials and transport factors	The material balance and the transport factors give an indication of the supply, emissions and discharge of the 5 substances per water body. Changes in the material balance and/or transport factors alters the situation per water body. Given the WFD objectives, it is necessary to employ more or maybe less measures to comply with the standards. There is no evidence of changes in the cost effectiveness of individual measures. Only the scope of the cost effective package of measures changes.
Explanation of the internal load per water body	The explanation of the internal load can have an influence, on the composition of the cost effective package of measures. Since sources which account for part of the emissions in the water body are added (or excluded), it is possible to employ other measures which are especially relevant to these sources.
Load reduction through autonomous developments and prevailing policies	A change in the 'load reduction through autonomous developments and prevailing policies' has the same effect as a change in the 'balance of materials and transport factors'.
WFD standards	A change in the WFD standard also has only an effect on the scope of the cost-effective package of measures and not on the cost effectiveness of individual measures.
Potential measures: completeness of measures, correct details etc.	This 'premise' concerns the scope of the total package of measures which could potentially be employed to realise a reduction of the 5 substances. The moment a package is incomplete, or the details are incorrect (for whichever source of emission the measure relates to), potential for utilization is lost and the opportunity to create a more cost effective set is missed.

Table 6.15 describes how sensitive the most important assumptions are. It turns out that a 'change in the estimate of hectares of land use per water body' by 10% would lead to a change by a little over 5% in the total costs of the water body. This could be regarded as a dramatic effect if one realises that it refers to a change of only one assumption in one measure. This assumption proved to be the most sensitive of all assumptions. A second crucial assumption refers to the effects of measures (% reduction), viz. a change by 3.20% in the total costs if the effectiveness is estimated to be 10% lower. Likewise, the extent of the internal burdening and the annual costs of a measure proved to be important assumptions.

Table 6.15: results of the sensitivity analyses

Premise	Mutation in premise	Effect on total costs
(internal volume) Load	10% lower volume internal load per source of emission	2.75%
Effects of Measures (% reduction)	10% lower reduction through implementation of measure	3.20%
Investment costs for measure	10% higher investment costs	0.01%
Economic life expectancy of measure	10% shorter economic life expectancy	0.01%
Interest percentage	10% higher interest percentage	0.02%
Annual costs of measure	10% higher annual costs	1.99%
Estimate of hectares land use per water body	10% more land use per sector	5.74%
Cost specification factor	10% higher specification factor	0.09%
Balance of materials and transport coefficients	10% increase in reduction required per substance	2.98%
Load reduction through autonomous developments of prevailing policies	10% increase in reduction required per substance	2.98%
WFD standards	10% increase in reduction required per substance	2.98%

It should be noted that the specification factor is shown to be relatively insensitive. This could be underestimated. A minor change by 10% in the specification factor apparently leads to a minor change in the total costs, but because the specification factor has a wide range (between 0 and 1) it will depend strongly on the extent of this factor how dramatic the impact is. In other words, it might be that this

assumption could actually have a huge impact on the end result but that this coincidentally does not become evident from this analysis.

The analyses carried out showed that the following aspects determine costs:

- The estimate of the number of hectares for the various forms of land use (specification factor).
- The effects of the measures (% reduction).
- The extent of the internal burden.
- The annual costs.

It also became evident from the analyses that the sequence of the measures does not change. In itself, this should inspire confidence in the composition of the package of measures. However, it ought to be borne in mind that it is not fully known whether the situation in the region chosen for the sensitivity analyses is as representative as assumed. Moreover, the sensitivity analysis was carried out by changing the assumptions by 10%, which may be too moderate.

6.4 Learning experiences

6.4.1 Learning experiences with the East Rhine

Availability of information

In recent years, a great deal of work has been done in the East Rhine. Consequently, at the start of this project there was already a lot of information available about the regional water quality. However, in practice it became apparent that the combination of information from various sources creates problems, because different borders and surface areas had been used in different researches (this may also apply to other regions, in which this type of analyses will be carried out). Another problem was that the existing substance balances showed such large discrepancies that recalculations were necessary in order to be able to perform reliable analyses. Especially the fact that not all internal burdening can be explained properly had significant consequences for the reliability of the results (without a proper substance balance, a cost-effectiveness analysis becomes a shot in the dark). For the present analyses, however, which are focused on testing the practicability of the methods and available information, the existing calculations of substance concentrations were sufficient.

Furthermore, it became clear that the objectives for three regions are unattainable, because they are not technically feasible. It would be necessary to adjust the objectives for these regions.

For Rhine East, this study has clearly identified where the most important blank spaces are in the available knowledge. Meanwhile, the region has begun to act upon the recommendations formulated in the study. For example, the intended recalculation of the substance balances is one of the follow-up actions as a result of this project that is carried out in the region right now.

6.4.2 Learning experiences with the East Rhine and elsewhere

The most important learning experience for this manual is that the method is a practical, transparent, convenient and simple method, which is extremely suitable for analysing measures as well as changes in these measures in the event that assumptions change or certain causer categories are hit too hard. It has become evident that knowledge of measures and the region are extremely important to ultimately gain confidence in the formulated packages of measures. This refers particularly to the sensitivity of the results of, especially, the assumptions for costs, effects and the specification factor.

A disadvantage of the method used is that it is time-consuming if many analyses are to be carried out with large databases. This emphasises how important it is to formulate exactly in advance which analyses one intends to carry out (limitation of the number of analyses).

Practicability of the method

The method is simple and easy to use for water managers. Although the method used is not the only route along which a cost-effectiveness analysis can be achieved, it is a practical and workable method. On the other hand, the process turned out to be labour-intensive. This was due to the quantity of data that had to be analysed, as well as the processing related to the composition of the packages of measures. It is therefore recommended that water managers use the method and draw up the datasets themselves. The most important point is for water managers to be involved hands-on in the process from the start to the end, whilst being fully aware of all the assumptions that are being made and steps that are being taken.

Usefulness and realism of the results

The realism of the results in this research is moderate because it was necessary to work with dummies and make a large number of assumptions. Nevertheless, it is a point of departure. By supplementing as much missing information as possible in the coming period of time and by fine-tuning the assumptions, results will become increasingly realistic. It will

also make the outcome more solid. Within this context, the cost-effectiveness analysis that was carried out in this project must be seen as a first step in a cycle of improvements. By improving the most crucial assumptions and upgrading the input data, the best possible reproduction of reality will be achieved ever more accurately. In any case, it is up to the water manager to choose the moment at which enough solidness has been achieved to give policy makers the choice and the opportunity to set priorities. The method is certainly capable of providing this solidness. The contribution of regional knowledge is, however, indispensable. In addition to this, a great deal of work is meanwhile done by developing a Measures Knowledge System (see Appendix 4). This includes information on measures (effects, costs, etc). The use of this Measures Knowledge System will improve the realism of the results.

Transparency of the method

The advantage of the method used here is that all possible measures have been included and that it aims to achieve a complete attainment of objectives. If it would ultimately become clear that in certain regions the WFD standards cannot be attained in 2015, then the reasons for this will be completely transparent; for instance, because the costs for a certain sector are disproportionate; because it is impossible to reduce sufficiently due to the tackling of (all) sources or because the supply from abroad is expected to be too high. Another advantage of this method is that if a policymaker would choose not to implement a certain measure, it would soon become clear what other measure(s) could be taken instead, and what the costs of deviating from the cost-effective measure package would be. The method thus allows for a quick comparison between the pros and cons of the substitute measures and those of the original measures.

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Appendix 1: Glossary of terms:

Instruments

Instruments aim to alter preconditions in order to indirectly exert an influence on the conduct of relevant actors. Instruments can alter the legal and economic preconditions, but also ensure a change in conduct through better information and advice. In this way, the instruments support the implementation / execution of measures. According to WFD nomenclature, appendix VI, part B of the WFD suggests that instruments fall under 'supplementary measures'.

In Chapter 1 it was stated that the cost-effectiveness analysis is limited to the allocation of measures and is unable to pronounce upon the implementation of measures, because political preferences play an important part in this. For this reason, only the technical measures are included in the cost-effectiveness analysis and not the instruments. In principle, it is possible to use the method presented here also for the analysis of the cost-effective use of instruments. For a brief description, please see Appendix 6.

Costs: direct costs

Costs incurred when directly implementing a measure / for applying an instrument. These costs are mostly borne by the implementing organisations. This includes, for example, building costs for construction measures, staff and administrative costs incurred by the organisation as a result of implementing a measure / instrument.

Costs: indirect costs

Costs arising indirectly as a result of the implementation of a measure / instrument. Indirect costs are not borne by the implementing organisation but by the other actors.

Measures

This manual considers measures to be interventions that lead directly to an improvement in the status of the water body, i.e. through the removal or reduction of a load. In the case of reducing/preventing discharges, this will comprise both end-of-the-pipe and process-integrated measures.

Programme of measures

Article 11 of the WFD requires cost effective programmes of measures to be drawn up at river-basin district level in order to realise the WFD goals, in accordance with article 4. These programmes of measures must have been drawn up

before 2009, and the measures contained in these programmes must have been implemented before 2012. After 2015, the programmes of measures must be reviewed every six years.

Appendix 2: The role of the economy in underpinning any deviations to the objectives

In article 4, the Water Framework Directive (WFD) gives room for relaxing the prescribed objectives for specific water bodies when a number of preconditions are met (see article 4, sub3-7). These preconditions basically relate to, on the one hand, the **feasibility** and, on the other hand, the **affordability** of realising a good ecological state (GES) or good ecological potential (GEP) of a given water body.

In article 4, feasibility mainly concerns the technical feasibility of objectives (sub 3b, sub 4ai, sub 7d) given, for instance, specific unexpected, unforeseen or uncontrollable natural circumstances (sub 4aiii, sub 5, sub 6).

Affordability is expressed in terms of **disproportionate expense** (sub 4aaii, sub 5) or **disproportionately high costs** (sub 3b, sub 5a, sub 7d). Otherwise, when commenting on water bodies as being artificial or heavily modified, sub 3a still talks of **significant negative effects on sectors** such as shipping (including ports and recreation), drinking water facilities, energy production and irrigation, and sub 7c refers to reasons to do with a **higher public interest** and/or **the benefits to the environment and society of achieving the objectives**.

Economics does not contain standard definitions for terms such as affordability and disproportionately high costs, and neither does it contain standard methods for determining or estimating disproportionately high costs. The guidance document for the economic analysis in the WFD, published in 2002 by the European Water Economics (Wateco) working group, also fails to offer any definitions. However, it is clear that both terms indicate the financial and economic consequences (or effects) of the implementation of the WFD – realising the environmental objective GES or GEP by the possible application of supplementary measures – and the **proportionality** of these financial and economic consequences.

The question of whether there is evidence of (dis)proportionality or disproportionately high costs is, as suggested in the Wateco guidance, a political conclusion to be drawn from an estimate of the financial and economic implications of supplementary measures employed to achieve the GES or GEP objective. Even when the criteria or benchmark for disproportionality and affordability are made more explicit by the politicians and government, the decision remains a subjective one. This basically concerns a response to the question of what we are jointly (governmentally or socially) willing or able to pay to realise the GES and GEP objectives.

Appendix 4: The Measures Knowledge System

In order to support the regional water managers in the implementation of the cost-effectiveness analyses, a measures knowledge system has been drawn up which contains information with respect to the costs and effects of measures, and is accessible on the internet. This information is available for and by those involved in implementing the WFD. This concerns officials involved on both a national and a regional level but, within the framework of social consultation, also representatives of stakeholders and citizens. Efficient clarification, distribution and fine-tuning of information is the system's most important aim. The system can be referred and added to via <http://www.kaderrichtlijnwater.nl>. (first half of 2006 hosted on <http://www.paict.com>, however, only available in Dutch) Users may enter their own data. As a result of this, for instance, a regional water board which has specific know-how of and experience with a certain measure can enter the costs and effects of this measure or add comments to any measures that are already available. In this way, information is made available to other users. For practical private analyses of (packages of) measures, it is possible to download data as Excel files. Quality assurance is provided through workshops with various experts. In this way, an interactive platform is created at which information about measures will be exchanged effectively and efficiently.

The information system is an activity of the national *Afwegingskader* (reasoning framework) / CBA working group. This working group supports the regional and national analyses and evaluation of measures. There are now numerous activities and pilot projects being carried out in preparation for the choices that will have to be made concerning the river-basin management plans in 2007 and 2008. Utilizing all these initiatives, the information system is intended to offer an excellent location for the exchange of knowledge and information to as many as possible concerned parties. There is much to do, so efficiently exploiting everyone's insights can only prove beneficial.

Appendix 5: Instruments in a cost-effectiveness analysis

One problem when analysing the effectiveness of instruments is that an instrument only becomes effective if it leads to a change in conduct (the implementation of the technical measure).¹⁴

It is usually uncertain as to whether the sectors to which an instrument is applied are actually likely to change their conduct as a result. It may be assumed that the drawing up of orders and prohibitions creates a greater probability of stimulating a certain conduct, and the implementation of certain technical measures, than is possible by creating price incentives and that price incentives are more effective than when only information is communicated. Besides effectiveness, workability and affordability also play a role. Although subsidies may stimulate the desired conduct, when applied on a larger scale, they place an enormous burden on the availability of public funds.

Workability can also present an important criterion. For example, it is generally fairly simple to monitor and check point source discharges, but considerably harder to do the same for diffuse sources. For this reason, a levy on point source emissions to surface waters generally works better than for diffuse sources. When the object of the exercise is to stimulate agriculture to reduce its nitrogen emissions to surface waters, a levy on the use of artificial fertilizer is easier than a levy on nitrogen emissions into the soil (flushing beyond the root zone). This means that different types of measures and sectors may require the implementation of different instruments.

One way of taking account of the effectiveness of instruments in the cost-effectiveness analysis is by estimating the probability that sectors will change their conduct as a result of an instrument and then multiply the effectiveness of the technical measures by this probability. The costs could be increased by the monitoring and maintenance costs, while the effectiveness is multiplied by the probability that the instrument will lead to the desired conduct; the implementation of the measures concerned and subsequently the realisation of the required effect. The most attractive instruments are those with a greater probability of producing the desired change in conduct for the lowest possible costs.

¹⁴ When a levy becomes so high that it is no longer interesting for the sector concerned to continue with the given activity, the instrument has been effective, even if it has not rendered any revenues; after all, the object of this exercise is not to raise money, but rather to curb the activity and reduce its negative effects.