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Strategies for implementing the requirements of Article 11 (3) I of the Water Framework Directive aimed at preventing and minimising the consequences of unexpected water pollution arising from technical installations

Part III – Explanation of Action Concept
Proposed measures for implementing Article 11 (3) I WFD

by

Hamburg Institute for Hygiene and Environment

and the

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Part III – Explanation of Action Concept

Proposed measures for implementing Article 11 (3) I WFD

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1 Foreword

Hexachlorobenzene (HCB) is a fungicidal seed dressing which was widely used in the past. Within the European Community (EC) it was largely used in Germany. In view of its ecotoxic effects its approval as a pesticide was withdrawn in Germany in 1981. However, it also occurs as a by-product of various chemical production processes. Today HCB is one of the substances that are proscribed and prohibited by the Stockholm Convention ("dirty dozen")[1]. In the 1970s to early 1980s, worldwide production was in the region of 10,000 t/a. The substance was produced worldwide, and stored, transported, mixed and used by the tonne.[2] In December 2008 the European Community, in Directive 2008/105/EC (WFD daughter directive "Priority substances") laid down a maximum permitted concentration of 0.05 µg/l for the aquatic ecosystem in surface waters and an environmental quality standard of 0.01 µg/l (annual average). If these are exceeded, the status of the relevant body of water is to be adjudged "poor".[3]

What significance do these figures have for practical, real-life handling of such chemicals? If such substances find their way into rivers and lakes "by accident", what quantities does it take to exceed the relevant environmental quality standards? What preventive measures are possible, and what measures are required by law, specifically by the European Water Framework Directive?

The answer to the first two questions may come as a surprise to many people: with modern, practically tested forecasting software[4] it is possible to show that a quantity of 5 kg HCB entering the Elbe at low water over a 24-hour period in the Czech Republic 100 km upstream of the German border is sufficient to make the concentration as far downstream as Hamburg exceed the maximum permitted level of 0.05 µg/l by more

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1 POP Convention, Stockholm 22 May 2001, http://chm.pops.int/ .

2 Source: e.g. Fiedler, Heidelore; Hub, Michael; Willner, Susanne et al., Landesanstalt für Umweltschutz Baden-Württemberg, Handbuch Altlastensanierung, Texte und Berichte zur Altlastenbearbeitung 18/95, Stoffbericht Hexachlorbenzol (HCB), Karlsruhe 1995. www.fachdokumente.lubw.baden-wuerttemberg.de .

3 According to Directive 2008/105/EC (WFD daughter directive "Priority substances") Annex I Footnote 9, the EQS value of 0.01 µg/l for hexachlorobenzene (HCB) or 0.05 µg/l for mercury is to be replaced by a stricter value if the Member State does not perform biota studies for this substance. (For further details of the WFD etc., see Chapter 3.1.4, for quality standards see Chapter 3.3).

4 here: ALAMO, see Chapters 3.3.3.2 and 8.1.1.2.5.

than the same amount again.[5] Figure 1 shows the concentration along the Elbe from 105 km before the Czech-German border at Melnik (river km -105) to Geesthacht, just before Hamburg (river km 586), calculated using the ALAMO program.

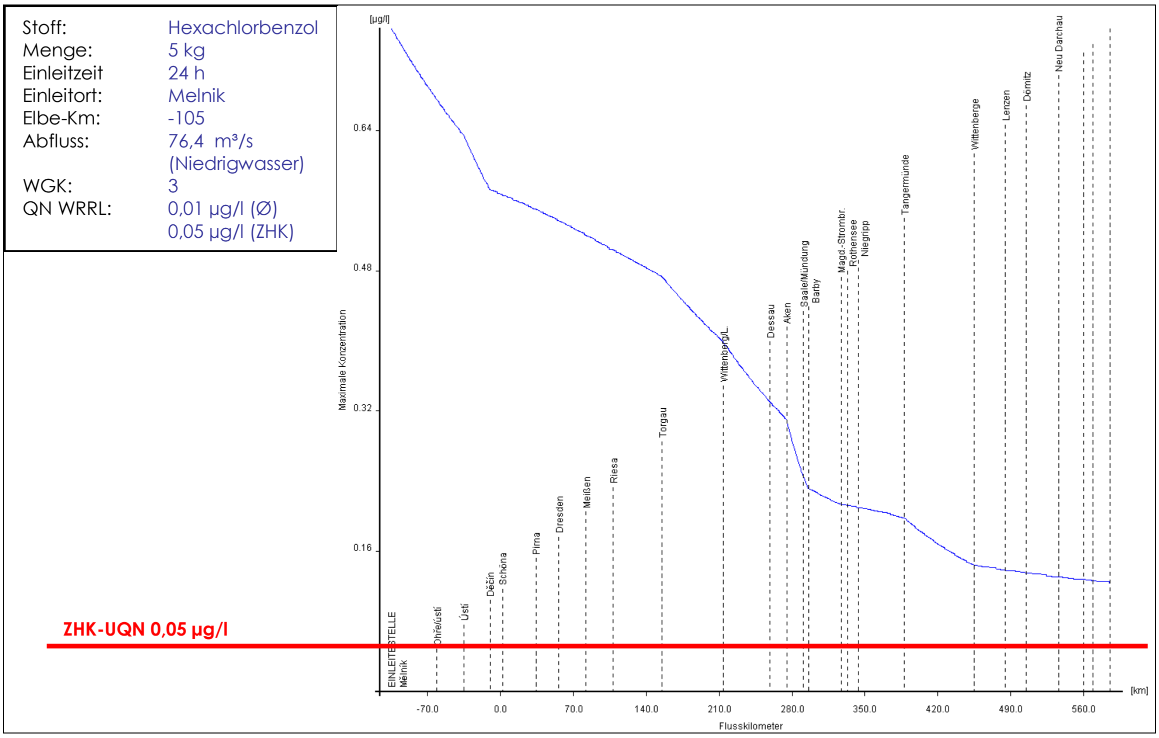

Figure 1 Concentrations resulting from a 24-hour input of 5 kg HCB in into the Elbe in the Czech Republic

The result is much the same, for example, if – at the same place and under the same flow conditions – a carton containing a water-soluble mercury salt compound with a mercury content of 5 kg accidentally falls into the Elbe. Here too, as Figure 2 shows, we find that the MAC-EQS figure is exceeded right down to just before Hamburg.

5 To date there has been no definitive clarification of how the environmental quality standard “maximum allowable concentration” (MAC-EQS) of Directive 2008/105/EC is to be applied to classification of chemical status pursuant to the WFD – which means that model calculations of this kind can make an enriching contribution to the discussion .

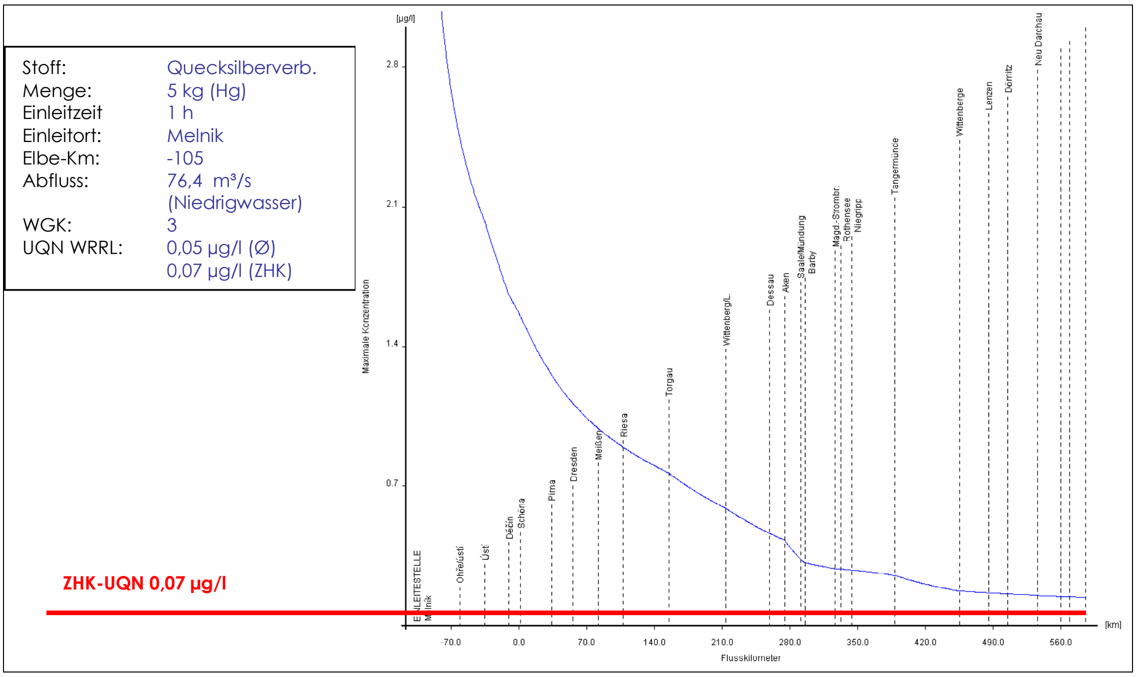

Figure 2 Concentrations for accidental input of mercury salts containing 5 kg of mercury into the Elbe in the Czech Republic

Although this case involved the simultaneous occurrence of two “unfavourable” factors – low water and low environmental quality standards – the examples show that even small accidental substance inputs that are far below “Seveso-II levels” may have substantial effects that are not compatible with the objectives of the WFD.

2 Introduction

As a “framework directive”, the Water Framework Directive (WFD) seeks to bring together all individual acts of legislation and international conventions relating to water utilisation and water conservation. With the entry into force of the WFD, waters in the EU are to be *managed* in accordance with a single legal framework. A new aspect is the fact that waters are no longer to be managed within the boundaries of administrative units (nation states, administrative districts etc.), but at the level of river basin districts (catchment areas). The goal of such management is to achieve good ecological status and good chemical status in the natural waters of the Community by 2015 or, in the case of heavily modified water bodies, to achieve good ecological potential and good chemical status.

One major instrument for achieving the goal is programmes of measures which together form part of the *management plans* due to start in 2010. The Water Framework Directive distinguishes basic measures, which satisfy the basic standard to be complied with, and supplementary measures, which may have to be planned and taken in addition in order to achieve good status. The basic measures also include (Article 11 (3) I WFD):

⇒ *"...all measures necessary to prevent significant losses of pollutants from technical installations and*

⇒ *to prevent and/or reduce the impact of accidental pollution incidents, for example as a result of floods,*

⇒ *including through systems to detect or give warning of such events and*

⇒ *including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems"*.

The implementation of Article 11 (3) I WFD raises a number of specific questions, some of which are outlined below:

1. The definition of the objectives of the WFD is based on an immission-oriented approach. All initially abstract goals, such as *protection of ecosystems*, *promoting sustainable use of water*, *long-term resource conservation* etc. are given more *concrete* shape by means of definitions of the *targeted water status* – which is ultimately to be *"good"* from both a chemical and an ecological point of view. What is or is not *"good"* is defined on an immission-oriented basis. For chemical parameters, this means that the status of the individual body of water is characterised by means of concentration levels for the body in question, and achievement of the objective is tied to compliance with a (concentration-based) environmental quality standard. By contrast, the assessment of water pollution in accident management situations is geared to emission-oriented criteria. The seriousness of the accidental pollution is evaluated partly on the basis of a selection of physical, chemical and toxicological properties (water hazard classes, R phrases), and partly on the basis of the absolute *substance quantity* that has escaped into the water (warning and emergency thresholds, water risk index etc.), which must however be known for this purpose. It is not possible to trans-

port this information directly into the immission-oriented, concentration-based assessment scheme of the WFD. Neither has there been any examination of the extent to which criteria and priorities for substance assessment in the WFD (water law) are compatible with those in installation-related water conservation (installation law). What are the consequences with regard to achievement of the environmental objectives of the WFD if a given quantity of substance A finds its way into a specific body of water? For example, when does the *early warning* required under Article 11 (3) I WFD have to be given, and how does one obtain the necessary data? Are there any approaches to solving such problems?

2. Experience shows, and model calculations performed at the HU provide impressive confirmation, that even relatively small installations can involve considerable risks to water. For example, Figure 1 shows that 5 kg of the pesticide hexachlorobenzene (no longer approved) input into the Elbe one hundred kilometres upstream of the German-Czech border is capable of rendering the status of the Elbe, as defined by the WFD, "poor" right down to below Hamburg. In Germany, the handling of substances dangerous to water in installations ("installation-related water conservation") is subject to separate regulation under water law. In international river basin commissions and in bilateral agreements, Germany seeks to ensure the acceptance and application of fundamental principles of installation-related water conservation. Elements of installation-related water conservation have found their way into various agreements, programmes or guidelines of international river basin commissions. Here too, however, it is necessary to examine whether adequate protection is ensured in accordance with Article 11 (3) I WFD, or whether there is a need for additional action; also, where appropriate, what simple additional technical or organisational elements are suitable for meeting the material requirements of the planned measures. In doing so, it would seem sensible to focus on implementation requirements and ways and means of implementation, since it has to be assumed that from a purely legal point of view, the provisions of the WFD have been transposed into the legal systems of the Member States.

3. Article 11 (3) I WFD calls for *"systems to detect or give warning of such events"* – are the international warning and emergency plans of the river basin commissions adequate in this respect?

4. There are several other provisions of relevant Community law which are concerned primarily or incidentally with installation-related water conservation mea-

sures or protection against other harmful events relating to bodies of water. As a rule, these are not superseded by the WFD, but are expressly included in the list of basic measures for achieving environmental goals. This means that obligations under other existing Community provisions may be appropriate measures within the meaning of the Water Framework Directive. However, it is not clear whether measures under these provisions are adequate for the purposes of Article 11 (3) I WFD.

5. The Water Framework Directive requires the inclusion of cost-effectiveness and proportionality considerations in connection with programmes of measures (but not only these). When it comes to taking precautions against events that only occur rarely, if at all, this is a complex question. Is there any potential here for approaching the issue in a verifiable manner?

The work on the project was divided into three packages:

1. Inventory of past and planned activities in the international river basin commissions for the Elbe, Oder, Danube and Rhine, assessment of the technical and organisational aspects of compliance with the requirements of Article 11 (3) I WFD; analysis of deficits;

2. Development of an action concept with suggested solutions for implementing the requirements of Article 11 (3) I WFD based on the findings of the inventory and its assessment; in this connection ways of investigating cost-effectiveness are also considered;

3. Comparison and coordination of results, exchange of experience through international cooperation between experts in the form of workshops, Internet representation, presentation of results to the EU Commission etc.

Structure of the Final Report

The final report on the project consists of three parts. Each of the three parts is designed, with limitations, to be read and understood on its own. There is therefore a certain intentional redundancy in the introductory sections.

While **Part I** provides an introduction to the project and an abstract summary of the results, **Part II**, entitled *"Action concept – Suggested measures for implementing Art. 11 (3) I WFD"* contains a guide to working through the implementation requirements of Article 11 (3) I WFD. This “action concept” has the character of a “checklist”: it contains the graphic “safety chain” scheme already described, with the measures and implementation examples appended in tabular form, but without detailed explanations or reasons.

The present part, **Part III**, provides in-depth explanations of the “action concept”.

Chapter 3 is concerned with the framework conditions of Article 11 (3) I WFD, i.e. their legal foundations and their place in the WFD context, and especially the relationship to the WFD objectives in general and the environmental quality standards in particular. **Chapter 4** shows the results of the inventory and identifies deficits; it also discusses cost-effectiveness aspects and proportionality considerations in relation to measures. **Chapters 6 to 9** work through the “safety chain” drawn up for the “action concept”, and provide in-depth treatment of selected examples of how to apply Article 11 (3) I WFD. **Chapters 10 and 11** then take a brief look at two aspects which do not belong to the central themes of the project, but which cannot be totally disregarded in the context investigated: quality assurance and public involvement.

3 Framework conditions

3.1 Legal framework – Introduction

While the Water Framework Directive touches on both installation-related water conservation and protection against other water-related harmful events, and also flood control, regulation of these fields is not really among the main objectives of the directive. This may be due to the fact that shipping accident aspects were considered to be largely regulated by international conventions and by other EU provisions, and the possibility that Article 11 (3) l WFD was essentially added as a "review assignment" aimed at detecting and filling any remaining "legal loopholes". In the case of flood control it is also due partly to the decision to create a separate directive, which was enacted on 23 0ctober 2007 as Directive 2007/60/EC of the Parliament and of the Council.

This chapter is intended as an introduction which will help to provide a temporal and legal context for the legislation and conventions repeatedly mentioned and discussed in the course of this report, and to describe the relevant key points considered important for this report. In-depth explanation and discussion is provided in the individual chapters.

3.1.1 Conventions under international law

The starting point of global environmental law is the ban on transboundary environmental damage under Principle 21 of the Stockholm Declaration of 1972[6], which

6 Stockholm Declaration 1972, http://www.unep.org/Law/PDF/Stockholm_Declaration.pdf .

Principle 21: "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

obliges states (initially Western states) to ensure that no damage is caused to the environment in other states or regions outside their national territory by activities within their national jurisdiction. At the Rio Conference of 1992, this fundamental principle was fully confirmed in Principle 2[7]. Even if the legal character of the Stockholm Declaration and the Rio Declaration is such that neither is binding under international law, these principles in particular are today recognised as *fully accepted basic rules of customary international law*, at least in cases where the harmful environmental effects on the neighbouring state are *"substantial"*. The reciprocal information and warning obligations of the states (Principles 18 and 19 of the Rio Declaration)[8] are also regarded as binding for the purposes of customary international law.

The United Nations Economic Commission for Europe (UNECE) is one of the five regional economic commissions of the United Nations. In addition to the European countries, UNECE also includes all non-European successor states to the Soviet Union, the USA, Canada, Turkey, Cyprus and Israel . For transboundary planning of incident response in Europe and adjacent areas of Asia, it is the legal platform of choice for establishing single binding standards. Two important UNECE conventions in this field were adopted in Helsinki in 1992:

- CONVENTION ON THE PROTECTION AND USE OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES // ("UNECE Water")[9]
- CONVENTION ON THE TRANSBOUNDARY EFFECTS OF INDUSTRIAL ACCIDENTS // ("UNECE Accident")[10]

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7 Rio Declaration 1992, http://www.unep.org/Law/PDF/Rio_Declaration.pdf .

Principle 2: "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

8 http://www.unep.org/Law/PDF/Rio_Declaration.pdf

Principle 18: "States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted."

Principle 19: "States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith."

9 Convention on the Protection and Use of Transboundary Watercourses and International Lakes ("UNECE Water"), Helsinki, 17 March 1992, for text see http://www.unece.org/env/water/text/text.htm .

10 Convention on the Transboundary Effects of Industrial Accidents ("UNECE Accident"), Helsinki, 17 March 1992, for text see http://www.unece.org/env/teia/text.htm .

3.1.2 Conventions at river basin level

Even before the UNECE conventions mentioned above, there had been various agreements and conventions between countries in the individual river basins, particularly in Western Europe. Some of these were models for the UNECE conventions, others were more specific and far-reaching. After the ratification of the UNECE conventions, many of these river-basin conventions were updated or revised. International river basin commissions have been established for most transboundary river basin districts in Europe, and among other things these provide forums for implementation of the aforementioned UNECE conventions.

Examples of international river-basin conventions:

<u>Rhine:</u>

- "International Commission for the Protection of the Rhine against Pollution", Basel 11 July 1950
- Agreement of 29 April 1963 on the International Commission for the Protection of the Rhine against Pollution[11] ("Bern Convention")
- Convention of 3 December 1976 on the Protection of the Rhine against Chemical Pollution (Chemical Convention)[12]
- Convention of 3 December 1976 on the Protection of the Rhine against Chloride Pollution (Chloride Convention), Supplementary Convention 1991.[13]
- Action Programme "Rhine" of 30 September 1987
- Convention of 12 April 1999 on the Protection of the Rhine[14]

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[11] German-Dutch Boundary Waters Commission, Agreement of 29 April 1963 on the International Commission for the Protection of the Rhine against Pollution, Federal Law Gazette II 1963, p. 653; Federal Law Gazette II 1998, p. 1831.

[12] Convention of 3 December 1976 on the Protection of the Rhine against Chemical Pollution, Federal Law Gazette II 1978, p. 369.

[13] Convention of 3 December 1976 on the Protection of the Rhine against Chloride Pollution (Chloride Convention), Supplementary Convention 1991; Federal Law Gazette II 1987, p. 1065.

[14] Convention of 12 April 1999 on the Protection of the Rhine, Bern, 12 April 1999, for text see http://www.iksr.de/fileadmin/user_upload/Dokumente/uebereinkommen_zum_schutz_des__rheinsVers._12.04.99.pdf .

Mosel/Saar:

- Protocol of 20 December 1961 between the governments of the Federal Republic of Germany, the Republic of France and the Grand Duchy of Luxembourg on the establishment of an International Commission on the Protection of the Mosel against Pollution[15]

Danube:

- Convention on Co-operation for the Protection and Sustainable Use of the River Danube (Danube River Protection Convention) of 29 June 1994[16]

Ems:

- Supplementary Protocol of 22 August 1996 to the Ems-Dollart Treaty regulating Cooperation on Water and Nature Conservation in the Ems Estuary[17]

Elbe:

- Convention of 8 October 1990 on the *International Commission for the Protection of the Elbe* (CZ/D/EU)[18]

Oder:

- Convention of 11 April 1996 on the *International Commission for the Protection of the Oder*[19]

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[15] Protocol of 20 December 1961 between the governments of the Federal Republic of Germany, the Republic of France and the Grand Duchy of Luxembourg on the establishment of an International Commission on the Protection of the Mosel against Pollution, Paris, 20 December 1961, for text see http://213.139.159.34/servlet/is/399/Moselprotokoll_d.pdf .

[16] Convention on Co-operation for the Protection and Sustainable Use of the River Danube (Danube River Protection Convention) of 29 June 1994, Federal Law Gazette II 1996, p. 875, http://www.icpdr.org/icpdr-pages/about_us.htm .

[17] Supplementary Protocol of 22 August 1996 to the Ems-Dollart Treaty regulating Cooperation on Water and Nature Conservation in the Ems Estuary, Federal Law Gazette 40 II of 23 September 1997.

[18] Convention of 8 October 1990 on the *International Commission for the Protection of the Elbe* (CZ/D/EU), Magdeburg, 8 October 1990, Federal Law Gazette II 1992, p. 943.

[19] Convention of 11 April 1996 on the *International Commission for the Protection of the Oder,* Federal Law Gazette 40 II of 23 September 1997.

3.1.3 Bilateral agreements

Numerous originally bilateral agreements were the forerunners of present-day multinational conventions. More recent bilateral agreements mostly serve to clarify details between specific states in the implementation of multinational conventions (e.g. division of labour and allocation of costs); for example:

- Agreement of 19 May 1992 between the Federal Republic of Germany and the Republic of Poland on Cooperation in the field of Water Management of Boundary Waters[20]
- Agreement between the Federal Republic of Germany and the European Economic Community, on the one hand, and the Republic of Austria, on the other, on cooperation on management of water resources in the Danube Basin – Statute of the Standing Committee on Management of Water Resources – Declaration[21]
- Agreement of 12 December 1995 between the Federal Republic of Germany and the Czech Republic on Cooperation on Water Resources Management in Boundary Waters[22].

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20 Agreement of 19 May 1992 between the Federal Republic of Germany and the Republic of Poland on Cooperation in the field of Water Management of Boundary Waters, Federal Law Gazette 3 II of 15 January 1994.

21 Agreement between the Federal Republic of Germany and the European Economic Community, on the one hand, and the Republic of Austria, on the other, on cooperation on management of water resources in the Danube Basin – Statute of the Standing Committee on Management of Water Resources – Declaration, OJ L 90 of 05.04.1990, p. 20 - 25; Federal Law Gazette II 1990, p. 791.

22 Agreement of 12 December 1995 between the Federal Republic of Germany and the Czech Republic on Cooperation on Water Resources Management in Boundary Waters, Federal Law Gazette 17 II of 2 May 1997.

3.1.4 EU provisions

3.1.4.1 Principles

Under the principle of enumerative individual empowerment, the Community can only act if it has been contractually empowered to do so (lack of "competence competence"). Originally the EC treaties did not include explicit powers for the Community to enact comprehensive environmental legislation. It was not until Articles 130r - 130t EC Treaty (Maastricht 1992[23]; in the latest consolidated versions Art. 174 - 176[24]) that the Community was given clear competence in the field of environmental protection.

Both the EC[25] and the individual EC Member States have joined the UNECE Conventions "UNECE Water" and "UNECE Accident" mentioned in Chapter 3.1.1. The EC has adopted directives relating to both conventions, and these have to be transposed into national law by the EC Member States (even if they did not sign the UNECE conventions as individual states)[26, 27, 28].

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23 Treaty establishing the European Community, OJ C 224 of 31/08/1992, p. 0052 et seq. (Maastricht, consolidated version).

24 Treaty establishing the European Community, OJ C 325 of 24/12/2002, p. 0107 et seq. (Nice, consolidated version).

25 According to Art. 281 (ex. Art. 210) EC Treaty the EC (EU) possesses its own personality under international law, OJ C 340 of 10/11/1997, p. 0254 – consolidated version.

26 COUNCIL DECISION of 24 July 1995 on the conclusion, on behalf of the Community, of the Convention on the protection and use of transboundary watercourses and international lakes (95/308/EC), OJ L 186 of 5.8.1995, p. 42.

COUNCIL DECISION of 24 July 1995 on the conclusion, on behalf of the Community, of the Convention on the protection and use of transboundary watercourses and international lakes (95/308/EC), OJ L 186, 5.8.1995, p. 42.

27 Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Federal Law Gazette II 1994, p. 2334-2350.

28 COUNCIL DECISION of 23 March 1998 concerning the conclusion of the Convention on the Transboundary Effects of Industrial Accidents (98/685/EC), OJ L 326, 03.12.1998.

3.1.4.2 Water pollution

As a result of industrial accidents and water pollution, in some cases with transboundary effects within the EC, extensive provisions were enacted even before the UNECE conventions mentioned earlier, for example:

- Directive 82/501/EEC on the control of major-accident hazards (Seveso Directive) [29],
- Directive 96/82/EC on the control of major-accident hazards involving dangerous substances (Seveso II Directive) [30],
- Directive 76/464/EEC on water pollution caused by certain dangerous substances[31].

In a number of bilateral agreements on water pollution control, and also in conventions relating to the river basin commissions, the EC is either an additional party or has observer status.

To a certain extent as a means of broadening Directive 76/464 and supplementing it by an emission-oriented approach, Directive 96/61/EC concerning integrated pollution prevention and control (IPPC Directive)[32] was passed in 1996. However, since the IPPC Directive only covered certain installations, the Commission integrated the other relevant provisions of Directive 76/464 in its amended proposal for the Water Framework Directive, which as a concept for integrated water conservation is in a better position to solve overlap problems.

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[29] COUNCIL DIRECTIVE 82/501/EEC of 24 June 1982 on the major-accident hazards of certain industrial activities, OJ L 230 of 5.8.1982, p. 1 (Seveso Directive).

[30] Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances; OJ L 010 of 14.01.1997, p. 13 (Seveso II Directive).

[31] Council Directive of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (76/464/EEC), OJ L 129, 18.5.1976, p. 23,

codified version: 2006/11/EC of 15 February 2006, OJ L 64, 4.3.2006, p. 52,

and daughter directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC.

[32] Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control, OJ L 257, 10.10.1996, p. 26ff, codified: Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (codified version), OJ L 24, 29.01.2008, p. 8.

3.1.4.3 Water Framework Directive

For a number of reasons, some of which are discussed elsewhere in this report, and especially with a view to ensuring integrated protection of water and sustainable use of water resources, *"Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy"* (Water Framework Directive, WFD)[33] initiated a reorganisation of the entire EU water legislation. As a "framework directive", the WFD seeks to bring together all individual acts of legislation and international conventions relating to water utilisation and water conservation. The WFD applies to all types of waters within the territory of the EU, i.e. surface waters (rivers, lakes, transitional waters and coastal waters[34]) and groundwater.

3.1.4.3.1 Concept of the WFD

To make it easier to understand the discussions in the chapters that follow, we give here some brief introductory notes on the concept of the WFD.

The *general objectives* of the WFD are described in Article 1; the following in particular should be noted:

- Ban on deterioration; requirement to protect and improve aquatic ecosystems and terrestrial ecosystems that depend on them,
- Promotion of sustainable use of water,
- Gradual reduction or discontinuation of discharges and emissions of priority substances or priority hazardous substances,
- Contribution to mitigating the effects of floods and droughts,
- Realisation of objectives of international conventions.

The *environmental objectives* are specified in Article 4 in conjunction with Annexes named there and in conjunction with other Articles relating to implementation.

[33] DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive, WFD), OJ L 327, 22.12.2000, p. 1.

In practice the objectives are to be achieved by means of *"programmes of measures"* (Art. 11, Annex VI). A distinction is made here between specified "basic" measures which are to be fulfilled as a minimum requirement (Art. 11 (3) a-l)[35] and a non-exhaustive list of "supplementary" measures, which may be necessary in addition in order to achieve the objectives in Article 4. The first basic measure (Article 11 (3) a[36]) contains what amounts to an exhortation to (continue to) implement all other Community provisions relating to water conservation. In fact the WFD hardly repeals any existing provisions. Only in a very few cases, mostly for systematic legal reasons or because individual points are regulated newly and differently by the WFD, does the WFD repeal existing legal acts or phase them out within a specified period (Art. 22). As a result, all other basic measures which follow in Article 11 (paragraphs 3 b-l) can be regarded as an invitation to investigate the extent to which measures in Article 11 have already been implemented in the national provisions transposing other Community provisions or by national provisions that were already in existence anyway, or whether there is a need for supplementary arrangements.

All Member States must draw up the programmes of measures under Article 11 not later than 2009 and put them into practice by 2012. The measures are to be reviewed and, if necessary, updated not later than 2015, and every six years thereafter (Art. 11 (7)). This will be accompanied by extensive reporting both to the EU and by the EU (Art. 15).

The prerequisites for drawing up the programmes of measures were an inventory consisting of an analysis of the characteristics of the river basin district, a review of the environmental impacts of human activity and an economic analysis of water use by the

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> *Continued from previous page* <

[34] Although the provisions of the WFD also serve to *protect* the "seas" and the "marine environment", the WFD does not include any concrete provisions such as quality standards for the "open sea" (the coastal waters regulated by the WFD correspond to a "1-mile zone").

[35] Article 11

Programme of measures

(1) Each Member State shall ensure the establishment for each river basin district, or for the part of an international river basin district within its territory, of a programme of measures, taking account of the results of the analyses required under Article 5, in order to achieve the objectives established under Article 4. Such programmes of measures may make reference to measures following from legislation adopted at national level and covering the whole of the territory of a Member State. Where appropriate, a Member State may adopt measures applicable to all river basin districts and/or the portions of international river basin districts falling within its territory.

(2) Each programme of measures shall include the "basic" measures specified in paragraph 3 and, where necessary, "supplementary" measures.

(3) "Basic measures" are the minimum requirements to be complied with and shall consist of…(3) a-l.

end of 2004 (Art. 5, Annexes II, III), the results of which were communicated to the Commission as a report in March 2005. On the basis of this, the monitoring programmes were first drawn up, then implemented from 2006 onwards (Art. 8, Annex V). The inventory and the initial results of the monitoring programmes form the technical basis for drawing up the monitoring programmes pursuant to Article 11.

A significant new aspect of the Water Framework Directive is the fact that waters are no longer to be managed within the boundaries of administrative units (nation states, provinces etc.), but at the level of river basin districts (catchment areas). As a result, the "transboundary character" (e.g. of water pollution due to accidents), which is otherwise so important in international law, is relegated to no more than secondary importance, at least within the Community of the EU Member States In the case of transboundary river basin districts, appropriate consultations between the Member States are to be coordinated right from the start of the WFD implementation process, clearly regulated in administrative agreements, and reported in suitable form to the Commission (Art. 3)[37].

Extensive *"management plans"* are to be drawn up for the river basin districts (Art. 13, Annex VII). One important component of the management plans is a summary of the programmes of measures pursuant to Article 11, including information on how they are intended to achieve the objectives under Article 4; this must include a summary of the measures taken to prevent or reduce the impact of accidental pollution incidents. The deadlines for publishing (2009), reviewing and updating the management plans (2015 and every 6 years thereafter) are the same as those for the programmes of measures. Management plans and their precursor stages are an important part of the public involvement required by the Water Framework Directive.

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36 Article 11 3 a) Measures to implement Community water conservation provisions including measures pursuant to the provisions of Article 10 and Annex VI Part A.

37 In the case of river basin districts extending beyond the territory of the Community, the Member States concerned are to "endeavour" to establish appropriate coordination with the relevant neighbouring states (Art. 3 para. 5).

Table 1 Timetable for implementation of WFD

Key data	Date	Action
Entry into force of WFD	**Dec. 2000**	Perform inventory
Transposition into national law	**Dec. 2003**	
Results of inventory Report to Commission (March 2005)	**Dec. 2004**	
Monitoring programmes complete Report to Commission (March 2007)	**Dec. 2006**	Draw up monitoring programmes
Programmes of measures/ management plan drawn up Report to Commission (March 2010)	**Dec. 2009**	Perform monitoring Draw up programmes of measures/ management plans
Measures put into practice Report to Commission	**Dec. 2012**	Implement programmes of measures
Objective of "good status" achieved; start of new management plan Report to Commission (March 2016)	**Dec. 2015**	Period for achieving objectives

The WFD goes into great detail in its descriptive definitions of bodies of water (Annex II) and its definition of water status (Annex V). Compared with previous provisions, the biological and structural status of the water has become considerably more important compared with purely chemical water quality. Nevertheless, in view of the greater experience available the definition of *immission-oriented chemical* quality standards[38] is currently more advanced than for biological or structural water quality. Water status is to be monitored (Art. 8); this is necessary for drawing up the programmes of measures and reviewing their progress, and also in order to identify unknown input sources.

With regard to implementation of the programmes of measures laid down in the management plans for the catchment areas, Article 4 (environmental objectives) requires for surface waters that "good status", or in the case of heavily modified bodies of water

[38] The classification of "ecological status" is also based partly on environmental quality standards for chemical components.

"good ecological potential" in conjunction with "good chemical status", is to be achieved not later than 2015.[39]

It is however possible in principle to claim exceptions.

This is possible, for example, if

- there are technical feasibility problems (extension of deadline) (Art. 4 (4))
- it would be disproportionately expensive (extension of deadline) (Art. 4 (4))
- achievement of the objectives would for practical or cost reasons be impossible (less stringent environmental objectives) (Art. 4 (5))
- there is a temporary deterioration in status as a result of exceptional circumstances which could not reasonably have been foreseen, such as floods, droughts and accidents (Art. 4 (6)).

However, the barriers to claiming exceptional situations are high. Extensive justifications are required in the management plan, and steps must be taken to prevent further deterioration and to restore the original state. It is also necessary to establish the conditions under which one can claim circumstances which are exceptional or which cannot reasonably be foreseen, and the indicators that are to be used for this purpose. The impacts must be reviewed regularly (annually).

Another point which was not a focal aspect of the "established" water management legislation is the compulsory inclusion of *cost-effectiveness analyses*. In particular, an economic analysis of water use is to be made, and on the basis of its results steps must be taken to ensure that water services cover costs (Art. 5, Art. 9, Annex III). The Member States are also to provide for the use of economic instruments in the programmes of measures (Recital 38).

The Water Framework Directive attaches great importance to *public information and consultation* (Art. 14). In particular, management plans and, on request, background documents must be made available at an early stage, i.e. at the start of planning (periods of 1-3 years in the different stages of specification) and periods of 6 months must be granted for written comments on the documents.

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39 In the case of groundwater, "good status" is to be achieved by 2015.

In Germany the intention is that with the adoption of the nationwide Environmental Code, which is planned for 2009, large areas of water law, which have hitherto been the province of the federal Länder, will be transferred to the federal level; this also includes competence for a large part of the further implementation of the WFD. However, it seems unlikely that a consensus will be reached on the Environmental Code in its planned form. There are however plans to adopt the part relating to water law separately in unchanged form as a revised version of the Federal Water Act *(Wasserhaushaltsgesetz – WHG)*. The bill had its first reading in the Bundestag on 20.03.2009 and was then referred to the committees.

3.1.4.3.2 Relationship between environmental objectives and measures

Article 11 (3) specifies the “basic measures” which are to be performed as a minimum to achieve the environmental objectives defined in Article 4. Here it is important to bear in mind the overriding “purpose of this Directive” set out in Article 1 with its five points a) – e).[40]

Important aspects of this purpose are the **“ban on deterioration”** and the **“improvement commandment”**.

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[40] Article 1 WFD

The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;

b) promotes sustainable water use based on a long-term protection of available water resources;

c) aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;

d) ensures the progressive reduction of pollution of groundwater and prevents its further pollution, and

e) contributes to mitigating the effects of floods and droughts, and thereby contributes to:

- the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use,
- a significant reduction in pollution of groundwater,
- the protection of territorial and marine waters, and
- achieving the objectives of relevant international agreements, including those which aim to prevent and eliminate pollution of the marine environment, by Community action under Article 16(3) to cease or phase out discharges, emissions and losses of priority hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.

The **ban on deterioration** is associated with achieving “good status” for all bodies of water within 15 years after the entry into force of the Directive.[41] For surface waters that means good chemical status and good ecological status. For groundwater the objectives are good chemical status and good quantitative status. In the same period, artificial and heavily modified bodies of water are to be protected and enhanced with the aim of achieving good chemical status and good ecological potential. If there is reason to expect that these objectives will not be achieved for a body of water, appropriate measures must be taken to achieve the individual objectives. These requirements initiate an implementation process which progressively reduces the existing difference between the current status and the targeted status over the planned period. The improvement commandment is thus a prospective goal, the achievement of which should be regarded as a continuous process and which is due to be completed by the end of 2015, subject to any exceptions.

The **ban on deterioration** is intended to place a lower limit on the current status of a body of water, so that any further deterioration in its status can be ruled out.[42] In this context it is irrelevant whether the status of the body of water at the time in question is good or poor. Neither does a highly deficient initial situation justify a further deterioration in the body of water, and this is intended to prevent any further obstacles to achieving the objective of “good status”. For this reason the ban on deterioration is permanently binding, and not tied to a prospective target horizon. In the general debate there are various points of view regarding the starting date for the ban on deterioration. It can be argued that the ban comes into force with the implementation of the programmes of measures, since the environmental objectives under Art. 4(1) WFD are to be understood in relation to their application and there is no need to take any earlier measures aimed at the objectives of the WFD. This interpretation would, however, run contrary to the real purpose of this ban, since there would conversely be no ban on deterioration until the preparation (2009) or even the implementation (2012) of the programmes of measures. For this reason some people put forward the opposing argument that the ban on deterioration became effective upon the entry into force of the WFD, or at least with its transposition into national law (2003), in order to fulfil its real purpose.[43] Furthermore, the WFD also lacks a concrete definition of the term

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41 Cf. Art. 4(1) a) ii) and iii) and Art. 4(1) b) ii).

42 Cf. Art. 4(1) a) i) and Art. 4(1) b) i).

43 Cf. for example Ginzky, H. (2008): Das Verschlechterungsverbot nach der Wasserrahmenrichtlinie. Natur und Recht, Vol. 30 (2008), p. 147-152, Springer Verlag.

"deterioration". This means there is a need for an interpretation that clarifies what is meant by deterioration in the context of the Directive. This point is also the subject of broad discussion in the relevant circles. The results are of decisive relevance to this examination, and are therefore discussed in the following Section 3.2.

With its requirement to prepare **programmes of measures** for every river basin district and **management plans** for their catchment areas, the WFD lays down the general instruments for implementing the objectives. The programmes of measures contain the measures deemed necessary to achieve "good status" and at the same time prevent deterioration (see above). Chronologically, the management plan is a "subordinate" document which, in addition to a summary of the programmes of measures, also contains the results of the inventory and further information about the situation in the individual catchment area. Thus it has a largely informative and normative character, in that it seeks to bring together all relevant facts and figures and to prepare them for public participation.[44] The benefit relevant to action is therefore to be expected from the programme of measures, which gives a concrete indication of the measures that are to be implemented to achieve the objectives.

In the **inventory**, the first point of interest is the identification of the anthropogenic impacts acting on the body of water. This reveals what material, ecological and structural problems exist for future planning which need to be remedied by appropriate measures in the course of time. The economic analysis accompanying the inventory is also intended to make it possible to ascribe the individual pollution loads to a polluter or group of polluters and thereby identify the source of the problem. The result of linking these two steps is a differentiated **pollution impact analysis**[45] which is intended to permit a targeted approach to the relevant trigger paths. It must however be remembered that this approach is merely a snapshot at the time the inventory is performed. This consideration take no account of any possible changes due to natural influences or human activity which will probably take place between this time and the relevant target horizon 2015, and which could have a serious impact on the body of water. This gap in the forecast is closed by the **baseline scenario**, in which all foreseeable natural, political, legal, economic and technical developments that are likely to influence the water situation are to be integrated. Such influences could be positive, e.g. as a result

[44] Cf. Breuer, R. (2007): Praxisprobleme des deutschen Wasserrechts nach der Umsetzung der Wasserrahmenrichtlinie. Natur und Recht, Vol. 29 (2007), p. 503-513, Springer Verlag.

of measures planned or implemented, or negative, e.g. as a result of modified or intensified uses or exhausted ecological regeneration potential. For measures planning, the **baseline scenario** indicates the relevant actual situation, by which the deviation from good status is to be measured.[46]

For the programmes of measures, the concrete action requirements with regard to the individual river basin district arise from the discrepancy between the actual situation, which results from determining the baseline scenario, and the targeted "good status", which is to be seen as the planned quantity. To this end the programmes pursuant to Art. 11 WFD contain the appropriate measures in the light of the inventory for taking the steps necessary to achieve the environmental objectives under Art. 4 WFD. They thus serve the requirements for compliance with the ban on deterioration and those for achieving "good status" in the body of water. Programmes of measures consist of **basic measures**, which in accordance with Art. 11 (3) WFD represent the necessary minimum requirements, and **supplementary measures** pursuant to Art. 11 (4) WFD, which may also be needed to achieve the objectives.

Consequently the programmes have to make a distinction between measures that serve to prevent further deterioration in water status, and measures that will in the medium to long term remedy the deficit between the actual and planned situations. This does not exclude the possibility that individual measures may contribute simultaneously to achieving both objectives. It does however demonstrate the need to go beyond considering the pollution actually detected in the water, which is frequently of a structural or continuous character, and to include potential impairments which are not acting all the time and which may for example be the result of accidents or incorrect handling. The choice of appropriate measures should not be based exclusively on their ecological effectiveness. This factor should rather be combined with economic efficiency.[47] In this respect Annex III to the WFD calls for "the most cost-effective combination of measures in respect of water uses to be included in the programme of measures under Article 11".

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[45] Consideration of cause-effect relationships, cf. European Commission (2002): Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document no.°3. Analysis of pressures and impacts. Working group 2.1 Impress, German translation.

[46] Cf. Henneberg, S.C. (2006): Randbedingungen und Aspekte bei der Aufstellung des Maßnahmenprogramms für eine Flussgebietseinheit. KA Abwasser, Abfall, Vol. 53, No. 2, p. 140-145.

In practice the implementation of this methodological approach still causes a number of problems. For one thing, the abstract definition of good status is not sufficiently meaningful at the level of individual polluter groups. It is therefore important to first define good status with regard to individual criteria, in order to give more concrete shape to the objective. Whereas assessment of chemical status does not cause many problems as a result of ample past experience, use of the terms "good ecological status" and "good ecological potential" is still much more of an experimental field. It continues to be difficult to estimate the effectiveness of individual measures. Where chemical criteria in the form of pollutant loads are concerned, this is relatively practicable. Effectiveness can be expressed as avoided or reduced emissions. Consideration of biological or structural factors is far more difficult, since the effectiveness figures mostly have to be aggregated in terms of a comparable quantity. Even if it is possible in most cases to do without expressing the effectiveness of measures in money terms, there are still numerous problems with regard to forecasting, and above all quantifying, the effects of plans.

3.1.4.4 Directive 2008/105/EC – "Daughter Directive Priority Substances"

Christmas 2008 saw the publication of Directive 2008/105/EC, to be implemented by 13.07.2010.[48] It is commonly known as the "Daughter Directive Priority Substances" (to the Water Framework Directive). Thus 32 years after the approach of Directive 76/464/EEC introducing binding immission and emission values for particularly problematic substances in bodies of water, the Community has succeeded in laying down environmental quality standards for surface waters in the European Union for the "priority substances" announced in Annex X to the WFD (Annex I).[49] Moreover, the

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47 Cf. Görlach, B.; Kranz, N.; Interwies, E.; ***Vorschlag für eine Methodik zur Auswahl der kosteneffizientesten Maßnahmenkombinationen für die Wasserrahmenrichtlinie***, GWF Wasser, Abwasser, Vol. 146, No. 5, p. 412-417, 2005.

48 Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC, OJ L 348, 24.12.2008, p. 91; entry into force 13 January 2009, to be transposed into national law by 13 July 2010.

49 Directive 76/464/EEC introduced a relevant list of substances under the heading "List I", but this was never finally adopted with substances and values. It was only for a small number of substances that immission quality objectives and emission limit values were laid down through the daughter directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC to Directive 76/464/EEC. The provisions of these directives are incorporated in Annex IX to the WFD. Directive 2008/105/EC repeals the 76/464/EEC daughter directives with effect from 22.12.2012.

"daughter directives" to Directive 76/464/EEC were repealed, because the provisions for the substances regulated in them were incorporated in the Water Framework Directive (Annex IX) or the daughter Directive 2008/105/EC. This introduced environmental quality standards both for annual average concentrations (AA-EQS) and, in the case of certain substances, for maximum allowable concentrations (MAC-EQS). The monitoring results for the substances regulated here are included in the assessment of "chemical status". Non-compliance leads to classification as "poor chemical status", which results in the overall status of the water body[50] being downgraded to "poor", with the necessary counter-measures.

Directive 2008/105/EC distinguishes "priority substances", inputs of which are to be gradually reduced, and "priority hazardous substances", which are toxic, bioaccumulative and persistent or which give comparable cause for concern (Annex II = revised version of Annex X WFD). These include cadmium, mercury, pentachlorophenol, tributyl tin and polychlorinated aromatics. Inputs and emissions of these substances are to be phased out completely within the next 20 years, so that in the long term they will no longer occur in bodies of water and the marine environment (Art. 16 WFD). To this end an inventory of emissions, discharges and losses is necessary. There is also a list of substances which are to be examined with a view to possible classification as priority substances or priority hazardous substances (Annex III).

Although – like Directive 76/464/EEC before it – the WFD expressly claims that it intends to lay down both emission and immission rules for bodies of water, the "WFD Daughter Directive on Priority Substances" initially contains no new provisions on emissions.

Originally it was planned to effect the transposition of Directive 2008/105/EC into German law by means of the nationwide Environmental Code *(Umweltgesetzbuch – UGB)*, which was to be adopted in 2009, or the revised version of the Federal Water Act *(Wasserhaushaltsgesetz – WHG)* that was to be enacted instead. Due to time pressures, this will no longer be possible, so a separate ordinance is to be issued at federal level.

The creation of environmental quality standards under the WFD and their relationship to other values and requirements of relevance in the field of water conservation is discussed in more detail in Section 3.3.

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50 or the potential in the case of heavily modified bodies of water.

3.1.4.5 The Floods Directive

The management plans of the Water Framework Directive, which are intended to achieve good ecological and chemical status in bodies of water, also help to mitigate the effects of floods. However, reducing the flood risk is not one of the principal aims of that directive; and it does not take any account of future changes in the flood risk as a result of climate change.[51] And so when the Water Framework Directive was passed, it was clear that a separate directive addressing the flood problems would follow; this was published in November 2007.[52] In terms of conceptual structure, this directive follows on directly from the Water Framework Directive. The Floods Directive too takes the river basin unit or river catchment area as its geographical action level, and the international administrative arrangements made pursuant to Art. 3 WFD are used to implement the Floods Directive (Art. 3).

It is to be implemented in three steps, each limited by a deadline (Chapter II – Chapter IV):

1. Preliminary flood risk assessment (by 22.12.2011)
2. Flood hazard maps and flood risk maps (by 22.12.2013)
3. Flood risk management plans (by 22.12.2015)

On the basis of the *preliminary assessment* (Chapter II), which is based on available or readily derivable information (e.g. from existing studies), the Member States designate those areas where it has to be assumed that a potential significant flood risk exists or is considered possible.

The *flood hazard maps* (Chapter III) show the geographical areas that could be flooded according to scenarios of varying degrees of probability.

The *flood risk maps* (Chapter III) show potential adverse consequences associated with flood scenarios, such as

- number of inhabitants potentially affected,
- types of economic activity.

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[51] From Recital 4 to the Floods Directive

[52] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks , OJ L 288, 6.11.2007, p. 27 et seq.

- installations as referred to in Annex 1 to the IPPC Directive[32],
- protected areas potentially affected,
- other information, e.g. on other significant sources of pollution.

On the basis of the above mentioned maps the Member States develop coordinated *flood risk management plans* (Chapter IV) including

- the conclusions drawn from the preliminary assessment,
- the flood hazard maps and flood risk maps and the conclusions drawn from them,
- a description of the objectives of flood risk management,
- a summary of the measures and their order of priority in relation to achievement of the objectives, including the measures from other legal acts of the Community, such as the Environmental Impact Assessment (EIA) Directive[53], Seveso-II Directive[30], SEA Directive[54] and WFD,
- a description of its implementation, including public involvement.

The *flood risk management plans* take account of relevant acts such as costs and benefits, environmental objectives of the Water Framework Directive, water resources management, regional policy, land use, nature conservation, shipping and port infrastructure. They address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems. They must not have adverse effects on upstream or downstream countries, unless such measures have been coordinated.

Unlike the WFD, which involved considerable readjustment for established water resources management in all Member States, the Floods Directive offers the option of using existing flood risk assessments, flood hazard maps and flood risk maps, and

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53 Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, OJ 175 of 05.07.1985, p. 40ff.

54 DIRECTIVE 2001/42/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, OJ L 197 of 27.06.2001, p. 30ff.

The foundations for the introduction of the SEA were laid, among other things, by the entry into force of the Aarhus Convention and the *Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991)*.

flood risk management plans if these were prepared before 22.12.2010 and their content complies with the requirements of the Directive (Chapter VII).

3.2 Article 11 (3) l WFD – Scope and limits

Article 11 (3) l WFD[55] calls for measures that address installation-related water conservation, the consequences of unexpected pollution, timely detection and early warning of relevant events, and risk reduction in the case of unforeseen accidents which have already occurred. These measures are classified as basic and are therefore a compulsory requirement.

However, the WFD does not provide any clear concrete suggestions or provisions regarding strategies or implementation measures, which means the Member States can pursue their own course here[56]. The Commission will however report on the implementation of the Water Framework Directive not later than 2012 (and every 6 years thereafter, Art. 18 (1)). The Commission may if appropriate draw up its own “strategies against pollution of water by any other pollutants or groups of pollutants, including any pollution which occurs as a result of accidents” (Art. 16 (9). This will largely depend on the Commission’s assessment of the individual national measures relating to the topic.

3.2.1 Relevance to WFD context

Article 11 (3) l WFD describes one of the basic measures to be used to achieve the objectives of the WFD, and takes a broad look at *precautions against unexpected pollution incidents*. Correct placement in the context of the WFD measures is far from trivial, since for one thing it is very difficult to measure the contribution that such individual measures make to achieving good status (e.g. if the “unexpected incident” never occurs, the (precautionary) measure has not achieved anything). For another thing, the WFD deals elsewhere with measures and legislation that also cover at least part of this

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55 Art.11 (3) “Basic measures” are the minimum requirements to be complied with, and comprise

l) any measures required to prevent significant losses of pollutants from technical installations, and to prevent and/or to reduce the impact of accidental pollution incidents for example as a result of floods, including through systems to detect or give warning of such events including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems.

56 In the case of the “Floods” complex, however, it was clear when the WFD was published that there was going to be a separate directive on this subject.

subject. Thus looking at this part of the Directive on its own does not permit any reliable statements about the steps necessary for implementation. Nevertheless, we intend first to take a look at the provisions of Article 11 (3) I WFD, in order to lay the necessary foundations for the provisions that follow and to clarify what concrete requirements the Directive lays down, so that they can then be integrated into the overall context of the implementation process.

The topic of precautions against hazards is taken up in the Recitals to the WFD. For example, Recital (39) states:

"There is a need to prevent or reduce the impact of incidents in which water is accidentally polluted. Measures with the aim of doing so should be included in the programme of measures."

Thus the Directive makes it clear at an early stage that the task of preventing hazard situations and the resulting adverse impacts on bodies of water must be addressed in the context of the Directive.

This claim is taken up in Article 11 (3) I WFD. Here the EU calls upon the Member States to ensure that the programme of measures includes *any measures required*

(i) *"to prevent significant losses of pollutants from technical installations and" ...*

(ii) *"to prevent and/or reduce the impact of accidental pollution incidents, for example as a result of floods," ...*

(iii) *"including through systems to detect or give warning of such events and" ...*

(iv) *"including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems."*

The breakdown of this section adopted here – and also used later in this report – is intended to make it clear that the WFD addresses various areas of hazard precautions and hazard management. These are largely based on the course of a hazard incident and therefore involve a variety of actors.

The task of *distinguishing between Article 11 (3) I WFD and other measures and legislation* becomes relevant as soon as we look at Article 11 (3) a WFD, which regards all *"measures required to implement Community legislation for the protection of water"* as belonging to the basic measures. According to Annex VI Part A WFD, for example, these also include the Seveso-II Directive[30] and the IPPC Directive[32]. Accordingly, for installations that fall within the scope of the two directives mentioned, Article 11 (3) I WFD does not give rise to any additional need for regulations with regard to preventing substance releases.

Thus the wording of Article 11 (3) I WFD makes it clear that precautions against hazard situations and control of hazard situations arising from the release of pollutants require a multi-stage approach to a solution. This sequence of steps is relevant to the programme of measures, but it needs to be specified in more concrete terms. It is thus necessary to describe what possibilities are available within the individual points and how they are to be integrated in the programmes of measures.

The preceding description of Article 11 (3) I WFD provides the basis for concrete specification of the requirements arising from this sentence in the Directive. Nevertheless, individual points are not comprehensively highlighted without further interpretation, and for this reason they need to be examined more closely in the context of the overall regulatory scope of the Directive, in order to give more concrete shape to the requirements. Essentially this step is necessary to narrow down the scope of Article 11 (3) I WFD. The following subsections therefore take a detailed look at the individual elements of Article 11 (3) I WFD.

3.2.2 Losses of significant quantities of pollutants from technical installations

Article 11 (3) I WFD first of all speaks about **preventing significant losses of pollutants from technical installations**, without any detailed definition of the terms (a) losses, (b) significant quantities and (c) technical installation. “Pollutant” means “any substance liable to cause pollution, in particular those listed in Annex VIII”[57].

Item a) The German term used here – “Freisetzung” – means “release” and can generally be interpreted as a kind of emission. The word “losses” is used at this point [58] in

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[57] Art. 2 No. 31 WFD.

[58] The wording of the English version of Art. 11 (3) I) WFD is: „*[…] to prevent significant losses of pollutants from technical installations […]*“.

the English version of the Directive.[59] Thus the release of a substance is equated with a loss to the environment. This means that "release" as a kind of emission differs from the term "discharge" otherwise used, which is to be interpreted as an intentional emission of a substance. "Release" is therefore to be understood solely as an unintentional emission which may be spontaneous or not directly controllable. Thus the scope of Article 11 (3) I WFD is confined to this type of emission of substances.

Item b) The prevention of pollutant losses is relativised by the significant quantity. The logical conclusion is that preventive measures are to be taken in particular if there is a theoretical possibility that a certain quantity of a pollutant may be released. Whether a quantity is significant is not clearly defined, but can be narrowed down with the aid of the following criteria:

- *Significant* in everyday usage is employed for things that are not of minor importance, but are considerable or substantial. Moreover, something significant is usually clear or recognisable. Applying this to its use in Article 11 (3) I WFD, a loss of a significant quantity of a substance takes place if it is possible to detect in the water an effect that can be ascribed to the unusual emission.[60]
- Within the Directive, *significant* is also used in connection with *significant pollution*. Thus it can be argued that the quantity of a pollutant is *significant* if it can cause *significant pollution* of the water. In the implementation process for the Directive, pollution is defined as a "direct effect of an environmentally relevant human activity"[61], which leads to an effect in the water (e.g. change in water quality). The pollution is considered significant if it influences the status of the water so much that it fails to comply with the objectives of the Directive. In principle we speak here of a hazard assessment which analyses the relationship between pollution and impacts.[62]

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59 Article 1 c) WFD reads: „*[…] measures for the progressive reduction of discharges, emissions and losses of priority substances […]*".

60 In the WFD, emissions are examined in connection with their impacts on the body of water. For definition purposes this raises the problem that the loss is seen in relation to the flow rate of the water in question. For this reason the same quantity of a pollutant may have to be judged significant in water body X, whereas it has no detectable effects in water body Y.

61 European Commission (2002): Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document no. 3. Analysis of pressures and impacts. Working group 2.1 Impress, German translation.

62 Cf. EC (2002), Footnote 61: Under the WFD, it is not only the resulting status of the water that is of interest when assessing pollution, but also the (ecological) impact triggered by the change.

- Losses of pollutants from technical installations are, by their nature, spontaneous events which may result in sudden, non-continuous pollution of the water or in slow or gradual emissions, which as such are not intended and not directly perceived. In terms of the environmental objectives pursuant to Art. 4 WFD, such incidents will therefore not be of great strategic relevance for the achievement of good status[63], but will be of much greater importance for compliance with the ban on deterioration. This is particularly true if there is reason to fear that losses will produce a negative deviation from the prevailing actual situation. On this basis the pollutant quantity is significant if its release can be expected to bring about a deterioration in status under the WFD[64] and this continues to endanger the achievement of good status.

- This interpretation is also confirmed by the exception under Art. 4 (6) WFD[65], according to which a deterioration due to accidents is not necessarily to be equated with infringement of the environmental objectives of the Directive, if the accidents are due to exceptional and unforeseeable circumstances and if suitable preparatory measures are to be taken for such cases as well, in order to prevent further deterioration and prevent any spread to adjacent bodies of water. At the same time the WFD requires[66] all practicable steps to be taken to restore the status of the body of water to what it was before the exceptional impacts occurred. This implies that in fact a deterioration in status only exists if the original status cannot be restored without human intervention.[67] Thus the pollutant quantity is significant if a loss can be expected to give rise to a deterioration due to a non-self-remedying (temporary) negative change and one cannot reasonably rule out the possibility that this change will occur.

- What is more, the significant quantity must be dependent on the pollutant in question and its individual properties. The quantity of pollutant that leads to pollution of

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[63] Above all, it is difficult to imagine that as a result of a pollution/impact analysis the (possible) incidents will find their way into the planning of measures in the interests of the targeted improvement in status, in order to remedy the deficit between actual status and good status, since it is only the hazard that exists and not the actual pollution.

[64] This line of argument is in turn based on an interpretation of the term “deterioration”, which is also not defined by the Directive. Here the underlying interpretation regards the ban on deterioration in the overall context of the Directive as a means of supporting and safeguarding the way to good status. On this basis a deterioration in the status of the body of water only exists if the requirement to achieve the objectives is threatened or additionally impeded by an external influence. Not every adverse change is to be equated with a deterioration (in status), especially not if the adverse change only occurs temporarily and clears up without additional intervention. Cf. Ginzky (2008).

[65] Article 4 (6) WFD states that *“temporary deterioration in the status of bodies of water shall not be in breach of the requirements of this Directive if this [...] is the result of circumstances due to accidents which could not reasonably have been foreseen […]”.*

[66] See Article 4 (6) d WFD

the body of water is then to be regarded as significant. The WFD speaks of pollution in the case of substance releases *"which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems, which result in damage to material property, or which impair or interfere with amenities and other legitimate uses of the environment"*[68]. In this context there is once again no automatic connection with the environmental objectives in Art. 4 WFD, since even if there is no infringement of the ban on deterioration, a release can still result in pollution in the sense discussed here and can thereby become relevant to the requirements of Article 11 (3) I WFD. This is true especially in cases where other uses are restricted by a brief adverse change in the status of the water which later clears up on its own and no longer presents a threat to long-term achievement of the objectives.

Item c) Prevention of pollutant losses from technical installations must be guaranteed. The WFD does not provide a more detailed definition of the term "technical installation" either. The term "installation" is defined differently in the Seveso-II Directive and the IPPC Directive. Both approaches could be taken as a guide to its use in the WFD.

- According to the IPPC Directive, an installation is a "stationary technical unit" where industrial activities are carried out which "could have an effect on emissions and pollution"[69].

- According to the Seveso-II Directive, an installation is "a technical unit within an establishment in which dangerous substances are produced, used, handled or stored. It shall include all the equipment, structures, pipework, machinery, tools, private railway sidings, docks, unloading quays serving the installation, jetties, warehouses or similar structures, floating or otherwise, necessary for the operation of the installation."[70]

Both definitions permit the conclusion that a (technical) installation is a stationary object. It can therefore be concluded first of all that the field of regulation does not

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[67] It must be noted that not every deterioration is the result of accidents which could not reasonably have been foreseen, and that there are a large number of foreseeable hazards.

[68] See Art. 2 No. 33 WFD.

[69] Art. 2 No. 4 IPPC Directive.

[70] Art. 3 No. 2 Seveso II Directive.

relate to the transportation of pollutants, except insofar as transhipment from a means of transport to the installation is concerned.

Thus the first part of Article 11 (3) I WFD is concerned with stationary technical installations in which pollutants are kept or used. Measures to prevent losses from such installations are necessary if the pollutants are present in significant quantities. This is the case if, in the event of immission of this quantity into a body of water, a deterioration in status cannot be ruled out and achievement of the objectives in Art. 4 WFD is endangered. Also relevant are quantities of substances which, by polluting the water, impair both natural and human uses, even if in the long term they do not contribute to failure to achieve the environmental risks.

After these points, the properties of the pollutant handled are of relevance in conjunction with the quantity of pollutant stored, since both factors permit conclusions about the potential scale of the damage. The more dangerous the properties of the substance, the smaller will be the quantity we have to regard as significant. This takes account of the emission-relevant factors, but what is still missing is the immission relationship to the potentially affected bodies of water. Depending on their size, different quantities of pollutant can result in different impact levels. Whether this third factor of the sensitivity of the water body is catered for by an examination of the individual case, or whether the range of application is catered for by minor incident thresholds for substances, remains an open question. At any rate the existing law of installations does not know any such direct relationship with the object of protection affected.[71] In addition to the scope of the Seveso-II Directive and the IPPC Directive, however, Article 11 (3) I WFD evidently results in a broader focus, which above all covers installations below the fields of application of the two directives.

3.2.3 Impact of accidental pollution incidents

In the second part, Article 11 (3) I WFD also calls for the implementation of any measures required *"to prevent and/or to reduce the impact of accidental pollution incidents"*. A central element in this part of the sentence is (in the German version) the expression *unexpected pollution*, which first needs to be defined more clearly. Here too the English version of the WFD provides greater clarity. The English expression is *accidental pollution incident*, which is somewhat clearer than *unexpected pollution*. Interpreting this expression, we find that an incident is accidental if it occurs unexpectedly and is associated with adverse impacts resulting from human or technical failure. Thus natural hazards of the kind cited in connection with floods may give rise to unexpected pollution by causing technical or human failure. Further pollution entrained by such natural occurrences is not relevant to this requirement. Thus accidental pollutions incidents satisfy the following criteria:

- they occur suddenly and/or unexpectedly;
- they are due to an accidental occurrence which is directly or indirectly associated with human or technical failure,
- which may also be triggered by natural causes.

Unlike losses from technical installations, pollution addresses immissions into an environmental medium, the impacts of which on natural and human use are to be counteracted by prevention and containment. The integrating approach of the WFD can be seen here again, in that it calls for safety measures relating to both the source of the hazard and the relevant object of protection or environmental medium; at this point, by contrast with the paragraph previously discussed, the cause of the pollution is initially immaterial.

This draws attention to the fact that unexpected pollution may not be due exclusively to problems in technical installations. Accidents – e.g. during transportation of hazardous substances – may also result in unexpected pollution. Furthermore, the scope of precautionary measures must not be confined to internal event triggers, but must also take in external hazard sources, e.g. natural events such as floods, earthquakes etc.).

Thus the immission-oriented approach requires a new perspective, since it results in requirements which – as well as improving safety at the source of the hazard – also include measures in the environmental medium, especially at the level of the individual body of water. This also makes it clear that total prevention of the entire spectrum of possible hazard sources is not possible, and that precautionary measures must be

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[71] An exception to this is special requirements for installations in protected areas, where one can see the rudiments of an immission-oriented approach.

extended to take in the level of the object of protection. For the management plans, however, it can only be a question of strategic measures, since the kind of pollution involved and the time and place of its occurrence is not known at the time the plans are drawn up. This aspect is illustrated below by the further requirements of Article 11 (3) I WFD (cf. Chapters 3.2.4 and 3.2.5).

3.2.4 Systems for timely detection and early warning

The third item in Article 11 (3) I WFD, with its mention of the implementation of "[…] systems to detect or give warning of such events[72] […]", specifies *technical instruments* as a basic measure for achieving the objectives of the WFD. Although giving warning to people downstream – at least in the case of transboundary impacts – has long been an element of international conventions (e.g. Rio Declaration, see Chapter 3.1.1), the obligation to ensure *active preventive provision of information* with regard to accidents and other events relevant to Article 11 (3) I WFD must, in view of the required degree of concretisation and generalisation[73], be regarded as a genuine *new* requirement of the WFD. Moreover, the *transboundary* aspect which is so important in international conventions becomes less important, since under the WFD bodies of water are managed on the basis of river basin districts, which means that *all* those living downstream, with their uses and other interests affected, have to be given identical treatment regardless of nationality.[74]

Systems for timely detection relate to both the emission and the immission side. The aim is to ensure early detection of a release occurring within a technical installation, in order to make it possible to contain it effectively and to protect and, if necessary, rescue persons potentially affected (e.g. suspension of drinking water uses, evacuation, active control measures). Direct detection of unexpected pollution in the body of water is also important to ensure an adequate level of protection even if the loss is not detected on the emission side.

[72] Note: "such events" relates both to losses from technical installations and to accidental pollution incidents.

[73] Such facilities already existed in bilateral agreements/conventions; e.g. the Dutch/German water quality measuring station at Bimmen/Lobith on the Rhine.

[74] At the EU's external borders the global international conventions (e.g. UNECE Accident, UNECE Water) apply once again, or individual agreements between the EU and these third countries.

Detection is immediately followed by early warning. The warning mechanisms should also use a systematic structure which applies throughout the river basin district and ensures the functioning of all necessary emergency measures if such an event occurs.

Systems to detect or give warning of such events require

- the provision (possibly including new development) and permanent continuous operation of technologies for detecting and assessing sudden events of relevance to water quality
    - both at the potential emitter (e.g. installation operator)
    - and on the immission side in the body of water (e.g. networked automatic monitoring stations with suitable measuring, evaluation and assessment technology)
- the development of emission-oriented and immission-oriented warning and alarm criteria that are compatible with WFD environmental quality standards,
- the preparation of warning and emergency plans including emission-oriented and immission-oriented data,
- the establishment of the necessary organisational structures and preparedness.

3.2.5 Accidents which could not reasonably have been foreseen

The fourth item in Article 11 (3) l WFD also relates to the preceding requirement to reduce the impact of unexpected pollution. The relevant requirements include, *“in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems”*. This emphasises the importance of the water path, whereas in the previous requirements the accidental pollution incidents were not confined to a single environmental medium. The objective does not distinguish whether the reduction in the risk to aquatic ecosystems is to be achieved by isolating the pollutant from the water cycle or by containing the pollutant to prevent it spreading in the water network to protect other ecosystems not so far affected. What is clear, however, is that it is a matter of measures which are taken in response to an incident and which may serve the interests of subsequent after-care to further minimise the damage.

At this point the German version of the Directive uses the term *accident* for the first time. This is not defined either, but it could give the impression that there is a third category of incidents alongside losses from technical installations and unexpected pollution. As already mentioned (cf. Chapter 3.2.3), however, the English text makes it clear that the expressions *accidental pollution incident* and *accident* are to be regarded as largely synonymous. To use the German expressions: unexpected pollution includes the results of accidents.

Various situations are conceivable in which there is a risk to aquatic ecosystems. The appropriate measures to avert danger could be applied to various interfaces. If the incident has taken place but the pollutant has not yet reached the body of water or the water path, the risk to aquatic ecosystems is reduced by stopping it spreading. However, if the pollution has already been identified in the water, this option is probably reduced to preventing further inputs of the pollutant. Even if the pollutant has already been input into the water, the measures to avert danger are aimed at using the means available to prevent further diffusion within the water network, in order to avoid impairing other ecosystems not yet affected (e.g. adjacent bodies of water). In the sequence of events, this action comes after detection of the incident and information of the relevant actors. The immediate response to an incident and the subsequent after-care measures to restore the original status should be individually geared to the course of the incident and the resulting impacts in the body of water. This point is emphasised by Article 4 (6) a WFD, which in the case of accidents that could not reasonably have been foreseen demands that *"all practicable steps are taken to prevent further deterioration in status and in order not to compromise the achievement of the objectives of this Directive in other bodies of water not affected by those circumstances."* Measures of this kind cannot be planned in advance. Therefore the requirement in the Directive can only be intended to activate functioning structures when the circumstances mentioned occur – structures which permit an appropriate response to accidental incidents and make it possible to minimise the risk to aquatic ecosystems.

Another aspect that is not completely clear is when an accident cannot reasonably be foreseen. In this respect, Article 4 (6) b WFD requires the river basin management plan to state *"the conditions under which circumstances [...] that could not reasonably have been foreseen may be declared, including the adoption of the appropriate indicators"*. The Directive does not give any examples of such indicators. Following the logical structure of Article 11 (3) I WFD, it may be argued that an unforeseeable event has not so far occurred in comparable form, so the danger is not recognised as such, or the possibility of its occurrence is ruled out sufficiently, since appropriate safety precautions have been taken or the influence of external triggers is sufficiently improbable. If an accident occurs nonetheless, Article 11 (3) I WFD calls for response measures to contain the impacts as far as possible.

3.3 Accidents and WFD quality standards

The definition of the goals of the WFD is ultimately based on an immission-oriented approach. Many of the initially abstract goals set out in Article 1 are given more concrete shape by means of definitions of the targeted water status – which is ultimately to be “good” from both a chemical and an ecological point of view. What is or is not “good” is defined on an immission-oriented basis. For chemical parameters, this means that the status of the individual body of water is characterised by means of concentration levels for the body in question, and achievement of the objective is tied to compliance with a (concentration-based) quality standard.

In this context, accidents or other incidents within the meaning of Article 11 (3) I WFD are to be regarded as temporary pollutant emissions which are capable of producing a deterioration in the status of the water, and which may even result in its being downgraded to “poor status”. Although the WFD makes it possible to claim exceptional circumstances when assessing the status of the body of water if the “temporary deterioration in status is the result of circumstances which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents” (Art. 4 (6) WFD), the obstacles to this are high (see Chapter 3.1.4.3.1). Moreover, the daughter directive “Priority Substances” (Chapter 3.1.4.4) introduced maximum allowable concentrations (MAC-EQS), at least for certain pollutants; exceeding these results in downgrading of the status of the body of water. In this connection it is interesting to consider whether and to what extent short-term substance inputs are capable of causing environmental quality standards to be exceeded and whether this may have consequences for the established warning and emergency management systems in the river basins. Before we go into these aspects in Chapter 3.3.3 onwards, it is important to describe the standards and substance-related assessment criteria relevant to Article 11 (3) I WFD and discuss them in their various contexts (if desired, this in-depth treatment may be read later).

3.3.1 Development of quality standards for surface waters in the EU

Within the European Community there are not very many quality standards for surface waters that are valid everywhere. Also there is some uncertainty about what is actually legally binding, in view of a number of items of EC legislation which have been implemented differently and incompletely in the Member States. The following digression is intended to clarify the picture. In our examples we always look at the situation in Germany as well. There are bound to be certain differences in implementation in other countries, but the principle should be clear. As implementation of the WFD continues, further standardisation should take place – at least compatible conditions should be created within the river basin districts defined by the EC.

3.3.1.1 Immission standards

In 1976 the EEC issued Directive 76/464/EEC as an action programme for preventing and reducing pollution caused by certain dangerous substances discharged into the aquatic environment of the Community[31]. The chemical pollutants were divided into "List I substances" which were considered particularly toxic, persistent and bioaccumulative and were to be regulated at Community level (Article 6), and the less problematical "List II substances", the regulation of which was to be left to the Member States (Article 7).

In 1982 the Commission, on the basis of Article 6 of Directive 76/464/EEC, put forward a list of 132 substances[75] which were candidates for inclusion in List I. Of these, 30 substances had already been classified as "priority substances". By the time of the entry into force of the Water Framework Directive[76], however, no final List I had been adopted[77].

75 Communication of 22.6.1982 from the Commission to the Council, OJ C 176, 14.7.1982, p. 3. (The Commission had proposed 129 (later extended to 132) substances as candidates for List I, and regarded 30 of them as "priority substances".)

76 See Chapter 3.1.4.3

77 By 1990 five "daughter directives" had been adopted, laying down emission limit values and quality standards for (only) 18 of these 132 substances (Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC (amended by Directives 88/347/EEC and 90/415/EEC). Then the Council stopped regulation for the other substances proposed by the Commission (COM(90) 9 final of 8.2.1990 (ISBN 92-77-57387-2)) with the argument that the law-making process was too slow and ineffective. It called upon the Commission to review its strategy having regard to the new policy of integrated pollution prevention and reduction. This was one of the (main)

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In Germany, the List II substances to be implemented by the Member States were regulated by the 16 Länder (in view of their competence) in 16 largely identical "quality objective ordinances"[78] and implemented under Article 7 of Directive 76/464/EEC by means of programmes (of measures)[79]. The programmes run for 6 years and started in Germany in 2001.

Following a similar system to Directive 76/464/EEC, the Water Framework Directive also seeks to achieve the environmental objectives[80] by providing for substances to be regulated by the Community and substances to be regulated by the Member States. In principle, one could here have simply taken over the definitions (and provisions) from Directive 76/464/EEC – but the Commission was faced with the dilemma that, among other things, the non-implementation or non-existence of Lists I and II even many years after the entry into force of Directive 76/464/EEC prompted the Commission's change of strategy with regard to integrated pollution prevention and control. This led first to the industry/installation-oriented IPPC Directive[32], and then to the WFD, which was geared to bodies of water. For the industries/installations under its regulation, the IPPC Directive adopted as minimum standards the emission limit values of the 76/464/EEC daughter directives.

In the WFD system, the substances to be regulated by the Community reappeared in the criteria for "classification of chemical status" and the substances to be regulated by the Member States in the criteria for "classification of ecological status" of the bodies of water, described in Annex V WFD.

The list of criteria for "classification of chemical status" includes the "priority substances" which are to be regulated pursuant to Article 16 (6-8) WFD and which, since

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reasons for the enactment of the WFD (Communication from the Commission to the Council and the European Parliament concerning "Integrated prevention and control of chemical pollution of surface waters in the European Union", COM(2006) 398 final of 17.7.2006; accompanying the presentation of the proposal for the daughter directive on "Priority Substances", COM(2006) 397 final of 17.7.2006).

[78] In Hamburg, for example: Ordinance concerning quality objectives for certain hazardous substances and programmes for reducing water pollution, of 20 March 2001 (Hamb.GVBl. No. 10 of 26.03.2001, p. 40), last amended on 29 June 2004 by Article 2 of the Ordinance on the implementation of Annexes II, III and V to Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Hamb.GVBl. No. 32 of 09.07.2004, p. 277).

[79] In Hamburg, for example: Programme of the Free and Hanseatic City of Hamburg for reducing water pollution in accordance with Article 7 of Directive 76/464/EEC concerning the discharge of harmful substances into waters, November 2001.

[80] Article 4 WFD

Decision 2455/2001/EC[81] by the Council and the Parliament, have been listed in Annex X WFD, and also the previously regulated substances from the daughter directives to Directive 76/464/EEC (Annex IX WFD). These substance technically replace the List I substances of Directive 76/464/EEC and are currently regulated by the WFD daughter directive "Priority Substances" 2008/105/EC of 16 December 2008.

The list of criteria for "classification of ecological status" includes all substances to be regulated by the Member States. Annex V WFD refers to them as (river basin) "specific substances" and Annex VIII provides an "indicative list of the main pollutants", broken down into 12 groups (partly by chemical criteria, partly in terms of their potential impact). These substances correspond to the List II substances of Directive 76/464/EEC.

As in Directive 76/464/EEC, the environmental objectives of the WFD are to be achieved by means of programmes of measures lasting 6 years (Article 11). A significant new aspect here is the fact that bodies of water are no longer to be managed within the boundaries of administrative units (nation states, provinces etc.), but at the level of river basin districts (catchment areas). The management plans, also for 6 years, including their monitoring programmes and programmes of measures, are to be presented by the Member States during 2009 and implemented starting in 2010 (Article 13 WFD).

With the entry into force of the Water Framework Directive, Article 6 of Directive 76/464/EEC concerning the List I substances was repealed[82] and freshly regulated in the WFD through the provisions on "Priority Substances"[83]. As a result, Article 7 concerning the List II substances of Directive 76/464/EEC became Article 6. The consolidated revised version of Directive 76/464/EEC was published on 4 March 2006 as Directive 2006/11/EC.[84]

Under Article 22 (2) WFD, Directive 76/464/EEC – except for the directly deleted Article 6 (List I substances) – will not be repealed until the end of 2013. This is intended to ensure the continuation of the very hard-earned results of Directive 76/464/EEC with

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81 Decision No. 2455/2001/EC of the European Parliament and of the Council of 20.11.2001 establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC, OJ L 331 of 15.12.2001, p. 1.

82 Art. 22 (2), third indent, WFD

83 Article 16 (6-8)

84 Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community, OJ L 64, 4.3.2006, p. 52.

regard to the List II substances, at least until the measures under the WFD take effect from 2010 onwards[85, 86].

In Germany the “specific substances” which the WFD requires to be regulated by the Member States were defined by the responsible Länder in 2004 in 16 Land ordinances implementing Directive 2000/60/EC[87], where they were included in the list of “Chemical quality components for classification of ecological status” (e.g. Annex 4 to the Hamburg Ordinance). These ordinances contain, among other things, the complete list of List II substances from Directive 76/464/EEC imported via the Länder quality objective ordinances. Certain items were updated in the process: some substances, e.g. benzene, dichloromethane, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, fluoranthene were added to the “Environmental quality standards for classification of chemical status” (e.g. in Annex 5 to the Hamburg Ordinance), because – for the first time since Decision 2455/2001/EC by the Council and the Parliament – there was now an “official” list of the “priority substances” that were *not* to be laid down by the Member States. In some case substances were added or quality objectives were adjusted, which are now known synonymously as “environmental quality standards”. The fact that environmental quality standards for the Priority Substances that were really to be laid down by the Community were defined in Germany and other Member States 4 years before publication of the daughter directive on Priority Substances and nearly 6 years before the deadline for its implementation, results at least temporarily in a situation where different environmental quality standards are legally valid in different Member States. This could hardly be avoided, however, since quality assessments for these substances were to be submitted for the inventory required by 2005 under the WFD.

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85 Directive 76/464/EEC was implemented in Germany *from an emission point of view* by the provisions of Section 7 of the Federal Water Act in conjunction with the relevant annexes to the Wastewater Ordinance. However, since *from an immission point of view* no binding quality objectives were drawn up for 99 “hazardous substances” (List II) and no programmes were established for reducing these substances, the European Court of Justice (ECJ) sentenced the Federal Republic of Germany on 11.11.1999 on the grounds of failing to implement Directive 76/464/EEC (Case C-184/97). The federal Länder thereupon enacted 16 Land ordinances which now contain binding quality objectives for the “99 substances”.

86 The no less hard-earned results for the List I substances are preserved in the WFD by means of Annex IX (continued validity of the daughter directives to Directive 76/464/EEC as emission limit values and environmental quality standards of the WFD, since newly regulated by Directive 2008/105/EC).

87 Joint Water Commission of the Federal States (LAWA): *Model ordinance for the implementation of Annexes II and V of Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy*, 02.07.2003, http://www.lawa.de/pub/kostenlos/wrrl/mustervo020703.pdf .

Taken as a guide by the relevant ordinances of the 16 Länder, e.g. for Hamburg: Ordinance for the implementation of Annexes II, III and V of Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, of 29 June 2004, HmbGVBl. 32 of 9.7.2004, p. 277,

Table 2 Overview of the development of the EC quality standards for surface waters

☑ legally binding after implementation by the Member States,
☑ legally binding in Germany, 💣 possibly conflicting standards

Time	Legal act	Remarks	Regulated by EC	Regulated by Member States, D
1976	Dir. 76/464/EEC	Action programme for preventing and reducing pollution caused by certain dangerous substances Objective: Both emission and immission limits ♦ Introduces two lists of substances phased by importance ♦ but: without specific substances ♦ Implemented via programmes lasting 6 years, consisting of a "monitoring component" and a "measures component"	"List I" Substances <u>especially</u> toxic, persistent and bioaccumulative Basis: Article 6	"List II" Substances "less problematical" Basis: Article 7
1982	Comm. Com. to Council	Proposal for a list with 129 (132) substances as candidates for "List I", of which: 30 (33) priority substances	-	-
up to 1990	Dir. 82/176/EEC Dir. 83/513/EEC Dir. 84/156/EEC Dir. 84/491/EEC Dir. 86/280/EEC	So-called "76/464 daughter directives", regulate a total of (only) 18 substances, incl. from emission point of view ☑ (☑) in D only emission aspect implemented, Section 7 Federal Water Act in conjunction with Annex to Wastewater Ordinance	-	-
1990	COM (90) 9 final.	Council stops law-making process for List I, Argument: slow + ineffective, Com. prepares actions against Member States for non-implementation of List II	-	-
1992	Treaty of Maastricht	♦ Legal level from EEC to EC ♦ EG empowered for environmental law ♦ modified law-making procedure ("co-decision procedure", Parliament can prevent law)	-	-
1996	Dir. +96/61/EC "IPPC Directive"	"New policy for integrated pollution prevention and control" ♦ adopts emission values from 76/464 daughter directives for certain industries ☑, (☑)	-	-
1999	Case C-184/97	ECJ sentences D for non-implementation of List II	-	-

Time	Legal act	Remarks	Regulated by EC	Regulated by Member States, D
2000	Dir. 2000/60/EC WFD	Framework for Community action in the field of water policy, ♦ Management plans lasting 6 years (Art. 13), to include ♦ Monitoring programme (Art. 8) ♦ Programme of measures (Art. 11) ♦ Management area is river basin district ♦ Art. 6 Dir. 76/464/EEC (List I) repealed ♦ Rest of 76/464 to be repealed in Dec. 2013	List of substances for classification of chemical status, ♦ Annex X (but no content) ♦ Annex IX (daughter Dir. 76/464) (☑)	List of substances for classification of ecological status, ♦ Annex VIII (but without specific substances) ♦ Art. 7 Dir. 76/464 still valid
2001	"Quality objective ordinances of the Länder"; relevant programmes	D implements Article 7 Dir. 76/464/EEC D: start of programmes for 76/464	-	+Land quality objective ordinance: List II 76/464 ☑
2001	Decision 2455/2001/EC	Council and Parliament decide on selection of substances for Annex X WFD	Annex X, but without quality standard figures	Land quality objective ordinance: List II 76/464 ☑
2004	Land ordinances for implementation of WFD	Implementation of Annexes (II), III, V WFD Annex 4 contains corrected List II (with additions; some substances have become priority substances under WFD) Annex 5 contains Annex X WFD with standards from draft papers	Land ordinances implementing WFD e.g. Annex 5 in Hamburg "Chemicals" list ☑	Land quality objective ordinance: List II 76/464 ☑ +Land ordinances implementing WFD e.g. Annex 4 in Hamburg "Ecological" list☑
2006	Dir. 2006/11/EC	Dir. 76/464 codified Article 7 becomes Article 6 (List II) D: End of first programme for Dir. 76/464/EEC		
2007		Start of measuring programme Art. 8 WFD		
2008	Dir. 2008/105/EC	Daughter directive "Priority Substances" ♦ Substances (Annex II = new Annex X to WFD) ♦ Quality standards (Annex I) annual average AA-EQS, max. allowable conc. MAC-EQS ♦ + additional candidates (Annex III)	Land ordinances implementing WFD e.g. Annex 5 in Hamburg WFD Implementation Ordinance "Chemicals" list ☑ Annex I 2008/105/EC QS list "Chemicals"☑	Land quality objective ordinance: List II 76/464 ☑ Land ordinances implementing WFD e.g. Annex 4 in Hamburg "Ecological" list ☑ Implementation via federal ordinance planned (☑) not later than July 2010

Since 2007 the monitoring programmes in accordance with Article 8 WFD have been in progress throughout the EU. These programmes are to include not only the "Priority

Substances" under Annex X WFD and the additional substances under Annex IX for the "classification of chemical status", but also the "river basin specific substances for classification of ecological status"[88] which result from the requirements of Annex V WFD, so that the planning of measures for the first management period starting in 2010 can make use of a stock of basic data that has been acquired and assessed in accordance with WFD criteria. The assessment is to be made right from the start, i.e. even before final transposition of the WFD daughter directive "Priority Substances" into national law, on the basis of its EQS values.

3.3.1.2 Emission standards

Although the WFD expressly seeks to achieve its objectives by reducing or completely stopping discharges of problematical substances into bodies of water and also to control water pollution by means of emission restrictions and emission limit values (Art. 10 WFD "Combined approach", Art. 16 WFD "Strategies against pollution of water"), no emission limit values – apart from the provisions taken over from the daughter directives to Directive 76/464/EEC – have been passed to date, not even in the WFD daughter directive "Priority Substances" which entered into force in January 2009 (Directive 2008/105/EC, see Chapter 3.1.4.4). However, the Commission will, on the basis of reports by the Member States, investigate the need for amendments to existing legal acts and additional specific Community-wide measures, such as emission restrictions (Art. 7 (1) WFD daughter directive "Priority Substances"). It remains to be seen whether the evaluation of the monitoring results received in the next few years prompts the Commission to lay down emission limit values, either its own values or (river basin specific) values to be determined by the Member States.

For the purposes of Article 11 (3) I WFD, emission limit values, which relate to ongoing normal operation of installations, are of no further relevance. What is important, however, is immission limit values, in connection with the detection of accidents and alerts in the context of the required *"systems for timely detection and early warning"* (e.g. automatic water quality measuring stations or other immission measurements). Alert thresholds should in particular correlate with the new MAC-EQS of the daughter directive on "Priority Substances", where a single infringement results in the status of the

88 Thus the monitoring obligations under Directives 76/464/EEC and 2006/11/EC are also covered.

body of water being downgraded to "poor". The input quantity thresholds in the warning and emergency plans of the river basin commissions, which have hitherto been exclusively emitter-oriented, should also be checked for relevance in view of the immission standards of the WFD.

3.3.2 Substance assessment criteria

The criteria to be used for deriving quality standards for the objectives defined in the WFD are laid down in Article 16 (2) WFD. Assessment takes the form of a targeted risk-specific assessment in accordance with the procedures of the Existing Substances Regulation (EEC) 793/93[89] (now covered by REACH Regulation (EEC) 1907/2006, see Chapter 3.3.2.2), with the examination confined exclusively to aquatic ecotoxicity and toxicity to humans via the aquatic environment. The risk assessment also has to include the Biocides Directive[90] and the Pesticides Directive[91]. This is a binding requirement, first on the Commission for defining Priority Substances and their environmental quality standards (Directive 2008/105/EC), but also similarly on the Member States in accordance with Annex V 1.2.6 WFD for deriving the environmental quality standards for the (river basin) specific pollutants under Annex VIII WFD. In Germany (and other Member States) the environmental quality standards for the Annex VIII WFD substances were largely taken over from the quality objective ordinances for the List II substances from Directive 76/464/EEC (see Chapter 3.3.1) and implemented in the Land ordinances for the WFD.[92] This is logical in view of the basic conceptual similarity of the two directives with regard to chemical pollutants, although it should be noted when discussing the figures that Directive 76/464/EEC had a less marked aquatic ecotoxicology focus than the WFD. For example, figures from the relevant provisions on the use of drinking water were also included when deriving the quality objective figures for Directive 76/464/EEC. The WFD makes no *a priori* provision for such "mix-

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89 Council Regulation (EEC) No. 793/93 of 23 March 1993 concerning the Evaluation and Control of the Environmental Risks of Existing Chemical Substances (OJ L 84 of 5.4.1993, p. 1 et seq.).

Note: Regulation (EEC) 793/93, like the associated "real" assessment regulation (EEC) 1488/94 is repealed and superseded by the REACH Regulation (see Chapter 3.3.2.2); the WFD needs to be adjusted accordingly.

90 Directive 98/8/EC, OJ L 123 of 24.4.1998, p. 1 et seq.

91 Directive 91/414/EC, OJ L 230 of 19.8.1991, p. 1 et seq. Directive last amended by Directive 98/47/EC (OJ L 191 of 7.7.1998, p. 50).

tures of objects of protection" when deriving its environmental quality standards – for example, if there is a regional threat to drinking water abstraction from river water because an – ecotoxicologically derived – environmental quality standard for a pesticide is above the limit values for drinking water (e.g. Dir. 2008/105/EC: isoproturon AA-EQS = 0.3 µg/l, MAC-EQS = 1 µg/l (see Table 6), EC Drinking Water Directive limit value = 0.1 µg/l), the WFD would require measures specific to the individual case to be taken here (e.g. regional reduction in EQS figures or technical improvements in treatment of raw water). It is to be expected that in the course of the transposition of Directive 2008/105/EC into national law in individual Member States there will also be a revision of the (national) Annex VIII WFD substances.

With regard to assessment of the consequences of accidents or other Article 11 (3) I WFD events, and especially the issue of warning and emergency criteria, it may be necessary to take other relevant concentration standards into account in addition to the original WFD-based environmental quality standards. Following is an – incomplete – selection of provisions/recommendations that may have to be observed:

- ⇒ Bathing Waters Directive 2006/7/EC[93]
- ⇒ Fishing Waters Directive (Freshwater Directive) 2006/44/EC[94]
- ⇒ Directive on quality requirements for surface water intended for the extraction of drinking water 75/440/EEC[95]
- ⇒ Drinking Water Directive 98/83/EC[96]
- ⇒ Assessment of the presence of partly or completely unassessable substances in drinking water from a health point of view[97]

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92 See Footnote 87; it should be noted that the scope and EQS figures for the *Priority Substances* regulated in Annex 5 to the Land ordinances are not completely identical to the figures in Annex I to the WFD daughter directive 2008/105/EC.

93 Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC, OJ L 67 of 4.3.2006, p. 37 et seq.

94 Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life, OJ L 264 of 25.9.2006, p. 20 et seq.

95 Council Directive 75/440/EEC of 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking water in the Member States, OJ L 194 of 25.7.1975, p. 26–31.

96 Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330 of 05.12.1998, p. 32 et seq.

⇒ LAWA insignificance thresholds[98]

⇒ Figures from international conventions (e.g. Rhine, border D/NL, see Table 12, p. 127).

3.3.2.1 Water hazard classes

The water hazard potential of substances handled in installations is determined in German law on major accidents and dangerous substances by classification in one of three (four) water hazard classes (WHC)[99]. Determination of the water hazard class is regulated by the administrative guideline on substances dangerous to water (VwVwS) of 17.05.1999[100]. In 2005 there was a further revision of the administrative guideline, in which definitions of the physical state of substances were adjusted and Annexes 1+2 (List of substances not dangerous to / dangerous to water) were updated.[101] Currently there is need for a further update, because the basis for assessment, Directive 67/548/EEC, has been amended and replaced by the REACH Regulation[102] and by the GHS Regulation[103] (see Chapters 3.3.2.2 and 3.3.2.3).

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97 Recommendation by the Federal Environment Agency after hearing the Drinking Water Commission at the Federal Environment Agency: *Bewertung der Anwesenheit teil- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht*, Bundesgesundheitsbl - Gesundheitsforsch-Gesundheitsschutz 2003/46, p. 249–251.

98 LAWA (Joint Water Commission of the Federal States): Ableitung von Geringfügigkeitsschwellenwerten für das Grundwasser, http://www.lawa.de/pub/download.html , December 2004.

99 At present there are in fact three water hazard classes, plus the classification as a "substance not dangerous to water"; the latter is not identical to the former water hazard class 0 ("generally not dangerous to water") of the outdated "List of substances dangerous to water" of 1991 (LTwS No. 12), which is still referred to, for example, by the currently valid 2006 version of the International Warning and Emergency Plan for the Elbe (IWAE).

100 Administrative guideline on substances dangerous to water (VwVwS) of 17.05.1999, Federal Gazette 98a of 29 May 1999;

For explanations, see also: Federal Environment Agency, *Einstufung von Stoffen und Gemischen in Wassergefährdungsklassen gemäß Verwaltungsvorschrift wassergefährdende Stoffe (VwVwS) vom 17.05.1999 - Leitfaden für Selbsteinstufer* -, Berlin, 1999.

101 General administrative guideline concerning the amendment of the administrative guideline on substances dangerous to water (VwVwS) of 27.07.2005, Federal Gazette 142a of 30 July 2005.

102 Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, OJ L 396 of 30.12.2006, p. 1 et seq.

103 Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, OJ L 353 of 31.12.2008, p. 1 et seq.

The administrative guideline on substances dangerous to water is based on Section 19 g of the Federal Water Act *(Wasserhaushaltsgesetz – WHG)*, which although it cites a number of examples of substances and substance groups which are "capable of having adverse effects on the physical, chemical or biological properties of the water", did not originally go into any further detail (in the current version of the Federal Water Act as revised on 6 August 2009, Federal Law Gazette Part I No. 51, the handling of substances dangerous to water is regulated in Section 62). In 1986 an authorisation for general administrative guidelines for the detailed determination and classification of "substances dangerous to water" was introduced; in 1999 the administrative guideline was systematically revised and rewritten. Among other things, this introduced the derivation of water hazard classes on the basis of the EG-wide "R phrases" and created the possibility of "self-classification" by the user. The administrative guideline on substances dangerous to water has four annexes:

- Annex 1: List of substances not dangerous to water,
- Annex 2: List of substances dangerous to water, divided into water hazard classes (WHC) 1 to 3,
- Annex 3: Description of the classification procedure for all substances not listed in Annexes 1 and 2, on the basis of the R-phrase categories of European law on hazardous substances,
- Annex 4: Description of the procedure for classifying preparations and mixtures.

Thus the revised version of the administrative guidelines was primarily intended to bring the water hazard class classification into line with the law on dangerous substances. At the same time, however, it sought to provide greater opportunities for self-classification by the industry in question and thereby strengthen its own responsibility. The administrative guideline provides for a combination of prescribed WHC classifications (Annexes 1 and 2) and self-classifications (based on the schemes in Annexes 3 and 4). All WHC substance classifications are centrally collected and published by the Federal Environment Agency. Thus it is of no further relevance for the enforcement of water law whether a classification is based on Annex 1, 2 or 3 of the administrative guideline. All these classifications are equally valid for enforcement purposes. As a rule, classifications of preparations/mixtures on the basis of Annex 4 of the administrative guideline are not centrally collected and published. They are entirely the responsibility of the classifier.

The first step in classifying a substance is to compile a basic record consisting of the following hazard criteria:

- acute oral or dermal toxicity to mammals (e.g. LD50 for rats),
- information about aquatic toxicity (fish (acute), Daphnia (acute) or algae),
- biodegradability,
- bioaccumulation potential.

If these results of the research for the basic record make it necessary to classify the substance using an R-phrase from Directive 67/548/EEC[104] or if the substance is already "legally assigned" to an R-phrase in Annex 1 to the said directive, then the relevant R-phrases for the substance are included in the assessment for classification under the administrative guideline.

Since classification by R-phrases and water hazard categories is, under the law on dangerous substances, an obligatory criterion for the production, handling and marketing of a substance, such classifications exist for a very large number of substances (approx. 2000). Against this background, the IWAE has linked its emission-oriented warning thresholds to the water hazard classes.[105]

Furthermore, the water hazard classes, which are only legally binding in Germany, are definitely the subject of criticism, especially the allegation that the underlying basic record is not sufficient for an exhaustive assessment of the substance. The dilemma of an inadequate basis of data for risk assessment of the roughly 100,000 so-called "existing substances" is however a fundamental problem, which led to the adoption of the REACH Regulation in December 2006 (see Chapter 3.3.2.2). That being so, the WHC must probably be regarded as the most practicable solution at the present time. Certain problems could arise if these figures were used to arrive at more far-reaching conclusions or derived values (see Chapter 3.3.4).

[104] Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, OJ L 196, p. 1.

[105] However, in the latest version of the IWAE dating from 2006 the allocation of the R-phrases is no longer included in the table for assessing accident-induced water pollution (Annex 5, Sheet 1/2).

3.3.2.2 REACH

As the scope of the title REACH Regulation[102] indicates, it is just as important for the law relating to substances in the Community as the Water Framework Directive is for water law. More than 40 currently valid directives and regulations are to be integrated in or superseded by REACH. There are points of contact with the WFD wherever it is a question of substance risk assessment which the WFD requires to be performed in accordance with the criteria of the Existing Substances Regulation (EEC) 93/793[89] which is replaced by REACH (see introduction to Chapter 3.3.2).

This section only provides as much introduction to the content of the REACH Regulation as is necessary to understand the effects on the WFD.

Until the entry into force of REACH, the risks arising from substances marketed in the Community were assessed in accordance with two different sets of legislation. For "existing substances", i.e. substances that were put on the market before 18.09.1981 and were to remain on the market, were subject to the provisions of the "Existing Substances Regulation" (EEC) 93/793[89]. These existing substances – a total of 100,106 – are listed in the EINECS[106] list of existing substances and currently still account for about 97% of the chemicals market in the Community. Assessment of their risks to human beings and the environment was to be undertaken by the Member States according to a scheme of priorities; each substance was assigned a specific country as managing *rapporteur*. Industry was to supply the substance data for assessment purposes. Substances could continue to be traded without restriction until they had been assessed.

Before REACH, substances that were first marketed in quantities of more than 10 kg a year after 18.09.1981, had to be registered under Directive 67/548/EEC[104] as "new substances"; their risk to humans and the environment had to be investigated, and if necessary conditions were imposed before they were put into circulation. These substances are listed in the ELINCS[107] list of notified chemical substances, which is

[106] *EINECS*: European Inventory of Existing Commercial Chemical Substances, http://ecb.jrc.it/existing-chemicals/ at the European Chemicals Bureau (ECB) in Ispra/Italy;

[107] *ELINCS*: European List of Notified Chemical Substances

updated and published at irregular intervals by the European Chemicals Bureau ECB, and which today comprises about 3700 substances.[108]

By August 2000, however, the Community risk assessment had only been completed for 21 existing substances.

As long ago as 1998 the Council of Environment Ministers called upon the EU Commission to review European legislation on chemicals. Seven months later the Commission presented a report in which it confirmed the failure of the European chemicals policy. The Council of Environment Ministers thereupon requested the Commission to draw up proposals for a reform of chemicals legislation that would address the criteria sustainability, precautionary principle and single internal market. In 2001 the Commission presented the White Paper on "Strategy for a Future Chemicals Policy". In its comments, the Council of Environment Ministers advocated that the proposals in the White Paper be tightened up. This view was to a large extent supported by the EU Parliament. In December 2006 the reform was published in the Official Journal as REACH Regulation (EG) 1907/2006.

In future, working on the principle "no data, no market", ***ch**emical* substances are only to be put on the market, if they are ***R**egistered),* ***E**valuated* and, if appropriate, ***A**uthorised)*. This procedure is to be completed by 01.06.2018 and conducted in accordance with a timetable linked to the quantities marketed and the hazard criteria (see Figure 3).

[108] Upon the entry into force of REACH, the functions of the ECB in connection with the registration and assessment of substances were successively transferred to the newly established European Chemical Agency (ECHA) in Helsinki.

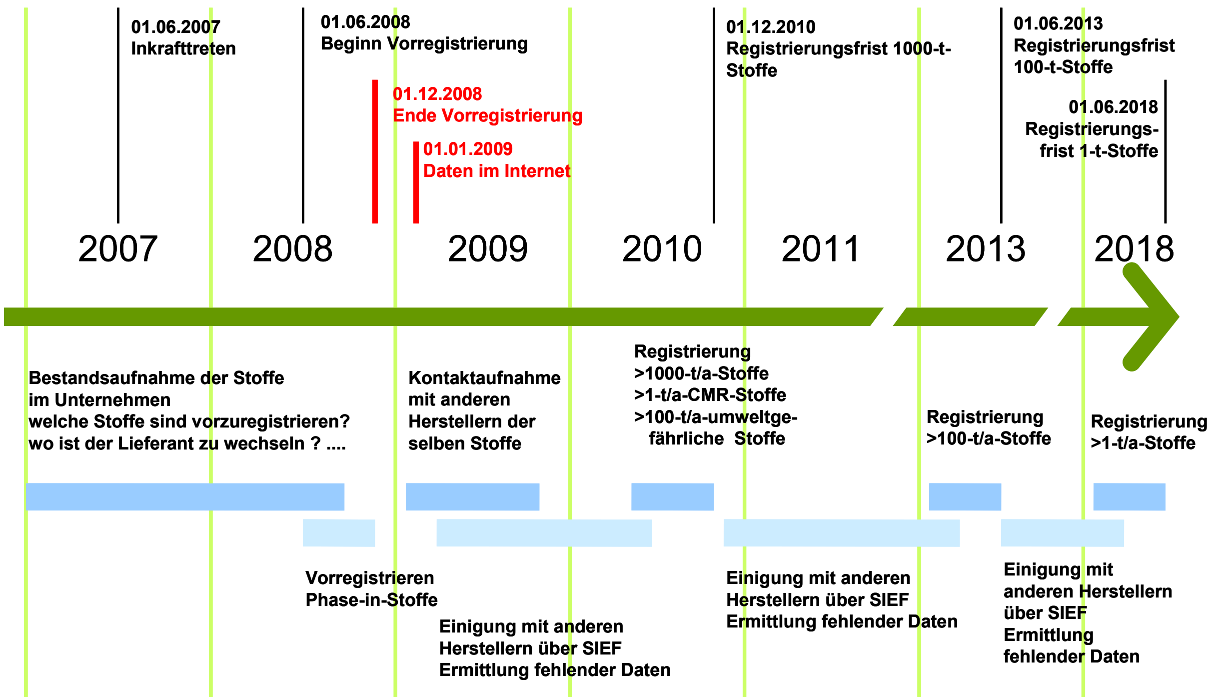

Figure 3 Timetable for implementation of REACH[109]

The main principles of REACH are outlined below:

- Following the principle of *reversal of the burden of proof*, REACH transfers the responsibility for reviewing chemicals safety from the national authorities to the manufacturers and importers. In future they have to show convincing evidence that their products are safe to handle and do not have undue adverse effects either on the health of employees and consumers or on the environment. The manufacturers and importers pass on their substance information to all down-stream users.
- The evaluation of “existing” and “new” substances is in future performed according to the same criteria.
- The data requirements increase with the annual quantity of the substance to be registered that a manufacturer or importer wishes to produce or import. The obligation to register starts at an annual marketing quantity of 1 t.[110]

109 Based on BAuA/REACH Helpdesk: Brochure *REACH-Info 1*, http://www.reach-helpdesk.de/ .

- The minimum requirement is a technical dossier plus, where appropriate, a substance safety report. In the case of dangerous substances and substances of very high concern, the substance safety report must identify exposure scenarios. This must take account of the entire life cycle of the substance (production / use / disposal).
- To avoid duplication of work, and especially tests involving animals, REACH obliges manufacturers and importers to share their data.
- "Existing substances" (in REACH: "phase-in substances") may only profit from the timetable for the implementation of REACH if they have been pre-registered by the relevant deadline. The purpose of this pre-registration is to form consortiums of manufacturers and importers who wish to register the same substances. Pre-registration is sent electronically to *ECHA,* the *European Chemicals Agency*, which is based in Helsinki and was established specifically for REACH; it is free of charge and without obligation. As a forum for data exchange, a SIEF (*Substance Information Exchange Forum*) is set up for every pre-registered substance with the same identity.
- "Phase-in substances" which are not *pre-registered* by 01.12.2008 may no longer be put on the market and must if necessary be newly registered as new substances.
- Additional communication obligations arise in the supply chain: downstream users acquire additional tasks and duties. They must supply the upstream manufacturers and importers with information about the precise use, so that the latter can take account of such use in their information on exposure in the technical dossier and, where appropriate, in their exposure scenarios, and recommend appropriate risk mitigation measures. Thus "use" becomes "identified use". The downstream user has a duty to apply the risk mitigation measures. The most important instrument in the supply chain is still the safety data sheet, which is now no longer regulated by Directive 67/548/EEC or the GHS Regulation (EC) 1272/2008.

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110 However, the requirements for substances in the annual marketing quantity range of 1-10 t are only a few basic items – the "ability to solve the existing substances problem" was "bought" at the cost of a relaxation of the requirements for the registration of new substances, for which the old rules required more data if the annual quantity marketed exceeded as little as 10 kg .

- “Non-identified uses” are not permitted; if necessary, the user must prepare a separate substance safety report (and acquire the necessary data for it).
- Especially hazardous substances are subject to an authorisation procedure.
- There is an extensive obligation to use substitutes for especially hazardous substances.

By the year 2018, REACH is expected to yield substantial advances in our knowledge about the risks that substances present to human health and the environment. With regard to the implementation of the WFD, however, this will only make itself felt gradually in that environmental quality standards could change in response to new substance data and risk evaluations, and standards for further substances could be added.

3.3.2.3 GHS

The GHS Regulation[103] which entered into force on 20 January 2009 replaces Directive 67/548/EEC[104], known as the “Labelling Directive” or “Substance Directive”, which can be regarded as the origin of Community chemicals legislation. The field regulated by the GHS Regulation, insofar as labelling and packaging are concerned, is largely identical to that of Directive 67/548/EEC. However, the registration, evaluation and, if appropriate, authorisation of “new substances”, like requirements regarding the design and transmission of the safety data sheet, fall within the purview of REACH.

Since the water hazard classes are largely based on the risk classification of Directive 67/548/EEC, a brief introduction to the GHS Regulation is given here to make it easier to understand its place in the context of this project.

At the UN Conference for Environment and Development in Rio in 1992, Chapter 19 of the Agenda 21 gave the United Nations a mandate to draw up a harmonised worldwide system for the labelling and packaging of chemicals. The aim is worldwide harmonisation of existing classification and labelling systems for transport, occupational safety and health, consumer protection and environmental protection.

This “***G****lobally* ***H****armonised* ***S****ystem of Classification and Labelling of Chemicals*” (GHS) was presented for the first time as a “Purple Book” in 2003. It has been continuously improved, and large parts were published in December 2008 as EC Regulation 1272/2008. Since 20 January 2009 it has been directly applicable law in all Member States. The English title "*Regulation on **C**lassification, **L**abelling and **P**ackaging of Substances and Mixtures*" forms the basis for the synonymous term "CLP Directive".

The GHS Regulation lays down

- what classification, packaging and labelling requirements are to be complied with before substances and mixtures (formerly: preparations) are put on the market,
- what criteria are to be used for classifying substances and mixtures,
- how substances and mixtures are to be packaged, and
- what mixtures require special labelling.

Unlike the REACH Regulation, the provisions of which are coupled to certain marketing quantity thresholds, all substances and mixtures are subject to a general classification and labelling requirement before being put on the market.

The timetable for the implementation of GHS is synchronised with the timetable for REACH (Figure 4).

Classification and labelling under GHS are based on the intrinsic properties of the substances and mixtures considered. In this respect the GHS Regulation does not differ from the existing system based on the Substances and Preparations Directive 67/548/EEC. The labelling symbols used, which are now called "pictograms", are also very similar to those in the old procedure, which at least means there is no great learning curve for the user. The old **S**(afety) and **R**(isk) phrases/codes, on which the water hazard classes are largely based, are dropped. Instead the new regulation uses **H**(azard) statements and **P**(recautionary) statements, which are essentially comparable.

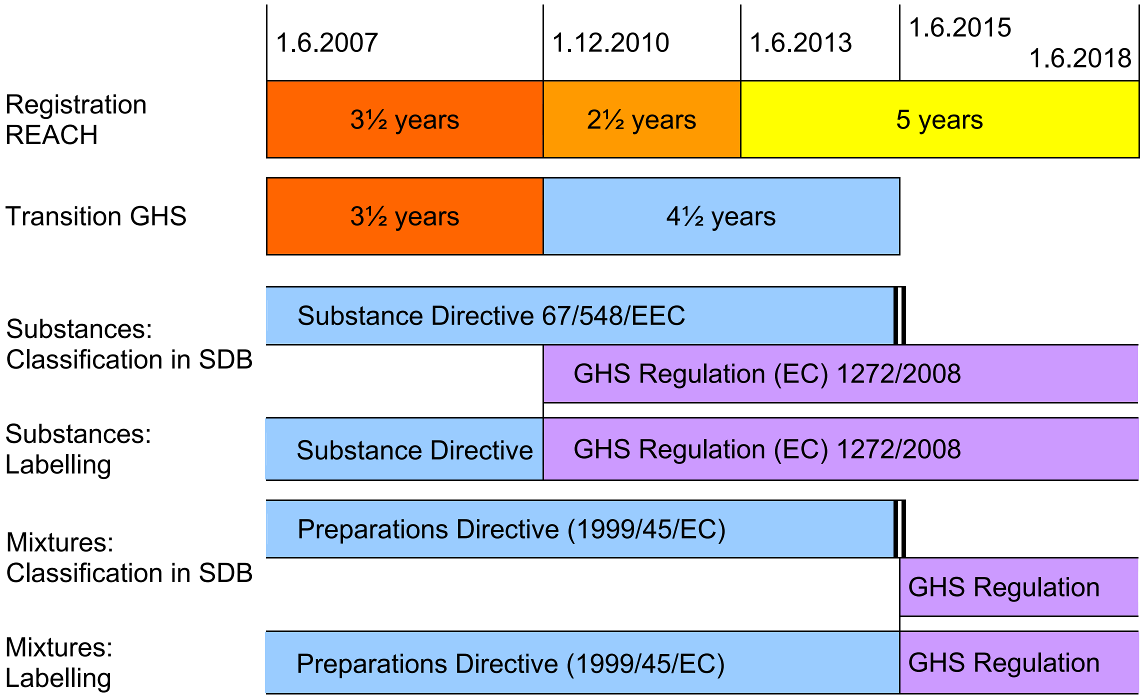

Figure 4 Transitional phases REACH and GHS[111]

In spite of the conceptual similarities between the GHS Regulation and the Substance Directive, the classification rules and the criteria for evaluation of certain substance properties are not identical, which rules out a linear conversion from the old to the new classification. As a result, all substances and mixtures on the market must be reclassified under GHS. Annex VII to the GHS Regulation contains a "conversion table", with rules for simplifying conversion from the existing classification to the new one. On more than 1000 pages, Annex VI lists the "legally classified" substances from Annex I to the old Substances Directive with their new GHS classification ("Harmonised classification and labelling for certain hazardous substances").

The result of these changes for the water hazard classes is that all substances so far classified would also have to be reclassified. However, estimates indicate that a maximum of 5% of all substances classified to date would have to be assigned to a different water hazard class. For this reason no reassignments are planned, except on applica-

[111] Based on: Federal Environment Agency (UBA), brochure: *Das neue Kennzeichnung- und Einstufungssystem für Chemikalien nach GHS*, Forschungsvorhaben 206 67 460/06, Berlin 2007, http://www.umweltbundesamt.de/ .

tion. Parallel existence of old and new water hazard classes based on GHS does not raise any problems.[112]

Owing to the reform of the federal system in Germany, the federal level now has exclusive competence in respect of "substance-specific or installation-related rules" for the water regime. The "Administrative guideline on substances dangerous to water" (VwVwS)[100], which regulates the water hazard classes, is therefore to be replaced by a future (federal) "Ordinance on the handling of substances dangerous to water" (VUmwS), which was originally to be linked to the nationwide Environmental Code *(Umweltgesetzbuch – UGB)* that was scheduled for adoption in 2009. Since it is generally considered that a consensus cannot be reached on the Environmental Code at present, the new ordinance could be linked to the planned revised version of the Federal Water Act *(Wasserhaushaltsgesetzes – WHG)*. The new federal ordinance brings together the rules of the Länder ordinances on installations for handling substances dangerous to water (VAwS) and the substance-related rules of the administrative guideline on substances dangerous to water, and updates them to take account of new developments in related fields of law. In the process, the changes resulting from GHS are to be incorporated in the federal ordinance on the handling of substances dangerous to water.

3.3.3 EQS infringements due to accidents

We started the foreword to this report with the (computer modelled) example of a quantity of only 5 kg of hexachlorobenzene or a mercury compound released into the Elbe in the Czech Republic, which resulted in the MAC-EQS being exceeded right down the Elbe as far as the tidal region. The framework conditions were undoubtedly extreme, but by no means impossible (low water + low MAC-EQS), which raises the question of whether it is possible to derive more generally valid information about input quantities and the resulting immission values along the length of a river. Under the EASE[113] project, the Hamburg Institute for Hygiene and Environment used the forecast software ALAMO from the Federal Institute of Hydrology (BfG) to compute several

[112] Eisenträger, Adolf, Federal Environment Agency (UBA), first project workshop in Schkopau on 29 November 2007.

[113] Hamburg Institute for Hygiene and Environment *"Entwicklung von Alarmkriterien und Störfallerfassung in Messstationen im Elbeeinzugsgebiet für die internationale Gefahrenabwehrplanung (EASE)"*, final report on UBA research project FKZ -200 48 314/02 - Subproject 2, Hamburg 2004.

accident scenarios for the Elbe. These were later confirmed by empirical measurement in connection with a real accident (cyanide accident in the Czech Republic) (see Chapter 8.1.1.2.5). The computed accident scenarios are based on accidental input quantities regarded as realistic under the International Warning and Emergency Plan for the Elbe (IWAE)[114].

3.3.3.1 Emission-oriented warning thresholds

To permit a realistic appraisal of the calculated results, we first give a brief outline of the warning and emergency criteria of the International Warning and Alarm Plans (IWAP) for the Elbe, Oder and Danube. (The procedure for the Rhine is different: here the focus is on agreed maximum accidental loads and derived concentrations at the Bimmen/Lobith measuring station at the German/Dutch border, see Table 12, page 127; for more information on the warning and alarm plans, see Chapter 4.3.)

A warning/emergency alert under the IWAE generally relies on the author of the accident (pollutant emitter) sending a message stating at least the time of the incident and the nature and quantity of the substances input into the Elbe. For this purpose the IWAE lays down “warning thresholds” in the form of input quantities (i.e. “*emission* oriented”). These thresholds are dependent on the water hazard class (WHC) of the substance released (see blue fields in Table 3).

[114] International Commission for the Protection of the Elbe River (ICPER) – International Warning and Emergency Plan for the Elbe (IWAE) 2006, with updated address list 2008, http://www.ikse-mkol.org .

Table 3 Alarm thresholds of IWAP Elbe, Oder, Danube, schematic

Instructions for assessing accidental water pollution under the International Warning and Alarm Plans for the Elbe, Oder, Danube

The following table can be used to assign alarm thresholds to substances classified on the basis of water hazard classes (WHC[1]) or R-phrases[2]. If these thresholds are exceeded as a result of an accidental release of the substance into the water, this triggers a "notification" or "warning" in accordance with the alarm plan of the International Warning and Alarm Plans; there are differences of detail, e.g. in the case of the Elbe there is no "Notification" message.

The alarm thresholds listed (accident-induced daily loads), and the open scale based on water-body damage indices/water risk index (GSI/WRI)[3], are merely intended as a **guide** for decisions within the system of the International Warning and Alarm Plans.

[1] List of substances dangerous to water, VwVwS 27.07.2005
[2] Directive 67/548/EEC ff.
[3] The water-body damage index/water risk index is used to scale the cases of damage to the body of water.

Classification of substances		Quantity of substance released – Alarm thresholds		
WHC	R phrases	NOTIFICATION [kg] or [l]	WARNING [kg] or [l]	WARNING [kg] or [l] for n>2
Not dan-ger-ous	22	≥ 10,000	≥ 100,000	$\geq 10^{n+3}$
1	25, 52/53, 52 or 53	≥ 1,000	≥ 10,000	$\geq 10^{n+2}$
2	▪ 50, 51/53, 28 or 45 ▪ (52/53, 52 or 53) <u>and</u> (22 or 25)	≥ 100	≥ 1,000	$\geq 10^{n+1}$
3	▪ 50/53 ▪ (50, 51/53, 52/53, 52 or 53) <u>and</u> (45 or 28) ▪ 45 <u>and</u> 28	≥ 10	≥ 100	$\geq 10^{n}$
Water-body damage index (GSI/WRI)[3]		≥ 1	≥ 2	≥ n

If the quantity of the substance input exceeds the warning threshold, a warning message is sent in accordance with the alarm plans of the IWAP.

3.3.3.2 Resulting immission values down the Elbe

Here we use ALAMO to model the "effects" of accidents on the Elbe. In this context, "effects" means the concentration of a substance. Starting from an accident at a particular point on the Elbe (usually river km 0 = border between D/CZ), the program calculates the distance downstream until the value *falls below* a "specified substance concentration, e.g. a MAC-EQS value" . ALAMO basically allows a free choice of all parameters that are relevant here. To ensure that the result bears a conceivable relationship to the alarm thresholds discussed, the "scale of the accident" is in particular computed using input quantities of the kind laid down as phased alarm thresholds in the *emission* oriented approach of the current IWAE (see Table 3). Moreover, the "specified substance concentrations" chosen are in the size range of the MAC-EQS values of the "WFD daughter directive Priority Substances". For comparison, Table 6 shows the environmental quality standards under the "WFD daughter directive on Priority Substances" ("Chem" list) for classification of the chemical status of bodies of water[48]; Table 8 shows the environmental quality standards for the river basin specific substances under the WFD implementation ordinances of the Länder, to be used for classifying the ecological status of bodies of water ("Eco" list)[78]; in each case with the associated water hazard classes (WHC).

The model calculates the distance down river until the concentrations fall below a minimum of 0.01 µg/l and 100 µg/l. This provides a graphic illustration of the relationship between *"emission"* and *"resulting immission"*. Although the model is tailored to the situation on the Elbe, it can also be used to produce a rough idea of the effects in other similar river systems – e.g. Danube and Rhine.

Table 4 uses red bars to indicate the "range" of various accidents with phased input quantities for three standard flow situations: mean high water level (MHQ), mean water level (MW) and mean low water level (MNQ). The river kilometre marks[115] are indicated in red until the concentration falls below the thresholds shown in Column 2. If the red bar extends to the end of the km range, this means that as a result of the accident the peak of the travelling pollutant wave exceeds the specified concentration along the entire length of the Elbe from the Czech border to the Geesthacht weir (just before Hamburg). It can be seen that, even under high water conditions, a 10 t accident results in a maximum concentration of at least 10 µg/l for the entire modellable length of the Elbe. At mean water level as little as 1 t is sufficient, whereas under low water conditions a spilled bucket containing only 10 kg of the substance results in the 0.1 µg/l threshold being exceeded from the Czech border right down to Hamburg.

[115] The river kilometre marks correspond to the positions of stationary water level measuring stations on the Elbe; ALAMO outputs results for these positions as standard.

Table 4 Distance (red bar) until concentration falls below various thresholds, for different input quantities and flow situations,
Input location: river km 0 (border CZ/D), Duration of input: 2 h

Input quantity [kg]	Threshold [µg/l]	34	56	82	108	154	214	259	290	332	388	454	484	504	536	585
Mean high water																
100	100															
1,000																
10,000		■	■	■	■	■	■	■	■							
100	10															
1,000		■	■	■	■	■	■	■	■							
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
100	1	■	■	■	■	■	■	■	■							
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	0.1	■	■	■	■	■	■	■	■							
100		■	■	■	■	■	■	■	■							
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mean water level																
100	100															
1,000		■	■	■	■											
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
100	10	■	■	■	■	■										
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	1	■	■	■	■	■										
100		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	0.1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
100		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mean low water																
100	100	■														
1,000		■	■	■	■	■	■	■								
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
100	10	■	■	■	■	■	■	■								
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	1	■	■	■	■	■	■	■								
100		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
10	0.1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
100		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
1,000		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

(Column header over the kilometre columns: River kilometre. ■ = red bar.)

A rather different presentation was chosen for the following table: For two typical flow rates, 200 and 2,000 m^3/s[116] (which are also typical of other major European rivers), this shows the distance in steps of powers of ten until the concentrations resulting from input quantities of 1 – 100,000 kg fall below thresholds of 0.01 - 100 µg/l. The red areas indicate that the concentration threshold is exceeded for the entire modellable length of the German Elbe or for comparable river systems. Where the effects of accidents are indicated by the orange areas, a more precise evaluation should be undertaken by means of an ALAMO calculation based on concrete data. The white areas indicate accidents with only local effects.

Table 5 Phased distances until concentration falls below various thresholds for the flow rates 200 and 2,000 m³/s; input location CZ/D border (km 0), Input duration 2

Flow rate [m³/s]	**Input quantity [kg]**	**Distance [km] until concentration falls below threshold**				
		100 µg/l	**10 µg/l**	**1 µg/l**	**0.1 µg/l**	**0.01 µg/l**
200	1	< 1	< 1	approx. 10	**approx. 100**	**approx. 1,000**
	10	< 1	approx. 10	**approx. 100**	**approx. 1,000**	**approx. 10,000**
	100	approx. 10	**approx. 100**	**approx. 1,000**	**approx. 10,000**	**> 10,000**
	1,000	**approx. 100**	**approx. 1,000**	**approx. 10,000**	**> 10,000**	**> 10,000**
	10,000	**approx. 1,000**	**approx. 10,000**	**> 10,000**	**> 10,000**	**> 10,000**
	100,000	**approx. 10,000**	**> 10,000**	**> 10,000**	**> 10,000**	**> 10,000**
2000	1	< 1	< 1	< 1	approx. 10	**approx. 100**
	10	< 1	< 1	approx. 10	**approx. 100**	**approx. 1,000**
	100	< 1	approx. 10	**approx. 100**	**approx. 1,000**	**approx. 10,000**
	1,000	approx. 10	**approx. 100**	**approx. 1,000**	**approx. 10,000**	**> 10,000**
	10,000	**approx. 100**	**approx. 1,000**	**approx. 10,000**	**> 10,000**	**> 10,000**
	100,000	**approx. 1,000**	**approx. 10,000**	**> 10,000**	**> 1,000**	**> 10,000**

[116] At the input location (CZ/D, river km 0) these figures are slightly above mean low water and mean high water.

Table 6 Priority substances as per Directive 2008/105/EC ("Chem" list): AA-EQS ascending, MAC-EQS, WHC

No.	Substance	CAS No.	AA-EQS	MAC-EQS	WHC
(30)	Tributyl tin compounds (tributyltin-cation)	36643-28-4	0.0002	0.0015	3
(5)	Brominated diphenylether	32534-81-9	0.0005		-
(28)	Σ benzo(g,h,i)-perylene + indeno(1,2,3-cd)-pyrene	191-24-2, 193-39-5	0.002		-
(14)	Endosulfan	115-29-7	0.005	0.01	3
(26)	Pentachlorobenzene	608-93-5	0.007		-
(16)	Hexachlorobenzene*	118-74-1	0.01	0.05	3
(9b)	Para-para-DDT	50-29-3	0.01		3
(9a)	Σ cyclodiene pesticides: Aldrin, Dieldrin, Endrin, Isodrin	309-00-2, 60-57-1, 72-20-8, 465-73-6	0.01		3
(18)	Hexachlorocyclohexane	608-73-1	0.02	0.04	3
(9b)	DDT total		0.025		3
(9)	Chlorpyrifos (chlorpyrifos-ethyl)	2921-88-2	0.03	0.1	3
(33)	Trifluralin	1582-09-8	0.03		-
(28)	Σ benzo(b)fluoranthene + benzo(k)fluoranthene	205-99-2, 207-08-9	0.03		-
(28)	Benzo(a)pyrene	50-32-8	0.05	0.1	-
(21)	Mercury + compounds*	7439-97-6	0.05	0.07	3
(6)	Cadmium + comp. (dep. on water hardness) class 1+2	7440-43-9	0.08	0.45	3
(6)	Cadmium + compounds (dep. on water hardness) class 3	7440-43-9	0.09	0.6	3
(2)	Anthracene	120-12-7	0.1	0.4	-
(8)	Chlorfenvinphos	470-90-6	0.1	0.3	3
(15)	Fluoranthene	206-44-0	0.1	1	-
(17)	Hexachlorobutadiene*	87-68-3	0.1	0.6	3
(25)	Octylphenol ((4-(1,1',3,3'-tetramethylbutyl)-phenol))	140-66-9	0.1		2
(6)	Cadmium + compounds (dep. on water hardness) class 4	7440-43-9	0.15	0.9	3
(13)	Diuron	330-54-1	0.2	1.8	3
(6)	Cadmium + compounds (dep. on water hardness) class 5	7440-43-9	0.25	1.5	3
(1)	Alachlor	15972-60-8	0.3	0.7	-
(19)	Isoproturon	34123-59-6	0.3	1.0	3
(24)	Nonylphenol (4-nonylphenol)	104-40-5	0.3	2.0	3
(7)	C10-13 chloralkanes	85535-84-8	0.4	1.4	3
(27)	Pentachlorophenol	87-86-5	0.4	1	3
(31)	Trichlorobenzene	12002-48-1	0.4		3
(3)	Atrazine	1912-24-9	0.6	2.0	3
(29)	Simazine	122-34-9	1	4	-
(12)	Bis(2-ethyl-hexyl)phthalate (DEHP)	117-81-7	1.3		1
(22)	Naphthalene	91-20-3	2.4		-
(32)	Trichloromethane	67-66-3	2.5		3
(20)	Lead + compounds	7439-92-1	7.2		2-3
(10)	1,2-dichloroethane	107-06-2	10		3
(4)	Benzene	71-43-2	10	50	3
(29a)	Tetrachloroethylene	127-18-4	10		3
(29b)	Trichloroethylene	79-01-6	10		3
(6a)	Carbon tetrachloride	56-23-5	12		3
(11)	Dichloromethane	75-09-2	20		2
(23)	Nickel + compounds	7440-02-0	20		2

* Lower AA-EQS values must be derived for these substances if no biota studies are performed, Directive 2008/105/EC Annex I Footnote 9.

Working on the basis of the WFD criteria, the calculated results show that even in the major European rivers accidents involving inputs of single-digit tonnes are potentially capable of giving rise to substance concentrations of ecotoxicological relevance along the entire length of the river. In the case of more toxic substances and unfavourable flow conditions, this can happen with spills of only 1-10 kg. In view of the large number of potential accident sites in the large, often densely populated and highly industrial catchment areas, there is reason to suspect, even bearing mind the limited duration of exposure due to individual accidents, that the combined total of the accidents occurring every year which remain below the warning thresholds of established warning and emergency plans is on its own sufficient to make it permanently impossible to achieve “good ecological or good chemical status” for the relevant body of water. This is all the more true when one considers that the pollution due to accidents has to be added to the “background noise” resulting from diffuse inputs from sewage works, continuous industrial discharges, carpet inputs (e.g. pesticides) etc. In the case of contaminants for which MAC-EQS were laid down under the “WFD daughter directive on Priority Substances”, even a single exceedance of the limit can result in downgrading of the water status.[117] Against this background, there may be a need to make a critical review of the alarm thresholds of established emission-oriented warning and alarm plans and to test them by practical empirical means.

3.3.4 Emission thresholds versus environmental quality standards

Early warning systems installed in the watercourse need criteria for identifying events of relevance for warning purposes. For chemical parameters these are concentration-dependent threshold values that have to be derived in a meaningful relationship to the quality objectives of the WFD. This gives rise to the situation that on the one hand established emission thresholds for notification by the polluter exist, and on the other hand water quality standards are laid down by the WFD as target values for the status of the body of water. This raises the question of when the concentration detected by a continuous water quality monitoring station, for example, exceeds the threshold for an

[117] It remains to be seen whether this interpretation will become accepted in practice, especially if occasional infringements of the MAC-EQS values are part of the “normal pattern of findings” in continuous measurement systems.

event requiring a warning. This issue has already been addressed in the EASE[113] project and is to be updated in connection with this project.

When using limit, test, target, quality standard and similar values, it is important to know the purpose for which they were originally derived (even if the evaluation basis was originally identical). The depth and breadth of knowledge about the substance properties at the time of derivation also has a considerable influence on the reliability (and possibly legal certainty) of the standards, especially in cases where, for lack of better data, one loses sight of the original protection target. Incompatibilities frequently become evident where two systems of standards derived from different directions come into contact. In the last chapter it was shown that the emission-oriented warning thresholds based on water hazard classes can lead to far-reaching infringements of the EQS values from the WFD, which are derived from aquatic toxicology considerations. Is this just a question of "a need for magnitude adjustment", or it is possible that fundamental incompatibilities exist here?

The water hazard classes are derived from a standardised database intended for standardising requirements relating to transport, storage and other handling of substances "on land". In principle, a very broad differentiation of substance properties is neither intended, nor is it necessary for the objectives for which the values are to be used.

Problematical substances within the meaning of the water hazard classes require especially safe handling – here, for example, high solubility in water is a "problematical property" that results in assignment to a higher water hazard class, because it is virtually impossible to recover the substance if it escapes into the water. But a substance that is completely dissolved in the water phase following an accident no longer derives its potential harmfulness to aquatic organisms from its solubility properties, but from its toxic properties.

To this extent there is a need to investigate whether and to what extent the established emission-oriented warning thresholds provide a meaningful basis for deriving immission-oriented warning thresholds for early warning systems for the purposes of the WFD.

3.3.4.1 Deriving immission warning thresholds from water hazard classes

Deriving concentration thresholds from the WHC-based emission warning thresholds of the IWAE in Table 3 is at best possible under highly generalised boundary conditions, since the introduction of a specific quantity of a substance into the river results in concentration differences of several orders of magnitude depending on the input location, the present flow rate, and – last but not least – the location where the measurement is made. In other words, the currently valid *emission* thresholds derived from the law relating to major accidents and dangerous substances cannot be directly transformed into *immission* thresholds.

If one nevertheless wants to take emission thresholds as a basis for immission thresholds, it would seem to be more sensible to assign the WHC warning thresholds on a *pragmatic basis*. It was suggested in EASE[113] that the following classification be examined (Table 7):

Table 7 Proposal for deriving immission warning thresholds from the WHC

Substance with WHC	Alarm threshold [µg/l]
Not dangerous	100
1 slightly dangerous to water	10
2 dangerous to water	1
3 very dangerous to water	0.1

Apart from a few exceptions, these values approximately cover *from a formal point of view* the range that would result from deriving warning thresholds by multiplying the values in the WFD “Chem” and “Eco” lists by a factor of 100 (Table 6, Table 8). However, the following shows that when one gets down to detail, there are considerable discrepancies regarding compatibility with quality standards based on concentration values.

Table 8 River basin specific substances ("Eco" list): AA-EQS, ascending, WHC

EC No.	Substance	AA-EQS	Unit	WHC
94	Mevinphos	0.0002	µg/l	3
(101)	PCB-28[2]	0.0005	µg/l	-
(101)	PCB-52[2]	0.0005	µg/l	-
(101)	PCB-101[2]	0.0005	µg/l	-
(101)	PCB-118[2]	0.0005	µg/l	-
(101)	PCB-138[2]	0.0005	µg/l	-
(101)	PCB-153[2]	0.0005	µg/l	-
(101)	PCB-180[2]	0.0005	µg/l	-
125-127	Triphenyltin cation[2]	0.0005	µg/l	3
70	Dichlorvos	0.0006	µg/l	3
108	Tetrabutyltin [3]	0.001	µg/l	3
116	Trichlorfon	0.002	µg/l	3
15	Chlordane (cis and trans)	0.003	µg/l	3
75	Disulfoton	0.004	µg/l	3
81	Fenthion	0.004	µg/l	3
L.II	Etrimphos	0.004	µg/l	3
(100)	Parathion-ethyl	0.005	µg/l	3
103	Phoxim	0.008	µg/l	3
80	Fenitrothion	0.009	µg/l	3
26	Chloronaphthalenes (techn. mixture)	0.01	µg/l	-
5	Azinphos-ethyl	0.01	µg/l	3
6	Azinphos-methyl	0.01	µg/l	3
L.II	Cyanide	0.01	mg/l	3
49-51	Dibutyltin cation[1]	0.01	µg/l	
89	Malathion	0.02	µg/l	3
(100)	Parathion-methyl	0.02	µg/l	3
113	Triazophos	0.03	µg/l	3
19	4-chloroaniline	0.05	µg/l	3
43	Coumaphos	0.07	µg/l	
L.II	Hexazinone	0.07	µg/l	-
(47)	Demeton (sum of demeton-o and -s)	0.1	µg/l	
(47)	Demeton-o	0.1	µg/l	
(82)	Heptachlor	0.1	µg/l	-
(82)	Heptachloroepoxide	0.1	µg/l	-
98	Oxydemeton-methyl	0.1	µg/l	-
104	Propanil	0.1	µg/l	-
107	2,4,5-T	0.1	µg/l	-
44	Cyanuric chloride □(2,4,6-trichloro-1,3,5-triazine)	0.1	µg/l	1
45	2,4-D	0.1	µg/l	2
(47)	Demeton-s	0.1	µg/l	2
(47)	Demeton-s-methyl-sulphone	0.1	µg/l	2
69	Dichlorprop	0.1	µg/l	2
90	MCPA	0.1	µg/l	2
91	Mecoprop	0.1	µg/l	2
105	Pyrazon (chloridazon)	0.1	µg/l	2
132	Bentazone	0.1	µg/l	2
L.II	Nitrobenzene	0.1	µg/l	2
8	Benzidine	0.1	µg/l	3
(47)	Demeton-s-methyl	0.1	µg/l	3
73	Dimethoate	0.1	µg/l	3
88	Linuron	0.1	µg/l	3
93	Methamidophos	0.1	µg/l	3
95	Monolinuron	0.1	µg/l	3
97	Omethoate	0.1	µg/l	3
L.II	Metolachlor	0.2	µg/l	2
L.II	Metazachlor	0.4	µg/l	-

EC No.	Substance	AA-EQS	Unit	WHC
L.II	Chlortoluron	0.4	µg/l	3
L.II	Ametryn	0.5	µg/l	-
L.II	Prometryn	0.5	µg/l	-
(52)	3,4-dichloroaniline	0.5	µg/l	3
L.II	Terbuthylazine	0.5	µg/l	3
L.II	Bromacil	0.6	µg/l	-
(32)	2-chloro-6-nitrotoluene	1	µg/l	
(32)	3-chloro-4-nitrotoluene	1	µg/l	
(32)	4-chloro-3-nitrotoluene	1	µg/l	
(32)	5-chloro-2-nitrotoluene	1	µg/l	
(52)	3,5-dichloroaniline	1	µg/l	-
11	Biphenyl	1	µg/l	2
18	3-chloroaniline	1	µg/l	2
20	Chlorobenzene	1	µg/l	2
25	1-chloronaphthalene	1	µg/l	2
29	1-chloro-3-nitrobenzene	1	µg/l	2
(32)	2-chloro-4-nitrotoluene	1	µg/l	2
38	2-chlorotoluene	1	µg/l	2
40	4-chlorotoluene	1	µg/l	2
(52)	2,3-dichloroaniline	1	µg/l	3
(52)	2,4-dichloroaniline	1	µg/l	3
(52)	2,5-dichloroaniline	1	µg/l	3
(52)	2,6-dichloroaniline	1	µg/l	3
109	1,2,4,5-tetrachlorobenzene	1	µg/l	3
(122)	2,4,5-trichlorophenol	1	µg/l	3
(122)	2,4,6-trichlorophenol	1	µg/l	3
(122)	2,3,4-trichlorophenol	1	µg/l	3
(122)	2,3,5-trichlorophenol	1	µg/l	3
(122)	2,3,6-trichlorophenol	1	µg/l	3
(122)	3,4,5-trichlorophenol	1	µg/l	3
128	Vinylchloride (chloroethylene)	2	µg/l	2
L.II	Metabenzthiazuron	2.0	µg/l	2
48	1,2-dibromoethane	2	µg/l	3
(52)	2,4/2,5-dichloroaniline	2	µg/l	3
17	2-chloroaniline	3	µg/l	2
27	4-chloro-2-nitroaniline	3	µg/l	2
21	1-chloro-2,4-dinitrobenzene	5	µg/l	2
31	4-chloro-2-nitrotoluene	10	µg/l	
34	3-chlorophenol	10	µg/l	
36	Chloroprene	10	µg/l	
56	Dichlorobenzidines	10	µg/l	-
57	Dichlorodiisopropylether	10	µg/l	-
(63)	1,2-dichloro-4-nitrobenzene	10	µg/l	-
(63)	1,4-dichloro-2-nitrobenzene	10	µg/l	-
66	1,3-dichloropropane-2-ol	10	µg/l	-
(129)	1,2-dimethylbenzene	10	µg/l	-
(129)	1,3-dimethylbenzene	10	µg/l	-
(129)	1,4-dimethylbenzene	10	µg/l	-
72	Diethylamine	10	µg/l	1
79	Ethylbenzene	10	µg/l	1
87	Isopropylbenzene (Cumal)	10	µg/l	1
2	2-amino-4-chlorophenol	10	µg/l	2
14	Chloralhydrate	10	µg/l	2
16	Chloroacetic acid	10	µg/l	2
24	4-chloro-3-methylphenol	10	µg/l	2
28	1-chloro-2-nitrobenzene	10	µg/l	2
30	1-chloro-4-nitrobenzene	10	µg/l	2
33	2-chlorophenol	10	µg/l	2

EC No.	Substance	AA-EQS	Unit	WHC
35	4-chlorophenol	10	µg/l	2
37	3-chloropropene (allylchloride)	10	µg/l	2
41	2-chloro-p-toluidine	10	µg/l	2
(42)	3-chloro-p-toluidine	10	µg/l	2
53	1,2-dichlorobenzene	10	µg/l	2
54	1,3-dichlorobenzene	10	µg/l	2
55	1,4-dichlorobenzene	10	µg/l	2
74	Dimethylamine	10	µg/l	2
112	Toluene	10	µg/l	2
114	Tributylphosphate (phosphoric acid tributylester)	10	µg/l	2
123	1,1,2-trichlorotrifluoroethane	10	µg/l	2
9	Benzylchloride (a-chlorotoluene)	10	µg/l	3
10	Benzylidenechloride (a,a-dichlorotoluene)	10	µg/l	3
22	2-chloroethanol	10	µg/l	3
39	3-chlorotoluene	10	µg/l	3
(42)	3-chloro-o-toluidine	10	µg/l	3
(42)	5-chloro-o-toluidine	10	µg/l	3
58	1,1-dichloroethane	10	µg/l	3
60	1,1-dichloroethylene (vinylidene chloride)	10	µg/l	3
61	1,2-dichloroethylene	10	µg/l	3
(63)	1,2-dichloro-3-nitrobenzene	10	µg/l	3
(63)	1,3-dichloro-4-nitrobenzene	10	µg/l	3
64	2,4-dichlorophenol	10	µg/l	3
65	1,2-dichloropropane	10	µg/l	3
67	1,3-dichloropropene	10	µg/l	3
68	2,3-dichloropropene	10	µg/l	3
78	Epichlorohydrin	10	µg/l	3
86	Hexachloroethane	10	µg/l	3
110	1,1,2,2-tetrachloroethane	10	µg/l	3
119	1,1,2-trichloroethane	10	µg/l	3
120	1,1,2-trichloroethane	10	µg/l	3
4	Arsenic	40	mg/kg	3
L.II	Copper	160	mg/kg	-
L.II	Chromium	640	mg/kg	-
L.II	Zinc	800	mg/kg	-

[1] alternatively for the sediment 100 mg/kg
[2] alternatively for the sediment 20 mg/kg
[3] alternatively for the sediment 40 mg/kg

3.3.4.2 Compatibility problem: emission thresholds and EQS

Water hazard classes provide only a very rough differentiation with regard to the possibilities of assessing what concentration of a substance, once it has entered the water, produces what adverse effects on which protection target. Thus although it is possible to establish pragmatic links between the emission-oriented warning thresholds, which (merely) regulate the polluter's notification duties in relation to the quantity of pollutant input, and water hazard classes, simply assigning a substance to one of four classes does not provide a sufficiently stringent basis of data for deriving concentration values that a measuring station somewhere along the river at an unknown distance from the input location can use to identify the measured value as "accident-induced". One of the reasons is that there is no scope for further differentiation of the hazard potential within WHC 3 (very dangerous to water). However, the various water quality norms geared to objects of protection – such as the WFD or the Drinking Water Regulation – provide for a very wide range of values for the "dangerous" substances in particular.

A look at the annual average environmental quality standards (AA-EQS) sorted in ascending order in Table 6 and Table 8 shows that under the WFD system the main differentiation of quality standards takes place within the group of "substances very dangerous to water" (WHC 3). It is also evident that in the range of AA-EQS values from 0.1 µg/l upwards, WHC 2 is represented with much the same frequency as WHC 3, and that there is no clear correlation between EQS and WHC 2/WHC 3. The ranges of EQS values in the individual water hazard classes are summarised in the following table.

Table 9 WHC and ranges of AA-EQS values according to WFD

WHC	Range AA-EQS WFD Chem/Eco [µg/l]
1 slightly dangerous to water	0.1 - 10
2 dangerous to water	0.1 - 20
3 very dangerous to water	0.0002 - 10

It is also possible to cite isolated examples where substances classified as very dangerous to water in accordance with the administrative guideline on substances dangerous to water (WHC 3) are assigned higher quality objective values in the WFD "Eco" list than those in WHC 1 (see Table 10). There are a number of reasons for this which we cannot examine in detail here. To some extent it is due to different assessment criteria[118], but no doubt it is also partly due to differences in the data available at the different times of assessment.

Table 10 Compatibility problems: WHC versus AA-EQS values under WFD (examples)

EC No.	Substance	WHC	AA-EQS [µg/l]
44	Cyanuric chloride (2,4,6-trichloro-1,3,5-triazine)	1	0.1
21	1-chloro-2,4-dinitrobenzene	2	5
14	Chloralhydrate	2	10
5	Azinphos-ethyl	3	0.01

In summary, therefore, we can say: Although it might make sense for systematic reasons, the *immission-oriented* warning thresholds needed for early warning systems cannot be derived stringently from the *emission-oriented* WHC-based warning thresholds. If such a classification is nevertheless established using a pragmatic approach, the resulting threshold values are not compatible with the system of values in the Water Framework Directive.

However, since the quality of water bodies has to be assessed using the criteria of the WFD, we propose here that the immission-oriented warning thresholds also be based on the system in the Water Framework Directive, if necessary including criteria for other objects of protection. Since the ecotoxic effect (for example) of the introduction of a substance dangerous to water is ultimately only indirectly dependent on the absolute quantity input, but in fact depends on the concentration of the substance in the water, warning thresholds should also be derived on the basis of immission quality standards.[119] A method based on our proposal in the EASE[113] project is discussed in Chapter 8.1.2.1.

> *Continued from previous page* <

118 Under the system of the water hazard classes, for example, “good solubility in water” is a substance property that is “dangerous to water”, whereas this parameter is irrelevant when assessing the threat to a body of water posed by a substance that is already *dissolved* in the water.

119 In 1999 the Major Incidents Commission therefore called for the inclusion of flow data in connection with the assessment of water accidents on the basis of water hazard classes;
Störfall-Kommission SFK-GS-18, *“Orientierende Beurteilung von Gewässerunfällen”*, 1999, http://www.kas-bmu.de/publikationen/sfk/sfk_gs_18.pdf .

4 Inventory and conceptual delimitation

This section introduces the conventions, recommendations, guidelines, warning and alarm plans that have been made available by the river basin commissions for the Rhine, Danube, Elbe and Oder or are otherwise publicly accessible for the individual river basin districts, and discusses their relevance to Article 11 (3) I WFD.

4.1 Recommendations in the field of installation-oriented water conservation

Apart from the provisions of European legislation, there are already a number of recommendations and activities at transnational level which are concerned with improving and harmonising precautions against accidental water pollution from technical installations. The findings derived from them serve as a basis for the study, in order to give more concrete shape to the requirements of Article 11 (3) I WFD and implement them.

The background to the emergence of these aspects comprises two main factors: (i) relevant major incidents in the past and (ii) installation-related water conservation, which was already regulated separately in German water legislation.

(i) Serious industrial accidents in the past have made it clear that their impacts do not stop at national borders. The conclusion to be drawn is that mere national precautions against such events are not sufficient, and that there is a need for transboundary consultation and coordination. This is the only way of ensuring equivalent protection everywhere. This need has also been confirmed by the legal requirements of the European Union. Among other things, this is made clear by Article 11 (3) I WFD.

(ii) Pollutant losses from even fairly small installations can give rise to substantial harmful effects on bodies of water. For this reason, the handling of substances dangerous to water is regulated by water body legislation, in addition to the provision for installations covered by the major accident regulations.

This is why Germany has for a long time been making efforts to incorporate the resulting requirements and findings in the harmonisation process within the international river basin commissions and in bilateral and multilateral agreements. However, this has also resulted in a situation where fragments of installation-related water conservation are today embodied with varying degrees of diffusion in international cooperation. This is an important starting point for the application of the WFD. There is a need to examine whether the decisions taken to date are sufficient to ensure comprehensive satisfaction of the EU requirements.

The following synopsis (see Table 11) of recommendations by the river basin commissions, multilateral organisations and, in some cases, national bodies makes no claim to be exhaustive, but it does contain the documents which form the basis for implementing the project objectives and which are therefore of crucial thematic importance.

Table 11 Overview of recommendations and activities relevant to installation safety

	IRBC	Recommendations – Title	Published
International river basin commissions	ICPR / IKSR	Definition of substances dangerous to water Authorisation procedures for installations of major-accident relevance Overfill protection Pipework safety Joint storage Sealing systems Wastewater substreams Transhipment Fire protection concept Installation monitoring Site alarm and emergency response planning	1998
	ICPER / IKSE	Recommendations on problems of fire-fighting water retention Recommendations on improving major-accident precautions on the Elbe Recommendation on basic structure of safety reports	1993 1994 1996 1997

	IRBC	Recommendations – Title	Published
		with regard to water hazards Site alarm and emergency response planning – Recommendations Requirements for installations for handling substances dangerous to water in flood areas or areas at risk of ponding – Recommendations Overfill protection – Recommendations Organisational measures and material-related basic requirements for protection against accidents involving floating substances dangerous to water – Recommendations Pipework safety – Recommendations Basic requirement for installations for handling substances dangerous to water – Recommendations Recommendations on storage facilities for substances dangerous to water/hazardous substances	1998 1999 2000 2001 2002 2004
	ICPDR / IKSD	Recommendations on safety requirements for contaminated sites in flood-risk areas Performing inventories of accident risk spots	2005 2001
	ICPOaP / IKSO	Requirements for installations for handling substances dangerous to water in flood areas or areas at risk of ponding	2005
	IKSMS IKSMS	Recommendations to the Member States of the IKSMS on precautionary measures for oil and hydrocarbon storage in areas at risk of ponding	1995

	IRBC	Recommendations – Title	Published
Checklist method		Operationalising the ICPER and ICPR recommendations *additions:* *(Kura River Basin)* Technical safety recommendations for industrial tailing management facilities Technical safety recommendations for supervising the closure of dangerous industrial units: - permanent closure - temporary closure *(Technology transfer)* Checklists for inspecting and assessing the condition of installations involving substances and preparations dangerous to water in the cellulose and paper industry Checklists for refinery safety	2006 2006 2006
Multilateral organisations	UN ECE	Safety guidelines and standards for pipelines Safety guidelines for transboundary emergency planning Safety guidelines for industrial tailing management facilities	2006 planned planned
	OECD	Guidelines for Chemical Accident Prevention and Response	2003
BAT reference documents (BREF)		BAT reference document on the best available technologies for the storage of bulk or dangerous materials	2005

4.1.1 International river basin commissions

The international river basin commissions are important bodies for developing and updating the standard of installation-related water conservation. The entry into force of the WFD has added the task of international coordination of implementing the directive to the commissions' spectrum of activities. This also makes them an important bridge between hazard precautions and the Water Framework Directive, in that they combine competencies in the two fields. This section focuses on the river basin commissions that are most active in this respect. The next item introduces the checklist method, which is a more advanced application of the existing recommendations and experience of several commissions.

4.1.1.1 International Commission for the Protection of the Danube River (ICPDR)

The ICPDR is composed of representatives of 13 member states and the EU. This makes it the largest international river commission in which Germany takes part. Among other things, the ICPDR is concerned with precautions against accidental water pollution and improving response capacity in the event of accidents. Its work focuses on three key areas[120]:

(i) Performing inventories of accidental risk spots;

(ii) Basic recommendations for member states on improving safety standards at hazard sites;

(iii) Development of checklists (see Chapter 4.1.2 for implementation and checking of safety requirements at hazard sites).

To **identify accidental risk spots**[121] *(ARS),* the ICPDR initiated an inventory of sites in the Danube catchment area that could be expected to present a threat to the quality of the waters in the event of an accident. The analysis of individual sites considered the nature and quantity of the hazardous substances used or stored there. The basis for assessing the hazard potential of substances and substance mixtures is their allocation to *water hazard classes (WHC),* as used in Germany. In connection with the quantity of the substance it is possible to derive from the water hazard classes a *water risk index (WRI)*, which provides a comparable reference value for the hazard potential of an installation. The survey made it possible to identify areas with a concentration of

[120] Cf. IKSD/ICPDR, accidental pollution, http://www.icpdr.org/icpdr-pages/accidental_pollution.htm.

hazard potential and prepare a graphic representation of geographical data. Industrial locations of “typical”“ risk industries were considered, as were risks arising from intensive mining activities and associated spoil tips, e.g. in Romania. The result merely reflect the fact that the sites listed could give rise to hazards. The inventory does not reflect the actual risk that has to be assumed, since the individual safety precautions are not considered in the inventory and need to be assessed separately.

Safety requirements for contaminated sites in flood-risk areas[122] are the subject of the ICPDR’s only “classic” safety recommendation to date. It provides recommendations on technical and organisational measures for reducing the hazards that could potentially arise from contaminated sites in flood situations. The safety requirements are divided into (i) administrative requirements, (ii) risk assessment and (iii) technical requirements, and include the following detailed aspects:

(i) The administrative requirements form the basis for dealing with contaminated sites. They cover the registration of suspected or known contaminated sites and regulate responsibility for financial obligations and official powers regarding access to data and monitoring results.

(ii) Several steps, which must be documented, are necessary for assessing the hazard potential of contaminated sites. Contaminated sites must first be identified and must then undergo a more detailed examination. Detailed studies focus on zones of high contamination within a site.

(iii) Technical requirements are divided into preventive measures for preventing the creation of new contaminated sites, and measures for remediation of existing contaminated sites. The preventive recommendations address endangered sites and companies which have to be prepared for contamination as a result of local flood risks. Possible decontamination measures for remediation of existing contaminated sites are mentioned. As an alternative, zones of high contamination can be isolated from the influence of flood situations.

> *Continued from previous page* <

[121] ICPDR / IKSD. Inventory of Potential Accidental Risk Spots in the Danube River Basin. ARS *ad-hoc* Expert Panel of the AEPWS EG, 2001.

[122] IKSD/ICPDR Recommendation Safety Requirements for Contaminated Sites in Flood-risk Areas. APC (Accident Prevention and Control) Expert Group, Final Draft (no year stated).

For completeness' sake the ICPDR documents concerning best available technologies should be mentioned here. These are not classic safety recommendations and are above all aimed at general emission reduction in specific industrial sectors. In some cases, however, these documents contain information of safety relevance. The following relevant recommendations have been published by the ICPDR[123]:

- Recommendation on best available technologies in the food industry
- Recommendations on best available technologies in the chemical industry
- Recommendations on best available technologies in cellulose production
- Recommendations on best available technologies in the paper industry
- Recommendations on best available technologies in agriculture

4.1.1.2 International Commission for the Protection of the Elbe River (ICPER)

The active actors in the ICPER are the Federal Republic of Germany and the Czech Republic. Within the ICPER, working group H on "Accidental Pollution" is concerned with installation-related precautions, with the aim of harmonising safety standards in the two countries.

For this reason the ICPER has published a number of technical safety recommendations[124]. The recommendations range from general basic requirements, through requirements for specific risk sources, to options for action once an accident has occurred. The following list provides a concise outline of the individual recommendations.

- **Recommendations on problems of fire-fighting water retention:** The basis for this document is the *Assessment Guideline for Fire-fighting Water Retention in Storage Facilities for Substances Dangerous to Water (LöRüRL)*. If fires occur at sites where substances dangerous to water are stored, there is a risk that

123 See also IKSD/ICPDR http://www.icpdr.org/icpdr-pages/guidance_documents.htm.

124 Published together in: IKSE, Stand der Umsetzungen der Empfehlungen der Internationalen Kommission zum Schutz der Elbe (IKSE) für den Bereich der Störfallvorsorge, Anlagensicherheit und Störfallabwehr, 2007.

these substances may be carried out in the fire-fighting water. This results in the need to retain the fire-fighting water. Four safety categories are distinguished on the basis of parameters relevant to fire protection. The safety category, the size of the storage facility and the WHC of the substances stored determine the estimated volume of fire-fighting water that has to be retained. With regard to technical ways and means of implementing the requirements, the recommendations refers to the Assessment Guideline.

- **Recommendations on improving major-accident precautions on the Elbe:** This document is a snapshot of the situation (in 1994) with regard to major-accident precautions and the deficits that it indicates along the Elbe. It makes a number of specific recommendations which essentially address administrative requirements in the member states and action options for the public-sector actors regarding handling of major-accident situations throughout the river basin. The document does not contain any general installation-related safety requirements.

- **Recommendations on basic structure of safety reports with regard to water hazards:** With regard to installations falling within the scope of the *Seveso-II Directive* (see relevant section above), the document contains detailed notes on appropriate inclusion of the aspect of water hazards in the required *safety reports*. On the basis of this concrete field of application, the recommendation is primarily aimed at *installations covered by the major-accident regulations*. It is nevertheless possible to use the information to deduce generally valid requirements of importance for a methodical approach to improving plant safety in installations that do not fall within the regulatory scope of the *Seveso-II Directive*. When investigating the relevant factors the recommendation uses the following breakdown: characterisation of site or installation environment, description of (hazardous) substances, description of installations and processes, hazard analysis regarding expected incidents and relevant precautions, determination of precautionary measures to prevent accidents and minimise damage, and assessment and critical appraisal of the safety level achieved. From this methodical sequence it is possible to derive a basic approach to the implementation of an installation-related safety standard that can be taken up and usefully employed above and beyond its use in *safety reports* on *installations covered by the major accident regulations*.

- **Recommendations on site alarm and emergency response planning:** The document addresses installations that use substances dangerous to water, though sometimes it refers more specifically to installations of *major-accident relevance*. Site alarm and emergency response planning has to be regarded as a *basic safety obligation* of the operator of such installations. It serves to plan and document the response measures available for containing the hazard when a hazard situation occurs (incident). The recommendation mentions the following points as particularly relevant when drawing up a site alarm and emergency response plan: once a hazard situation is detected, (i) the necessary alarm sequences must take effect. To this end a hazard notification on the basis of defined notification hierarchies must be guaranteed. Internal and external responsibilities and information duties must clarified in advance, and responsibility for damage containment measures must be clearly allocated. For installation-related emergency response planning it is first necessary to collect (ii) basic installation-specific information. This includes in particular the inventory of substances, local factors (objects of protection, external sources of danger), available resources, structural and planning details of the installation, definition of key hazards, major-accident scenarios including impact estimation, and a description of the possible incident containment measures for the scenarios identified. Site alarm and emergency response planning must be (iii) reinforced by regular exercises, updated, and made known to internal/external participants. It is clear from the content that site alarm and emergency response plans also contain certain basic methodological steps that are of crucial significance for the conceptual approach to ensuring appropriate hazard precautions.

- **Recommendations on requirements for installations for handling substances dangerous to water in flood areas or areas at risk of ponding:** The recommendation is aimed at installations that are or could be affected by ponding. This applies to the threat of inundation by floods, and also backwaters from sewage systems, rising groundwater or build-ups of fire-fighting water. The requirements are differentiated for underground and surface installations in buildings and in the open. Flooding of parts of installations can cause additional hazards which may result in losses of pollutants. To counteract these hazards it is necessary to protect parts of the installation from flotation, external (water) pressure, outwash and flotsam. As far as possible, containers and pipework in the open air should be built above the expected floodwater level (HW_{100}[125]). Parts of the installations that are necessary for the use of the installation (especially openings, filling/ emptying connections, ventilation etc.) must be protected from expected external influences to prevent leaks.

- **Recommendations on overfill protection:** The recommendation is concerned with precautions against losses of substances when filling containers with substances dangerous to water. An overfill protection system must always be used, unless overfilling can be excluded by other means. Overfill protection automatically stops the filling operation or gives an acoustic warning that it needs to be stopped. The functioning of the protection system must be constantly monitored and checked.

- **Recommendations on organisational measures and material-related basic requirements for protection against accidents involving floating substances dangerous to water:** Technical options for dealing with accidents in bodies of water are largely confined to floating material. Their effectiveness is also dependent on the prevailing water conditions (flow rate, wind conditions, tide situation etc.). The recommendation states requirements for strategic determination of control sites in connection with areas requiring special protection. Such sites must however also be selected on the basis of their suitability for carrying out the control measures. For spatial containment and elimination of floating pollutants, the appropriate technical equipment (oil booms, skimmers, transport systems and boat technology etc.) is to be kept available at the designated control site. The document lists additional requirements for general measures to be carried out after accidents with substances dangerous to water, and these are similar to the recommendations of the alarm and emergency response plans. Follow-up measures to remedy the damage are also discussed.

- **Recommendations on pipework safety:** The document is aimed at in-plant movement of substances dangerous to water via pipelines. It lists the basic technical requirements for this area. As a general principle, pipelines must safely contain the substances dangerous to water, and they must be resistance to the substance and to possible external influences. Compliance with these requirements must be assured by means of regular inspection and control mecha-

[125] HW_{100} is the expected high water level for a hundred-year flood

nisms. The recommendation also lists special requirements, e.g. for underground pipelines. The structure and protection of an in-plant pipeline network are to be documented.

- **Recommendations on basic requirements for installations for handling substances dangerous to water:** There are no restrictions on the scope of this recommendation. It sets out the fundamental (basic) requirements for installations for handling substances dangerous to water. These are broken down into (i) primary containment of the dangerous substances (freedom from leaks, resistance to expected influences), (ii) timely detection of leaks and damage, and (iii) the secondary barrier to retain escaped substances dangerous to water. As an alternative to retention facilities, automatic leak detectors or double-walled storage tanks offer an equivalent level of protection. The basic requirements also include preparation of various organisational plans (surveillance, maintenance, alarms) for additional documentation of the safety measures.

- **Recommendations on storage facilities for substances dangerous to water/hazardous substances:** The recommendation concerns both underground and surface installations for the storage of substances dangerous to water. The requirements are listed one after the other and do not have any clear structure. In addition to the general basic conditions (see above), which also apply to storage facilities, detailed individual requirements are also listed. The recommendation also provides information on the dimensions of retention spaces. For storage tanks, detailed information is also provided about selecting the erection site and about the resulting additional requirements (minimum distances, fire exposure duration, leak detection etc.). Special requirements are also listed for combustible substances dangerous to water. Moreover, special requirements have to be observed with regard to storage of solids. Storage facilities are to be labelled to identify the dangerous substances present.

The ICPER also has a draft version[126] of a **recommendation on tank equipment**, but this has not yet been officially published. The document is aimed at stationary tanks installed above or below ground and operated with or without internal overpressure. The draft contains specific technical and organisational recommendations about

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[126] ICPER, draft. Empfehlungen zur Ausrüstung von Tanks. Online at: http://www.umweltbundesamt.de/anlagen/Checklistenmethode/Entwurf-Empf-Ausrustung_von_Tanks.pdf Version: 31.08.2008.

ventilation, flame-proof fittings, level and leak indicators, overfill protection, shut-off valves on pipelines, filling and emptying facilities, entry and coating openings, labelling, and additional requirements for overpressure or partial vacuum.

4.1.1.3 International Commission for the Protection of the Oder River against Pollution (ICPO),

The ICPO is made up of delegations from Germany, Poland and the Czech Republic. Installation safety issues and precautionary measures for the Oder catchment area are dealt with by working group *G3 "Pollution caused by shipping accidents"*. The activities of the working group focus on the *International Warning and Alert System for the Oder*, the *International Contingency Plan for the Oder*, making an inventory of potential accident sources, and suggesting recommendations for preventive measures, including sharing experience with working groups in other river basin commissions. In addition, G3 has a mandate to support implementation of the WFD in the field of accidental water pollution.[127]

The only ICPO publication in the field of technical safety recommendations is its ***Recommendations on handling substances dangerous to water in flood areas or areas at risk of ponding***[128], which are identical to the corresponding ICPER document. For this reason we do not give a separate summary here.

4.1.1.4 International Commission for the Protection of the Rhine (ICPR)

The ICPR coordinates the work of the five Rhine states (France, Germany, Luxembourg, Netherlands and Switzerland) and the European Union on protecting and improving the quality of this international river. In the field of installation safety and incident precautions, the ICPR provided a certain initial stimulus. Following the fire disaster in Schweizerhalle in 1986 and the resulting adverse impacts on water use and the ecosystem of the Rhine it was considered necessary to draw up technical safety

[127] Cf. mandate of ICPO working group G3 "Accidental Pollution", http://www.mkoo.pl/index.php?mid=15&aid=231, Version: 15.05.2006.

[128] ICPO, Requirements for installations for handling substances dangerous to water in flood areas or areas at risk of ponding – Recommendations

recommendations for installations which handle *significant quantities* of substances dangerous to water. The ICPR claims that the application of these recommendations has already brought a considerable decline in accidental pollution of the Rhine.[129]

The individual recommendations have been put together to form a **compendium entitled "*Recommendations of the International Commission for the Protection of the Rhine (ICPR) on accident prevention and installation safety*[130]"**, the contents of which are summarised under the following headings. The compendium does not follow any specific structure, but is a succession of individual recommendations. It is nevertheless possible to recognise the rudiments of a workflow-oriented sequence, even if this is not explicitly stated.

- **Definition of substances dangerous to water:** As a starting point for defining the overall scope of the recommendations, the ICPR defines the term *substance dangerous to water* on the basis of *EC Directive 67/548/EEC*. Accordingly, a substance is to be classified as dangerous to water if it satisfies one of the criteria *very toxic (T+), toxic (T), corrosive (C), harmful to health (Xn), dangerous to the environment (N), harmful to aquatic organisms (R52)* or *may cause long-term adverse effects on the aquatic environment (R53)*.

- **Authorisation procedures for installations of major-accident relevance:** In the case of authorisation procedures for installations of major-accident relevance the ICPR identifies key areas where compliance is considered necessary for a harmonised approach in the individual member states. Authorisations must be issued in writing and must include installation-specific information from the planning process. This provides a summary of information about the inventory of substances, the planned safety measures, and the influences expected in emergency situations. Public involvement (general public, technical authorities etc.) is essential before authorisation is granted. This approach ensures that safety aspects are examined from various angles.

- **Overfill protection:** The ICPR recommendation on overfill protection is very largely identical to the ICPER recommendation on the same topic (see above), so the summary is not repeated here. The ICPR justifies the relevance of this

[129] Cf. http://www.iksr.org/index.php?id=70, version 09.12.2005.

[130] IKSR, Empfehlungen der Internationalen Kommission zum Schutz des Rheins (IKSR) zur Störfallvorsorge und Anlagensicherheit (no year stated).

recommendation on the grounds that overfilling of receptacles is one of the major factors responsible for accidental pollution.

- **Safety of in-plant pipework:** The ICPR recommendation on the safety of in-plant pipework is very largely identical to the ICPER recommendation on the same topic (see above), so the summary is not repeated here.

- **Joint storage:** The ICPR recommends special requirements for joint storage of dangerous substances. For this purpose "joint storage" means the storage of two or more dangerous substances which are accommodated (i) in the same room, (ii) outdoors without an adequate safety gap or structural separation, or (iii) in the same collecting area or subdividable containers. Joint storage of dangerous substances depends on the properties of the individual substances. Substances which can easily trigger dangerous situations must not be stored together with other substances. To this end the recommendation includes a table of key properties with details of whether or not the substances are suitable for joint storage, and also sets out specific requirements for various groups of substances. There are special requirements for fire protection in cases of joint storage. Furthermore, the safety requirements within a storage facility must always be geared to the substance with the greatest hazard potential.

- **Sealing systems:** *Sealing systems* are used in spillage collection spaces. They are designed to ensure that the collecting space is leakproof and stable if substances are released. The ICPR recommends requirements intended to guarantee that the collecting spaces are leakproof. The sealing system must be appropriate to the physical and chemical properties of the substance handled and must if necessary be fire resistant. The time for which it has to remain leakproof has to take account of the organisational framework conditions (time to detection, elimination). The material of which the collecting space is made must be supplemented if necessary by coating materials. Joints and openings are to be avoided as far as possible or sealed with equivalent effect.

- **Wastewater substreams:** The recommendation on *wastewater substreams* is concerned with accidental pollution of plant wastewater or wastewater systems. If there is reason to expect a risk that substances dangerous to water will be released in a system, then the system must satisfy appropriate requirements to contain the substance as well as possible and stop it spreading. To this end it is necessary to monitor the wastewater to detect unusual influences, and provide facilities for retention and for shutting off affected subsystems. In addition, retention areas must be adequately dimensioned and sufficiently resistant to cater for the expected adverse situation. The conceivable scenarios with regard to polluted wastewater substreams must be included in the *alarm and emergency response plans*.

- **Transhipment:** Ports and terminals frequently have a high throughput of substances dangerous to water, and this involves a relatively high risk of spillage. In its recommendation, the ICPR lists requirements for reducing such risks. They are concerned with stationary (transhipment) installations used for transferring substances between ships, railway or road vehicles, and storage facilities. Transhipment sites are subject to the relevant requirements for the area on which the operation takes place, which must be leakproof and resistant, and the requirements for overfill protection. Precipitation on transhipment sites must be separately collected and treated. Suitable facilities for control and elimination of released substances must be kept available for immediate use. Special requirements also apply to the loading and unloading of ships. Transhipment sites must be identified as such.

- **Fire protection concept:** When fires occur in connection with substances dangerous to water, the biggest problem from a water conservation point of view is that dangerous substances may be mixed and spread by the fire-fighting water. If this possibility exists in an installation, the ICPR recommends that this aspect should always be included in the fire protection concept. Fire protection is concerned not only with preventive measures (structural and material precautions), which reduce the probability of a fire as far as possible, but also with early detection, control and containment. Contaminated fire-fighting water is held back by suitable retention facilities, the size of which should be based on specific parameters relating to the installation and the fire protection concept.

- **Installation monitoring:** Internal and official monitoring of installations where substances dangerous to water are handled is recommended particularly for interfaces where there is a likelihood of accidental releases. The purpose of installation monitoring is timely detection, in order to prevent hazard situations from escalating or to take immediate countermeasures if a release has already occurred. Aspects to be monitored are that critical parts of the installation are free from leaks and that the safety elements are functioning. Depending on the substances handled, the monitoring should be geared to the relevant chemical, physical and biological parameters. The operational status of the monitoring system must be visible at all times. Tests and maintenance measures are to be documented, as are accidents or malfunctions. The operator's own monitoring system is checked by the authorities and inspected at regular intervals. It may be necessary to extend the monitoring system to take in nearby bodies of water.

- **Site alarm and emergency response planning:** The ICPR recommendation on site alarm and emergency response planning is very largely identical to the ICPER recommendation on the same topic, so the summary is not repeated here.

4.1.1.5 International Commission for the Protection of the Mosel and the Saar against Pollution (ICPMS)

The Mosel and Saar rivers belong to the catchment area of the Rhine. Nevertheless, the delegations of France, Germany and Luxembourg traditionally form a separate river basin commission for the protection of the two rivers.[131] Within the IKSMS, the *group PS "Accident Precautions"* is concerned among other things with *Article 11 (3) l WFD* in conjunction with *Annex VII Item 7.8*[132]. The working group' mandate mentions as key activities the contribution to implementing *Article 11 (3) l WFD* and exchanging information with neighbouring river basin commissions.[133]

As long ago as 1995 the ICPMS published a technical safety recommendation on ***precautionary measures for oil and hydrocarbon storage in areas at risk of ponding***[134]. To a large extent the document corresponds to the relevant recommendations of ICPER and ICPO. However, the ICPMS recommendation goes further, and draws attention more clearly to the potential dangers, such as flotation, damage to containers due to external pressure, and releases via leaking container openings. Its also recommends that dangerous substances packed in movable form should not be

[131] This is probably due to the fact that the ICPR focuses its work on the River Rhine rather than the river basin district itself. Thus the Mosel and Saar are not comprehensively covered by the activities of the ICPR, and this situation justifies a separate commission.

[132] Annex VII to the WFD describes the required content of the management plans. In Item 7.8 it mentions the *"summary of the measures taken to prevent or reduce the impact of accidental pollution incidents"*.

[133] Cf. mandate of group PS "Accident Precautions" of the ICPMS, http://213.139.159.34/servlet/is/1231/#.

stored in areas at risk of ponding, or at least that appropriate precautions should be taken to prevent them floating away.

4.1.2 Checklist method

The method developed as part of the project commissioned by the Federal Environment Agency on *“Technology transfer for plant-related water protection in Romania, Moldavia and the Ukraine”*[135] serves to apply and implement the technical safety recommendations issued by the river basin commissions. The *“checklist method”* operationalises the individual action requirements in the recommendations to permit practical application and makes it possible to evaluate the technical safety aspects of an installation. The basis for this is essentially the recommendations of ICPER and ICPR, supplemented by the safety requirements for contaminated sites from the ICPDR. Like the technical safety recommendations, the individual checklists can be used independently of one another. They address specific functional units, industries or risk areas. They consist of a recommendations section, which recapitulates the requirements of the underlying recommendation, a corresponding check on the installation-specific situation, and the resulting recommendations for the short, medium and long-term action that is to be taken if the requirements are not satisfied. Short-term measures are immediately available options that can usually be implemented by simple means and at no great expense, and which bring an immediate improvement in the safety level. Medium-term measures make direct reference to the individual requirements in the recommendations, having regard to the operator’s economic capacity. The long-term measures are technical options for implementing European safety standards, which may involve substantial financial expenditure. However, the fact that appropriate measures are suggested does not rule out the possibility of investigating further options that might be a better alternative in the individual case. [136]

> *Continued from previous page* <

134 ICPMS, Recommendations to the Member States of the IKSMS on precautionary measures for oil and hydrocarbon storage in areas at risk of ponding, 1995.

135 See http://www.umweltbundesamt.de/anlagen/Checklistenmethode/index.html.

136 Cf. Federal Environment Agency (2006). Checklists for surveying and assessing industrial plant handling materials and substances which are hazardous to water. Overview and notes on using the checklists.

The industry-specific checklists (for "branches") can be seen as further developments of the documents for the individual functional units, which are based on the recommendations of the river basin commissions. One of these industry-specific checklists results from the cooperation project *"Technology Transfer for the Improvement of Plant Security and Environmental Protection in the Russian Pulp and Paper Industry"*[137]. This investigated the extent to which the checklists and recommendations not geared to particular industries could be used in the pulp and paper industry, and what specific aspects needed to be added for this purpose. This led to the ***Checklists for inspecting and assessing the condition of installations involving substances and preparations dangerous to water in the cellulose and paper industry***. In a similar context, another accident precautions project on the Danube drew up ***Checklists for refinery safety***.[138]

The project *"Transboundary cooperation for hazard prevention in the Kura River basin"*[139], commissioned by the Federal Environment Agency, also developed the checklist method further on an application-oriented basis. This resulted in three more checklists concerned with temporary and permanent closure of hazardous installations, and with the safety of industrial tailing management facilities, and which to some extent contain new recommendations in these fields.

The ICPDR recommends its member states to use the checklist method as a methodological basis for examining safety-relevant installations.[140]

4.1.3 Multilateral organisations

Not only the European Union, but also other multilateral organisations are making efforts to transport safety-relevant hazard precaution issues to a higher, international level. The main aim of these activities is also to standardise safety standards, which despite intergovernmental coordination may differ from one region to another, and to embody them in national efforts. This does not exclude the possibility that such publica-

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137 See http://www.umweltbundesamt.de/anlagen/Technologietransfer_Zellulose/.

138 See R+D Industrie Consult, Checklists for Refineries. Second Draft. UNDP/GEF Danube regional project "Activities for Accident Prevention – Pilot Project – Refineries", 2006.

139 Federal Environment Agency, Report on preparation for the transboundary cooperation for hazard prevention in the Kura River basin, http://www.kura.iabg.de/, 2002.

140 Cf. http://www.umweltbundesamt.de/anlagen/Checklistenmethode/index.html and http://www.icpdr.org/.

tions may be based on findings from individual river basins established as a criterion. In the context of WFD implementation, the relevant activities in UNECE and OECD are particularly important here.

4.1.3.1 United Nations Economic Commission for Europe (UNECE)

In 1998 a joint expert group[141] was established under the UNECE *Industrial Accidents Convention* and the *Water Convention*. It is concerned with the consequences of major industrial accidents and their transboundary impacts on bodies of water, and ways of preventing such accidents. The working group works on various key areas of transboundary hazard precautions. Its main tasks are to compile national and international safety recommendations, to support their application in international river basins, to make independent recommendations in fields that are not adequately covered, and draw up transboundary emergency response plans. It also sees a need to address the issue of methods for hazard sources of potentially smaller scale.[142]

In the interests of protection from accidental water pollution, the working group compiled and developed guidelines and standards concerned with ***Pipeline safety***[143]. Like installations that handle substances dangerous to water, pipelines used to transport such substances may also pose serious threats to human health and the environment. The commonest cause of pipeline accidents is external factors or material failure. The document also takes a very comprehensive look at the technical safety requirements and the responsibilities of the actors involved, and in the process it defines the individual fields of activity and requirements for the harmonisation of safety standards. The following is only a summary of the structure adopted:

- **Basic principles of pipeline safety:** The document first sets out general basic principles for pipeline safety. These do not exclusively address individual safety aspects, but form the framework for ensuring a safe approach to hazards due to pipelines. They deal with creating an administrative framework for a safe infrastructure including pipelines, identifying the operator's responsibility for aspects

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141 UNECE Joint Expert Group on Water and Industrial Accidents.

142 Cf. http://www.unece.org/env/teia/water.htm.

143 UNECE, Prevention of Accidental Water Pollution. Safety Guidelines and Good Practices for Pipelines, 2006.

relevant to safety and malfunctions, taking active precautions against uncontrolled releases of dangerous substances by means ranging from appropriate risk assessment, through reliable leak detection to a comprehensive management system, ensuring strategic incorporation of possible damage scenarios in emergency and land-use planning, reducing possible threats due to external factors, and informing the parties concerned and the general public.

- **Recommendations to the UNECE member states:** For the member states the crucial initial requirement is the creation or adaptation of the existing legal basis to ensure the targeted safety level, strengthen hazard awareness and promote the exchange of knowledge and experience. The rules should be clear, capable of enforcement and uniform on an international comparison. To this end it may be necessary to implement suitable structures for authorisation planning and strategies for land-use planning in order to guarantee and check pipeline safety. The member states name the competent authority empowered to enforce the legal basis.

- **Recommendations for the competent authorities:** The competent authorities ensure in the broadest sense the implementation of the legal requirements. This primarily comprises carrying out the authorisation procedures, which also includes assessing specific environmental effects. They run appropriate systems for checking the required safety standards, emergency response planning and the necessary flow of information between authorities and operator. In addition, the authority coordinates the preparation and updating of external emergency response plans, ensures the inclusion of safety-relevant aspects in land-use planning, takes account of any external influences by third parties that could give rise to accidents, and promotes awareness of and responsibility for safety standards. The authority assists in preparing site plans of pipelines and making any additional information available to the public concerned.

- **Recommendations for pipeline operators:** All operating phases of pipelines must be aimed at meeting the basic technical safety requirements with regard to precautions and containing impacts. This falls within the responsibility of the operator, who must be guided by the international state of safety technology. A basic precondition here is prior risk assessment covering a variety of influences and possible exceptional circumstances. To coordinate these aspects the operator should establish and implement a *pipeline management system (PMS)*. Its functioning must be documented, monitored with the aid of performance indicators, and evidence furnished to the authority. The operator's obligations also include drawing up and updating internal emergency response plans, and helping with the preparation of corresponding external plans.

- **Technical and organisational aspects:** The annex to the document takes an in-depth look at the general requirements and specifies concrete action options. It provides detailed information on design, construction and monitoring, PMS execution, internal and external emergency response plans, inspection, risk assessment and land use.

In addition, UNECE experts are working on two more safety guidelines on

- transboundary emergency response planning[144] (containing the impacts of accidents with dangerous substances on water) and
- tailing management facilities[145], concerning the hazards arising from tailings from underground and open-cast mining operations.

As both these documents are still at the draft stage, no further details are given here.

4.1.3.2 Organisation for Economic Cooperation and Development (OECD)

In the OECD, a key area in the field of sustainability and the environment is *chemical safety*. In its chemical accidents programme, the working group on *chemical accidents*[146] is working on issues concerned with prevention, emergency response, and control of such accident impacts. The group's objectives also include sharing information and experience.[147] The work is not geared exclusively to technical safety aspects of preventing water pollution, but in view of its general approach and analytical method it also forms an important basis for dealing with hazards to bodies of water.

[144] UNECE, Draft Safety guidelines and good practices for cross border contingency planning, 2008.

[145] UNECE, Draft Safety guidelines and good practices for tailing management facilities, 2008.

[146] Working Group on Chemical Accidents – WGCA.

[147] Cf. http://www.oecd.org.

An important publication addressing these issues is the ***OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response***[148]. These principles are intended as general guidance recommendations for all technical installations, regardless of size, which handle hazardous substances. The idea behind this is that all such hazard situations involve comparable *safety expectations* – they differ only in the effort required to achieve them and the nature and scale of the necessary measures. This very comprehensive document is divided into the following five complexes, of which we can only give a broad outline here:

- **Prevention** of accidents by implementing precautionary aspects in all phases of plant operation.
- **Preparedness/Mitigation** of accidents through targeted preparation for possible hazard situations and communication with parties potentially affected and involved, including individual site factors.
- **Response** to accidents by taking appropriate and available steps to control or contain the impacts of accidents, whether developing or in progress, on people, environment and material assets.
- **Follow-up to incidents** is primarily concerned with further reporting, specific investigation of the triggering and influencing factors, and the necessary medical activities, and initial remediation measures.
- **“Special issues”** addresses questions relating to international or transboundary aspects of the handling and transport of hazardous substances.

The *Guiding Principles* are addressed to all parties involved in the occurrence and development of incidents. Above all, they are aimed at industry in the form of the operators, and the public authorities. But the *stakeholders* also include the general public and other parties concerned (e.g. interest groups), who are therefore addressed as well.

Among the documents on installation safety and hazard precautions which are described here, the OECD Guiding Principles are the only one where the structure chosen is so closely based on the sequence of possible events. Even if the sequence of

[148] OECD/BMU, OECD Guidelines for Chemical Accident Prevention, Preparedness and Response. Guidance for Industry (including Management and Labour), Public Authorities, Communities, and other Stakeholders. 2. edition, OECD publications Environment, Health and Safety, Chemical Accidents Series No. 10, 2003.

other recommendations tends to imply a similar structure, these guidelines come closest to providing a methodological approach to controlling the hazards arising from technical installations that handle hazardous substances, regardless of the nature and size of the individual installation. This makes it clear that from a safety perspective the starting point for specific ideas has to be an overall strategy. The degree of detail with which this is applied, and the expenditure involved, depends in turn on the individual requirements of a specific installation. At this interface a methodological approach therefore needs the flexibility to allow it to be applied as broadly but effectively as possible.

4.1.4 Best available technology and BREF documents

Under the IPPC Directive, authorisation of relevant industrial installations is granted on the basis of *best available technologies*. This expression defined a level of technology that is comparable to the German *"Stand der Technik"* (state of technology). *Best available technology* indicates *"most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole"*[149]. The *best* technologies means the methods or measures that have proved most effective in practice. A technology is *available* if it is accessible to the operator under reasonable conditions, including the resulting cost-benefit situation.

The *best available technologies* are defined and updated in concrete form in **BREF documents** (BREF – Best Available Technique Reference Document). Publication of these documents is preceded by a supranational consultation process between public authorities, industry and environmental organisations in the Member States. In line with the scope of the IPPC Directive, the majority of BREF documents are aimed at specific industries. However, there are also BREFs that cover a broad field of applications within a number of industries.

[149] Art. 2 No. 12 IPPC Directive.

In line with their scope, the documents also include recommendations on safety measures. In the present context, special mention must be made of the BREF document on the **Storage of hazardous substances and bulk materials**[150]. The field of application of this document provides a horizontal cross-section of the scope of IPPC installations, since it addresses all industries which involve the storage, transport or transhipment of liquids, liquid gases and solids. In accordance with the integrated approach of the IPPC Directive, the focus is on emissions into the air, soil and water, though in this case the emphasis is on atmospheric emissions. It considers not only emissions resulting from normal or intended operation, but also emissions that arise from an unforeseen event, malfunction or accident. Emissions resulting from such events are described by the BREF as being of short duration, but considerably greater intensity than is normally the case with "deliberate" emissions. There is no exhaustive consideration of the possible types of incidents, and no distinction between minor and major incidents.

The BREF first discusses the technologies used for storage, transport and transhipment of substances. These are, for example, types of tanks used for storing liquids, or systems for the transport and transhipment of liquid substances. For each type of storage listed, the document then describes emission control measures that can be regarded as possible *best available technologies*. At this point there is a discussion of measures relating to releases due to incidents and (major) accidents. In the field of liquid substances these include, for example, safety management and risk management measures, operating processes and training, level indicators, leak and overfill protection, and fire protection, extinguishing equipment and containment. Finally the document determines which of the measures available appears most suitable, thereby identifying the *best available technology*. Here too, the document look separately at emissions resulting from abnormal operation.

The BREF document on **Storage of hazardous substances and dangerous goods** takes a very extensive look at the large number of possible installation types and discusses them in relation to integrated prevention of environmental impacts. For this reason we can only provide an overview of the structure of the document, without going into detail about individual recommendations for action relating to technical installations.

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150 Cf. Federal Environment Agency, Integrierte Vermeidung und Verminderung der Umweltverschmutzung. BAT reference document on the best available technologies for the storage of bulk or dangerous materials. Dessau, 2005.

4.1.5 Miscellaneous activities

In addition to the river basin commissions discussed in detail, mention must also be made of the **International Commission for the Meuse/Maas (IMK)**. In this body, Belgium, France, Germany, Luxembourg and the Netherlands in the working group on *"Accidental Pollution"* are also working in the field of prevention and control of accidental water pollution. However, the main focus is on the *warning and alarm system* for the Maas/Meuse. To date the IMK has not published any technical safety recommendations relating to installations.[151]

The less comprehensively discussed field of incident response, which is concerned with ways and means of reacting to pollutant releases that have already occurred and are spreading, is being addressed in Germany by the *Expert committee on "Equipment and resources for dealing with hazards to bodies of water" (GMAG)*. Even if this is not an international body, its recommendations have a similar character to the documents of the river basin commissions, and are thus also of importance for transboundary use. For example, special mention must be made here of the publication ***"Information on response measures following accidents involving substances dangerous to water"***[152]. In addition to precautionary planning aspects, this deals primarily with the sequence of events in the event of an incident, broken down into accident reporting, emergency measures, follow-up measures and post-sortie measures. The document is supplemented by "Planning precautions for averting oil pollution on inland waters". The requirements of the GMAG committee are partly taken into account in the ICPER recommendation *"Organisational measures and material-related basic requirements for protection against accidents involving floating substances dangerous to water"* (see above).

Finally, in view of its topical relevance, mention must be made here of the work on evaluating the tank storage fire at Buncefield (Hemel Hempstead, UK), which was caused by massive overfilling of a fuel tank in conjunction with the failure of several safety elements. To clarify the causes and draw conclusions with the aim of preventing comparable accidents in the future, the **Buncefield Major Incident Investigation Board** was set up. Among other things, its extensive work led to the ***Recommenda-***

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151 Cf. http://www.cipm-icbm.be.

152 Federal Environment Agency (Ed.) (2000). Hinweise für Einsatzmaßnahmen nach Schadensfällen mit wassergefährdenden Stoffen. Vorsorgeplanung für die Ölwehr auf Binnengewässern. LTwS No. 30.

tions on the emergency preparedness for, response to and recovery from major incidents.[153] In view of its massive proportions, the incident elicited a worldwide response. In Germany too, the **working group on tank storage** within the *Technical Committee on Plant Safety (KAS)* is evaluating the findings that have emerged from this major fire, and is deriving possible requirements for German tank storage facilities.

4.2 Deficits between technical safety recommendations and WFD requirements

4.2.1 Conflicts between preventive approach and planning of measures

The idea behind the implementation of the WFD is to take the approaches so far pursued in European water conservation and integrate them in a Community concept. In this process, it soon becomes clear that there is a problem with the simultaneous existence of different approaches: those that aim to achieve environmental quality objectives, and those that seek to avoid emissions at source. The result is a conflict between the use of emission limit values and immission thresholds.

The link between emission controls and environmental quality objectives while simultaneously considering point sources and diffuse sources is embodied in the combined approach in Article 10 WFD[154]. The emission controls pursuant to Article 10 (2) WFD are to be based first of all on the best available techniques, existing relevant emission limit values and, in the case of diffuse impacts, on best environmental practices. If the

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[153] Buncefield Major Incident Investigation Board, Recommendations on the emergency preparedness for, response to and recovery from incidents, 2007.

[154] Article 10 WFD

Combined approach for point and diffuse sources

(2) Member states shall ensure the establishment and/or implementation of:

(a) the emission controls based on best available techniques, or

(b) the relevant emission limit values […]

[...]

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resulting emission controls prove insufficient to achieve individual quality objectives in the body of water, more stringent emission controls can be set in accordance with Article 10 (3) WFD.

Under the precautionary principle, a potential danger to the environment is to be counteracted by appropriate measures before it takes effect in order to prevent or minimise any adverse impacts on the environment. The imposition of regulatory requirements in the form of emission limit values is a targeted instrument for this purpose. Especially in the field of hazard precautions, this makes it possible to confront the complex structure of conceivable combinations of events, from the source via various diffusion paths to the environmental medium affected, with a high level of safety. As a result, the relevant prevention strategies tend to be based on regulatory requirements, rather than being optimised for specific conditions between the hazard source and the object of protection.

The planning of measures with a view to achieving predetermined environmental objectives, as also used in the WFD, differs from this in that the focus is primarily on the environmental medium or on integrated pollution prevention. Planning is seen here as an instrument for gradually achieving the environmental objectives, which at the same time permits extensive integration of multi-dimensional problem fields. For hazard precautions too, this would mean the preparation of an integrated management plan which merely attempted to control existing risks to the extent that reduced impacts no longer present a threat to achievement of the targeted objectives and thereby "optimise" the precautionary efforts. Here the WFD works on the basis of the status of a body of water. The entire need for action is geared to identifying existing water pollution and assessing the extent to which it influences the prevailing status of the body of water. The plans for status improvement are then based on the identified deficit between the actual status of the water and the targeted status.

Potential adverse impacts on a specific body of water, e.g. as a result of accidental water pollution, are difficult to integrate in such an approach from a planning point of view owing to lack of information, since it is not possible to predict with sufficient accuracy the time of their occurrence, the intensity of their impact on the body of water,

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(3) Where a quality objective or quality standard, whether established pursuant to this Directive, in the Directives listed in Annex IX, or pursuant to any other Community legislation, requires stricter conditions than those which would result from the application of paragraph 2, more stringent emission controls shall be set accordingly.

and the effects they will have. For this reason the efficiency of preventive measures does not depend on the actual emission reduction, as in the case of more easily assessed measures applying to continuous discharges, but on the reduction brought about by the measures in the hazard potential of the source.

Thus the regulatory approach to preventive avoidance of accidental water pollution, as practised to date, differs from the planning approach to targeted achievement of a specific environmental status, but nevertheless does not conflict with the WFD. Art. 10 WFD maintains the basis for the present approach based on laying down emission standards.

Under the emission-oriented approach, installations which handle pollutants and which are therefore to be classified as a hazard to bodies of water must be protected in such a way as to prevent or minimise the threat. This implies an emission limit value that aims for zero emission. It addresses possible accident scenarios, and also incorrect handling of pollutants by the operator. Appropriate implementation of this limit value is based on the best available technology[155] for potential safety measures in the field of application. While this does not completely rule out potential incidents, it renders them sufficiently improbable.

Planning and developing measures will only become necessary if compliance with the best available technology appears insufficient to ensure achievement of the targeted environmental objectives. However, since hazard precaution measures aim to prevent accidental or unforeseen pollution entirely, it is difficult to imagine, at least at the technical safety level, that relevant extended measures would have to be included in the planning of measures. Although it is possible to control accidents or comparable incidents by means of targeted intervention in operational workflows, it is not usually possible to forecast the precise effects. Thus within a precautionary concept there cannot be a “planned” range of acceptable emissions that are deliberately not prevented.

This means that a standard of requirements which exists over and above this can only be interpreted at the level of identification of possible pollution, with regard both to hazard sources, and to early warning and alerts when pollution takes place. In this respect the planning approach also offers the prospect of use for precautionary water conservation. In this way the integrated and holistic approach of measures planning can register the combined action of individual hazard sources and make an appropriate response. Similarly, there is a need to discuss preventive avoidance of the emergence of hazard sources in areas where there has hitherto been little or no pollution.

4.2.2 Deficit analysis

4.2.2.1 Technical and organisational aspects

A comparison of WFD and the technical safety recommendations raises the question of whether technical and organisation requirements resulting from the Directive are taken into account adequately by the present situation, which derives from the recommendation documents.

It is not possible to deduce any specific technical or organisational requirements from the wording of Article 11 (3) I WFD (cf. Section 3.2). The question as to which measures are to be implemented is merely answered by the abstract “all necessary measures”. For this reason it is not possible to examine in detail whether the recommendations and measures drawn up by international river basin commissions or multilateral organisations are sufficient to satisfy the requirements of the WFD from a technical and organisational point of view. What is necessary must first be identified through the implementation process.

Important guidance is nevertheless provided by the documents introduced in Section 4.1. Especially since transboundary consultation was necessary when they were drawn up, the recommendations and guidelines are to be interpreted as a technical safety standard aimed at preventive avoidance of accidental water pollution and appropriate emergency response measures. It is however difficult to make a strict distinction between technical and organisational aspects, because the individual fields dealt with by the recommendations usually involve interaction between technical and organisational measures to reduce the damage potential. A more crucial aspect in this connec-

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155 Also known in the European context as *best available technique*.

tion is whether the documents take adequate account of the individual parts of Article 11 (3) I WFD (see Sections 3.2.2 - 3.2.5).

A large number of the recommendations (see Table 11) relate to preventing releases from technical installations, and hence to the first part of Article 11 (3) I WFD. Like the Directive, the technical safety recommendations do not provide a concrete definition of the term "technical installation". In some cases, however, the scope of the recommendations is described more precisely, though without any quantitative delimitation.[156] Thus the quantity thresholds above which application of the recommendations becomes relevant remain an open question here too.

The question of deficits with regard to technical and organisational requirements cannot be answered clearly. Thanks to the expert knowledge involved in their preparation, the documents described to a certain extent reflect the state of the art in the field of hazard precautions and at the same time give expression to a multilateral consensus.

Basically the technical safety recommendations all follow a similar basic principle which achieves the reduction in hazard potential by means of various stages or barriers in which the individual measures can be classified. The steps can be described as follows:

- **Stage 1: Containing the dangerous goods:** The primary safety barrier consists in containing the substance. This must be done in such a way that the substance cannot be released. This basically means freedom from leaks and resistance to all expected influences. This requirement is clear in that it cannot be reduced or increased in the individual case.
- **Stage 2: Retaining/collecting the dangerous goods:** If the primary barrier fails, secondary barrier measures serve to retain or collect the dangerous goods. The requirement is relative in that it is necessary to weigh up how much volume is to be retained and how long the retaining structure must be resistant to the dangerous goods.
- **Stage 3: Control and monitoring measures:** Above and beyond the requirements of the primary and secondary barriers, control and monitoring measures

[156] One exception here is the documents which use the terminology of the Seveso-II Directive and which are evidently concerned with installations in this field.

serve to reduce the hazard potential still further. These are mostly measures for indicating leaks or for preventing incorrect operation, such as overfilling of storage tanks. Such precautions can be implemented as both technical and organisational measures. Some arrangements concerned with workflows and behaviour in hazard situations (warning and alarm plans) must also be classified in this stage.

- In addition, there are recommendations for **special measures** or **special structures** aimed at functional areas where for operating or design reasons it is impossible to implement the basic requirements, or to implement them adequately. This is often a case of installations for the production or use of hazardous substances where general requirements are not very practicable in view of the specific framework conditions and equivalent measures have to be found in the individual process.

The majority of measures mentioned in the technical safety recommendations serve the purpose of applying this barrier concept in various functional areas or industries and specifying it in greater detail. For this reason, deficits with regard to the first part of Article 11 (3) I WFD are not to be sought in the scope of the requirements of the recommended measures, but are rather a question of the methodological approach to implementing them effectively and ensuring that this implementation is reliable.

In this connection an opportunity arises from the river basin approach of the WFD. The field of application of the measures suggested in the technical safety recommendations is specifically focused on the installation. In the past the focus of preventive measures has usually been the individual installation, which raises the question of the quantity of a specific pollutant above which safety precautions are to be taken and the operation is therefore to be scrutinised. This question is however put in perspective by broadening the view to the level of the river basin (or individual sections thereof). In detail, the technical and organisational requirements for the individual installation remain the same. Which installations may ultimately pose a significant threat is a question that can be answered better from the overarching perspective in conjunction with the entire inventory of installations and the areas which are at risk in emergency. Furthermore, this permits a better combination of installation-related and location-related precautionary measures. This aspect, which looks beyond the limits of the individual installation, is not taken into account sufficiently in the recommendations as they stand at present. The action concept described below takes up this deficit and makes suggestions for dealing with the problem.

Regarding the remaining items in Art. 11 (3) l WFD, which are subsumed under the heading of accidental pollution, we are left with the question of which additional objects or activities can give rise to such pollution. We can see from the recommendation documents that these include contaminated sites, and also the (external) transport of hazardous substances, neither of which falls under the restrictive heading of *technical installation*. The safety of pipelines is discussed in connection with the transport of hazardous substances. However, there is no comparable discussion of flexible means of transport that use other routes (road, rail, inland waterway), though in this connection one has to ask how relevant the quantities transported would be in the event of an accident.

In addition, the recommendations include requirements which do not have a direct preventive effect at the polluter or the source of the hazard, but which make a significant contribution to the detection of and response to hazardous events. The river basin commissions also make recommendations regarding in-plant monitoring and early warning, or alarm and emergency response. The existing warning and emergency response plans of the river basins provide an exemplary illustration of how the requirements of the WFD are to be implemented in this respect, and can thus be seen as implementation recommendations for other river basins as well. The warning and emergency response plans of the river basins are discussed in detail in Section 4.3.

4.2.2.2 Actors, responsibility for costs and responsibility for implementation

The requirements of the WFD are not allocated to specific groups of actors. However, the nature of the requirements of Art. 11 (3) l WFD identified in paragraph 3.2 means that they address both the operators and the competent authorities. The Directive does not specify the relevant competencies, as it addresses the Member States and assigns them responsibility for its proper implementation.

Thus the question of which actors can implement the requirements of Art. 11 (3) l WFD is once again one of interpretation, when it comes to detailed design and the allocation of responsibility for implementation and costs to specific actors. Here the Member State is called upon to allocate the tasks between operators and public authorities. The WFD does not directly oblige the operator himself to take any action.

The WFD embodies not only the precautionary principle, but also the polluter-pays principle.[157] This is not confined solely to the polluter's obligation to bear the costs of environmental pollution caused by himself, but also includes the polluter's responsibility to avoid potential damage before it occurs. Thus the allocation of responsibility for implementation and costs depends on whether the individual requirements can be attributed specifically to the field of activities of a particular (potential) polluter.

With regard to the actors' responsibilities, it is therefore relevant whether a measure deals with a general danger or is applied to a specific safety hazard. When it is applied at the safety hazard, the polluter is usually known. Thus for technical installations or transport of pollutants, responsibility for implementing technical safety measures will in the first instance be attributable to the operator. Like implementation, the financing of the relevant activities belongs to the requirements to be satisfied by the operator. However, it will not be sufficient to make the operator responsible for implementing measures if the authorities do not ensure that the operator discharges these obligations appropriately. This can be done by the authority itself, or by independent third parties (e.g. independent experts) who confirm to the authority that operator has complied with the requirements. This division of labour essentially reflects standard practice in installation-related water conservation. But this does not take account of those requirements of Art. 11 (3) I WFD which do not relate to the consideration of a known safety hazard. To prevent unexpected pollution it is necessary to keep certain instruments permanently available. It these instruments are used outside the plant-specific field of application, it is no longer possible to tell what (specific) safety hazard they are supposed to provide protection against. This means that such implementation serves to raise the general safety standard, so it falls within the field of activities of the public authority, with funding from public resources. A financial contribution by the operator makes sense in cases where alarm systems are used and emergency response measures taken following an incident which can be attributed to the operator. But the need to keep these instruments ready does not depend on this.

Even if the integrated and planning-oriented approach of the WFD is apparently difficult to combine with the workflows used in hazard precautions, the synthesis nevertheless creates potential for improving the effectiveness of safety strategies. It has already

[157] Recital 11 to the WFD:

"[…] this policy [Note: environmental policy of the WFD] is [...] to be based on the precautionary principle and on the principles that preventive action should be taken, environmental damage should, as a priority, be rectified at source and that the polluter should pay."

been observed that one deficit is not so much the question of what to do to prevent or reduce accidental water pollution, but rather the question of HOW, i.e. the methodological approach to implementing the requirements, which often receives insufficient attention. With regard to this aspect in particular, a more strongly planning-oriented approach by the public authorities can be useful. For example, it is perfectly conceivable that approaches which have proved effective in the past may be retained and supplemented by an overarching perspective at the level of river basin management. This applies in particular to the identification of dangers and sensitivities in relation to accidental releases. These raise awareness of risks and also permit more targeted use of instruments and measures. Whereas this step has in the past tended to be generally tied to the safety hazard, a complex view of hazard and objects of protection in conjunction with targeted strengthening (or reduction) of precautionary efforts could make for an increase in effectiveness where two or more different action options act together.

4.3 Early warning, warning and emergency plans

Article 11 (3) I WFD requires *"systems to detect or give warning of such events".* In Chapter 3.2.4 we said that this indicated a need to establish warning and emergency plans and to set up suitable systems for detecting and assessing sudden events relevant to water quality in the river basins.

The Community's major international river basins have "International Warning and Alarm Plans" (IWAP), mostly dating from before the WFD came into force. As a rule they are developed, implemented and operated by "international river basin commissions", the establishment of which goes back to international conventions on reciprocal warning and liability in cases of transboundary accidental environmental incidents, such as the Stockholm Convention of 1972 and the ensuing international agreements (see Chapter 3.1). Their development received a strong boost from the Sandoz accident in Basel on the Rhine in 1986. By their origin, these plans had a strong focus on the international transboundary aspect, which is becoming less important in view of the WFD concept of management by river basins.

Only the websites for the Rhine[158] and the Elbe[114] make the text of the international warning and emergency plans publicly available. The document containing the text of the IWAP for the Oder was kindly supplied by the river basin commission for the Oder. [159] There does not appear to be a complete text document for the Danube IWAP, but the ICPDR portal has a website on the IWAP for the Danube (AEWS – Accident Emergency Warning System), which sets out the objectives, further information (e.g. on past accidents) and a map of the *"Principal International Alert Centres in the Danube River Basin"*.[160] The alarm criteria can be found as Annex 4 in the document already mentioned in Chapter 4.1.1.1 on the *"Inventory of Potential Accidental Risk Spots"*[121] of the *"ARS-ad-hoc Expert Panel"* on the ICPDR "Accidental Pollution"[120] site; there is no description at all of the alert paths and alert mechanisms.

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158 http://www.iksr.org , http://www.iksr.org/uploads/media/bericht_nr_137d.pdf

159 http://www.mkoo.pl/

160 AEWS (Accident Emergency Warning System) http://www.icpdr.org , http://www.icpdr.org/icpdr-pages/aews.htm

The following section looks at the characteristics – similarities and differences – of the IWAPs examined for the Rhine, Danube, Elbe and Oder. This is followed by an examination of the *"systems for timely detection"* in these river basins, and a brief summary of the situation with regard to compliance with the requirements of Article 11 (3) I WFD.

4.3.1 IWAP Rhine, Elbe, Danube and Oder – Similarities

The definitions of the objectives of the IWAPs investigated are very similar in concept. Here is the wording of the oldest version, the IWAP Rhine:

The objective of the Warning and Alarm System is to pass on reports on sudden pollutions with substances noxious to water in the Rhine watershed, if the amount and concentration may detrimentally impact the Rhine water quality and to warn the authorities in charge of fighting accidents, using the Rhine alarm model, so that

- *threats may be fought,*
- *causes may be identified,*
- *polluters may be identified,*
- *measures to clean up pollution may be taken,*
- *measures to avoid and reduce damage may be taken,*
- *consequential damage may be avoided.*

Damaging incidents, which are expected to raise great public interest, should be reported as information.

For the corresponding wording of the other IWAPs, see the following footnote[161].

The common core of the IWAPs is the regulation of reports and reporting paths between warning centres with defined hierarchical and geographical structures. Along the course of the river there are "International Warning Centres" (IHWZ) named by each river basin country, the functions of which can be summarised as follows:

- receive the initial report for accidents within its sphere of responsibility,
- assess/classify the "seriousness of the accident" in accordance with the IWAP criteria; this also indicates the type of report to be passed on (information, warning, alarm etc.),

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[161] **Elbe**

The objective of the Warning and Alarm Plan is to report any sudden occurrences within the Elbe catchment area of contamination with substances dangerous to water that could have significant impacts within the sphere of responsibility of the international warning centre (IHWZ), and to warn water users and the authorities responsible for combating harmful effects, so that

- threats may be fought,
- causes may be identified,
- polluters may be identified,
- measures to eliminate the causes and clean up pollution may be taken,
- consequential damage may be avoided.

Furthermore, damaging incidents in the Elbe which are expected to arouse great public interest are to be reported.

Oder

The objective of the Warning and Alarm Plan is to report any sudden occurrences within the catchment area of the Oder of contamination with pollutants dangerous to water in quantities or concentrations capable of adversely influencing the quality of water in the Oder, in order to provide timely warning for water users and the authorities and agencies responsible for accident protection. At the same time the following objectives are to be achieved:

- eliminate the danger,
- identify the polluter,
- analyse the causes,
- take measures to remedy the causes and effects of the accident,
- remedy consequential damage.

The plan is implemented in the following cases:

- in the event of contamination of the water by oil and its products, other chemical pollutants with harmful effects on water quality (solid, liquid, gaseous), radioactive substances.
- in the event of other incidents which pose a threat to water quality, attract public attention or threaten the life of aquatic organisms.

Danube

The Accident Emergency Warning System (AEWS) is activated whenever there is a risk of transboundary water pollution, or threshold danger levels of hazardous substances are exceeded. The AEWS sends out international warning messages to countries downstream. This helps the authorities to put environmental protection and public safety measures into action.

- send report to other warning centres as laid down in the IWAP (standardised forms with required minimum information (including identity and quantity of the substances input), defined reporting paths and means of communication),
- receive and confirm reports from other warning centres, forward them as required by IWAP,
- give "all clear" in accordance with IWAP,
- document the processes.

Thus the IWAPs primarily have functions in the field of communications management, i.e. receiving the first report of the incident and passing on the information. Here the main direction of communication is from upstream to downstream, with obligatory feedback from downstream to upstream. Recipients of messages under the international, river-basin warning and alarm plans include other downstream and upstream warning centres, agencies that are not usually directly responsible for averting danger, or the water users.

In line with their historically determined international, transboundary character, no arrangements are made with regard to regional and internal measures (regional warning plans etc.). Thus in the major international river basin districts it has been possible to exclude national and regional differences. The responsibility of the IWAP begins with the arrival of the first report. How this report gets there, what source of information it comes from, and what regional criteria it is subject to, is not part of the IWAP. However, all IWAPs investigated work on the basis that the specific information on the accident and the substances which have entered the water comes from the author of the accident. The responsibility of the IWAP ends with the report to the responsible regional warning centre listed in the IWAP. Once the message is received, the regional warning centre decides in accordance with regional rules who is to be informed in the region and who is to be deployed.

The international warning centres of the warning and alarm plans for the Rhine, Elbe, Danube and Oder have access to substance databases, most of which are also available to the public, e.g.:

- Information about dangerous substances for fire brigades, police and environment departments (GSBL) [162]
- Database of substances relevant to soil protection / environment [163]
- Substance database with focus on occupational safety and health [164]
- Water hazard classes (see Chapter 3.3.2) [165]

The IWAPs examined contain very few requirements – if any – with regard to quality management (training, “lessons learned”). However, the river basin commissions for the Rhine, Elbe, Danube and Oder have expert groups with the task of constantly reviewing and updating the IWAP; this also include alarm exercises.

The IWAPs investigated do not contain any information about or in the field of informing the public. The websites of the river basin commissions include annual reports of a kind, listing past reports in various degrees of detail and topicality.

4.3.2 IWAP Rhine, Elbe, Danube and Oder – Special features

In addition to the conceptual similarities described in the previous chapter, there are a number of divergent special features.

The most important concerns the defined warning and alarm criteria: the decision as to whether the first report received does in fact represent an event that requires a warning to be issued calls for a rapid assessment of the relevance of the event on the basis of clear and simple criteria. For the Elbe, Oder and Danube this is done with the aid of a simple scheme based on water hazard classes, which differs little between the three river basins. However, it can only be used to classify events where the event and the identity and quantity of the substances dangerous to water are reported by the polluter. This method was described and discussed in Chapter 3.3, and the assessment scheme is summarised in Table 3 on page 74.

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[162] GSBL - Gemeinsamer Stoffdatenpool Bund / Länder, http://www.gsbl.de/ .

[163] Stoffdatenbank für bodenschutz- /umweltrelevante Stoffe, http://www.stoffdaten-stars.de/ .

[164] Gefahrstoffdatenbank der Länder, http://www.gefahrstoff-info.de/

[165] http://www.umweltbundesamt.de/wgs/

The IWAP for the Rhine also assumes that information about the event “generally” reaches the authority from the polluter. However, the assessment criteria are guiding daily load thresholds (and concentration thresholds calculated from them), which must not be exceeded at the German/Dutch border (reference point Rhine measuring station Bimmen/Lobith). On the basis of the polluter’s information, the competent warning centre receiving the first report calculates the resulting loads/concentrations for the relevant section of the Rhine and decides whether to issue an information report or a warning. Guide values are laid down for 10 substances or groups of substances (see Table 12). They are primarily derived with a view to ensuring a reliable drinking water supply in the Netherlands, where drinking water is largely obtained from surface water. Thus these values are not based on the EQS criteria of the WFD and may need to be checked.

According to the IWAP Rhine, the guide values shown in Table 12 relate “exclusively to concentration increases in Lobith, but not to possible prior pollution already present.” This raises the question of how practicable this “clause” is – it would undoubtedly be easier to define and apply immission warning thresholds valid for the entire length of the Rhine. The fact that the IWAP for the Rhine establishes a relationship between emissions and concentration thresholds, makes it possible – unlike the methods for the Elbe, Oder and Danube – to assess the warning relevance of immission data already detected. Thus the IWAP Rhine lays down that “monitoring data exceeding the guidance values may result in information being released in accordance with the alarm plan.”

Table 12 Warning thresholds at the Bimmen/Lobith measuring station on the Rhine

Guidance values, Rhine/Lobith		[Source: Warn- und Alarmplan Rhein, 2003, http://www.iksr.org/]
Substance	**Daily load**	**Resulting increase in concentration at Lobith in the daily mixed sample**
	kg	µg/l
Arsenic	500	5
Beryllium	100	1
Cadmium	300	3
Organic micropollution (individual substances)	300	3
PAH (individual substances)	50	0.5
PCB (individual substances)	10	0.1
Pesticides (individual substances)	50	0.5
Mercury	100	1
Selenium	500	5
Cyanide	500	5
The following values apply to radioactivity:		
Parameters	**Activity**	
	GBq	**Bq/l**
Total -Alpha	20	0.2
Total -Beta	200	2.0
Tritium	10000	100

Other divergent features of the IWAPs for Rhine, Elbe, Oder and Danube:

1. In addition to information reports and warnings, which are only triggered in the event of extensive serious water pollution, the IWAP Rhine is increasingly being used for exchanging reliable information about water pollution measured in the Rhine and Neckar, for example by measuring stations. To identify possible authors of detected water pollution in cases where the suspected source is outside the sphere of responsibility of the individual warning centre, the IWAP Rhine also uses another type of report in practice, the "search report".

2. The procedure for alert management in the IWAP Danube, such as functions of the warning centres or the existence of other warning centres apart from the *"Principal International Alert Centres in the Danube River Basin"*, of which there are very few compared with the Elbe or the Rhine, is not documented.

3. The IWAP Danube takes account of the flow situation by laying down much higher alarm thresholds (loads increased by a factor of 10) for high flow rates in excess of 1000 m³/s.

4. The "Inventory of Potential Accidental Risk Spots in the Danube River Basin"[120]at least contains a (not quite complete) list of potentially hazardous installations, largely based on the criteria of the Seveso-II Directive (2001). For the Elbe catchment area there is a similar document dating from 1998 entitled "List of potentially hazardous installations in the Elbe catchment area".[166] The two lists have in common that they are apparently the results of individual projects and are not continuously updated.

5. As a result of a UBA research project (No. 104094106), there is a tabular overview dating from 1995 of the main possible response measures for the Elbe in the form of the "List of measures for preventing accidental water pollution in the Elbe catchment area".[167] This lists measures with short, medium and long-term implementation objectives, which we believe are still up to date. No detailed information is available about their implementation status.

6. Software tools for assessing/predicting pollutant diffusion (flow time models) are valuable aids to crisis management for the protection of downstream parties. The better the hydraulic properties of the body of water in question are surveyed and documented, the more reliably forecasts based on mathematical models of this kind function. Very useful models exist for the Rhine ("Rhine alarm model") and the Elbe ("Alarm model Elbe", "ALAMO", see Chapter 3.3.3 and description in Chapter 8.1.1.2.5), and for the large catchment area of the Danube the "Danube Basin Alarm Model" (DBAM) is in preparation.

Table 13 provides an overview of selected aspects of the IWAPs for the Rhine, Elbe, Danube and Oder.

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166 Verzeichnis der potentiell gefährlichen Anlagen im Einzugsgebiet der Elbe, IKSE 1998.

167 Maßnahmenkatalog zur Vermeidung unfallbedingter Gewässerbelastungen im Einzugsgebiet der Elbe, IKSE 1995, http://www.ikse-mkol.org/index.php?id=86&L=0

Table 13 Selected characteristics of the IWAPs for the Rhine, Elbe, Danube, Oder

Criterion	Rhine	Elbe	Danube	Oder
Document on the Internet	Yes	Yes	(No)	No
Warning stages	2	1	2	2
Alarm communication	Fax (phone)	Fax and e-mail	Web	Fax
Emission-oriented warning thresholds	Indirect	Yes	Yes	Yes
Inclusion of flow volume	Indirect	No	Warning threshold raised by factor of 10 at > 1000 m³/s	No
Assessment of "incident severity"	No	GSI/WRI	GSI/WRI	GSI/WRI
Immission-oriented warning thresholds	to some extent	No	No	No
Regulated procedures for taking immission alerts into account	Taken into account if data available and reported	No	No	No
Flow time model	Rhine alarm	ALAMO	DBAM	No
Installation inventory Seveso II	No	Yes (status 1998)	Yes (ICPDR website, status 2001, incomplete)[121]	No

4.3.3 Systems for timely detection

4.3.3.1 State institutions

Neither as part of the warning and alarm plans nor outside them are "systems for timely detection" a binding requirement at river basin level or integrated in alert management, not even where suitable technologies are already installed. This has to do with the fact that there were no mandatory legal requirements for obligatory introduction of expensive systems of this type in the existing Community legislation on accident precautions (IPPC Directive, Seveso Directive) – at least for sectors organised (and funded) by the state. Nevertheless, the ICPR and the ICPER have long operated a complex and well documented water monitoring system covering several countries, and they also have a number of measuring stations well equipped for warning functions. These stations are operated by nation states, individual Länder or special-purpose organisations (e.g. waterworks operators, Federal Institute of Hydrology – BfG). With continuous automatic operation, they are designed specifically for early detection and warning purposes and form part of local or special-purpose networks, but are not integrated at river basin level.

Table 14 Provides an overview of monitoring stations in the Elbe catchment area and their networks.[168] These stations differ in their equipment, for example the stations of the Federal Institute of Hydrology belong to the nationwide radiological measuring network, which was developed along federal inland waterways after the Czernobyl disaster for precautionary monitoring of radiation.[169] Other stations are abstraction points belonging to the ICPER monitoring programme, and in this capacity they are registered with ICPER as monitoring stations, but not integrated in the communications system. However, all monitoring stations in Table 14 belong to monitoring networks and possess the necessary technical equipment.

On the Rhine, in addition to the Bimmen/Lobith measuring station which has already been mentioned, there are numerous other monitoring stations, some of them equipped with very complex measuring technology. In Germany, as on the German Elbe, they are integrated in Land monitoring networks. In the Netherlands, where drinking water is drawn mainly from surface waters, the stations perform key functions in a highly integrated warning and alarm management system in the field of drinking water protection (Infra-web, Aqualarm [170]).

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168 Blohm, Inst. f. Hygiene und Umwelt Hamburg, personal communication 2009.

169 Integrated measurement and information system (IMIS) for monitoring radioactivity in the environment with 40 stationary radiological warning stations.

Legal basis: Radiological Protection Precautions Act *(Strahlenschutzvorsorgegesetz – StrVG)*, 1986 (EURATOM Treaty 1957, Art. 35 and 36); Radiation Protection Ordinance *(Strahlenschutzverordnung – StrlSchV)*; 1960 … 2001 (EURATOM Directives).

170 http://www.aqualarm.nl, Rijkswaterstaat, Center for Water Management Netherlands.

Table 14 Automatic measuring stations in the Elbe catchment area

Continuous measuring stations in the Elbe catchment area Version: 18.04.2009	**ICPER#**	**ICPER Monitoring**	**Network operator**	**River**	**Elbe-km**
Valy	C-1	x	CZ	Elbe	228.1
Lysá nad Labem	C-2	x	CZ	Elbe	152.2
Obříství	C-3	x	CZ	Elbe	115.05
Děčín	C-4	x	CZ	Elbe	21.3
Zelčín / Vltava	C-5	x	CZ	Moldau	
Kácov / Jizera			CZ	Jizera (Iser)	
Schmilka/Hřensko	D-1	x	CZ	Elbe	4.1
Zehren			CZ	Elbe	
Dommitzsch	D-2		ST	Elbe	
Bad Düben			ST	Mulde	
Böhlen Messsonde			ST	Pleiße	
Magdeburg	D-3	x	ST	Elbe	318
Dessau	D-10	x	ST	Mulde	
Rosenburg	D-11	x	ST	Saale	
Cumlosen	D-4a		BE	Elbe	
Potsdam-Humboldt-brücke			BB	Havel	
Kleinmachnow			BB	Teltowkanal	
Sophienwerder		x	BB	Spree	
Schnackenburg	D-4b	x	NI	Elbe	474.5
Grauerort	D-7		NI	Elbe	
Bunthaus (+ Zollenspieker)	D-5	x	HH	Elbe	609.6
Seemannshöft	D-6	x	HH	Elbe	628.8
Blankenese, Elbe			HH	Elbe	634
Lombardsbrücke, Alster			HH	Alster	
Haselknick, Alster			HH	Alster	
Wulksfelde, Alster			HH	Alster	
Wandsbeker Allee. Wandse			HH	Wandse	
Rosenbrook, Tarpenbek			HH	Tarpenbek	
Brügkamp, Ammersbek			HH	Ammersbek	
Fischerhof			HH	Bille	
Dresden			BFG	Elbe	
Wittenberg			BfG	Elbe	
Tangermünde			BfG	Elbe	
Geesthacht			BfG	Elbe	
Wedel			BfG	Elbe	
Cuxhaven			BfG	Elbe	
Halle			BfG	Saale	
Ketzin			BfG	Havel	
Berlin			BfG	Spree	
Fürstenwalde			BfG	Spree	
Zehdenick			BfG	Havel	
Parchim			BfG	Elde	

The fact that additional river basin wide networking of existing individual measuring stations is possible at all and without exorbitant additional technical effort, is demonstrated by the BMU-funded BfG project "UNDINE" (Information platform "*Datengr**und-***

*lagen zur E**in**ordnung und Bewertung hydrologischer **E**xtreme*“[171] – “Basic data for classification and assessment of hydrological extremes”), which was started after the Elbe floods of 2002, initially for the German part of the Elbe, and is to be extended to other river basins (for more information about UNDINE, see the application examples for the action concept in Chapter 8.1.1.1.1).

4.3.3.2 Plant-specific facilities

The river basin commissions do not have any comprehensive information about “systems for timely detection” run by installation operators. Under the Community legislation already discussed, such as the Seveso II Directive or the IPPC Directive, and the international agreements, states have a duty to warn each other. In the context of implementation, the states assign a duty of notification to the plant operators; the notification path generally runs in the direction of the competent local authority (see Figure 5). However, neither the Seveso-II Directive nor the BREF documents to the IPPC Directive (see Chapter 4.1.4) offer concrete provisions with regard to water conservation oriented “systems for timely detection”. It may be assumed that the safety concepts to be approved by the local enforcing authorities for the (major) Seveso II installations contain information on alarm monitoring systems, where appropriate – but there are no uniform criteria for this. There is no duty to inform the river basin commissions; neither are the installations directly integrated in the international warning and alarm plans.

[171] Informationsplattform „*Datengr**und**lagen zur E**in**ordnung und Bewertung hydrologischer **E**xtreme*“ (UNDINE), Bundesanstalt für Gewässerkunde (BfG), Koblenz, http://undine.bafg.de .

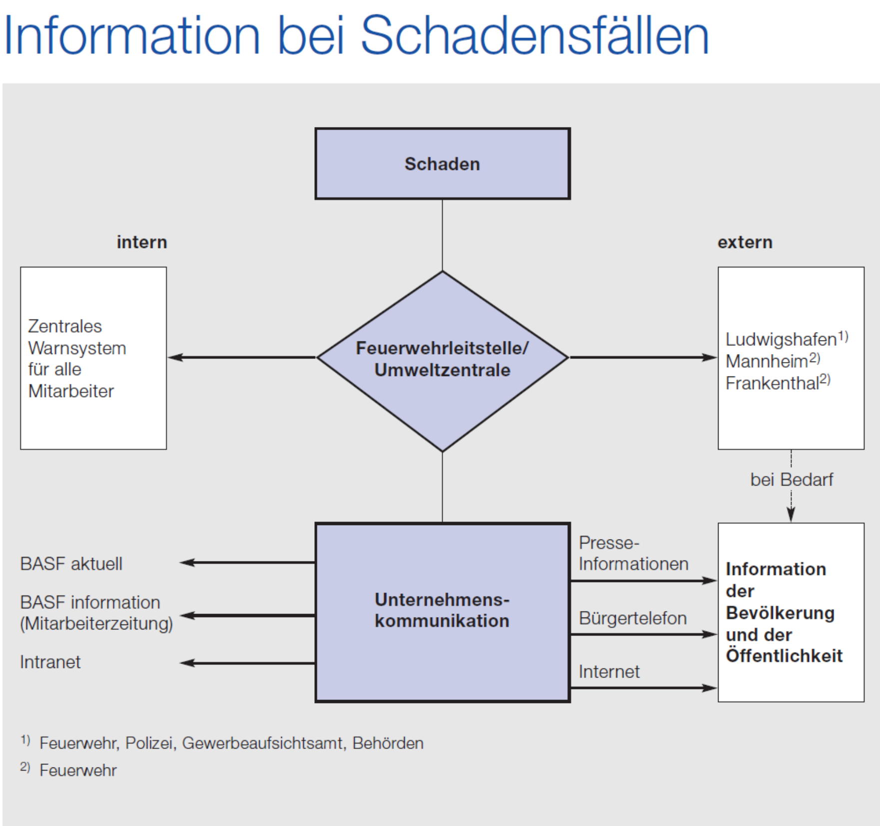

Figure 5 Notification paths in a large chemicals company (BASF)[172]

When emitting substances into air and water, the operators of all installations requiring permits are obliged by statutory requirements to comply with defined limit values; only a small number of the relevant parameters are regulated at Community level. The monitoring involved is to be ensured by the installation operator (self-monitoring), and by independent site inspections by the supervisory authorities.[173] Both the self-monitoring and the state inspections are usually based on samples, and are supposed to document the normal operation of the installation and compliance with the necessary requirements. On principle, sampling is not a suitable basis for a “system for timely detection”. Only very large installations have a continuous “online monitoring” system (see example in Chapter 8.1.1.1.3).

172 BASF, http://www.standort-ludwigshafen.basf.de/fileadmin/user_upload/BASF-Inhalte/umwelt/pdf/Im_Dialog_Januar_2006_d.pdf

173 This procedure is not prescribed by Community regulations; in Germany there has been a marked shift in recent years from state monitoring towards self-monitoring with occasional site inspections.

4.3.4 Deficits in the field of early warning / warning and alarm plans

As a result of the inventory of the warning and alarm plans for the Rhine, Danube, Elbe and Oder and other data from the river basin commissions, the authors take the view that solutions need to be found for the following deficits:

1. The IWAPs only cover incidents that are reported by the polluter with details of the time, place, identity and quantity of the substance emitted ("emission-oriented approach"). The "immission-oriented approach", i.e. taking account of findings from observations of water status by means of measuring stations, chemical tests or visual detection of unusual situations in the river (e.g. dead fish), is not provided for – or only optionally (Rhine) – even where appropriate technology (networked automatic measuring stations) is installed (especially on the Rhine and Elbe).

2. Existing emission-oriented warning and alarm thresholds based on the released quantity of an identified substance in conjunction with water hazard classes (risk index) are not tested for compatibility with the environmental quality standards of the WFD.

3. In the IWAPs for the Elbe and Oder, emission-oriented assessment of the severity of accidents and other incidents relevant to Article 11 (3) I WFD takes no account of the flow situation in conjunction with the quantity of the substance released; in the IWAP for the Danube only rudimentary provision is made for this. Since the effects of substance do not depend on the quantity, but on the concentration, a flow-dependent factor should be introduced (see also proposal by the Major Accidents Commission[174]).

4. There are no rules/requirements regarding the implementation of immission-oriented "systems for timely detection" of accidents or other water pollution incidents of relevance to Article 11 (3) I WFD (continuous measurement of selected physical and chemical parameters, biomonitors, intelligent automatic event recognition and assessment technology). The technology is available, but is not expressly provided for in the current versions of the IWAPs or other regulations

[174] Störfall-Kommission SFK-GS-18: Orientierende Beurteilung von Gewässerunfällen, 1999, http://www.kas-bmu.de/publikationen/sfk/sfk_gs_18.pdf .

(see Chapter 8.1.1.2 and EASE[113]). It seems rather improbable that water pollution incidents will always be reported by the polluter, and that this will be done in timely fashion.

5. There is a lack of warning and alarm thresholds that are compatible with the WFD environmental quality standards. Even the procedure in the IWAP Rhine, which specifies concentration thresholds, is ultimately based on an agreed emission threshold value for the Bimmen/Lobith border section. However, the WFD defines quality standards on the basis of concentrations, since the harmful effects of substances depend not on the quantity, but on the concentration.

6. There are currently no plans for integrating plant-specific and regional warning and alarm plans in the IWAPs. However, there should be uniform criteria for an entire river basin regarding what incidents are to be reported to the IWAP and what form the regional response at the end of the IWAP reporting chain should take.

7. The regulations for quality management are only rudimentary, and should also include the parts of the reporting and response chain before and after the responsibility of the IWAP proper, and basic rules for incident follow-up ("lessons learned"). This is important with regard to overall crisis management. Alarm exercises in parts of the overall chain of action only are not suitable for revealing deficits in the system as a whole. This can be illustrated by an example from the recent past: The management of the cyanide accident in the Czech Republic in 2006 (for details see Chapter 8.1.1.2.5) was considered both "good" and "uncoordinated", depending on the point of view. On the one hand: the reporting system within the IWAP Elbe ran according to plan, the water quality stations along the Elbe documented in detail the concentrations over time, and the roughly two-week progress of the pollutant wave forecast on the basis of the ALAMO flow time model calculations was confirmed several hundred kilometres downstream in Hamburg with regard to precise timing and concentration profile. On the other hand: there was never any initial report by the polluter. News of the accident first reached the press as a result of obvious fish mortality, and it was only a week after the responsible "technical problem" that it reached the German international warning centres; press releases by the authorities were just as diffuse as the data situation, and first calculations of the pollutant distribution were correspondingly inaccurate. It was not until the data from the Schmilka measuring station became available that the above-mentioned precise fore-

casts were possible. The information path to and between the Elbe measuring stations was through direct contact by the operating agencies, in parallel with the IWAP reporting system.

8. The means of communication most commonly used are in need of improvement (e.g. fax). The minimum requirement for a functioning warning and alarm system is a consecutive reporting path from the region of the accident site downstream towards the places to be warned, with "lateral branching" into the regions. One disadvantage is that the reporting chain is time consuming and essentially has to be manned all the time. Queries also have to follow the reporting path. A much more suitable solution is web-based systems in which all parties potentially involved have access to all available information at all times and in parallel (e.g. aqualarm/infra-net[170] in the Netherlands).

9. To permit an appropriate response in the case of incident reports where the polluters (and hence the pollutants as well) are not known, there is a need for up-to-date inventories of potential risk sources and substances for the entire river basin. At present these exist at the most for "Seveso-II installations". However, incidents relevant to Article 11 (3) I WFD may also arise from much smaller installations.

10. The river basin commissions do not have any reliable information on whether plant-specific early warning systems exist and on what scale. Plants are not directly integrated in the IWAP, but send reports to the local competent authority. There are no EU-wide rules on the nature and extent of plant-specific early warning systems.

11. Communication with the public is not included in the IWAP. Here there should be responsibilities and basic rules that apply throughout the river basin. Experience of incidents in the past reveals uncoordinated reports from the regions, whereas the IWAP coordination centres which are well informed about the overall situation do not issue any statements. This results in an uncoordinated external impact, even if the system functions as planned.

Proposals for warning and alarm plans are discussed in Chapter 8.1.2.

4.4 *Overview of positive features and deficits*

Table 15 provides a – very abstract – overview of positive examples of implementation and of deficits identified in the individual river basins.

Table 15 Schematic overview of positive features and deficits

Classification in terms of relevance to Art. 11 (3) I WFD **...all measures necessary**	**Positive features (technical and organisational aspects)**		**Deficits**
… to prevent significant losses of pollutants from technical installations	Technical installations (see Chapter 3.2.2)	- Basic requirements (ICPER) - Storage (ICPER, ICPR) - Overfill protection (ICPER, ICPR) - Transhipment and sealing (ICPR) - Wastewater and pipeline systems (ICPER, ICPR) - Handling in case of flood risk (ICPER, ICPO, ICPMS) - Handling of fire-fighting water (ICPER)	- (technical and organisational requirements and relevant measures exist) but - Lack of methodological approach for effective implementation of measures - Lack of quantity thresholds and lower limits for petty cases - No uniform legal procedure in the EU below the scope of the ICCP and Seveso-II Directives - Lack of river basin specific approach
… prevent and/or reduce the impact of accidental pollution - through timely detection and early warning - through measures to reduce the risk to aquatic ecosystems	Contaminated sites	- Contaminated sites (ICPDR) - Industrial tailing management facilities (UN ECE)	
	Other hazard sources	- Pipeline safety (UN ECE)	- Lack of multilateral recommendations for flexible transport of pollutants (road, rail, inland waterway) - Limited consideration of safety aspects for external influences on installations and transport facilities (especially pipelines)

Classification in terms of relevance to Art. 11 (3) I WFD ...all measures necessary	Positive features (technical and organisational aspects)		Deficits
	Measures to prepare for incidents	- Recommendations on plant-specific monitoring and early warning (ICPER, ICPR) - Recommendations on plant-specific alarm and emergency response (ICPER, ICPR) - International warning and alarm plans (IWAP) of river basins - List of hazardous installations basically exists (ICPER, ICPDR) - Recommendations on emergency planning (UN ECE) - International warning and alarm plans (IWAP) of river basins - Measuring stations basically exist (Elbe, Rhine)	- IWAP geared to notifications by polluter only - Emission-oriented warning thresholds need checking with regard to WFD-EQS - No immission-oriented warning thresholds - Immission-oriented water monitoring systems for timely detection and early warning are not planned or, if they exist, are not integrated - Lack of criteria for alerts within the sphere of responsibility of the warning plans - Lack of criteria for further procedure at end of warning chain - Communications technology in need of modernisation (web) - QM systems include only reporting chain within the IWAP - No criteria for informing the public - No up-to-date inventory of hazard sources

5 Economic considerations

5.1 Applying economic considerations when implementing the WFD

In order to achieve good status in all European lakes and rivers, the WFD – for the first time in European water policy – places greater emphasis on the use of economic instruments (cf. Chapter 3.1). In conjunction with the preparation of management plans and programmes of measures, cost-effectiveness analysis plays an important role in the choice of suitable measures. It is to be used to ensure, at the level of the river basin or, given suitably targeted use, at the level of the water body, the implementation of the combination of measures which achieves the targeted environmental objectives at the lowest cost.[175]

The programmes of measures contain both basic and supplementary measures (Article 11 (3) WFD, Article 11 (4) WFD). The basic measures largely serve to cover the existing European Directives of relevance to water conservation (cf. Annex VII WFD) and to prevent any further deterioration in present water status. However, if it can be foreseen for a specific body of water that the basic measures will not be sufficient to achieve good status, it will be necessary to take further measures to close the gap.

Exemption from achieving the objectives or the definition of alternative objectives may be considered if certain conditions are satisfied which present obstacles to achieving good status (see Chapter 3.1). One such situation is the existence of unreasonable costs in connection with a particular measure, which is the case, among other things, if the cost of a measure exceeds its benefits. If this is the case, it is possible when preparing the management plans to extend the deadline for achieving the objectives by at least one management cycle or to define less stringent environmental objectives, if it

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175 van Engelen, D. *et al.*, Cost-effectiveness analysis for the implementation of the EU Water Framework Directive. Water Policy, Vol. 10, p. 207-220; in conjunction with WATECO (2002): Economics and the Environment: The Implementation Challenge of the Water Framework Directive. EU Working Group guideline for WFD implementation, 2008.

can be foreseen that the cost will be excessive even if spread over three cycles. However, if unreasonable costs are to be used as an argument on failure to achieve good status, it is necessary to have selected the least expensive alternative that leads to the objective; in other words the objective must be achieved at minimum possible cost.

Determining cost-effectiveness is therefore of prime importance for the extended measures. After all, if exceptions are claimed on the grounds of unreasonable cost, this primarily means restrictions on the implementation of the extended measures. Since it is often the case that the basic measures are linked to corresponding legislation or the measures serve directly to prevent a deterioration in status, non-implementation on the grounds of exemption from the WFD is not an option here. Nevertheless, cost-effectiveness analysis can and should support the selection of possible alternatives even for basic measures, in order to live up to the requirement of making the programme of measures as (cost-)effective as possible and optimising the overall use of resources.

This section therefore sets out to examine whether cost-effectiveness is also a suitable selection criterion for the requirements of Article 11 (3) l WFD (cf. Chapter 5.2). We first describe the basic principles for performing a cost-effectiveness analysis, before looking in more detail at the special circumstances of Article 11 (3) l WFD measures. Finally, the costs arising from precautionary measures at installation level (cf. Chapter 5.3.1) are compared with the costs arising from accidental pollution (cf. Chapter 5.3.2). The comparison is intended to outline the approach of using a cost-benefit ratio with regard to precautionary expenditure and the damage it avoids.

5.2 Basic principles of cost-effectiveness analysis and its application to installation-related water conservation measures

The purpose of cost-effectiveness analysis is to compare the efficiency of a selection of alternative measures by assessing the resulting costs and the resulting effects. It is thus a conventional evaluation method belonging to the group of cost-benefit approaches, alongside cost-benefit analysis and multicriterial analysis (utility value analysis). These methods differ in their suitability for application to different fields. In cost-benefit analysis, all parameters investigated are valued in monetary units. This also includes the monetarisation of factors which are not subject to the usual market mechanisms for price formation, which may be true of environmental factors, for example. If all (macroeconomically) relevant parameters are included in the analysis, this permits a direct comparison of costs and benefits, and hence a decision as to whether a measure is economically viable. By contrast, multicriterial analysis dispenses with monetary valuation parameters. In simplified terms, the method aggregates individual sub-benefits from various impact levels and uses them to determine the utility value of a measure. The alternative with the highest utility value is the one to be preferred. Cost-effectiveness analysis seeks to combine the advantages of both methods and to avoid the various acquisition problems as far as possible. It expresses the costs of the measure in monetary terms, like cost-benefit analysis, but does not monetarise the resulting benefits. Instead, as in multicriterial analysis, the effects of a measure are expressed in suitable units of measurement, e.g. in environmental pollution avoided. Consequently the result is a relational quantity indicating the cost per unit of the selected impact criterion. Thus cost-effectiveness analysis does not provide any information about the economic viability of a measure, but in a comparison of several measures it shows which alternative achieves the planned measures at the lowest cost, i.e. with the greatest efficiency.

The following section introduces the elements – goal definition, identification of costs and effects – that are necessary for performing cost-effectiveness analyses in connection with water conservation measures.[176] Following the general requirements, we then examine the special requirements for determining the cost-effectiveness of installation-oriented water conservation measures.

5.2.1 General requirements for the definition of objectives

Before a list of measures for counteracting or preventing pollution can be drawn up, a detailed definition of the initial objective is necessary to be able to identify in concrete terms what effects the measures are intended to achieve. Overall objectives like those specified in the WFD (good status) must be broken down into individual, identifiable criteria (measurements, classification). These part objectives must be complete and be unambiguous in their wording.

In general it is possible to distinguish between societal (macroeconomic) and problem-oriented analysis of objectives. In the first case the focus is on the overarching perspective of the targeted objective. This is frequently done to clarify whether planned projects are justified in terms of their macroeconomic benefits. The problem-oriented approach, by contrast, does not serve to clarify this issue of justification. Here the focus is on comparing alternative implementations. Cost-effectiveness analysis is often used for engineering questions, with the result that the analysis is usually problem-oriented and is reduced to the process in view. Cost-effectiveness analysis is to be used to support the selection process when applied in the context of the WFD as well. The objective itself is not called into question, which reduces the inclusion of external factors.

5.2.2 Special features of the definition of objectives for installation-oriented water conservation measures

This approach cannot be transferred to installation-related water conservation measures. Precautionary measures only make an indirect contribution to the WFD's overall objective of achieving good status for all bodies of water and protecting them from

[176] Based on the fundamental examination by ARTNER & SINABELL. [Artner, A.; Sinabell, F.: *Grundlegendes zur cost-effectiveness Analyse*, Institut für Wirtschaft, Politik und Recht, Universität für Bodenkultur, Vienna 2003.]

deterioration. This is because they are intended to prevent accidents which would have an adverse impact of the status of the body of water.

However, this does not result in a *targeted* reduction in a pollutant load in the water. A comparison of the situation in the body of water before and after implementation of the precautionary measure is out of the question, since it lies in the nature of the measures that the pollution is (preventively) avoided before it occurs. The real objective of technical safety measures is to reduce the probability that the technical installations within a catchment area will give rise to an adverse effect on the body of water. As far as the cost-effectiveness of these measures is concerned, the problem arises that effectiveness in the form of a reduction in the risk to the body of water cannot be expressed in the “units of measurement” of the target water quality specified by the WFD. Also it is more difficult, on the lines of the maximum allowable pollutant concentrations in a body of water, to define related maximum acceptable probabilities for accidents in technical installations.

We are forced to the conclusion that installation safety measures do not work towards a fixed, quantifiable objective. We can therefore rule out optimisation of the input of resources to achieve the objective with the least possible expenditure, since the question of when the objective is achieved or when the hazard potential for the body of water has been sufficiently reduced cannot be fully clarified. Instead, it is presumed that the input of resources is maximised as a strategic approach to achieving the objective, in other words technical safety measures are used to reduce the probability of adverse effects on the body of water until an appropriate, i.e. generally accepted, safety standard is reached which is not usually quantified and which is therefore a matter of subjective perception. The cut-off criterion for preventing a requirement which would demand an unlimited amount of investment exists in the WFD to the extent that the latter does not call for absolute safety, the technical feasibility of which would in any case be a matter of doubt, but is qualified by expressions such as “minimising the impact” or “reducing the risk” by “including all appropriate measures”, without specifying concrete objectives. The objective is thus not the greatest possible reduction in hazard potential, but rather an “appropriate” or “reasonable reduction”. Ultimately, we can conclude that measures are no longer necessary if they result in unreasonably high costs, i.e. the cost of the measures is not balanced by an equivalent benefit, or their implementation would place an unreasonable burden on the party bearing the cost. The consideration of the costs and benefits of technical safety measures is pursued further in Chapter 5.3.

The fact that there is no concrete specification of the objective with regard to precautionary safety measures and that it is therefore impossible to optimise the use of resources means that an essential precondition for the application of cost-effectiveness analysis is missing. Without a defined limit value it is not possible to analyse what measures are the most efficient for achieving it. The following sections nevertheless examine whether and under what conditions it is possible to compare the cost-effectiveness of different safety-relevant measures.

5.2.3 General requirements for determining costs

Two types of costs are relevant when determining the underlying costs.

- Cash-based costs: Cash-based costs are the expenditure directly incurred as a result of implementing a measure. The amount is determined on the basis of prevailing market prices or the cost of acquisition. Items include in this expenditure figure depend on the type of measure and may include investment, operating, personnel, service or development costs.

- Opportunity costs: Opportunity costs arise from benefits lost where the implementation of a measure precludes or restricts a competing use of these resources. For example, opportunity costs arise if the resources necessary for implementing the measure cannot be used for a different (next best) purpose. Since they cannot be seen directly from the actual use of resources, they are much more difficult to identify, but they may be based on the chosen return on capital employed.

When weighing up alternatives with a view to selecting combinations of measures, opportunity costs play a secondary role, at least insofar as the objective itself is not called into question. Implementation of the measures cannot simply be left undone, but is rather the object of the exercise of achieving the defined objective with the minimum input of resources. Opportunity costs are only relevant if measures (in one area) result in restrictions on use (in another area)[177]. The following (idealised) example should illustrate the situation: as a result of intensive shipping, the natural structure of a river bed has been destroyed. In the course of a structural measure, the spawning grounds that formerly existed there are to be restored as far as possible. At the same time, however, the measure reduces the maximum draught available for shipping. The structural measure gives rise to opportunity costs as a result of the losses arising from the reduced capacity of the shipping use. This relationship remains “close” to the measure in view, but without claiming to represent a holistic cost approach.

5.2.4 Special features of cost determination for installation-oriented water conservation measures

When determining the costs arising from the implementation and operation of installation-related safety measures, there is first of all a serious problem. In the overall view, it is not possible to isolate the size of the costs from the costs actually caused by operation. Costs due to operation may be regarded as costs that would occur whether or not an installation was fitted with safety systems. Only components or technical elements that serve solely to increase the safety of the installation can be classified without further ado as safety-relevant costs. However, a large number of structural elements, operational processes or inputs of human resources not only serve to improve safety, but also form part of the actual production process within the plant.

In order to assess the additional cost of safety-relevant measures, it is therefore necessary to weigh up what contribution an entire cost item (production component + safety component) makes to improving safety standards in the operation of the installation. In the specific application in view it should in this way be possible to at least estimate the extent to which total costs increase as a result of integrating safety measures. Chapter 5.3 looks at examples of the problem of allocating costs to show the additional cost due to technical safety measures, and on this basis it gives an impression of the proportion they account for in the overall costs structure.

> *Continued from previous page* <

[177] In such a situation the WFD also speaks of resource costs.

5.2.5 General requirements for determining the effectiveness of measures

When determining the effectiveness of a measure it is basically important to observe two aspects. Firstly, the effect must have some relevance to the objective, and secondly, it must be measurable. Even if it can be assumed that relevance exists in most cases, since otherwise there would be no point in investigating the measure, the question of simultaneous measurability with regard to the objective criterion in view frequently presents problems.

Even if it is not necessary to monetarise effectiveness, it must be possible to define it in relation to the objective. It is at this point that the detailed definition of the objective and the determination of effectiveness converge. When assessing water criteria, it is possible to make use of physical, chemical, biological and also structural indicators. In the assessment process, it is important to be able to compare different effects of a measure that address the same causes. At the same time, individual measures often possess various partial effectiveness components, and may thereby contribute to the achievement of various partial objectives. Various possible methods of scaling are conceivable for assessing the partial effectiveness components. Ranking on a cardinal scale can be regarded as the ideal variant, with the effects measured in absolute or relative terms. This cannot directly represent the extent of the differences between various options. If a specific measurement of this kind is not possible, relational comparisons (ordinal scale; better/worse) or classifications (nominal scale; yes/no) may be used as an alternative, though this considerably reduces the information value of the analysis. Subsequent determination of the overall effectiveness of a measure or a combination of measures is rarely possible. The reason for this is that partial effectiveness components of a measure cannot necessarily be totalled, as they address different objective criteria. In a combination of several measures there is also a possibility of overlapping effects if partial effectiveness components only make a partial contribution or none at all to increasing the overall effect.

5.2.6 Special aspects of determining the effectiveness of installation-related water conservation measures

In conjunction with the remarks about the definition of the objective in Chapter 5.2.2, it is clear that it is not possible to say anything about the effectiveness of precautionary measures with regard to avoided emissions in the water, since accidental releases do not belong to normal operation of an installation. In other words, a measure would not have any effectiveness if no accidental releases had taken place (or were known of) within the installation to date without technical safety precautions and there were no change in this situation after the measure had been implemented. Thus the effect that really needs to be assessed here is not the reduction in water pollution, but the reduction in the hazard potential that existed for the water without the safety precautions. This means that while the individual measure is relevant to the objective, there are problems with measuring the reduced danger to the body of water.

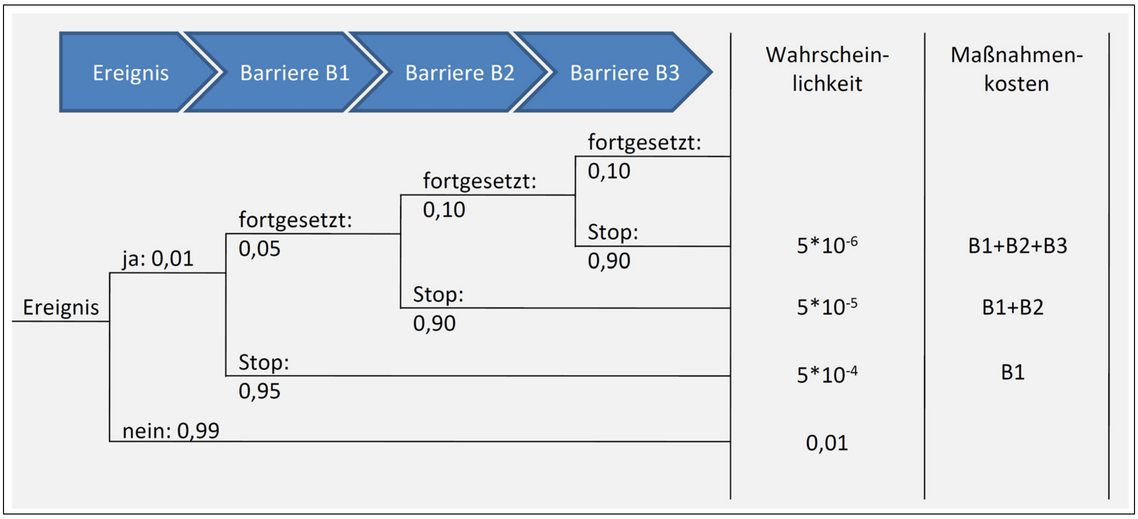

Figure 6 Example of an *event tree analysis* (ETA) for use in installation-oriented water conservation, including the resulting costs of the measures (own representation)

Risk assessment uses various approaches in an attempt to quantify how the combination of safety measures in an installation changes the risk of incidents. In this context, Figure 6 illustrates the Event Tree Analysis (ETA) method and shows how it can theoretically be used to compare cost and effectiveness in the chain of measures.

Each of the successive steps represents a barrier at which release of the substance can be prevented and indicates the probability of this happening. As a result it is possible to determine for each path the overall probability that release of the pollutant will nevertheless occur. The overall probability decreases with every increase in the number of barriers in the form of effective measures taken to prevent the incident. However, as the probability decreases, the cost of the measures increases. The analysis can make it clear how the costs increase in proportion to the decreasing probability of occurrence. If various options are available regarding measures for a given barrier, one can change the combination of measures to investigate which alternative achieves a risk reduction at the lowest cost. There are however various disadvantages associated with this method which cast doubt on its pragmatic usability:

- An event tree does not provide reliable information about the safety of a particular installation, but merely about the probability of a conceivable incident in that installation. Thus the effectiveness of the same combination of safety measures may vary in different scenarios.
- Consideration of an event is usually confined to the installation itself. Taking account of external influences and the diffusion behaviour of substances outside the influence of the installation would substantially increase the complexity of the analysis.
- For a large number of applications the probability that individual events will occur is not known, nor is it known how the course of these events will be influenced by safety measures. If usable values are nevertheless found, these are also likely to suffer from considerable uncertainties which are increased by the path-dependent multiplication.

Even if the method appears suitable in theory for at least making a comparison of cost-effectiveness ratings, in practice the disadvantages described mean that it will only be a practicable solution for a minority of operators. ETA in this form cannot provide a pragmatic solution that is capable of integration in the conceptual background to the WFD.

Another means of assessing the effectiveness of a measure at least at nominal level, is to examine it with regard to various event scenarios.

Figure 7 illustrates the systematic approach on the basis of two selected examples.

The starting point for this approach is to assume a probability of 1 for the occurrence of an event, i.e. when determining the effectiveness of the measure one disregards entirely the question of how probable it is that an incident will occur in the installation. Depending on the nature of the installation and the operational processes taking place in it, it is possible to derive a number of scenarios the occurrence of which cannot be ruled out. These scenarios are weighted against each other so as to arrive at a total probability of occurrence of 1. Thus in the example shown here, the scenario *overfill/operating error* is the one most likely to occur. The event types are set against the choice of measures, and for each measure an estimate is made of whether it will be effective in relation to the individual events. Measure 2 in the example is only effective in the event scenario *overfill/operating error*. However, since this scenario is weighted with the greatest probability, Measure 2 will be effective in 35 percent of the incidents that occur. Measure 1, by contrast, is effective in several scenarios and therefore reaches a total of 0.45. Thus the effectiveness of Measure 1 would have to be rated higher. In combination with the costs arising from the measures it is possible to compare the cost-effectiveness of the two measures. However, in the case of the two examples chosen here we can see that the effectiveness of the two measures would be additive. The fact that it is very likely that both measures would be implemented here (thereby reaching an effectiveness of 0.8 for the combination of measures) gives an idea of the problems arising from the lack of a defined objective (cf. Chapter 5.2.2) when performing a cost-effectiveness analysis, since a comparison of possible safety measures will not always make it equally obvious that preference should be given to the combination of measures instead of opting for one of the alternatives.

Ereignisszenarien	Gewichtung Häufigkeit	M1	M2
Überfüllung/Fehlbedienung	0,35	-	x
Materialversagen	0,15	x	-
Verkehr/Einwirkung v. außen	0,15	x	-
Überdruck/Zerbersten	0,10	x	-
Brand/Explosion	0,05	x/-*	-
Hochwasser/NATECH	0,05	x/-*	-
Sonstiges	0,05	-	-
Ereigniswahrscheinlichkeit	1,00	0,45	0,35

Figure 7 Determining effectiveness of measures on the basis of their relevance to possible event scenarios (own representation)

In the second approach described, the problem once again lies in the question how pragmatically and plausibly we succeed in weighting the possible event scenarios by their potential frequency of occurrence. Furthermore, while the approach is suitable for individual measures, safety strategies are usually of multi-stage design, with various measures preventing the same factor. In this case the method would produce unsatisfactory results, since it would again remain unclear which measure would make what contribution to preventing which event.

5.2.7 Problems and limits of cost-effectiveness analysis for installation-related water conservation measures

Even if cost-effectiveness analysis is not absolutely essential for basic measures under Article 11 (3) WFD[178], it may make sense to attempt a comparison of this kind for selecting suitable action options. In the field of installation-related water conservation, however, cost-effectiveness analysis involves considerable difficulties that pose major problems for its pragmatic use.

One crucial reason for this is that it is not possible to superimpose the levels of WFD and installation-related water conservation. The question that arises here, but which cannot be easily answered, is: How far does the risk of accidental water pollution have to be reduced to achieve or maintain good status according to the WFD? It is not possible to derive a fixed and quantified objective, e.g. the definition of a boundary risk, from the existing context. Without such an objective, however, cost-effectiveness analysis misses its real purpose. Determining costs and effectiveness also involves problems that would make its use considerably more difficult. On the costs side, that applies particularly to distinguishing between expenditure arising from protection against accidental water pollution and other expenditure. At the same time it has to be assumed that examining costs in the individual case makes it possible to identify ranges that can be used to estimate safety-relevant costs in relation to the overall capital cost of an installation (cf. Chapter 5.3). By contrast, it is more difficult to operationalise the determination of the sensitivity of measures. Even if one succeeds in comparing the effectiveness of individual measures, this still does not take account of the fact that parallel implementation of several alternatives continues to produce a reduction in the overall risk, though not to the same extent as the effectiveness of the individual measures. Thus there is also a need to decide whether, despite comparable

[178] It is frequently argued that basic measures do not originate from the WFD itself, but effect the transposition of existing European legislation, which the WFD merely unites under a common framework. This is at least partly true of the measures pursuant to Article 11 (3) I WFD in conjunction with the Seveso-II Directive and the IPPC Directive. This existing legislation is not “overruled” by the WFD, i.e. even if the economic instruments in the implementation of the WFD find that measures do not make sense on the basis of efficiency criteria, as basic measures they have to be implemented in view of existing European legislation. Following this line of argument renders an economic method of benefit assessment unnecessary for a large proportion of the basic measures.

relevance of the effectiveness, one option rules out another or creates an additional barrier. To put it another way, even if it is made possible to compare the cost-effectiveness of various action options, it is still necessary to clarify whether a measure can be implemented on an alternative or cumulative basis.

Any attempt to integrate the problems described above in the approach brings a corresponding increase in the complexity of the analysis. Linking influencing factors, e.g. by combining several measures, simultaneous increases the uncertainty of the results, since the data on costs, effectiveness, or the probability of occurrence of specific event scenarios are in each individual case based on estimates that are already subject to uncertainties. Thus multidimensional extension of the viewing levels does not necessarily lead to more accurate results, despite a substantial increase in expenditure.

In view of the problems described, we consider it more useful in the following sections to focus on the costs of installation-related water conservation, especially since these costs are the most tangible of the parameters considered. By comparing the costs involved in preventing accidental water pollution with the cost of the damage caused by accidents involving substances dangerous to water, it is possible to estimate the extent to which the effort required for precautionary measures is justified, regardless of how efficient this is. Chapter 5.3 contains a number of basic ideas on this aspect and seeks to underpin them with statistical data.

5.3 Costs incurred for installation-related water conservation

5.3.1 Costs incurred for installation-related safety measures to prevent losses of substances from technical installations

To determine the costs that arise from implementing safety measures in connection with a technical installation, it is first necessary to find a way of defining the various cost items so that they can be allocated to their specific purpose. In practice this is frequently a problem that should not be underestimated. The following remarks should help to express this in more concrete terms:

- The costs incurred are grouped under various cost headings. For example, a distinction is made between acquisition or capital costs, operating costs, personnel costs, service and maintenance costs, etc. However, this allocation of costs to cost headings does not make any distinction between costs that arise from use of the installation for its real purpose (e.g. storage), and costs that arise from improving existing safety standards or preventing malfunctions. Individual cost items may however serve both purposes, and it may be impossible to tell what proportion of the costs is due to which purpose.
- With regard to the capital cost of an installation equipped with safety systems, only those costs which are clearly attributable to the safety aspect can be allocated to safety expenditure. For example, the cost of an overfill protection system can be allocated in full to safety expenditure. But allocation is more difficult in the case of the tank itself. The tank would have to exist for the process, even if there were no safety requirements. However, once such requirements exist, the tank accounts for a certain proportion of the increased safety level by safely enclosing the substance.
- A similar situation applies to human resources, because personnel not only work on the actual production processes, but are also involved in implementing technical safety instructions (e.g. tours of inspection).

To get round this problem and simplify cost analysis to a pragmatic level, it would seem sensible to regard as safety relevant only those costs which are incurred in addition to the actual process costs. On this approach, personnel costs are only relevant if the personnel is concerned exclusively with installation safety and not the production process. In the case of capital cost, this can be done by comparing the cost of the "unsafe" installation and the cost of the "safe" installation: the difference between the two quantities represents the additional expenditure on safety.

This can be illustrated by the following simplified example. General statements about the size of safety-relevant costs in relation to the total capital cost of an installation are not possible in view of the variety and individual nature of such installations, so safety costs have to be determined on a case-by-case basis. However, this example of a storage facility is applicable to a large proportion of existing installations, since this type of installation represents a large share of the total, and also accounts for the greater part of total storage capacity.[179]

The example is based on a storage facility with a storage capacity of 3,000 litres. The aim is to analyse what additional financial expense arises if the installation is protected against the incident cause *"leak in storage tank"*. Other causes are disregarded. The cost comparison is made for various precautionary strategies, which are described below:

- Scenario 1: The storage facility takes the form of a single-walled steel tank. This is free from leaks and is resistant to the expected physical and chemical influences. In the event of a leak, the stored pollutant escapes and cannot be prevented from spreading further without taking further measures.
- Scenario 2: The storage facility takes the form of a single-walled steel tank. This is free from leaks and is resistant to the expected physical and chemical influences. The tank is set up in a resistant collecting space, which in the event of a leak retains the escaped volume of the pollutant.
- Scenario 3: The storage facility takes the form of a single-walled steel tank. This is supplemented by an anti-leak lining, a plastic inner envelope ("inner coating"),

[179] According to BAM (2007), storage facilities in Germany accounted for around 88 percent of installations in 2004 and had an average storage capacity of 100 m³ per installation.

[Federal Institute for Materials Research and Testing (BAM) (2007). Untersuchung der Statistik "Unfälle mit wassergefährdenden Stoffen" des Statistischen Bundesamtes aus dem Jahr 2004 im Vergleich zu den Vorjahren. Study commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.]

which is resistant to the expected physical and chemical influences. In the event of a leak in either the inner lining or the steel tank, the substance continues to be retained by the other envelope. A leak detection system between tank and inner lining indicates the fault and make it possible to take countermeasures.

- Scenario 4: The storage facility takes the form of a double-walled steel tank (largely identical characteristics to Scenario 3, but involves complete reconstruction of storage facility, whereas internal lining can be retrofitted).

Whereas the safety standard of the first scenario is unsatisfactory, because there is only one barrier preventing the pollutant from escaping into the environment, the other three scenarios offer similar improved safety standards with two barriers, but differ in the technical approach adopted. Figure 8 shows the resulting costs for the different scenarios.

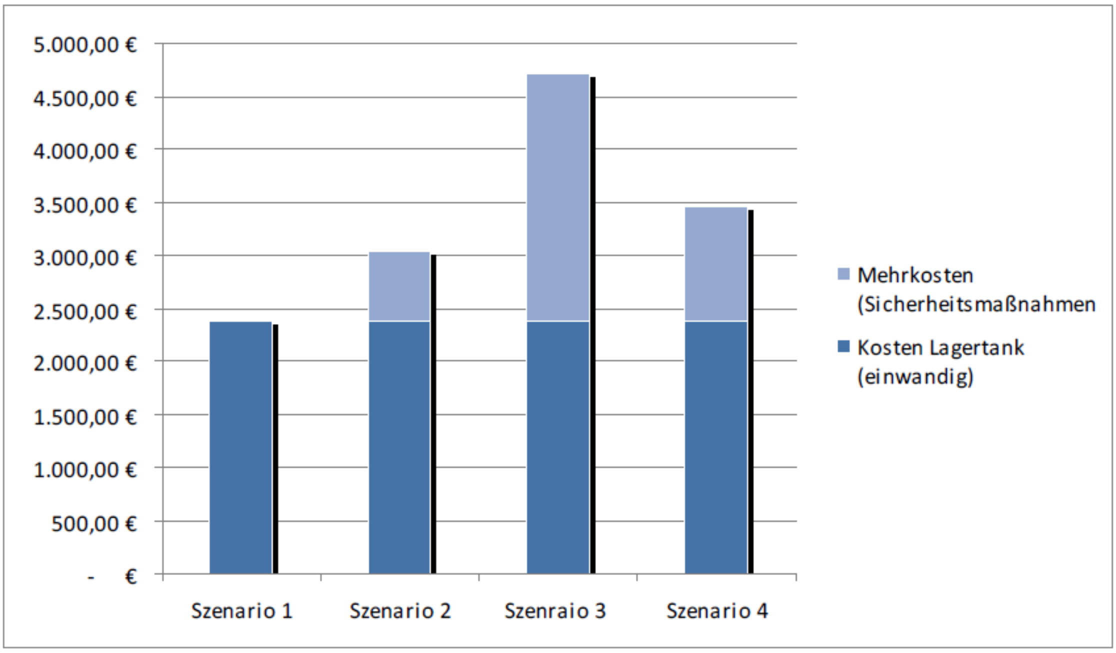

Figure 8 Comparison of costs for a 3,000-litre storage tank made of steel, with various safety systems (own representation, data: Messrs. Walter Ludwig[180])

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180 Walter Ludwig Behälter- und Anlagenbau: price list August 2004.

The diagram shows that the additional costs of technical safety systems for the storage facility range from 28 percent to nearly 100 percent of the cost of the single-walled tank. This does not take account of any extra land needed for creating the collecting space (Scenario 2). When considering the high cost of the inner lining (Scenario 3), it should be noted that this solution not only improves the safety level, but also reduces the stresses on the storage tank itself, which may allow it to be used for a longer period. Scenario 4, by contrast, would seem to be the desirable solution from a costs point of view as well, assuming corresponding safety requirements, especially if the position of the storage tank makes it impossible to create a collecting space without making concessions regarding usable space. Table 16 lists the details of costs for the four cases.

Table 16 Cost comparison 3,000-litre storage tank, steel

Scenario 1	Storage tank, steel, 3,000 litres, single-walled	2,365.00 €	
Scenario 2	Collecting pan, 10 m² coating incl. preparation of surface, 5 m door lip with concrete kerb h/d = 30/24 cm, incl. personnel costs for installation	+ 670.00 € = 3,035.00 €	+ 28.3%
Scenario 3	Internal coating for storage tank, steel, 3000 litres, single-walled, incl. leak detector	+ 2,350.00 € = 4,715.00 €	+ 99.4%
Scenario 4	Storage tank, steel, 3,000 litres, double-walled, incl. leak detector	= 3,460.00 €	+ 46.3%

It can be seen that as the tank size increases, the additional cost of the safety systems for the storage tank decreases as a percentage of the basic cost (cost of single-walled storage tank) (cf. Figure 9).

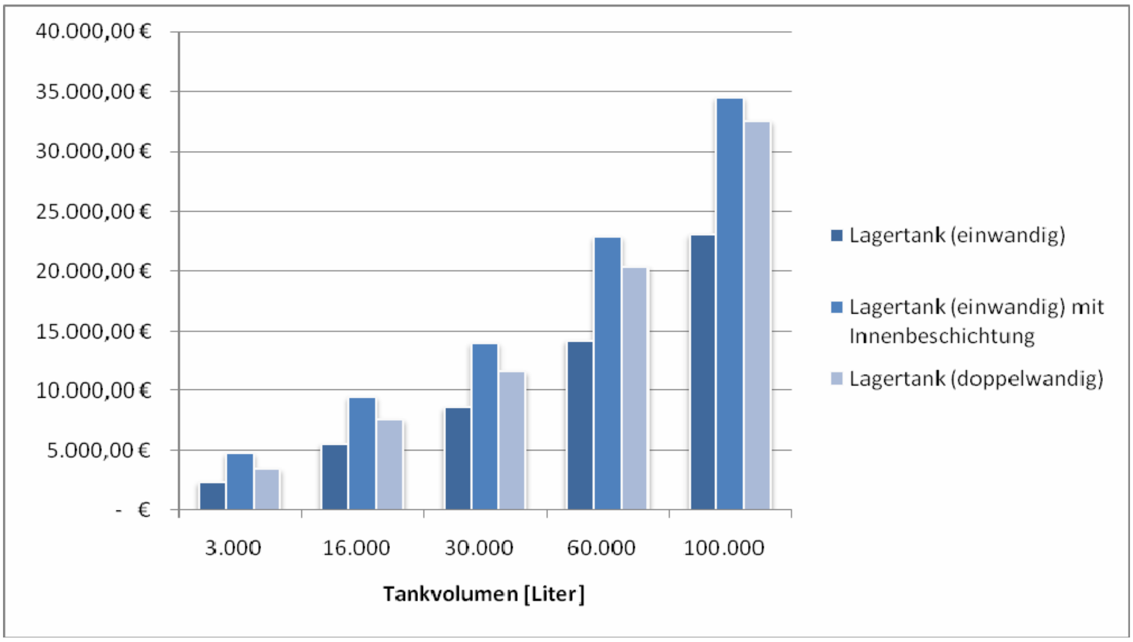

Figure 9 Comparison of costs for various storage solutions with increasing capacity (own representation, data: Messrs. Walter Ludwig)

For example, the additional cost of the double-walled tank ranges from 58 percent for the smaller tank sizes to around 41 percent for a storage volume of 100,000 litre. The situation is similar for equipping a single-walled tank with an inner lining: for smaller volumes the total cost is nearly twice that of the single-walled tank without safety systems, but as the capacity rises, this falls to 1.5 times. Much the same can be expected for Scenario 2, since the base area of the collecting space does not rise in proportion to the increase in tank volume. Owing to lack of data, it is not possible to provide statistical confirmation of this expectation here.

Even if these examples do not permit any generally valid conclusions about the actual level of the additional cost of safety systems for technical installations, they do make it clear that the financial cost of the improved safety standard can be considerable in relation to the basic cost necessary for the process alone. Especially when one considers that in this example precautions were taken against only *one* conceivable type of event, higher additional costs than shown here are by no means unrealistic. The pattern that the additional costs are greater in proportion for relatively small installations is likely to be repeated for more complex combinations of safety measures as well, especially when one considers that the cost of quite a number of safety systems or organisational measures is largely independent of the size of the installation. However, since the hazard potential of smaller volumes of substances (assuming the same type of substance) is smaller and the cost of the damage is therefore likely to be lower (cf. Chapter 5.3.2), lower costs for an appropriate safety level may be justified in economic terms for installations with a lower hazard potential.

5.3.2 Costs arising from emergency and follow-up measures in response to losses from technical installations and accidental pollution

Precautions make sense from an economic point of view wherever it is more expensive to remedy damage that has occurred than to prevent it from the outset. It is nevertheless difficult to "prove" this basic idea on the basis of cost data, because the costs that would in fact arise from notional damage which has not (yet) occurred are not known. This problem can to some extent be solved by falling back on experience gained in past incidents, i.e. assuming that historical cost data will apply on a similar scale to future accidents.

The costs arising from accidents involving substances dangerous to water can be derived for Germany from a number of statistical surveys performed between 2000 and 2005. These surveys included not only the number of accidents and the quantities of substance released, but also the cost of the necessary emergency and follow-up measures. It is also possible to distinguish between accidents associated with technical installation (handling accidents) and accidents during transport of substances dangerous to water.

<u>Which surveys were included in this study?</u>

This study is based on various reports and communications by the Statistical Offices of the Länder and the Federal Statistical Office. Continuous cost data came from the reports by Bavaria [181] from 2001 to 2005 and Mecklenburg/W. Pomerania[182] from 2003

181 Bavarian State Office for Statistics and Data Processing (Bayerisches Landesamt für Statistik und Datenverarbeitung, 2004): Unfälle beim Umgang mit und bei der Beförderung von wassergefährdenden Stoffen in Bayern 2003. Munich.

> *Continued on next page* <

to 2005. In some cases the samples in these surveys were small, permitting more definite conclusions about extreme values and the relationship between escaped quantity and cost magnitude than is possible with larger samples where the range of fluctuation has been smoothed out. The Federal Statistical Office provides data[183] from 2001 to 2003; here only the total figure for emergency and follow-up measures is given, and it is not possible to break it down into installation accidents and transport accidents. The largest collection of data is supplied by the Federal Institute for Materials Research and Testing (BAM)[179] for the years 2000 to 2004, which also permits a distinction between installation accidents and transport accidents. The survey summarises statistics for the whole of Germany and to some extent makes use of data not published by the individual Länder offices. Thanks to the large number of complete data records, this is the source with the greatest information value. Apart from the sources mentioned, which above all reflect statistical means for a specific area during a statistical period, cost information from individual incidents can provide useful information and contribute to a better understanding of the problem. Such sources are mentioned explicitly where they are used.

<u>What measures were examined?</u>

The costs arising from accidents are divided into costs for emergency measures and costs for follow-up measures. This takes account of "damage repair measures" for the purposes of the Environmental Statistics Act.

Emergency measures are interventions that first stop the release of a pollutant and prevent it spreading further. Examples include plugging leaks or deploying oil booms in

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AND Bavarian State Office for Statistics and Data Processing (Bayerisches Landesamt für Statistik und Datenverarbeitung, 2008): Unfälle beim Umgang mit und bei der Beförderung von wassergefährdenden Stoffen in Bayern 2006. Munich.

182 Cf. Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2004): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2003. Statistische Berichte Umweltbelastungen, Schwerin.

AND Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2005): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2004. Statistische Berichte Umweltbelastungen, Schwerin.

AND Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2006): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2005. Statistische Berichte Umweltbelastungen, Schwerin.

183 Federal Statistical Office (Statistisches Bundesamt, 2005): Anstieg des Umweltrisikos durch wassergefährdende Stoffe. Press release No. 134 of 21.03.2005.

water bodies. Emergency measures also include fire-fighting and damage analysis. Follow-up measures are concerned with cleaning up the substances released and if necessary treating the contaminated environmental media. Examples of follow-up measures include excavation and treatment of polluted soil layers, or remediation of groundwater bodies. One problematic aspect is the fact that the need for follow-up measures is not always evident immediately after an incident, which means that the allocation of follow-up costs incurred may be subject to considerable uncertainties.[179]

It may be assumed, at least in part, that the cost of long-term damage repair is not fully included in the statistical data examined here. This is also suggested by the relatively short time between the accident and the time the data were collected. In the case of intensive remediation measures it is by no means uncommon for such measures to give rise to substantial ongoing follow-up costs even years after the accident occurred. Out of a total of 2340 accidents with substances dangerous to water in 2004, it was stated in 110 cases that there was no knowledge of any follow-up measures or that they were unforeseeable. This corresponds to about five percent.[179] Neither do the cost data reflect any results of the accident that were not remedied by immediate emergency and follow-up measures, or will not be remedied in the future, but which should be assigned a monetary value from an economic point of view.

<u>Number of accidents and quantities of pollutants released</u>

Between 1996 and 2004 an average of 2491 accidents a year involving substances dangerous to water were registered and some 5377 m³ of pollutants released. The average quantity released per accident was thus 2.2 m³. On average, 44 percent of the accidents were due to handling of substances dangerous to water, but these accounted for nearly 81 percent of the total quantity of substances released. Fifty-six percent of the accidents occurred during transport of substances dangerous to water. Figure 10 and Figure 11 show the distribution of accident numbers and quantities released for the individual periods between 1996 and 2004.[179]

Another aspect of interest when considering the completeness of the cost data is the quantity of pollutants released that was not recovered despite the emergency and follow-up measures. Such quantities remain – initially or permanently – in the environment. The costs attributable to the resulting damage are not registered. Between 1996 and 2004 approximately 59 percent (an average of 3192 m³) of the pollutants released were not recovered. If one considers only handling accidents here, the figure increases to around 63 percent.[179] This leads to the conclusion that a considerable proportion of the costs for damage repair is missing, on the assumption that substantial additional costs are incurred for disposing of the substances not recovered.

The BAM survey for the year 2004 makes it possible to estimate the probability that existed then of an accident occurring in an installation for handling substances dangerous to water. There were 828 accidents in technical installations. and the total number of installations was 1,238,920. Thus the probability of an accident occurring in Germany in 2004 was less than 0.07 percent.

<u>Cost per accident</u>

From the data published in the various statistical surveys it is possible to derive average figures which make it clear what costs were incurred per accident for emergency and follow-up measures (Figure 10). While there is a lack of specific data on individual accidents which might be used to make a more detailed examination of the costs arising, it is nevertheless possible to draw individual conclusions from the different sample sizes of the statistics about the size of the deviation from the mean of all data. Thus the deviations shown are not individual values, but also statistical means. These, however, result from surveys for limited periods, whereas the real average was calculated from all available data across the entire period of the study.

It is clear from Figure 10 that the average of all data for emergency and follow-up measures is €5,318 per accident. The cost of accidents in connection with technical installations (handling), at €5,853 per accident, is slightly higher, while slightly lower costs of €4,964 per accident were incurred in the transport sector. On the whole, however, the average amount of the expenditure is relatively similar for both types of incident. The largest fluctuations were found in accidents when handling substances dangerous to water. Ranging from €2,350 per accident to €33,838 per accident, these show the most marked deviations from the average. For transport the range is only €3,558 to €17,448 per accident. Although the extreme values apparently have very little influence on the dataset, these figures illustrate how cost-intensive the necessary measures in response to accidents can be. They can reach between 3 and 6 times the mean.

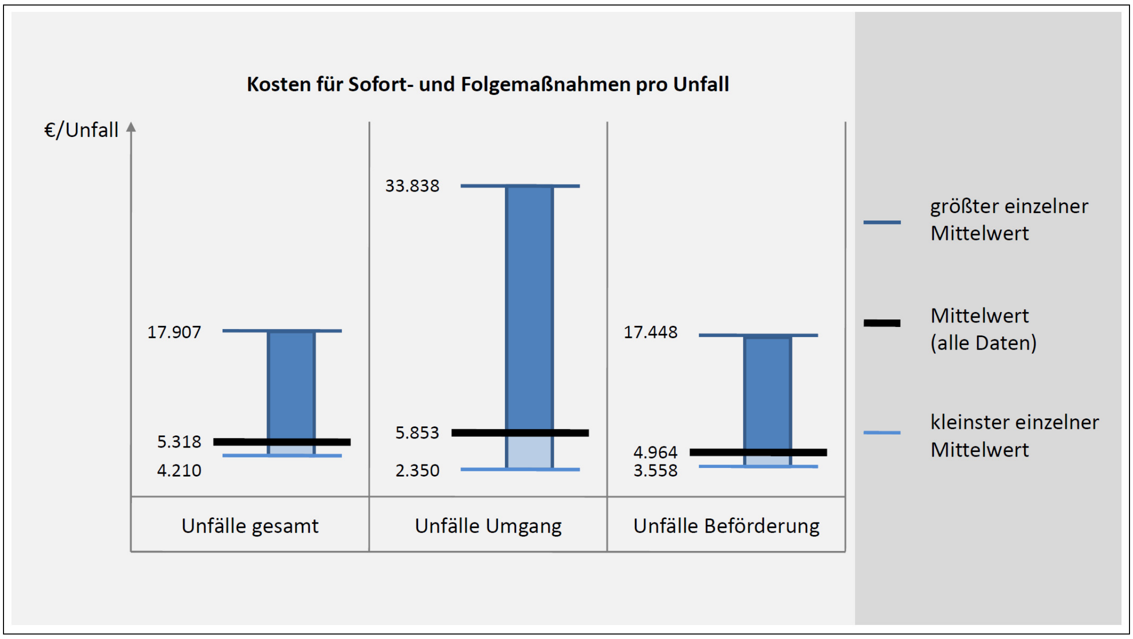

Figure 10 Cost of emergency and follow-up measures per accident (own representation, data: Statistical Offices of the Länder, Federal Statistical Office, BAM)

<u>Cost per m³ of pollutant released</u>

Examining the cost of the measures in relation to the quantity of substance released reveals a more differentiated view of handling accidents and transport accidents. On average, the cost of emergency and follow-up measures per m³ of pollutant released amounts to €2,199 (Figure 11).

For handling accidents, however, the figure is around half that amount, at €1,106 per m³, whereas transport accidents caused much higher costs of €9,595 per m³ of pollutant released. In particular, the upward deviations from the mean are considerable, reaching €56,600 per m³ for handling accidents and €58,077 for transport accidents. However, the position of the mean within the entire spread of the data indicates that these maximum figures are extreme outliers which do not have any great influence on the mean. What is more, they are the result of comparatively small samples in which the reference quantities of one m³ are divided among several accidents. It can therefore be assumed that at least the data at the upper end of the scale are subject to negligible distortion. On the other hand there are a number of conclusions that can be drawn from these facts.

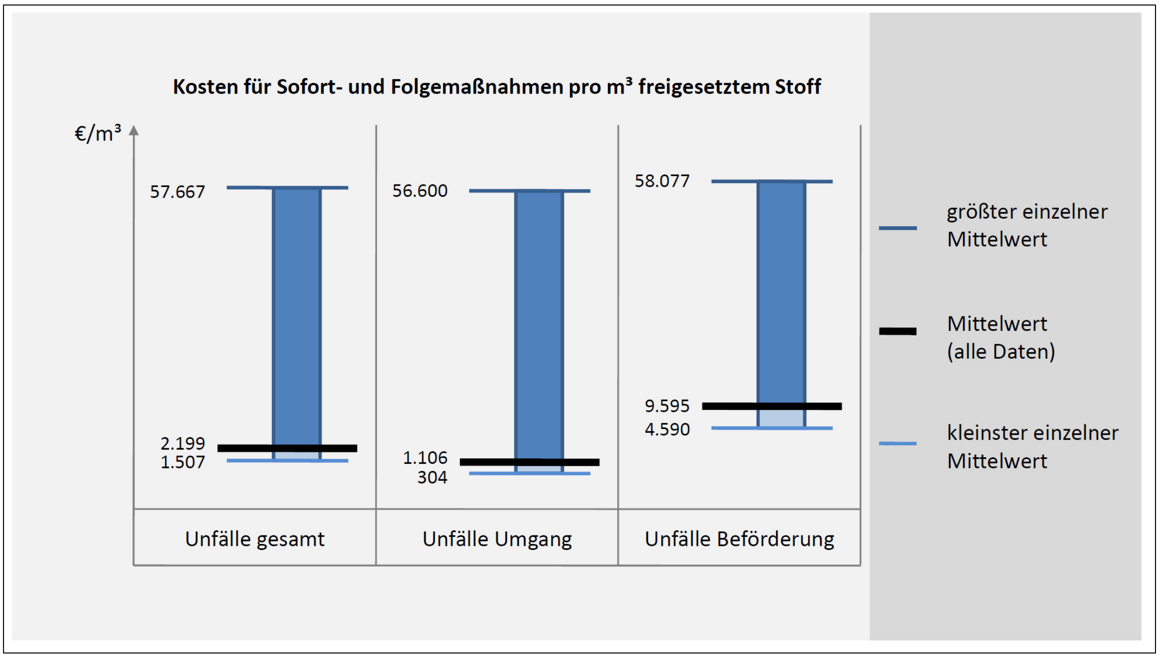

Figure 11 Cost of emergency and follow-up measures per m³ of substance released (own representation, data: Statistical Offices of the Länder, Federal Statistical Office, BAM)

The costs of emergency and follow-up measures after an accident are not in linear proportion to the quantity of substance escaped. The fixed cost component, which is independent of the quantity released, sometimes has a major influence on the cost structure, as can be seen from the following points:

- The average costs for transport accidents in relation to the quantity released are about nine times higher than the costs for accidents in technical installations. This is probably due in particular to the fact that transport accidents usually involve smaller quantities released, but costs for the emergency personnel are incurred on a similar scale. Also response measures for transport accidents are more difficult to anticipate and therefore have to be kept available on a mobile basis. This is also likely to increase the costs.

- In most cases the highest cost figures come from surveys with small samples and from accidents involving comparatively small substance quantities which may even be less than 1 m³. In such accidents the fixed cost components, e.g. for the activities of external personnel to minimise damage and clear up the effects, are spread over the smaller quantity of substance.

Thus it would seem that as the quantity of substance released increases, the cost per unit falls. This, however, fails to consider the question of whether large quantities of pollutants give rise to higher long-term costs because the risk of harmful long-term effects on nature increases. It may assumed that hardly any such costs are registered in the statistical data. The data on unrecovered pollutants tend to confirm this assumption.

5.4 Conclusions

On the face of it, a comparison of costs for precautionary measures and accident response suggests that the level is quite similar. If one looks at the average cost per accident of €5,853 and the additional cost of €6,100 for a double-walled tank with a storage capacity of 60,000 litres, the financial cost of the precautions is higher than that of dealing with the accident, and it has to be remembered that the example used here does not take full account of the entire costs due to precautionary measures. As a result, one might reasonably ask whether there is any justification for the cost of the precautionary measures, or whether it is not cheaper simply to clear up the damage after the event.

Here it is important to be aware that the actual cost arising as a result of an accident is in all probability substantially higher than indicated by the statistical data used here. This is due to the following points in particular:

- The statistical data used here is based on "protected" installations, i.e. the study is based on accidents that occurred despite the implementation of precautionary measures. If we assume that all precautionary measures are dispensed with, the statistical data would probably show the following changes:
    - The number (frequency) of the accidents would increase sharply, since no additional precautions were being taken to prevent them. Accordingly, the total cost of all such accidents would show a similar marked increase.
    - The scale of the accidents would increase, since no following safety barriers would prevent or minimise the diffusion of the pollutants released. If the quantity released increases, so does the average cost per accident. Thus the total costs are influenced not only by the increased number of accidents, but also by the increased cost of the individual accidents.
- The costs registered in the statistics do not include all costs actually incurred and probably fail to take account of a substantial proportion of costs. The reasons for this are as follows:

- Expenditure on long-term measures to restore the original status is hardly recorded, because in most cases the survey took place soon after the accident. At this point in time it is not usually possible to estimate the full amount of the actual costs of the damage.

- More than half the pollutant volume released was not recovered and therefore remained in the environment. It can be assumed that disposing of these substances, which are present, for example, as contamination in soil and groundwater, would give rise to considerably greater costs than suggested by the data compiled here. If these costs, regardless of whether disposal has taken place or not, are included as a valuation of the environmental damage caused, it can be assumed that the cost per accident would be substantially higher. The maximum figures in the statistical data give an idea of the kind of costs that can be incurred in practice for dealing fully with the effects of an accident, though it is not even certain that these outliers include all consequential costs.

Sources that take in the entire consequential costs of an accident confirm these assumptions. For example, for a loss of 15 m³ due to corrosion of the storage tank and the resulting contamination of soil and groundwater, the cost of remedying the damage came to around €550,000.[184] The specific costs per m³ incurred here (about €37,000) are thus in the upper range of the statistical spread and are far removed from the average figures.

Finally, therefore, it has to be assumed that the cost of precautionary measures will be considerably lower than the consequential costs resulting from a much increased accident risk. This particularly true if the environmental damage that cannot be remedied by active measures in view of technical restrictions or uncertainties in the restoration of natural processes is subjected to an environmental valuation and expressed in money terms. Accordingly, the data taken as a basis here failed to take account of more than half the actual damage, and the specific costs of the measures not taken are probably considerably higher than those actually performed. To this must be added an increase in consequential costs due to increased accident frequency as a result of dispensing entirely with precautions which really ought to form the basis for a comparison of the strategies “precautions” and “after-care”.

A more comprehensive consideration of the qualitative aspects concluded here is not possible for lack of reliable statistical data. The following data would be necessary for confirmation of these conclusions at statistical level:

- Capital cost of existing installations for the same level of examination of accident statistics. This could be used as a basis for estimating the safety-relevant costs. This would permit a comparatively simple addition of cost items for district-related measures, which would otherwise be difficult to transform into relative reference values .
- Probabilities and accident frequencies for installations without accident precautions. These could be taken as basis for estimating the accident impact costs actually incurred.
- Consequential costs that also include long-term measures and the assessment of environmental damage in cases where active restoration is not possible. This would permit a more complex assessment of the damage, instead of confining the view to an abstract view of the resulting consequential costs.

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[184] Stadtverwaltung Ludwigshafen (2003): Umweltbericht 2003. Teil VI Gewässerschutz und Umgang mit wassergefährdenden Stoffen. Ludwigshafen, p. 95-112.

6 Recommendations for action – Methodological approach "Safety Chain"

Proposed measures were drawn up on the basis of a risk management flow chart for the surface waters path ("Safety Chain")[185]. The safety chain is based on a time schedule in 3 main categories, each with 2 sub-categories, from strategic preparation for the event through damage containment to after care. Chapters 7, 8, and 9 describe the differentiation of the "links in the chain" into the overarching levels of activity

⇒ Hazard Management, p. 172,

⇒ Crisis Management, p. 206 and

⇒ After Care, p. 293,

each of which is sub-divided into two levels with the following headings:

⇒ 7.1 Basic Preparations (Pro Action), p. 172,

⇒ 7.2 Prevention, p. 191,

⇒ 8.1 Crisis management instruments (Preparedness), p. 206,

⇒ 8.2 Response measures, p. 291,

⇒ 9.1 Damage review, p. 294,

⇒ 9.2 Follow-up measures, p. 301.

Figure 12 provides a graphic representation of the situation.

The diagrams showing the further subdivision can be found – as in Part II "Action Concept – Suggested measures for implementing Article 11 (3) I WFD" – in the sections on the individual levels of activity (Chapters 7 - 9).

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185 The safety chain is not a rigidly defined concept. However, it can be derived in this or similar form, e.g. from the structure of the *UNECE Accidents Convention*[10] or the *OECD Guidelines for Chemical Accident Prevention, Preparedness and Response*[148]. The further differentiation is an interpretation which the authors believe makes sense for work on this project, but which could be structured differently for addressing other problems.

The aim is to identify individual measures relevant to Article 11 (3) I WFD. The suggested measures are allocated to the categories of the safety chain in tabular form in Part II "Action Concept – Suggested measures for implementing Article 11 (3) I WFD". In the present part – Part III – the tables of measures are appended to the sections on the levels of activity, in each case under the heading "Conclusions for the action concept". This is always preceded by descriptions of the suggested measures, where the tabular lists are not self-explanatory.

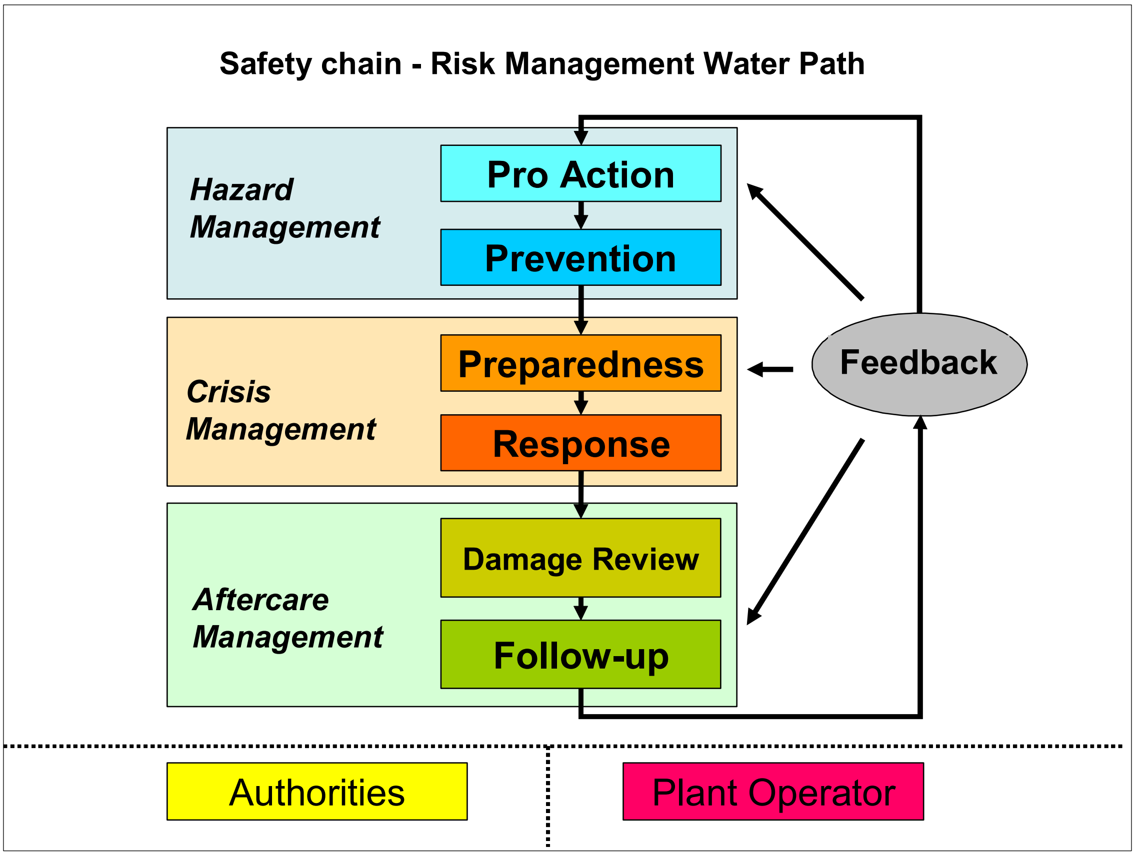

Figure 12 "Safety Chain" in risk management
(following the scheme: Authority tasks, Operator tasks)

Whereas in principle – albeit in varying degrees of detail – the differentiated scheme of the safety chain claims to cover all essential risk management action fields in the surface waters path, this is expressly not true of the suggested measures. These should only name measures that can be deduced (solely) from Article 11 (3) I WFD. Measures that have been or ought to have been implemented under other Community water conservation provisions, such as the IPPC or Seveso II Directives, do not fall within the purview of Article 11 (3) l WFD and do not need to be mentioned in the management plan at this point.

Definition problems arise where the wording of Article 11 (3) l WFD can be interpreted as imposing different or more far-reaching requirements than those derived from established legislation already implemented. This applies, for example, to the phrase (*"significant losses of pollutants"*) in connection with "technical installations". The WFD remains unspecific here. There are however indications that in addition to "Seveso installations and IPPC installations" there are other installations with significant risk potential with regard to the objectives of the WFD, though it may be the case that these are already covered by national provisions in the member states. Thus the tables of measures may also contain proposed measures which in principle have been or should have been implemented under other Community water provisions, but which should at least be scrutinised to identify any need for an extension of relevance to Article 11 (3) l WFD.

A further restriction with regard to the proposed measures is their basic suitability for inclusion in management plans. Here are two examples:

1. The safety chain model is a time-based causal flow chart that takes in all types of measures, from strategic preparation through disaster response to technical restoration of the original state. Of these, only those which can be planned in advance with an implementation horizon in the management period are suitable for inclusion in management plans.[186]

2. Since management plans are prepared by state administrations, they can impose obligations on such bodies only, i.e. they can only specify measures in which the actors are primarily the state or the authorities. The result of the measure may for instance be that a plant operator has to meet certain condi-

[186] Although such immediate response measures to an accident cannot in themselves be part of the management plan, the plan can include all preparatory measures that put the actors in a position to react appropriately and to learn the lessons from such reaction by improving the preparations. An emergency sortie by the disaster control force would not be a measure under the WFD management plan, but such measures would for example include the design and implementation of the emergency plans, or at least a review to see whether existing emergency plans took adequate account of incidents pursuant to Article 11 (3) l WFD.

Similarly, the measures to be stated under Article 11 (3) l WFD do not, for example, include the longer-term tasks in the action field shown in the safety chain as "After Care", such as restoring the original (good) status after an accident, especially since the occurrence of this accident could not have been foreseen when the programmes of measures were drawn up. However, the general need to perform after-care measures can be deduced from the objectives of the WFD (Art. 1, Art. 4, and especially paragraph 6). If restoration measures become necessary after the occurrence of an actual accident, these would form part of the programme of measures as "supplementary measures" (Article 11 (4) WFD), but not under Article 11 (3) l WFD.

tions under statutory provisions or individual orders, but the initiator of the measure can only be the authority.

The proposed catalogue of measures is not a list of measures to be worked through as a matter of routine, but should rather be seen as a check list for determining the need to include measures in the management plan for the relevant river basin pursuant to Article 11 (3) I WFD. Whether such a need exists and which of the measures may be involved depends on the results of the individual check. It may vary considerably between the different river basin districts, member states and administrative units. However, all measures pursuant to Article 11 (3) WFD are "basic" and represent "minimum requirements". Thus if the scrutiny of the catalogue of measures reveals a need for action, measures must follow.

The tables of measures show examples of the implementation of each of the proposed measures. The examples are based on a review of past and planned activities in the international river basin commissions of the Elbe, Oder, Rhine and Danube. Where there are no examples available in this field, other examples are used, largely from German law. The implementation examples may take the form of measures actually put into practice, but may also relate to laws, guidelines, implementation recommendations, technical rules, safety recommendations etc. In most cases they are not a "complete package" for the measure in question, but only cover part of it. The examples are only intended as a guide, i.e. they make no claim to present a complete picture of completed implementations in the EU region. Neither do they claim to offer the best solution for the individual measure proposed.

Since the wording of Article 11 (3) I of the Water Framework Directive provides considerable creative freedom of choice regarding the type of implementation, there may be a need for consultation at river basin level or at EU level about the necessary depth of regulation. In areas that require technical solutions, e.g. "systems to detect or give early warning of such events", it may be possible, by developing graded modular intelligent equipment concepts, to design new monitoring networks to be installed in river basin subsections so that they are at different development stages but are nevertheless compatible with the system used by the river basin association as a whole. This approach could be used to tackle differences in basic conditions, for example in non-member states belonging to river basin districts extending beyond the EU. This topic will be taken up again in the final report.

The Commission will report on the implementation of the Water Framework Directive not later than 2012 (and every 6 years thereafter, Art. 18 (1)). It may if appropriate draw up its own *"strategies against pollution of water by any other pollutants or groups of pollutants, including any pollution which occurs as a result of accidents"* (Art. 16 (9) WFD). This will largely depend on the Commission's assessment of the individual national measures relating to the topic.

Experience gained during the WFD implementation work to date, and also from the discussions during the project work and, not least, the two project workshops, has shown that integrated coordination of all administrative sectors concerned is indispensable for successful implementation of the proposed measures relating to Article 11 (3) I WFD. These are not only the "classic" water management administrations, which as a rule see to national implementation of the WFD with its primarily immission-oriented objectives, but also the emission-oriented authorities that are responsible for plant licensing/monitoring and accident prevention, plus the services that can be summed up under the heading of "disaster control".

7 Hazard Management

In the chronology of a hazard situation, hazard management comes before a hazard occurs or takes effect. This is a strategic field of action, within which both installation-related and district-related measures play a role. Hazard management measures therefore include all *strategic* measures

- to prevent and minimise the release of significant quantities of pollutants from technical installations and other potential sources and
- to protect humans, animals, the environment, property and any other objects of protection in the event of accidents and other unexpected pollution.

The core of hazard management consists of preparatory measures in the form of a specific analysis of requirements and measures to create necessary legal, planning and organisation structures (Pro Action).

On the basis of the structures created, the results of the analysis of requirements can then be used to implement strategic hazard precaution measures tailored to the specific river basin district to ensure a functioning crisis management system (prevention).

7.1 Basic Preparations (Pro Action)

Basic preparations involves laying the foundations that are a precondition for effective implementation of the subsequent steps. The aim of this step is ultimately to perform a specific analysis of requirements, the purpose of which is to register existing hazards and threats within a planning district and elaborate the resulting risk situation. To ensure conformity with the planning of measures under the WFD, this step is as far as possible performed individually on the basis of comparable planning units. However, before performing this district-specific analysis it is necessary to create the legal and criteria-related preconditions for implementation and allocate responsibilities.

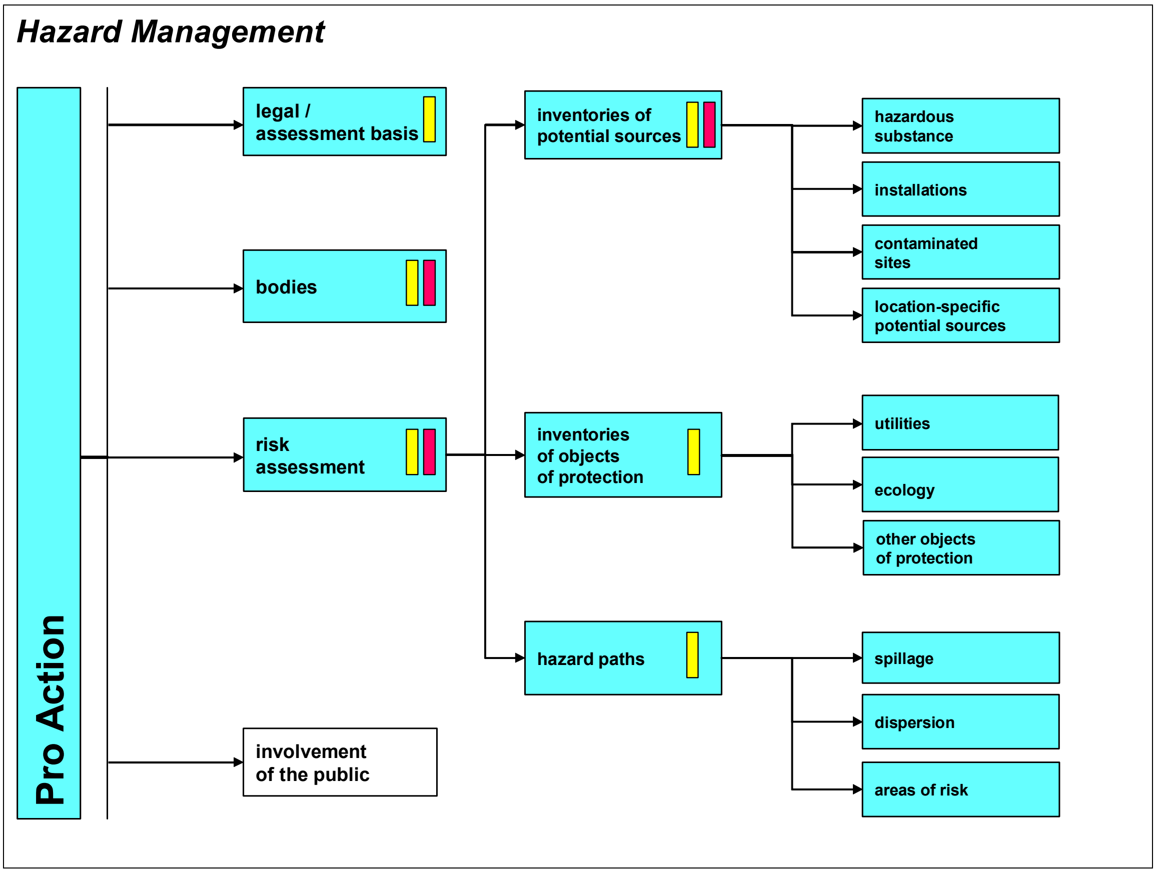

Figure 13 Hazard Precaution Management – Basic Preparations
(Authority tasks, Operator tasks)

7.1.1 Legal basis

For implementing the requirements of Art. 11 (3) I WFD and the recommended measures elaborated in this context, it may be necessary to create further legal bases at the level of the Member States. Even though the WFD is transposed into the national law of the individual states, it is still likely that further legitimation for more concrete requirements will have to be embodied in legislation.

The basis for creating the legal foundations should be the existing uniform EU law which is already implemented in practice in the Member States in the form of various Directives (Seveso-II Directive, IPPC Directive, EU legislation on hazardous substances, etc.). The structures and fundamentals that exist in these areas can be used to weave the – sometimes more stringent – requirements arising from Article 11 (3) I WFD into national legislation. Thus the allocation of official responsibilities in particular usually builds on existing foundations. Further networking of responsibilities and competencies can take place via the civil defence and disaster control bodies, for example.

7.1.2 Institutions and bodies

Depending on the legal provisions on the key areas dealt with in the *safety chain*, it is also necessary to set up institutions and bodies which handle the preparation and implementation of the proposed action strategies, and which follow up by assessing the results and investigating whether the objectives set were achieved and whether there is a need for operational/strategic changes in approach. The extent to which the necessary technical competence exists depends on the state of implementation of the relevant European directives. It can however be assumed that it is possible to build on existing structures.

The structural requirements will have to be linked with the structures of the public authorities. Despite the river basin approach, Member States will have to set specific priorities and assign responsibilities to various levels, and also create at national, regional and local level the means of implementing the requirements of Art. 11 (3) I WFD. In this context, bodies need to take action in the field of cooperation between authorities, in order to discuss questions of structural and workflow organisation and to create information sources and evaluation methods. Having regard to the river basin approach, there is also a need here for international networking of committee work. The international river basin commissions show how this requirement is already being implemented in practice today.

7.1.3 Hazard analysis

The basis for appropriate hazard analysis is the identification of existing risks. For this purpose there is a need for competent authorities within the EU Member States to devise methods that permit step-by-step identification of the hazards that exist. The following section indicates what steps are considered necessary for performing a targeted hazard analysis.

When performing such an analysis, it is not sufficient to confine the view simply to existing safety hazards and to reduce the probability of their occurrence by implementing blanket measures. Instead, it makes sense to take a closer look at the relationships between the origin of the hazard and the object of protection. For this purpose it is necessary to make an inventory not only of existing safety hazards (see Section 7.1.3.1), but also of relevant objects of protection (see Section 7.1.3.2) within a planning period, before going on to identify the hazard paths of conceivable scenarios with a view to linking hazard and threat (see Section 7.1.3.3). The resulting findings will subsequently permit targeted use of further measures. These, combined with a selection of basic technical safety requirements which must be implemented as a general principle in relevant installations, will contribute to a further improvement in the safety level. Hazard analysis is an important instrument for perceiving existing risks. This in itself helps to raise awareness of risks and to reduce potential damage.

7.1.3.1 Inventory of safety hazards

As a first step in hazard analysis it is advisable to make an inventory of safety hazards within the Member States which could give rise to water pollution or be a danger to human health. This inventory forms the basis for the implementation of measures in the field of incident precautions and crisis management. When selecting targeted safety measures, the focus on installations or activities for which a high hazard potential is identified in the course of the analysis will be stronger than in the case of safety hazards classified as less dangerous.

Registration of existing safety hazards should always take place within a selected period. This should preferably be based on the planning units of the WFD. The approach adopted should be as pragmatic as possible and should enable the authority making the inventory to proceed with due care. The largest planning unit used in the WFD is the river basin. The resulting data should be recorded at this level using comparable criteria, although a more detailed approach in smaller planning units, e.g. at the level of water bodies or groups of water bodies, with subsequent linking of the data is a suitable method.

Safety hazard means an installation or activity or situation that is capable of giving rise to an event. Relevant events for the purposes of Article 11 (3) I WFD are losses from technical installations and unexpected pollution, especially accidents, which could not reasonably have been foreseen (cf. Chapter 3.2). Thus the following types of safety hazards[187] are of relevance for this examination:

(i) plant-specific safety hazards;

(ii) local safety hazards;

(iii) interference by unauthorised persons.

For inventory purposes it is important to know first of all whether such safety hazards exist; at this point the question of the conditions under which they take effect is of secondary importance. Plant-specific safety hazards may take effect without being influenced by external factors or in conjunction with the influence of local factors and interference by unauthorised persons. The main criteria for their registration are the type of installation and the substances associated with it. Contaminated sites are also to be classified as safety hazards. Local safety hazards, by contrast, only play a role if their occurrence at the site of the plant-specific safety hazard is probable or can be expected. Interference by unauthorised persons can never be ruled out completely as a possible trigger. For this reason it should be kept in view within the plant-specific safety precautions concept, but is not significant for inventory purposes.

The intended result of the inventory of existing safety hazards is a collection of structured information about their location and characteristics within the area studied. Ideally this information should be processed with the aid of geographical information systems of the kind already used in some cases for supplying data acquired in the course of inventory and planning work under the WFD. By presenting a visual picture of regional hazard situations and geographical constellations, the collected information serves as an important instrument for targeted use of technical safety measures by giving the competent authority an overview of the geographical risk structure.

[187] Cf. BMU (2004), Vollzugshilfe zur Störfall-Verordnung vom März 2004.

7.1.3.1.1 Installations and inventory of substances

The following items of information are of interest when recording a technical installation as a plant-specific safety hazard:

- What hazardous substances exist and what effects can they be expected to have?

The state and properties of a substance have a major influence on the resulting hazard potential. In order to assess how a substance can be released and what effects it can be expected to have if released, it is necessary to ascertain at least a few basic items of information about the substances present. For example, properties such as toxic, corrosive, harmful to health, dangerous to the environment or dangerous to water in the long term are relevant to the impact level, and its physical state and behaviour in the event of a fire are relevant to potential release paths.

- What quantities of hazardous substances are stored?

When determining quantities the crucial factor is the maximum quantity of a substance that can be stored in the installation and/or can be produced by a reaction between various substances.

- What is the intended use of the installation?

To assess the hazard potential of an installation it is necessary to know what use it is intended for and what workflows and processes take place within it or in its immediate vicinity. The ways of handling the individual hazardous substances and the resulting differences in the way the hazard originates have to be assessed differently. For example, the requirements subsequently derived for installations that use (produce, process, treat) a substance will be different from those for installations for storage (transhipment, filling, transport, etc.). Moreover, even installations with similar uses may give rise to different hazard potentials. For example, a much frequented storage area can be expected to present a higher risk than one with less frequent delivery cycles. Thus while the inventory of substances is relevant above all to the potential scale of the damage, the type of installation can give an indication of the potential frequency of incidents.

For the purposes of the inventory it is initially the first two points that are important, whereas the special features of the installation have specific implications for the plant-specific precautionary measures. By creating a kind of hazard register, the authority acquires an overview of the overall inventory of hazardous substances and potential water pollution in the period studied. The type and quantity of substance are in direct proportion to the resulting hazard potential. A relatively large quantity of a less hazardous substance requires a similar safety standard to a small quantity of a very hazardous substance.

The water hazard classes used in Germany, which characterise the properties of a substance in terms of its potential effects, make it possible – in combination with the water risk index system – to assess the hazard potential of a substance inventory with the aid of a one-dimensional indicator (cf. Chapter 3.3.3). This considerably reduces the volume of data for a substance inventory without making any sacrifices in the desired overview information. The inventory of *accidental risk spots* by the ICPDR has already applied this system at river basin level (cf. Chapter 4.1.1).

7.1.3.1.2 Contaminated sites

Not only technical installations, but also contaminated sites have to be classified as safety hazards which can lead to unexpected water pollution. These may include sites where pollution is merely suspected as a result of past uses, but has not been proved to exist by specific investigations. Examples of potential contaminated sites include abandoned industrial or landfill sites where no specific safety measures have been taken to prevent the escape of substances. On the other hand, contaminated areas may also exist on industrial sites that are still in use, where they increase the hazard potential resulting from the substance inventory.

Particularly in cases of contamination with substances soluble in water, the inventory is important for subsequent consideration of vertical and horizontal diffusion paths. It is therefore important when making inventories of safety hazards to ensure that a register of known and potential contaminated sites containing information on substance contamination and possible impacts is made on the same lines as the register of existing installations. If there is no reliable information on the intensity of the contamination, potential hazards can initially be estimated in terms of the pollution that can be expected on the basis of the former use. Sites with high contamination potential should then be subjected to more intensive examination and protected in the further course of hazard management (prevention).

7.1.3.1.3 Local safety hazards

The internal factors arising from the substance inventory and the installation are largely due to the operational use of the installation. The resulting hazard potential can be compared between installations. In addition to these internal factors, however, there are external factors which result from local safety hazards and which may be of importance. They act on the site from outside and may result in impairment of normal operation and/or the functioning of technical safety measures. These factors must be included in any qualified risk assessment, as they may result in differences in the expected scale of damage from two installations which would be rated identical on the basis of internal factors alone.

Local safety hazards may have a wide variety of origins if they occur in the vicinity of an installation. They can be grouped in the following categories[187]:

- Natural safety hazards:

  Natural hazards result from natural events which are capable of having adverse effects on the state of an installation and increasing its susceptibility to damage or malfunctions. Examples of special relevance in this connection are floods, earthquakes, landslides or extensive fires. Extreme weather situations such as heat-waves or violent storms may result in increased risks to normal operation. The natural event may lead to structural failure of the installation, thereby triggering a chain of events which includes release of the substance and hence giving rise to the hazard situation. Particularly in the case of natural events affecting large areas, there is an increased probability of a large number of unrelated safety hazards taking effect at the same time.

  When considering precautions against natural safety hazards, there is a special focus on flood hazards. Such events involve a great risk of direct contact between the hazardous substance and the object of protection. Adverse effects on soil, water bodies, buildings and infrastructure may occur on a large scale and spread virtually uncontrolled over long distances.

  When making an inventory of natural safety hazards, it is often possible to make use of existing data. For example, flood hazard maps and flood risk maps are required to be prepared as part of the implementation of the EU Floods Directive (cf. Section 3.1.4.5). As in the WFD, the planning unit here will be the river basin, which means that comparable data can be expected on a transboundary basis. The geographical registration of natural safety hazards will make it possible to superimpose them on identified plant-specific risk areas, thereby simplifying the addition of potential individual scenarios.

- Neighbouring plant areas or installations within the field of influence:

External hazards to an installations may also originate from neighbouring plant areas or from sites that are close enough for an event there to have an impact on the site in view. Mutual endangerment of different safety-relevant installations has to be considered in particular where there is a risk that a fire, explosion or critical diffusion of hazardous substances may occur and the event in question may spread to neighbouring areas.

This does not directly give rise to additional work when making the inventory. If mutual hazards exist between different installations, this can initially be seen from the correspondingly short distance between the installation sites already registered in the inventory of plant-specific safety hazards.

- Transport facilities within the field of influence:

Additional hazards for installations may result from the infrastructure around the site. Transport routes in particular (road, rail, inland waterway) may play a role here, if the nature and intensity of their use means that they could trigger an incident. Nearby airports may also be a relevant factor if the installation site is located within the takeoff and landing zones.

If the inventory is made on the basis of geographical information systems, it makes sense to include critical infrastructure areas (e.g. junctions, ports, airports etc.) in the information registered.

7.1.3.2 Inventory of objects of protection

Making an inventory of objects of protection is of similar importance to identifying the possible safety hazards. This inventory makes it possible to compare the pollution source with a district-specific profile of potential impacts (hazards). The areas at risk are those in the vicinity of an installation where adverse effects on human health and the environment can be expected if an incident occurs. In particular, there is a need for the inventory to include areas or objects classified as sensitive, the state of which may be threatened by external impacts.

Although the assessment of the safety hazard is not influenced by the presence of nearby protected areas, their existence nevertheless has an influence on the specific need for precautions or results in different priorities for the implementation of protective measures. Thus the risk that can be accepted as emanating from a safety hazard is lower if there are objects particularly deserving of protection within its range of impact. Conversely, a higher risk is acceptable if the expected damage has to be regarded as limited in view of the lack of uses affected.

In view of the overarching environmental objectives of the WFD (cf. Chapter 3.1.4.3), all types of water bodies are bound to be regarded as objects of protection.[188] Distances between technical installations and water bodies are important when considering the probability of an influence in the event of an incident, and they must be taken into account when looking at objects of protection. The diffusion path via the soil into the groundwater must also be included, and it has to be borne in mind here that groundwater bodies spread over considerably larger areas than surface waters. Nevertheless, when making inventories of objects of protection the focus is on explicit examination of areas which enjoy special status because of their natural conditions or anthropogenic uses. The following section is therefore concerned specifically with protected areas designated as such, and sensitive uses requiring special safety standards.

7.1.3.2.1 Designated protected areas

Protected areas are areas which are highly vulnerable to external influences in view of protected environmental assets (biotopes, species etc.) or special use potential (e.g. drinking water resources). Depending on their protective purpose they are designated as such on the basis of legal provisions.

188 This also applies if a water body is not designated as a protected area. With regard to the WFD's ban on deterioration, every water body is potentially affected if its status would show a lasting change for the worse if an incident occurred.

Under the WFD a list is to be drawn up for each river basin showing the existing protected areas "which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water".[189] For this purpose the water bodies to which this point applies are to be determined, and the following types of protected areas are to be taken into account in accordance with Annex IV to the WFD:

- areas designated for the abstraction of water intended for human consumption,
- areas designated for the protection of economically significant aquatic species,
- water designated as recreational waters,
- nutrient-sensitive areas,
- areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites.

The register of protected areas is to be supplemented by maps indicating the location of each protected area within the catchment area.[190] Thus making an inventory of the protected areas in the context of hazard analysis does not involve any additional work, because – as in the case of natural hazards – it is possible to make use of existing data.

7.1.3.2.2 Sensitive uses and other objects of protection

Like natural objects of protection, sensitive human uses are potentially threatened by technical installations. Areas that require increased safety standards in this respect include, above all, residential areas or comparable areas where there is reason to expect a continuous public presence.

In the case of human uses, it must also be remembered that they may develop considerably more dynamically than is the case with protected ecosystems. For example,

[189] Article 6 (1) WFD

[190] Cf. Annex IV No. 2 WFD.

expansion of uses over time may result in situations where formerly adequate safety distances are reduced, thereby increasing the probability of danger. There are also rare cases where changes in the traditional use of an area may become important, for example when industrial sites are transformed into locations with mixed use and are consequently more frequented by the public.

Other objects of protection are not simply additional objects that have not been mentioned in the inventory steps described above. They form the link between two or more safety hazards which are mutually dependent, i.e. go hand in hand, in the event of an incident. For example, installations which have an identified hazard potential may at the same time be regarded as sensitive or deserving of protection when viewed from the perspective of a neighbouring safety hazard, in order to prevent "domino effects".

The registration of sensitive uses should be taken care of by regional planning activities and should exist in the form of maps. The group "other objects of protection" includes objects which have already been registered under plant-specific safety hazards. They do not involve any additional survey work. This distinction is however relevant in the subsequent examination of hazard paths, if additional safety measures are needed from the operator's point of view to reduce the danger to neighbouring safety hazards.

7.1.3.3 Hazard paths

The preceding two steps have identified objects which on the one hand give rise to dangers and on the other hand display a certain vulnerability to external influences, the next step is to link the two elements by means of the conceivable hazard paths. With the aid of the data collected, the task is to analyse the conditions under which a hazardous substance escapes from its intended use (What triggers the incident?) and the concrete dangers that have to be expected if the incident takes place (What objects are endangered in the individual case?).

An individual risk appraisal taking account of the relevant influencing factors is the basis for selecting preventive action strategies. Only if the factors responsible for the prevailing risks are known is it possible to ensure largely safe and reliable operations with hazardous substances by implementing and developing organisational and technical safety measures.

Depending on the application, the analysis of the hazard paths must take place at various levels of examination. To this end, the factors identified as relevant must be linked with the conceivable sequences of events. Here it is necessary to consider the circumstances in which a substance release can be expected, the speed and extent of diffusion of a pollutant, and the areas likely to be affected by the event in the individual case.

7.1.3.3.1 Examination levels

On the basis of the hazard inventory and the endangerment inventory it is possible, both for the individual installation and for an extensive district, to assess the existing risk of accidental water pollution by establishing a link between cause and effect. This step must be taken at the level of the operator and at the overarching level of the competent authority. However, the considerable work involved in this step calls for a different depth of detail at the level of the two groups of actors. For the purpose of analysing the hazard paths, the following distinction can be made:

- <u>Installation operator:</u> The operator of an installation merely considers his own processes and the dangers that could have an impact on the installation from outside. The approach analyses the operational workflows in detail to determine what event scenarios could occur and which objects of protection would be affected in what circumstances. The main results (e.g. impact radius of accident scenario) are made available to the authority in compact form. The results of this analysis serve the operator as a basis for implementing technical safety measures at site level.
- <u>Competent authority:</u> The competent authority scrutinises the overall risks occurring within the area in view (planning area within river basin). From the authority's point of view it is important in particular to know what maximum range has to be ascribed to a plant-specific safety hazard, if it is assumed that the diffusion of a pollutant is favoured by an unfortunate but not impossible chain of circumstances. In addition to the potential seriousness of a materialising hazard, which can for example be illustrated by the water risk index (WRI), this results in the collection of additional data on the range of the impact. The results of the examination of hazard paths at authority level thus provide important information about the entire damage potential in a district and the places where

its occurrence is most probable. The resulting knowledge makes it possible to implement district-related hazard precautions and crisis management measures on a targeted basis.

The integrated examination of accident risks in the area influenced by a water body also opens up a new approach to the question of what quantity of released pollutant is significant. In this way the significant quantity, which largely remains an open question in the WFD (cf. Chapter 3.2), is quantified on the basis of district-specific circumstances. In other words, depending on the existing hazard paths a large number of small installations which can individually only cause relatively small-scale damage may on a cumulative basis, e.g. as a result of flood events, make it necessary to implement measures going beyond the basic requirements. Conversely, if there is a lack of hazard paths in the vicinity of a safety hazard with a fairly high risk, satisfaction of the basic requirements may be sufficient to ensure appropriate protection.

7.1.3.3.2 Release of substances

From the inventory of safety hazards we already know what quantities of a pollutant are present in an installation and what effects its properties will produce. What has not yet been included is the question of what factors can lead to release of the substance or what can trigger the event. The course of an incident may vary depending on the type of release, resulting in more or less hazardous consequences.

The materialisation of a plant-specific safety hazard leading to the release of pollutants may result from the following aspects[187] in particular:

- Failure of structural or technical installation components, malfunctioning of parts of the installation or individual technical elements, failure of supply of electricity, compressed air, process water or cooling water, malfunctioning of monitoring systems etc.,
- Incorrect operation or failure to observe safety-relevant regulations during normal operation or during repair and maintenance work,
- Reaction processes of substances concerned get out of control,
- Adverse impacts on the installations due to external factors (local safety hazards, interference by unauthorised persons) results in failure of structural or

technical installation components (difference from first item above is external influence),

- etc.

For the analysis of hazard paths the important factor is not so much what triggered an event[191], but the route by which the pollutant escapes from the self-contained cycle in the installation. From this one can derive indicators for anticipating the further course of the danger situation. For example, one can estimate whether the entire substance inventory or only parts are affected, and the speed at which the incident takes place (spontaneous release of entire substance inventory, gradual release until measures are taken to stop it, etc.). The following can be distinguished:

- Release due to leaks, overfilling etc. means that one can expect a continuous stream of the substance to escape from the installation gradually until the total quantity is reached. In the case of filling operations it is possible for a larger quantity to be released than is calculated in the substance inventory. If the release is largely hidden, it may be a long time before it is discovered.

- Release by explosion or fire may result in the sudden escape of large quantities of the substance inventory. As a rule, the event is noticed immediately. When using fire-fighting water, it should be noted that this may favour diffusion of the substance.

- Release due to major accident, floods etc. also favours the diffusion of hazardous substances. In addition to the release of substances, it must be remembered that parts of the installation may be swept away and solids may be dissolved.

Possible release paths are to be considered to the extent that they cannot reasonably be excluded. This also applies to simultaneous occurrence of safety hazards which are independent of each other and not linked by external factors. It also applies to the simultaneous release of substances which only trigger an event if they come into contact with each other. In this connection, however, it must be mentioned that event

[191] This is not intended to mean that the causes of accidents are generally to be disregarded. The investigation of trigger factors provides crucial information for preventing similar incidents (accidents, near-miss events, etc.) in future by taking targeted countermeasures against the trigger factors. But this is of minor importance here when investigating diffusion behaviour.

constellations which have occurred in the past cannot be classified as improbable on the basis of the experience gained then.[187]

7.1.3.3.3 Dispersion

Now that we have analysed how the pollutant was released from the isolated system in the installation, the next step is investigate how it can spread in the environment. Depending on the type of release, the substance may be dispersed via the paths water, soil or air, which ultimately results in its input into groundwater or surface water.[192]

In conjunction with the transport medium, the plant-specific circumstances provide information about the distance the pollutant can be expected to cover and the route it is most likely to take. The following are examples of various conceivable diffusion paths:

- Release due to leakage: pollutant contaminates unsealed soil on the installation site; discharge into and dispersion in groundwater body;
- Release due to fire: pollutant mixes with fire-fighting water; drains away via wastewater system; possibly enters water cycle after passing through public sewage works;
- Release due to major accident: pollutant mixes with flood water and is spread over a large area; further dispersion via soil, groundwater, surface runoff.
- (Release due to leakage into the air: possibly entry into water bodies after rainfall; but dangers to objects of protection within range are more important)[193]

It is clear from the examples mentioned that the impact radius of the individual event will be different in every case. Especially for the authority, it is important to know when analysing the hazard paths what is the maximum impact radius that a safety hazard can be expected to have. The important question here is how large this radius can be in the worst possible case. The result is included in the inventory of the hazard district, along with the hazard potential arising from the inventory of substances.

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[192] Cf. Münchner Rück: Einschätzung von Umwelthaftungsrisiken. Casualty Risk Consulting, No. 22, Munich 2006.

[193] Even if dispersion paths are not directly relevant to water conservation, they must be examined for the purpose of implementing appropriate precautionary measures, or may be even more important if there is a direct threat to human health. Deterioration of water body status may also take place indirectly through adverse effects on associated ecosystems triggered, for example, via the air path.

7.1.3.3.4 Areas of risk

Once we have investigated the radius or range within which a safety hazard has impacts, it is possible, in conjunction with the inventory of objects of protection, to identify which objects of protection will be affected if the event takes place.[192]

On the basis of the results it is possible to plan measures to stop the substance reaching the objects of protections or to take emergency response measures to protect the endangered areas. This includes warning affected users or discontinuing water uses. An aspect that should not be underestimated is that the individual steps in the analysis raise awareness of the scale of the individual risk and potential damage.

7.1.4 Conclusions for the action concept

The consideration of basic preparations in the field of hazard precaution management, together with the requirements of Article 11 (3) l WFD, result in the following recommendations for measures:

- Reviewing/creating the necessary legal basis
- Reviewing/creating the necessary assessment criteria
- Reviewing/creating basic technical safety requirements:

Basic technical safety requirements form the basis for safety at technical installations which handle pollutants and which therefore represent a danger to human health and the environment. Their implementation must be ensured regardless of the individual hazard situation at an installation. They thus live up to the claim of Article 11 (3) WFD, under which basic measures are to be regarded as minimum requirements, and do not offer any option to dispense with them in exceptional cases unless alternative measures are taken to achieve a comparable level of safety. Basic technical safety requirements are to be defined in the context of fundamental preparations in hazard precaution management. If such documents already exist, they are to be reviewed in the light of the WFD requirements. The recommendations of the international river basin commissions and multilateral organisations, and also the BREF documents from the IPPC Directive implementation process can be used as a basis.

- Establishing/engaging competent institutions and bodies

- Analysis of potential hazards

On the basis of the analysis of potential hazards, decisions going beyond the basic technical safety requirements on where measures are necessary, and on what scale, can be taken for further implementation of the action concept, in order to satisfy the requirements of Article 11 (3) I WFD.

- Inventory of safety hazards: The plant-specific safety hazards (technical installations, contaminated sites etc.) must be registered and assessed. This information is supplemented by prevailing local safety hazards, some of which are already known to the authorities or are currently being worked on.

- Inventory of objects of protection potentially affected: The data on safety hazards is compared with information on objects of protection potentially affected. This makes use of existing data. Making an inventory of designated protected areas is also part of the implementation of the WFD.

The results of both inventory steps form the starting point for the analysis of the hazard paths that exist in the district in view.

Assessment of risks with regard to existing hazard paths: With the aid of the detailed study of conceivable release scenarios, dispersion paths and the resulting risk areas, links are established between safety hazards and objects of protection, in order to anticipate possible damage scenarios on a district-specific basis and raise risk awareness.

Table 17 provides an overview of the basic preparatory measures and cites examples of their implementation and elements that contribute to it.

Table 17 Suggested Measures – Pro Action

Hazard Precaution Management – Basic Preparations (Pro Action)	
Measure	**Implementation examples**
Reviewing/creating the necessary legal basis	Seveso Directive[30], IPPC Directive[32], Water Hazard Classes[101], □Facilities Ordinance (VAwS)
Reviewing/creating the necessary assessment criteria	WFD[33], 2006/11/EC[31], Seveso-II Directive[30], REACH[102], GHS[103], WHC[101], EASE[113]
Reviewing/creating basic technical safety requirements	Recommendations of river basin commissions, BREF, Technical Rules (DVGW, VDI)
Establishing/engaging competent institutions and bodies	Expert groups (river basin commissions, national, international), industry associations, JRC
Analysis of potential hazards • Making inventory of safety hazards with regard to o Substances o Plant location o Contaminated site location o Local safety hazards • Inventory of potentially affected objects of protection with regard to o Designated protected areas o Sensitive uses o Other objects of protection • Assessment of risks with regard to hazard paths o Release of substances o Dispersion o Areas of risk	ICPER – list of potentially hazardous plants ICPD – potential accident risk spots ICPDR - old contaminated sites Flood maps / Earthquake maps Land use maps, CORINE Protected area maps (water, nature) Implementation of Art. 6 WFD: List of protected areas GIS-based damage forecasting / modelling

7.2 Prevention

Prevention measures should, on the basis of the assessment of "basic preparations", comprise those measures which ensure that crisis management is tailored to the specific conditions of the individual river basin district and which guarantee appropriate hazard precautions both for the specific district and in line with the needs of individual installations. A distinction is made here between district-related and plant-related measures (see Figure 14). Crisis management must have at its disposal both technical (planning) instruments and precautionary measures of an organisational, constructional or plant-specific nature.

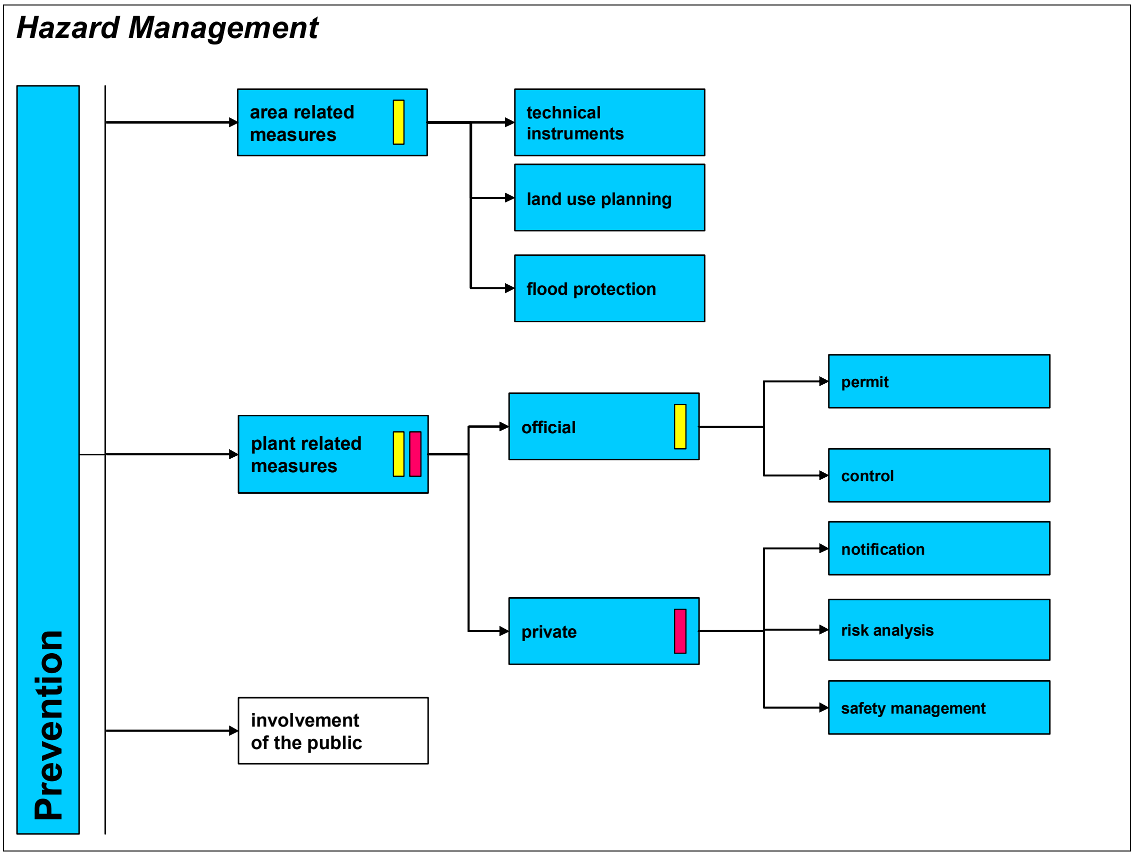

Figure 14 Hazard Precaution Management – Preventive measures (Prevention) (Authority Tasks, Operator Tasks)

7.2.1 District-related measures

The planning and implementation of district-related measures in the context of hazard precautions management belong to the sphere of responsibility of the competent authorities. Technical instruments, such as pollutant spread models (cf. Chapter 8.1.1.2.5) or the “Precautionary planning system of the North Sea coastal Länder” (see Chapter 8.1.3.1) are usually employed on a targeted basis to support overarching precautions against special hazard aspects.[194] Regional policy and land-use planning (cf. Chapter 7.2.1.1) and flood control (cf. Chapter 7.2.1.2) are general public-sector tasks, in each case supplemented by precautions against accidental water pollution.

7.2.1.1 Regional policy and land-use planning

Regional policy and land-use planning play a central role in district-related measures. This aspect of precautions against accidents was initiated with the implementation of the Seveso-II Directive[30], which provides for land-use planning in Article 12[195]. As a major point, it demands appropriate distances between establishments covered by the Directive and objects of protection potentially affected. To this end the siting of new establishments or modifications to existing establishments are to be evaluated, but the development of the relevant objects of protection in the vicinity of an installation is also to be monitored.

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194 These systems also employed if an event occurs, and they are therefore described in more detail in the chapters on crisis management (8).

195 Article 12 Seveso-II Directive

(1) Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land-use policies and/or other relevant policies. They shall pursue those objectives through controls on:

- the siting of new establishments,
- modifications to existing establishments covered by Article 10,
- new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.

The requirements arising from the Directive have so far been given more specific shape in the European Commission's Land Use Planning Guidelines[196]. These indicate that land use planning is merely to be seen as an individual element in a multi-stage precautionary concept which comes between plant-specific safety technology and safety management on the one hand and emergency planning and crisis management instruments on the other. Figure 15 provides a graphic representation of the relationships.

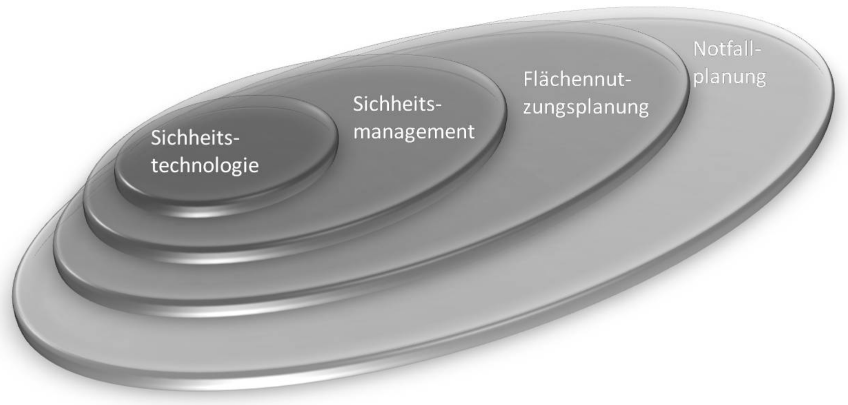

Figure 15 Position of land use planning within a multi-stage precautionary concept (after EC 2006)[196]

In general, regional policy and land use planning pursue a wide range of objectives. These include taking account of potential natural or anthropogenic hazard events with a view to improving the protection of people and the environment, by including hazard potential in the examination of future industrial developments (new establishments, significant modifications) in the context of land use planning.

To implement these objectives it is necessary to integrate risk considerations in the regional planning process. The foundations for this process are similarly laid under preparatory measures by means of the inventories of safety hazards and objects of protection. For land use planning this can also be done on the basis of a comparable outcomes-based approach, i.e. new establishments are assessed on the basis of their inventory of substances and the associated hazard potential (cf. Chapter 7.1.3.1). The resulting constellation is then analysed in relation to objects of protection situated

[196] European Commission (2006): Land Use Planning Guidelines in the context of Article 12 of the Seveso II Directive

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within range (cf. Chapter 7.1.3.2) an assessment is made of whether the safety distances from the safety hazard are adequate.

Regional policy and land use were originally seen as an instrument for mitigating the impact of accidents, which was used in connection with the planning of crisis management or incident containment. In conjunction with a system of official authorisations and associated technical conditions, however, it also serves as a preventive instrument for dealing with natural hazards, long-term and permanent environmental harm and the prevention of accidents of human origin involving the release of substances, although this has to be regarded as a relatively new element of the objectives of land use planning.

To improve precautions against accidental losses of substances and thereby reduce the risk to people and the environment, two kinds of measures are used in regional policy and land-use planning:[196, 197]

- Planning measures: Planning measures is taken to mean direct examination of industrial land use. Possible measures include new designation of settlement areas, reservation of official approval for new establishments in sensitive areas, planning of minimum distances from objects of protection, or possibly deliberate spatial concentration of risk establishments in conjunction with increased provision of monitoring and emergency response measures.

- Technical measures: These are general technical precautions tied to the authorisation of a new establishment. Additional technical measures in the context of regional policy and land use planning reduce the possible consequences of an incident so much that the result is as if the safety hazard were situated at a greater distance from the object of protection affording much greater safety. Accordingly these are measures taken in order to cater for special spatial conditions, in addition to the measures which are independent of the locality (or land use).

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96/82/EC as amended by Directive 105/2003/EC.

197 In view of their thematic focus, the Land Use Planning Guidelines (EC 2006) take a rather broader view of the range of measures than is assigned to regional policy and land use planning in the context of the methods presented here. Technical measures are included in the overall concept as findings of regional policy, but do not count directly as measures of the latter.

7.2.1.2 Flood control

Flood control is firstly a public task which is performed independently of hazard precautions management. Its role is therefore similar to that of land use planning, which also covers a wide range of individual objectives. Moreover, the two fields influence each other. Flood control is of importance for hazard precautions in that it reduces the scale of influences to be expected from the external safety hazard of natural flood events.

Flood control does not play a central role in the implementation of the WFD, although it is favoured by a large number of the Directive's objectives. Relevant stimuli are rather to be expected from the implementation of the EU Floods Directive (cf. Chapter 3.1.4.5). The flood risk management plans in particular are to be seen as an instrument which, in the interests of integrated implementation of flood control measures, also take account of district-related aspects for the protection of technical installations. One important aspect is already being achieved with the prevention of siting of new establishments in flood risk areas as a result regional policy and land use planning. Furthermore, precise flood forecasts make it possible to place safety hazards above the expected water line and thereby minimise the probability of external influences.

In addition, flood control also takes place on a targeted basis at plant-specific level if the installation in question may be at risk from flood events. In such cases, responsibility for implementing appropriate measures rests with the operator. From a technical point of view, a distinction is made between wet and dry precautions. Wet precautions are designed to combat hazards arising from water entering the immediate operating site. The expected maximum water levels for flood events can be forecast with the aid of probability assumptions. This makes it possible to place endangered parts of the installation above the expected water line to prevent them coming into contact with the water entering the site. If storage containers are located below the water line, they must be protected from flotation and external pressure. Openings and connections must be equipped with shut-off devices to prevent the contents of the tank mixing with the water. Substances in tanks are not only a risk for the water body in the event of a flood, but can also endanger the stability of buildings and may contaminate the fabric of the building if the substance escapes.

Dry precautions seek to prevent water from entering the endangered areas at all. They are implemented by raising the subsoil and by using stationary or mobile dyke structures which "seal" the site or the building from the approaching flood water. Such systems have to take account of and integrate the internal infrastructure, such as power supply and wastewater disposal. Dry precautions are to be preferred when planning and constructing technical installations.[198]

7.2.2 Plant-specific measures

Plant-specific measures are a key area within hazard management, as they apply technical and organisational measures directly to the safety hazard. However, the individual requirements, which may vary from one installation to another, make it difficult to offer general action recommendations for integrating the "right" measures. This aspect is rather to be seen as a process in which the interaction between individual responsibility and initiative on the operator's side and supervisory and steering functions on the authorities' side results in a viable approach to plant-specific safety. The necessary roles and methodological steps are examined in this section.

Within the site structures it is first of all the responsibility of the operator to ensure appropriate protection for the existing safety hazards and to protect the site as far as possible from external hazards. This priority (individual) responsibility of the operator has to be linked with plant-specific competencies on the part of the public authorities. The latter also seek to reduce the influence of potentially interacting risks (cf. Chapter 7.2.1.1) and check compliance with operator obligations at plant-specific level.

Strategies for implementing preventive measures can pursue various approaches, which may be effective at various levels:

- **Reduction in existing hazard potential:** Before implementing measures for managing existing hazards, the operator should examine whether the existing safety hazards are necessary in full to maintain the plant-specific processes. It may be possible to identify ways and means of replacing pollutants with less hazardous or non-hazardous substances. This may make safety measures either totally or partially superfluous. Statutory requirements which impose less stringent restrictions on smaller volumes of the substance, for example, may

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[198] Warm, H.-J.; Köppke, K.-E., Krätzig, W. B.; Beem, H.; *Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Untersuchung vor-*

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create incentives for the operator to act accordingly. It can nevertheless be expected that in the majority of cases this substitution strategy will not be an available option for the use of pollutants in plant-specific processes.

- **Precautions to prevent trigger factors taking effect (incident causes):** The possible causes leading to unintentional release of pollutants are prevented by appropriate constructional, technical and organisational safety measures, or the probability of their occurrence is much reduced. The main problem here is that the risks, i.e. possible incident causes, are not necessarily all known.
- **Precautions for containing and limiting incident impacts:** In case substance releases occur despite appropriate precautions, provision is made for measures which on the one hand stop the unimpeded spread of the substance and on the other, ensure that the release is detected quickly and countermeasures are taken. Once again, the measures may be of a constructional, technical or organisational nature. As a rule, there is a need to coordinate these with crisis management measures (cf. Chapter 8).

7.2.2.1 Official tasks

The authority's field of action in relation to plant-specific measures includes in particular measures that oblige the operator to act in a specific way or to review such action. As a preventive instrument, permits (cf. Chapter 7.2.2.1.1) play a key role. Administrative controls (cf. Chapter 7.2.2.1.2) also check whether the operator is complying adequately with his safety-relevant obligations and whether the statutory requirements are being satisfied. As an example of an appropriate set of instruments, the "Plant-specific Water Conservation Inspection" of the federal state of Hesse is described below.

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und nachsorgender Maßnahmen), F+E Project 203 48 362, UBA Texts 42/2007, http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php.

7.2.2.1.1 Permits

An official permit may be necessary for the construction or substantial modification of an installation or part thereof. To date, EU law has required permits for installations covered by the IPPC Directive. The detailed definition of a permit in this Directive is:

“that part or the whole of a written decision [...] granting authorisation to operate all or part of an installation, subject to certain conditions which guarantee that the installation complies with the requirements of this Directive […]“[199]

The permit is preceded by an application by the operator which contains general data on the planned installation (list of substances etc.) and describes planned measures designed to ensure compliance with the operator’s obligations. The permit is usually accompanied by imposed requirements which give the authority the power to prescribe specific measures designed, among other things, to prevent releases.[200]

7.2.2.1.2 Controls

As an example of the implementation of administrative control mechanisms, this section describes the set of instruments provided by the “In-plant Water Conservation Inspections” as used in the German federal state of Hesse. In view of a large number of methodological similarities with the concept of the safety chain, especially as regards the role of the authorities in the implementation of plant-specific measures, it becomes the focus of attention here as a concrete example of implementation, but can nevertheless be seen as a general objective of this item.[201]

The aim of the BGI as an instrument is to establish comprehensive minimum monitoring by the competent authorities of all parts of the plant that are relevant to water conservation. Relevant requirements at European level include those of the Water Framework Directive, Seveso-II Directive, IPPC Directive etc. and the resulting national legal acts for their implementation. In this context the BGI serves the purpose of discharging several administrative tasks:

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199 Art. 2 No. 9 IPPC Directive.

200 Cf. Article 9 (6) IPPC Directive.

201 In connection with in-plant water conservation inspections in Hesse, cf. among other things: Hofmann *et al.,* Durchführung von betrieblichen Gewässerschutzinspektionen. Handbuch. 1. Fortschreibung; Hessisches Ministe-

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- Checking on compliance with legal requirements,
- Advising the operator on remedying any deficits identified,
- Planning and prescribing response measures to remedy identified deficits and environmental impacts.

In detail, the BGI serves to establish whether a relevant part of the plant can be classified as *conforming to water conservation requirements*, i.e. whether and to what extent appropriate measures for preventing water pollution exist on an adequate scale. In particular, the following aspects are investigated:

- Protection of installations that could potentially release pollutants,
- Facilities for retaining fire-fighting water,
- Effectiveness of existing warning and alert equipment and other systems for minimising damage,
- Soil and groundwater pollution (if present, remediation measures required).

For an establishment to conform to water conservation requirements, the authority must be able to see evidence that self-monitoring is carried out by the operator and that repeat inspections are made by independent experts.

The implementation of the BGI distinguishes between initial registration following determination of the relevant installations, and repeat inspections. The inspection itself is made up of five modules structured as follows:

- Module 1: Site data and plant organisation: The focus of the module is on acquiring general data on the installation site and the structure of plant organisation that is of importance for complying with safety-relevant operator tasks.
- Module 2: Handling of substances dangerous to water: The focus here is on verifying compliance with regulatory requirements, since self-monitoring and expert inspections imply thorough technical inspection.

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rium für Umwelt, ländlichen Raum und Verbraucherschutz (no year stated): Der gewässerschutzkonforme Betrieb. Hinweise für Unternehmen in Hessen, Wiesbaden, 2003.

- Module 3: Wastewater systems and wastewater discharges: Verification of regulatory requirements and technical and organisational requirements with regard to safety of wastewater systems and discharges.

- Module 4: Accident management: This item investigates how well the operator is prepared for the occurrence of an incident (scenarios, workflow planning, emergency facilities etc.).

- Module 5: Hazard research measures: This module makes a summary of existing plant-related soil and groundwater damage, which may be supplemented by findings from remediation measures already initiated.

The modules bear certain similarities to the elements of the safety chain, even if they are largely confined to the direct sphere of influence of the establishment or safety hazard (to stay with the broader terminology of this report). This means the BGI provides a very constructive basis for a measure for implementation of the requirements of Article 11 (3) I WFD by the competent authorities.

7.2.2.2 Operator tasks

The tasks of the operator are primarily concerned with identifying the existing risks and actively eliminating them or using the available means to control them. Even if safety hazards cannot be dealt with by substituting substances, it is the operator's responsibility to take adequate and appropriate safety measures to make the occurrence of accidental water pollution improbable. The first step here is for the operator to notify the authority of the installation, at the same time supplying the information relevant to the installation and its safety (Chapter 7.2.2.2.1). Basic technical safety requirements are dealt with explicitly in the light of the relevant ICPER recommendations (Chapter 7.2.2.2.2, see also Chapter 4.1.1.2), before going on to take a closer look at the topics of *risk analysis* and *safety management* (Chapter 7.2.2.2.3).

7.2.2.2.1 Notification

The legislature may specify that installations where the size or hazard potential is below the limits that require authorisation may be registered by means of the instrument of a notification requirement. This places the operator under an obligation to collect detailed information about its own installation and communicate it to the authority using standardised forms.

The operator's duty to notify its own installation may be necessary in various situations to update the information held by the authority. Notification is expedient for the following situations of relevance to the installation:

- Commissioning: The construction of a new installation which is capable of containing significant quantities of a pollutant must be notified to the authority.
- Modification: The authority is to be notified of any modification to an existing installation that results in a significant change in the hazard potential of the installation.
- Closure: If an existing installation is closed down for a lengthy period, this must be notified to the authority. For one thing, the closure may alter the district-related hazard potential, and for another, it may give rise to new hazards such as the formation of contaminated sites.

On the basis of the notification requirement, the authority performing the hazard analysis described in Section 7.1.3 receives the necessary information in the event of changes in the installations registered. Depending on the data considered necessary, the information provided during notification can be selected for estimating a district-related hazard potential. In view of the remarks in Chapter 7.1.3, the following data in particular would be of interest:

- General information on operator, type of installation, location etc.
- Inventory of substances,
- Distance from water bodies, and possible influences of external safety hazards,
- Conceivable damage situations and associated diffusion behaviour,
- etc.

7.2.2.2.2 Basic technical safety requirements

As a rule, the selection of technical safety measures should be the result of a prior process of risk and hazard analysis in which possible chains of events are identified and precluded or prevented by use of targeted measures. In practice, however, there are a large number of cases where this approach is not very pragmatic. Especially where the hazard potential is low, a high degree of safety can be achieved for the large number of installations concerned by using a selection of standardised measures, thereby permitting satisfaction of basic technical safety requirements in relation to plant-related water conservation. Since the measures counteract a large proportion of conceivable risks, there is no need for a more detailed risk analysis and safety concept, provided the basic technical safety requirements are complied with and there are no special safety hazards. In the case of complex installations with correspondingly greater hazard potential, however, it is not usually sufficient merely to implement these basic requirements.

The ICPER proposals are used below to explain the basic technical safety requirements. These proposals contain six agreed key areas which rule out the majority of technical safety risks in the handling of substances dangerous to water. They deal with the following aspects:

1. Installations containing significant quantities of pollutants must basically be free from leaks. In other words, in the construction and operation of the installations, steps must be taken to ensure that the pollutant cannot escape or be released. Their construction must be such that they are sufficiently resistant to the expected influences (mechanical, thermal, chemical) (first barrier).

2. However, leaks cannot be ruled out. For this reason, timely and reliable detection of leaks must be possible.

3. In the event of a pollutant release, not only must this be reliably detected in good time, but retention of the escaped substance must be ensured, as must its safe utilisation or disposal. To this end, either collecting spaces must be created which are themselves resistant and leakproof in relation to the expected substances, or the installations must be double-walled and fitted with leak detectors (second barrier).

4. The requirement that collecting spaces must be free from leaks rules out the existence of outlets or drains within them.

5. Furthermore, Item 3 also applies to substances that may occur in damage situations and which may be contaminated by pollutants (e.g. fire-fighting water).

6. For installations containing significant quantities of pollutants, operating instructions must be prepared and personnel trained accordingly. In addition, monitoring, maintenance and emergency plans must be drawn up and implemented on the site.

7.2.2.2.3 Risk analysis and safety management

If there is reason to assume that the implementation of basic technical safety requirements will not achieve an adequate level of safety because of the hazard potential of specific installations and/or plant-specific or site-specific circumstances, there will be a need for further measures which will have to be worked out on the basis of the framework conditions prevailing within the technical installation. This is the purpose of risk analysis, which need not necessarily include a quantitative survey of probabilities of occurrence and scale of damage. On an internal basis within the plant, it serves to examine and assess possible event causes, diffusion paths and consequences of damage. Unlike the overarching consideration in the context of river basin oriented hazard analysis (cf. Chapter 7.1.3), a plant-specific risk analysis can take a much more detailed and better coordinated look at the concrete situation in the vicinity of the installation. Here the focus is not only on avoiding environmental damage due to pollutant escaping from the installation, but also, and above all, on ensuring trouble-free normal operation. As a rule, therefore, plant-specific risk analysis as a basis for selecting additional safety measures is more likely to result in targeted solutions than is the case with an overarching and somewhat standardised approach, but it also serves as a basis for river basin oriented hazard analysis by obtaining the necessary data for this purpose.

The safety management of an establishment is based on the risk assessment. By means of a combination of safety-relevant measures, it comprises the planning, implementation and control of safety standards within the plant and is therefore not a static measure, but a continuous process that is subject to regular review and any necessary changes and improvements. The choice of suitable safety measures and identification of necessary safety measures is based on the identified risk situation and general experience gained from past accidents and cases of damage. Systematic use of planned workflows, applications and overarching strategies ensures and improves risk identification and control specifically geared to individual plant-specific needs.

In addition to strategies that reduce the potential scale of the damage (change of raw materials and product, partial or total substitution of pollutants etc.) and thereby reduce the technical safety needs, safety management for precautionary water conservation is concerned in particular with approaches that result in reduced probabilities of occurrence. A variety of measures are possible, as characterised below:

- Technical functional measures: e.g. alert systems, overfill protection and automatic shut-off devices, functional queries;
- Technical constructional measures: e.g. leakproof and resistant enclosure, double-walled systems, collecting spaces, retention areas, protected connections and wastewater systems;
- Organisational measures: awareness raising, training of personnel, rules and operating instructions, labelling and symbols, instructions for action and recording duties for the user, integration of "safety consciousness".

Chapter 4.1 recommends not only basic technical safety requirements, but also measures which provide an important basis for integration in safety management for specific applications. Safety management may also adopt an integrated approach that includes aspects of occupational safety and health and accident prevention in addition to water conservation aspects.

7.2.3 Conclusions for the action concept

The ideas in the section on prevention, in conjunction with the requirements of Article 11 (3) I WFD with regard to district-related and plant-related measures, give rise to the action recommendations listed in Table 18. The table includes only measures which in view of their strategic character are capable of being part of the WFD programme of measures and which ensure appropriate implementation of the requirements of hazard precautions management. The operator obligations are not interpreted as primary measures pursuant to Art. 11 (3) I, since their implementation and compliance have to be based on regulatory law.

Table 18 Suggested Measures – Prevention

Hazard Precaution Management – Preventive Measures (Prevention)	
Measure	**Implementation examples**
Provision of technical (planning) instruments	Precautionary planning software (VPS), pollutant spread models (ALAMO, data from UNDINE, for example)
Obligation to include the requirements of Article 11 (3) I WFD in regional-policy and land-use planning District-related check for sensitivities and deficits, see Article 11 (3) I WFD	Land use planning (Seveso Directive) Implementation of Directive 2007/60/EC (EC Flood Directive) Flood action plans, UBA F+E 20348362[198]
Obligation on licensing authorities to include the requirements of Article 11 (3) I WFD in plant approval procedures	Approvals/conditions/prohibitions
Inspection and monitoring of plants with regard to implementation of and compliance with technical requirements resulting from Art. 11 (3) I WFD (inspection intervals)	Safety requirements of ICPER and ICPR, Checklist method – Federal Environment Agency, On-site checks Reporting requirements Reports by independent experts Manual on performing in-plant water conservation inspections (Hesse)
Encouraging/promoting voluntary measures at plant and higher levels (“responsible care”)	Transport accident and assistance system (TUIS), VDI cooling water concept

8 Crisis Management

This section on "crisis management" covers the range of measures from "preparedness" to "immediate response", and in the context of the concept presented here it is subdivided primarily into the sections on "Instruments for preparedness" and the actual "Response to a specific event". However, crisis management will only function efficiently if hazard management has created a viable structural foundation.

The following description of crisis management in the safety chain is therefore divided into two blocks, "Preparedness" (Figure 16) and "Response" (Figure 60). Only the first block is dealt with in detail, partly because only this part can be represented in the form of measures in a "management plan". The competence and quality of the actual response to the crisis is the result of the preparatory links in the safety chain. Another consideration is that in our opinion it is not possible to derive any additional "response" measures that are necessary solely on the basis of the precaution-oriented requirements of Article 11 (3) l WFD. It is undoubtedly not the intention of the WFD to bring about a reform of established structures in the field of disaster control.

8.1 Crisis management instruments (Preparedness)

To ensure "preparedness" it is necessary to create both a technological and an organisational basis.

Since the Stockholm Declaration of 1972 placed states under an obligation to ensure that no damage is caused to the environment in other states or regions outside their national territory, it may be assumed that there is a binding obligation under international law to give warning, at least in the case of serious transboundary accidents (Chapter 3.1.1). As a result of the new aspect of the WFD that water bodies are no longer managed within the boundaries of administrative regions, but at the level of river basin districts, the "transboundary character" is relegated to no more than secondary importance in this context within the Community. All EU provisions on accident prevention, and also a large number of conventions of the river basin commissions, lay down information and warning requirements. This resulted in the compilation of warning and emergency plans in many river basins long before the entry into force of the WFD (Chapter 3.1). One frequent deficit is that only the emission-oriented path, namely notification by the polluter, is regulated (Chapter 4.3).

The requirement in Article 11 (3) l WFD to use (technical) systems for timely detection and early warning is new to international law-making in this explicit wording, although it is virtually indispensable where warning and emergency plans take account of the immission path, and could therefore have been justified on the basis of older provisions.

The field of protective planning has existed in various forms and organisations ever since people in their habitats have been afflicted by "extraneous disasters" (not only via the water path) and have tried to prepare for such events. Certainly no essentially new principles for this have to be deduced from Article 11 (3) l WFD. However, the preparation of programmes of measures is good reason to review the suitability of the existing structures.

For the purpose of this concept, the field of "Preparedness" is divided here into three blocks:

- Early warning systems
- Warning and alarm plans
- Protective planning

In the light of the above, the first two blocks are the most profitable with regard to possible consequences resulting primarily from Article 11 (3) l WFD. Mention is made of *protective planning* to the extent that it provides concrete examples of applications in the field of water conservation showing how it is possible to modernise the integration of potentially involved parties and information distribution by means of modern databases (precautionary planning system) (Chapter 8.1.3.1).

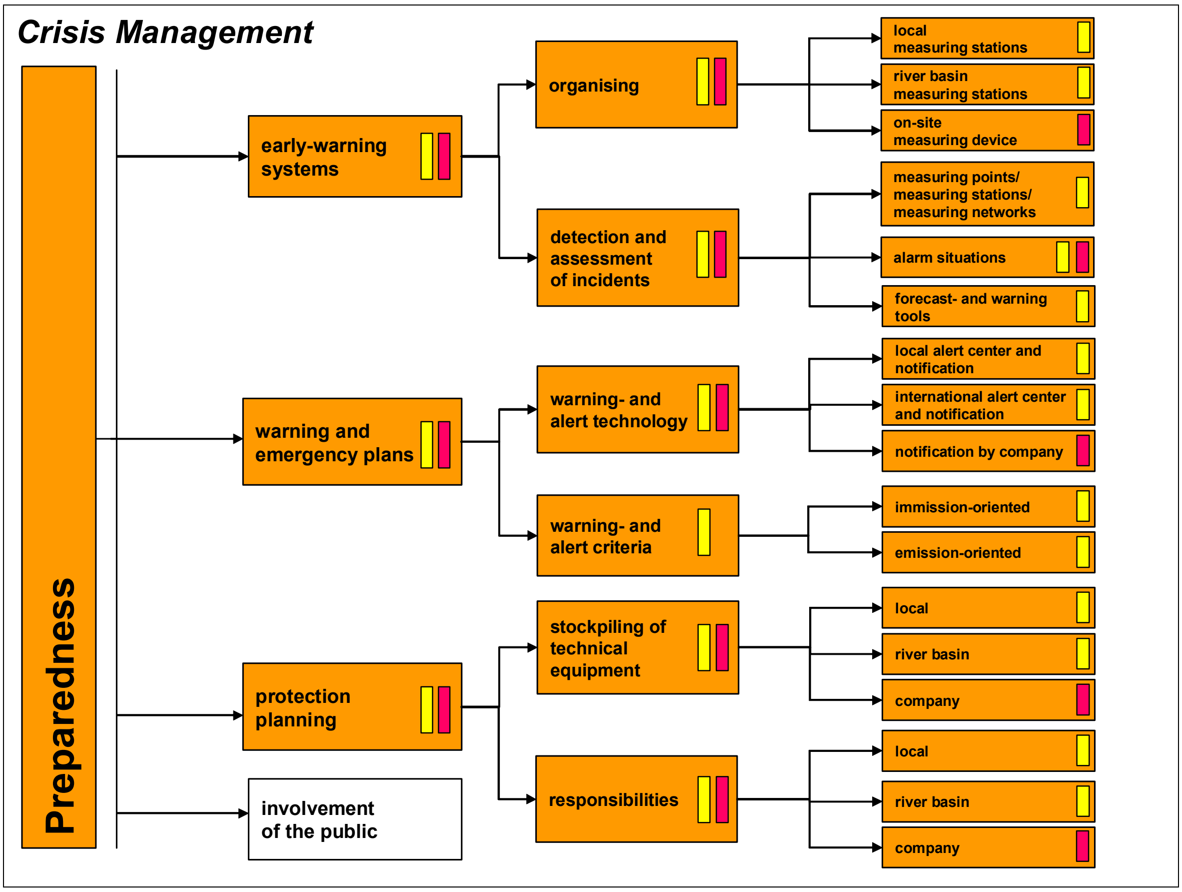

Figure 16 Crisis Management – Instruments (Authority tasks, Operator tasks)

8.1.1 Early warning systems

As described in Chapters 3.2.4 and 4.3, Article 11 (3) I WFD requires, in order to prevent and minimise the impact of unexpected pollution, *"systems to detect or give warning of such events including ... all appropriate measures to reduce the risk to aquatic ecosystems"*. The establishment of both operator-specific and river basin specific warning and alarm systems is thus basically obligatory. However, the WFD says nothing about their design.

The main elements of such early warning systems are discussed below. For an in-depth technical treatment, see also the report on the EASE project.[113]

Early warning systems need a suitable *organisation* (distribution of measuring equipment, network connections etc.), and also technical facilities that make it possible to *register events* of relevance to Article 11 (3) I WFD and *assess them in terms of warning and alarm relevance*. The following section looks at the organisation of early warning systems on water bodies. The technical requirements for incident registration and assessment can be found in Chapter 8.1.1.2.

8.1.1.1 Organisation

The organisation of early warning systems can first of all be broken down on the basis of who operates the system:

- *Emission-oriented* monitoring is carried out by the installation operator by means of *site-based measuring equipment*,
- *Immission-oriented* monitoring throughout the river basin will be the task of *state bodies*.

In the case of state-run early warning systems it may make sense to distinguish between *regional* and *river basin oriented* facilities, though this difference is reflected not so much by the technical equipment, but rather by budgetary allocations in connection with the specific tasks of the institutions. We have therefore subdivided the organisation scheme of early warning systems in the safety chain into three segments:

- state-run regional monitoring stations,
- river basin oriented surveillance monitoring stations, and
- operator-run measuring facilities.

Since the biggest deficits have been identified in the field of *immission-oriented* early warning (Chapter 4.3.4), this part is discussed in more detail than operator-run measuring systems. There are in any case no fundamental differences between the two systems as regards measurement technology. Since the installation operator should know exactly what substances are relevant for warning purposes in his installation and should be able to define precisely and detect “out-of-control incidents”, the measurement technology and technical facilities needed for *reliable* incident assessment are less than for a system that is intended to identify, along the course of the river, water changes of unknown origin and involving much great dilution that are relevant for alarm purposes.

For *immission-oriented* identification and assessment of incidents that require warnings, there is a need for monitoring systems meaningfully distributed along the water body which are coupled with a technology that first detects “unusual events” by means of suitable continuous measurements in the water, then identifies them as “natural” or “accidental”, and finally takes an alarm decision based on an evaluation of their “relevance”. The system should be integrated in the existing emission-oriented warning and emergency plans, and should also provide information for use in clarifying the cause of the pollution. This last aspect is also important with regard to the large number of suspected unknown cases of (illegal) discharges that are not notified. In order to cater for the various objectives, some of them demanding very specialised equipment, and also the varying degrees of development of water monitoring systems and the differences in technical and financial resources in different parts of Europe, there is a need for phased modular expansion of the system on the basis of the technology required. The technical equipment for monitoring stations and monitoring networks is discussed in greater detail in Chapter 8.1.1.2.

8.1.1.1.1 River basin oriented “surveillance monitoring stations”

The Water Framework Directive prescribes comprehensive water body monitoring (see Chapter 3.1.4.3) for the inventory and monitoring of the status of surface waters for the purpose of achieving the objectives in Article 1 WFD and the environmental objectives pursuant to Article 4 WFD. To this end, individual specimens (samples) are regularly taken at prescribed intervals at defined measuring stations and tested. Annex V to the WFD provides for three types of monitoring:

1. surveillance monitoring,
2. operational monitoring,
3. investigative monitoring.

According to Annex V to the WFD, selection of monitoring stations for surveillance monitoring is subject to the following criteria:

- the rate of water flow is significant within the river basin district as a whole (> 2500 km^2),
- the volume of water present is significant within the river basin district,
- significant bodies of water cross a Member State boundary,
- sites are identified under the Information Exchange Decision 77/795/EEC[202].

These monitoring stations represent water sections that are significant from a hydrological and water management point of view. They are – and were even under "pre-WFD criteria" – predestined for the establishment of fixed measuring stations for continuous monitoring of water quality and dynamics in conjunction with the inclusion of technology for detection and assessment of events relevant to Article 11 (3) I WFD. Table 19 shows the WFD surveillance monitoring stations in the German Elbe catchment area.[203] A comparison of the locations of these monitoring stations with those of the automatic monitoring stations along the Elbe in Table 14 (p. 131) shows that in many cases they are identical. This is not really surprising, since the WFD did not redefine the fundamental water management principles, monitoring tasks and monitoring objectives.

What is new is that the field of view for water management and EU reporting is now the river basin district. This demands a great deal of international and intra-national consultation and coordination, because the Water Framework Directive does not *a priori* affect the national and regional responsibilities for water monitoring. In the short term, therefore, neither the "river basin oriented surveillance *measuring sites*" nor any resulting "river basin oriented surveillance *measuring stations*" will be directly transferred to the operating responsibility of international river basin bodies, such as the river basin commissions. Thus a "network" of river-basin-wide warning and alarm monitoring stations will not in the medium term become the network of a single "international warning and alarm plan operator", but the measuring equipment necessary for early warning purposes will have to be connected by means of currently available technology so that the requirements of Article 11 (3) I WFD are met.

202 Council Decision of 12 December 1977 establishing a common procedure for the exchange of information on the quality of surface fresh water in the Community (77/795/EEC), OJ L 334, 24.12.1977, p. 29.

203 Survey by the expert group on "Suspended solids" of the ad-hoc working group "AQS", LAWA working group "OW", ELBE River Basin Commission, status April 2009.

Table 19 WFD surveillance monitoring stations in German Elbe catchment area (by federal state)

LAWA No.	Land number	River	Name of monitoring station	River km	Catchment area [km²]
BB04	631000001	Spree	Cottbus	231.50	2269
BB05	507310045	Spree	Neuzittau	49.00	6401
BB06	414160041	Havel	Hennigsdorf	12.50	3232
BB07	432000033	Havel	Potsdam	26.50	15610
	EL_0040	Elbe	Cumlosen	470	125000
BE01	160,00	Spree	Spandau	0.60	10104
BE04	320,00	Havel	above Spandau lock	0.70	3252
BE05	215,00	Dahme	Schmöckwitz	11.20	1960
BY08	F418	Sächs. Saale	Joditz	24.10	644
HH011	Uesh	Elbe	Seemannshöft	628.80	139755
HH03	Oezs/Oebu	Elbe	Zollenspieker/Bunthaus	598.70	135024
MV01	205130022	Elde	Dömitz	2.30	2626
MV02	204880024	Sude	Bandekow	8.50	2133
MV11	207180015,00	Elde	and Parchim	69.99	1748
NI01	59152010	Elbe	Schnackenburg	474.50	125482
NI03	59752051	Elbe	Grauerort	660.60	141327
NI18	59452251,00	Ilmenau	Bienenbüttel	35.20	1545
NI21	59292010	Jeetzel	Seerau		1871
NI22	59872220	Oste	Oberndorf		1484
NI23	59652013	Lühe-Aue	Daudieck		144
NI24	59942126	Medem	Otterndorf		184
SH07	120002 120003	Bille	Sachsenwaldau (from 2008) Reinbek	34.7	219
SH08	120019 120015	Stör	Heiligenstedten (from 2008) Willenscharen	22.9	1403
SH09	120207	Elbe	Brunsbüttel	694.0	
SH10	120098	Osterau	Baß	12.3	117
SN04	OBF00200	Elbe	Schmilka, right	3.90	51391
SN051	OBF02810	Elbe	Dommitzsch, left	172.60	55655
SN06	OBF32300	Freiberger Mulde	Erlln	0.30	2983
SN07	OBF40500	Zwickauer Mulde	Sermuth	0.50	2361
SN08	OBF47600	Vereinigte Mulde	Bad Düben	68.10	5995
SN10	OBF17700	Lausitzer Neiße	below Muskau	74.20	2558
SN11	OBF01800	Elbe	Zehren, left	89.60	54120
ST01	819380018,00	Elbe	Wittenberg	214.00	61879
ST02	732040010,00	Elbe	Magdeburg	322.00	94942
ST03	615150018,00	Schwarze Elster	Gorsdorf	3.80	5453
ST04	831000014,00	Mulde	Dessau	0.50	7399
ST07	714120017,00	Saale	Groß Rosenburg	9.50	23718
ST08	810100016,00	Unstrut	Freyburg	5.00	6327
ST09	832020017,00	Weiße Elster	Ammendorf	2.50	5384
ST10	707020018,00	Havel	Toppel	6.00	24297
ST11	712780011,00	Aland	Wanzer	4.90	1820
ST12	410195,00	Bode	Neugattersleben	6.80	
TH031	2167,00	Unstrut	Wundersleben	106.60	2494
TH06	2198,00	Saale	Camburg-Stöben	187.00	3977
TH07	2217,00	Weiße Elster	Gera, below	116.00	2186
TH09	2150,00	Unstrut	Oldisleben	76.60	4174
TH11	2258,00	Saale	Rudolstadt	258.00	2679

It is basically possible without excessive additional technical input to link regional monitoring networks, individual monitoring stations in different monitoring networks, or selected measurement data from such stations to form a common “information and assessment platform”. This is illustrated here by the example of the Federal Institute of Hydrology’s “Undine”4.3.3 system which was mentioned in Chapter [171]:

The Federal Institute of Hydrology's project “UNDINE”, which was funded by the Federal Environment Ministry, was not originally designed in response to the requirements of the WFD, but as a consequence of the Elbe floods in 2002.

“UNDINE” is intended to provide a regional overview of the major rivers in the form of compact descriptions of past extreme hydrological events, up-to-date measurements and historical comparative figures, and give references to sources of information. The main focus of this examination is on the representation of water quality in the case of extreme events. Information in the fields of hydrometeorology, quantitative and qualitative hydrology is brought together and shown in a standardised supra-regional form. The comparison with historical events and long-term indicators is intended to permit better classification and assessment of high or low water events.

The Undine information platform is currently under development. Information on the Elbe catchment area is already available. Work is in progress on providing information on the Rhine, Oder and Danube catchment areas.

Figure 17 shows the selection form (map/table) for the German Elbe catchment area. Clicking on the red dots (= monitoring stations) or black triangles (= level gauges) brings up information on the individual measuring facility and a large quantity of current and historical data. It is also possible to find out about current flood warnings, for example, or obtain detailed information on historical extreme events. Nearly all the monitoring stations available for selection are shown in Table 14 (p. 131). Figure 18 shows an UNDINE screenshot for the monitoring station Bunthaus, Hamburg, with some current measurement data.

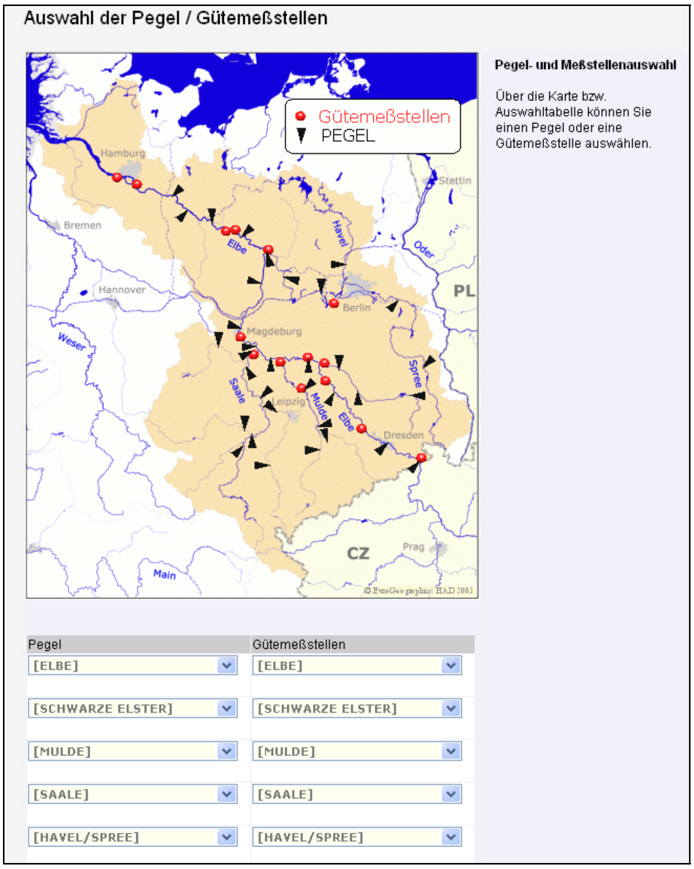

Figure 17 Screenshot UNDINE – Selection of gauges/monitoring stations on German Elbe

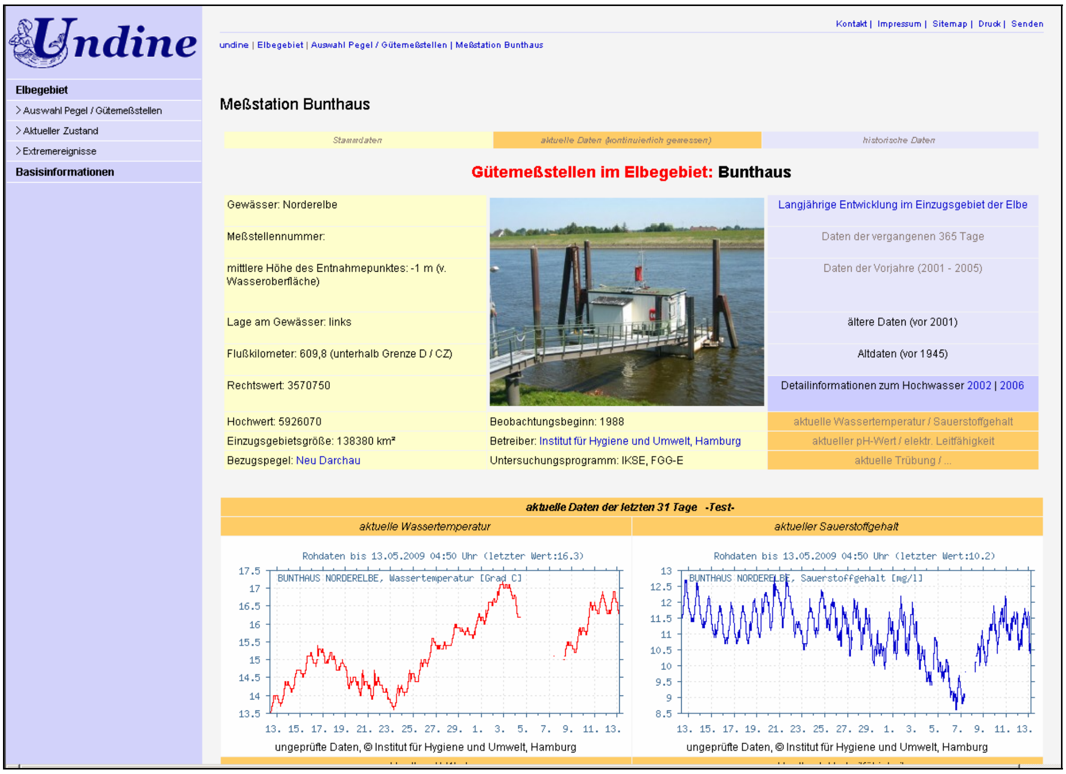

Figure 18 Screenshot UNDINE, monitoring station Bunthaus, Hamburg, with some current data

In the future, the “Undine” information platform could also serve as a river basin monitoring and communication network for the Elbe. For this purpose, it would have to include all relevant monitoring stations in the river basin, i.e. including the monitoring stations in the Czech Republic, and also manage and represent the alarm-relevant measurements from the monitoring stations. This would, for example, put all monitoring station operators and any connected warning centres in a position to respond promptly to water changes in the Elbe. With the aid of calculations by the alarm model Elbe (ALAMO, see Chapter 8.1.1.2.5) it would be possible to provide forecasts about the course of the pollution wave, give warnings if necessary, and feed them into the platform’s information pool. The automatic sampling system in the monitoring stations could be prepared for targeted event sampling and for supplying the laboratories with up-to-date pollution samples.

8.1.1.1.2 State-run regional monitoring stations

It might seem logical in terms of “river basin organisation” to have a hierarchical division of monitoring stations into, on the one hand, surveillance monitoring stations operated on a multinational basis and, on the other hand, other stations operated on a national or regional basis, allocated to part catchment areas and feeding the supra-regional network. In our opinion, however, this will only be true in exceptional cases, possibly at national borders. This due first of all to the fact that a number of regionally/nationally operated networks already exist with the necessary “know how” and often very specific “additional functions”; moreover, experience shows that there is little inclination to finance supra-regional systems, which can scarcely be influenced, on a regional basis. On the other hand a hierarchical structure of this kind is in any case not a prerequisite for the functioning of a river basin warning and alarm network with the web-based networking facilities available today (see “UNDINE” in preceding chapter).

Obvious candidates as locations for regional monitoring stations are selected monitoring points from the operational monitoring network pursuant to Annex V of the WFD. Operational monitoring is undertaken in order to:

- establish the status of those bodies of water identified as being at risk of failing to meet their environmental objectives, and
- assess any changes in the status of such bodies resulting from the programmes of measures.

According to Annex V to the WFD, the criteria for the selection of monitoring sites are:

- for bodies at risk from significant point source pressures, sufficient monitoring points within each body in order to assess the magnitude and impact of the point source. Where a body is subject to a number of point source pressures, monitoring points may be selected to assess the magnitude and impact of these pressures as a whole
- for bodies at risk from significant diffuse source pressures, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the diffuse source pressures. The selection of bodies shall be made such that they are representative of the relative risks of the occurrence of the diffuse source pressures, and of the relative risks of the failure to achieve good surface water status.
- for bodies at risk from significant hydromorphological pressure, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the hydromorphological pressures. The selection of bodies shall be indicative of the overall impact of the hydromorphological pressure to which all the bodies are subject

Surveillance monitoring sites are usually also monitoring stations in the operation monitoring network. In the case of regional monitoring station networks installed before the entry into force of the WFD, the requirements of the WFD do not usually result in any fundamental shifts in functions or locations.

8.1.1.1.3 Operator-run monitoring facilities

One result of the inventory was that at river basin level there was no up-to-date information available on “systems for timely detection and early warning” at installation level (Chapter 4.3.3). However, this does not mean that there was no technology available for these tasks or that installation operators were not using it.

Major installations, like the BASF factory in Ludwigshafen, which falls under the Seveso-II Directive and is regarded as the world’s largest contiguous chemicals complex, have a continuous "online monitoring system".[204] Its environmental monitoring system comprises production-specific monitoring of the operational units and general self-monitoring of the entire factory site by an environmental centre. The principal function of the environmental centre is continuous 24/7 environmental monitoring. The measurements from 46 in-plant measuring stations are delivered to the environmental centre by a process control system. The functions of the environmental centre include informing the authorities.

Figure 19 Sewage works at BASF factory in Ludwigshafen (source: BASF)

Monitoring of the water taken from the Rhine by the company's own water works in quantities of approx. 40 m^3/sec is undertaken separately for cooling water which does not require treatment (90% of the total volume) and process water which is fed to the factory sewage works. The cooling water system has 13 outlets, at which measuring stations continuously measure the water quantity, total organic hydrocarbon content, temperature and pH. These measurements are monitored in the environmental centre and fault response measures initiated if necessary. A large number of parameters are monitored at the sewage works inlets and outlets. If the feed water contains substances that endanger the operation of the sewage works, the polluted wastewater can

204 BASF, brochure on environmental monitoring, http://www.basf.com .

be diverted into storage basins for subsequent targeted treatment.[205] The environmental centre is not directly integrated in the reporting path for the IWAP Rhine; the reports go the local agencies affected (see Figure 5, p. 133).

This example shows the upper limit of what is possible, but the measuring technology used is “standard” throughout, e.g. in the process monitoring of production plant or the control of sewage works. In view of the greater proximity to the source and the simpler definition of what constitutes an exceptional event, the requirements regarding sensitivity and event identification methods are less than in the measuring stations for monitoring tasks in flowing waters (see Chapter 8.1.1.2). From a technical point of view it would also be possible to connect to web-based information systems/networks. If necessary, criteria should be developed for the design of in-plant “systems for timely detection and early warning”.

8.1.1.2 Incident registration and assessment

Whereas Chapter 8.1.1.1 looked at the river basin wide organisation of *systems for timely detection and early warning*, this section turns to the technical requirements and technical aids.

First there is a need for suitable methods that make it possible to

1. identify water-relevant incidents at an early stage by largely automatic means,
2. assess them with regard to warning and alarm plan relevance,
3. and if necessary feed the results into the regime of the warning and alarm plans.

Whether a warning or an alarm is sent via the warning centres to downstream residents, potentially endangered water users, rescue personnel etc., is a question that ultimately requires an expert decision in the individual case. However, the necessary information should largely be preselected automatically in the light of important decision criteria and made available to the expert body in pre-evaluated form. To avoid not

[205] Supplementary information: About 20 km downstream from the BASF sewage works in Ludwigshafen is the Worms (state) monitoring station operated by the three Länder of Rhineland-Palatinate, Hesse and Baden-Württemberg (in the pillar of the B47 bridge, river km 443.3), which has extensive equipment for water quality monitoring and for detection of unexpected events harmful to water (continuous measurement of all “standard parameters”, biomonitors, GC/MS screening, event-controlled samplers etc., see Chapter 8.1.1.2.4).

only false alarms, but also failure to give the alarm because incidents requiring a warning remain undetected, there is a need for an intelligent technical strategy for incident registration and assessment. The first of these problems is discussed in the following Chapter 8.1.1.2.1 *Identification of incidents*. Chapter 8.1.1.2.2 *Automatic incident assessment* – Alarm index describes technologies for automatic identification of alarm relevance from a number of automatically recognised unusual events. This is followed in 8.1.1.2.3 *Monitoring points – Monitoring stations* – Monitoring networks by a description of the structure of a water surveillance system in principle, and also taking the example of the Hamburg Water Surveillance System. Chapter 8.1.1.2.4 is concerned with equipment concepts for monitoring stations, also bearing in mind that costs may make it necessary to settle for less than the “ideal solution”. Basic principles for this have also been elaborated as part of the UBA project EASE; for in-depth information see the final report.[113] Computerised pollution spread models are a useful aid for preventive measures at river basin level (Chapter 7.2), and also at all levels of crisis management; Chapter 8.1.1.2.5 provides an introduction to the Elbe-specific software ALAMO as an example of similar models.

8.1.1.2.1 Identification of incidents – Unusual events test

Chapters 3.3 and 4.3 stressed the need for immission-oriented warning and alarm thresholds that are compatible with the WFD quality standards, and Chapter 8.1.2.1 presents suggestions for deriving such values. Nevertheless, even with such threshold values the great variety of substances means that it is currently impossible at reasonable cost to detect accidental discharges in the river by simultaneous analytical identification of all “conceivable” contaminants. Immission-oriented warning and alarm systems will for the moment have to be confined to continuous measurement of “basic parameters” which typically show changes as a result of the accident occurring. Here mention must be made of the “simple” classic physico-chemical water parameters which, however, are often not very informative on their own, such as turbidity, conductivity, pH, oxygen content, UV absorption, temperature etc. It would make sense to supplement these with methods such as “biomonitors” which continuously observe and assess the effect of the body of water on the behaviour of the organisms in it.[206]

The classic and widespread approach of identifying unusual events in the measured data automatically is based on comparison of the measured data with statistical threshold values.[207] The sensitivity of this method is severely limited by the fact that the typical monitoring parameters are mostly subject to considerable natural fluctuations, which may occur on a scale that exceeds the changes produced in the water by “accidents”. These fluctuations may be seasonal, daily or spontaneous, e.g. depending on the weather. Even alarm threshold systems adapted to the known periodic changes (summer/winter, day/night etc.) would fail to detect many accidents.

The following examples should help to illustrate the problem:

1. The curve in Figure 20 shows a considerable spread of the pH values measured during the year. The wide range of fluctuation is due among other things to the biological metabolic processes of algae and aquatic plants, and is thus of natural origin. Static threshold values for all-year monitoring of such measurements would have to have a sufficient spread to prevent natural fluctuations from causing false alarms (shown here as red lines, for example). As a result, the probability that a change in the water due to an accident would be recognised in these circumstances is very low.

[206] Where a limited number of specific potential contaminants can be named, it is possible to install a specific “online analysis”; examples of this are found at Rhine measuring stations, especially in the Netherlands, and in the emission monitoring of large chemical plants.

[207] These “thresholds” would be “technical” values for distinguishing between “normal” and “unusual/accidental”, and would *a priori* not bear any causal relationship to legal standards, such as the WFD-EQS.

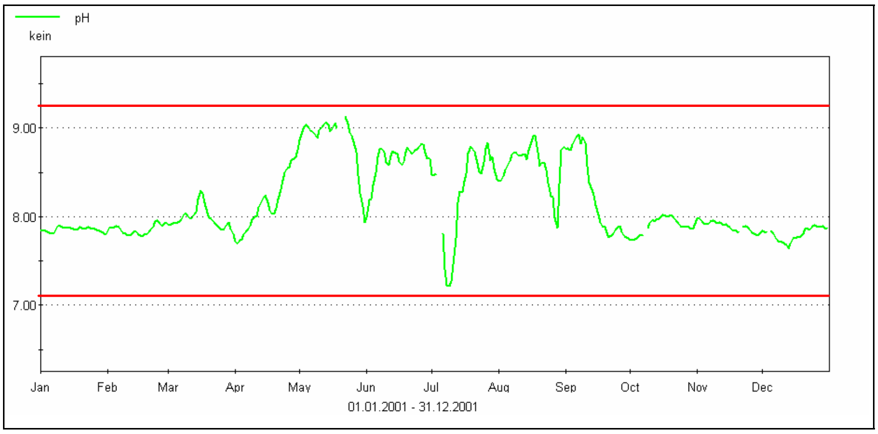

Figure 20 Annual pH curve (daily means, 2001) for the Elbe (river km 610) and static threshold values (red lines)

2. Even seasonally adjusted threshold values would be of limited use, because even the daily fluctuations in the measurements may be very strongly influenced by natural factors. Figure 21 shows in graphic form the day and night pH cycle resulting from algal activity. Here too, the static thresholds (red lines) would have to be chosen so that these fluctuations in the measured values did not give rise to a false alarm. In other words, even static thresholds that took general account of the typical seasonal changes or parameters from the previous week or the previous day would once again not result in a sufficiently sensitive accident alarm system.

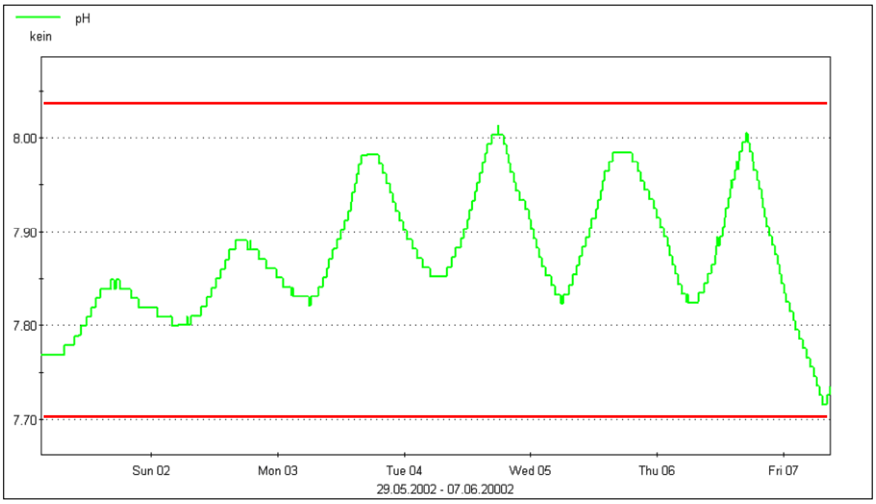

Figure 21 Day and night pH cycle (10-minute means) due to algal activity in a tributary of the Elbe (measuring station Fischerhof, Hamburg) and static thresholds (red lines)

3. Experience – from the Hamburg Water Surveillance System, for example – has shown that changes in the water body as a result of accidents frequently lie within the normal weekly or daily range of fluctuations. Figure 22 shows an example with a discharge confirmed by other means: The deviations of the measured data from “normal behaviour” in the region of the red mark (upper edge of graph) are clearly visible. It is also clearly visible that these deviations lie within the range of fluctuation of “normal” measurements. In Figure 22 the pH merely shows a decrease from pH 7.75 to pH 7.6. If the static pH thresholds had been set on the basis of the curves as in Figure 20 or Figure 21, this unusual event would not have been registered. This makes it clear that such unusual events may be overlooked with thresholds adjusted on a weekly or even daily basis.

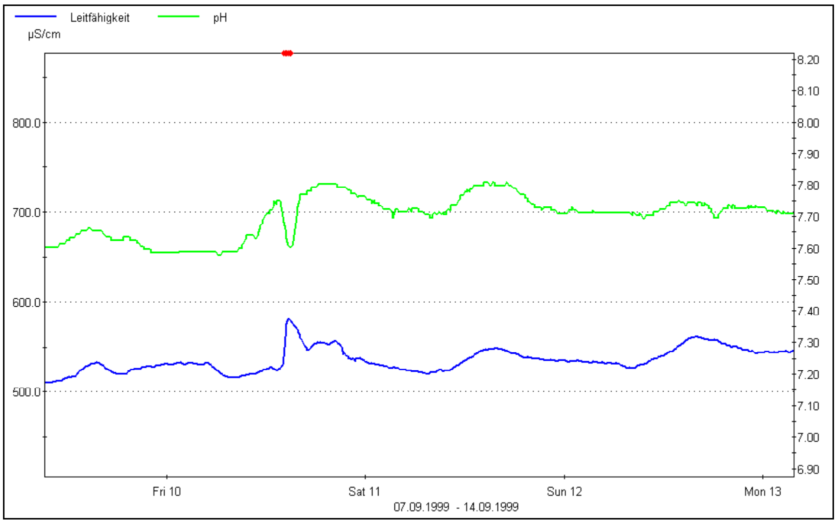

Figure 22 Unusual event (red mark) due to a discharge lies within normal fluctuation; blue curve: conductivity [µS/cm]; green curve: pH

The solution to the problem of static threshold values lies in methods for interpreting unusual events in the “dynamic” context of the measurement curve. These are statistical methods – also known as “detectors” – which examine the current reading in the light of the data measured in an immediately preceding interval of time to assess whether it satisfies the criteria for an “unusual event” (“dynamic detection of unusual events”). By using methods for constantly adapting “threshold values” to the current situation, it is possible to identify unusual events within the normal range of fluctuation of the measurements. Three methods have proved successful for use in monitoring stations as dynamic indicators of unusual events: double sigma test, Hinkley detector and gradient operators. [208]

8.1.1.2.2 Automatic incident assessment – Alarm index

An unusual event registered with the aid of dynamic unusual event detection methods need not necessarily indicate an accidental discharge into the river. For example, a sudden drop in the oxygen concentration may also be of natural origin (intense rainfall event etc.). Even a measurement showing a dramatic drop might in fact be the result of a faulty instrument.

Experience shows that in “genuine” incidents there is a tendency for several parameters to show changes close together in time. Thus the reliability of the alarm system could be improved if the results of the unusual event tests for several parameters were continuously and automatically compared and assessed. Figure 23 shows an incident of this kind:

The curves for oxygen concentration (red curve) and pH (green curve) show small deviations from the “normal” measured data. The dynamic unusual events test of the station’s computer has identified these as “unusual events” (red marks at top of diagram). The question nevertheless arises as to whether these are really indicators of a serious incident, especially since – taken on their own – the unusual events do not indicate any pollution dangerous to water. However, since a continuous biotest method (Daphnia toximeter) shows a simultaneous marked increase in the device’s internal “toxicity index” (purple curve), the result is significant.[209]

[208] For further details see EASE final report[113], Chapter 6.3 (Dynamic unusual event tests)

[209] The blue curve shows one of five parameters of changed behaviour (mean Daphnia separation) in the Daphnia toximeter, all of which together contribute to the “toxicity index” (purple curve).

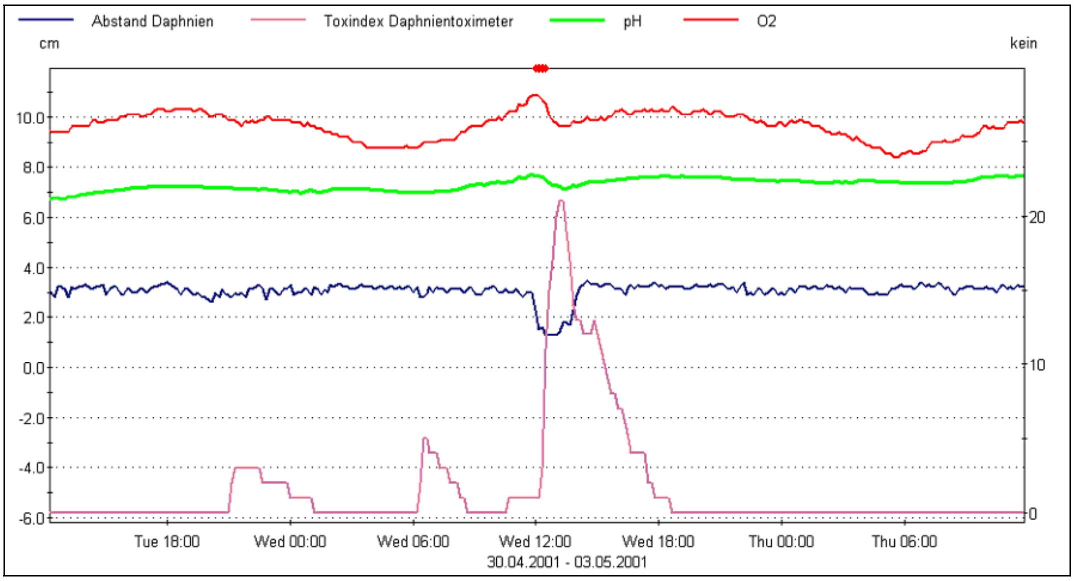

Figure 23 Change in several independent parameters during an incident (red mark) in the Elbe

(river km 610); upper red curve: oxygen content [mg/l]; green curve: pH; blue curve: mean Daphnia separation [cm]; lower purple curve: toxicity index of Daphnia toximeter

Thus a computer-controlled integrated alarm detection system would make it possible to optimise the dynamic registration of unusual events in the sense of an analysis and evaluation component. As part of the EASE project, the “**alarm index**” (AI) installed in the station computers of the Hamburg Water Surveillance System was introduced for this purpose.

In this method the results of the unusual events test are totalled using a specific algorithm to obtain a value known as the “alarm index”. The alarm index is constantly recalculated by the measuring station computer, using specific weightings, from all unusual events registered for each parameter. Every unusual event increases the value of the AI by an amount defined separately for the individual parameter. For automatic assessment of whether incidents require warnings, two or more limits can be freely defined in the analysis software. If the AI exceeds the first limit, an – internal – warning is given (“event”, “yellow” station alarm), if the next is exceeded, the “notification stage” (“red” station alarm) is reached. To prevent individual unusual events widely separated in time from provoking a gradual long-term rise in the AI, the unusual event contributions to the AI are assigned a “decay time”, so that if no further unusual events occur, the AI is automatically reduced again[210]. All parameters automatically registered by the monitoring station, including values from biomonitors such as Daphnia or algal taximeters, can be included in the system consisting of unusual events test and alarm index formation. Figure 24 provides a schematic representation of the course of an unusual event registration for several parameters, in which the alarm index increases until the notification stage is reached.

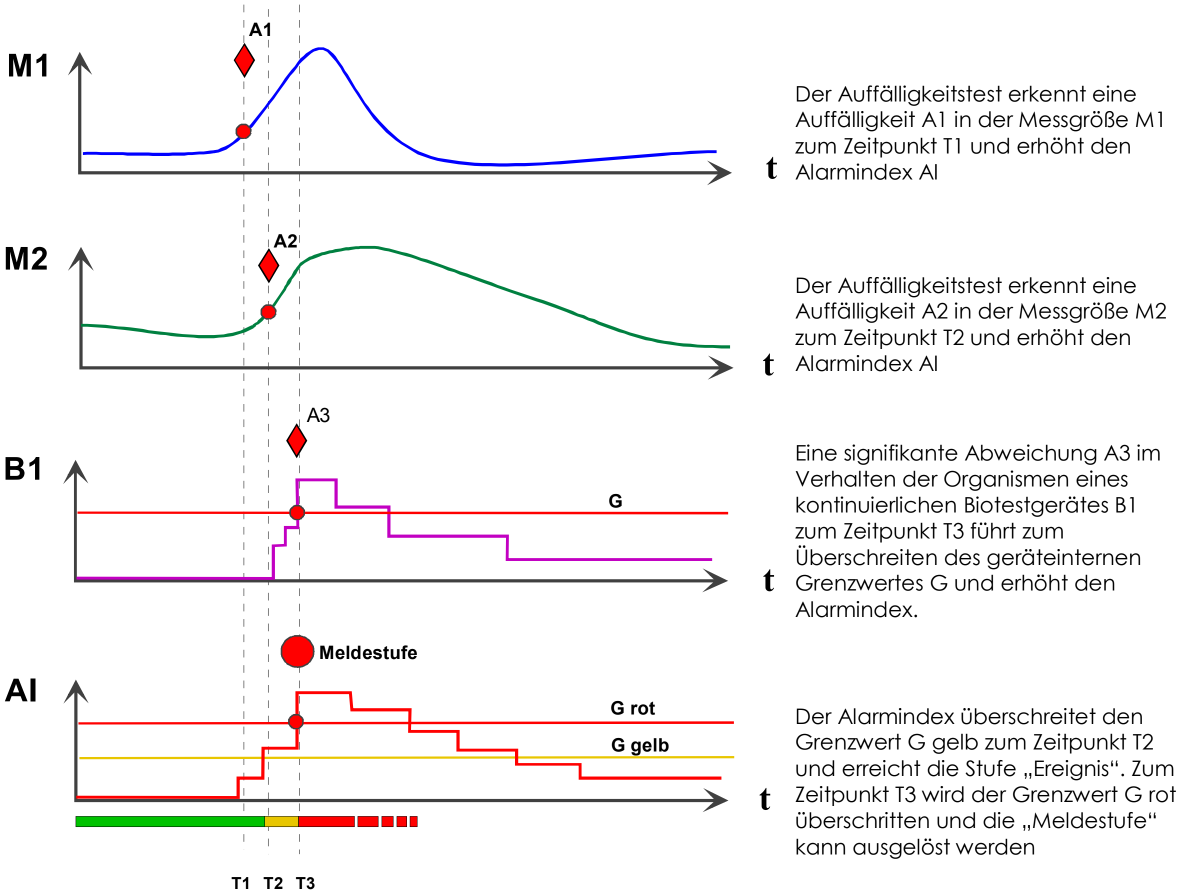

Figure 24 Schematic flow of incident detection using an alarm index

In the diagram the unusual events in the measurement curves can be seen with the naked eye. The station computer analyses the readings using the unusual events test (in this case double sigma test), detects an unusual event for each of the parameters M1 and M2, one shortly after the other (T1, T2), and marks it as the red lozenges A1

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210 See EASE final report[113], Chapter 8.2, 9.3.5

and A2. A little later, at time T3, parameter B1 (toxicity index) from a biotest device exceeds a specific limit (G). This indicates a significant change in behaviour or damage to organisms and is assessed by the station computer as a further unusual event (A3) and marked accordingly. The unusual events A1 to A3 each increase the AI by a certain amount: at time T2 the “yellow limit” is exceeded, triggering the internal “warning” (“incident”, “yellow” station alarm), and at time T3 the “red limit” is exceeded and the “notification stage” is reached (“red” station alarm). Since the individual parameters return to “normal” levels after a certain time, the unusual events reach their “expiry date” after specified times and the AI is gradually reduced to zero again.

These processes take place at the level of the monitoring network – whether such an incident is fed into the reporting system of the international warning and alarm plan is decided by expert appraisal. It would also be possible to feed suitable graphic representations directly into an information system such as UNDINE.

Figure 25 shows an example of a station alarm from the operation of the Hamburg Water Surveillance System. In May 2007 an automatic measuring station on a tributary of the Elbe (Wandse) reported a “red station alarm”. The station’s alarm identification software registered statistically unusual data for several parameters. In addition, oxygen levels fell below both the warning threshold of 4 mg/l for oxygen concentration monitoring and the “fish-critical” oxygen figure of 3 mg/l. The oxygen concentration finally fell to a figure of less than 0.5 mg/l. There was reason to expect fish mortality and serious harmful effects on the entire aquatic fauna.

The sharp drop in oxygen values (red line) to 0 mg/l can be clearly recognised in Figure 25. At the same time the turbidity figure (blue line) shows a sharp rise and the pH (green line) decreases. The normal level of turbidity in the Wandse is between 20 and 50 FNU (formazine nephelometric units). After intense rainfall, peak values of up to 150 FNU may be registered for a short period. In this case, however, the figures rose to over 650 FNU! The red marks at the upper edge of the diagram indicate the data below identified as unusual by the station computer. It is clear from the measurements that the discharge lasted approximately one hour (from start to maximum of turbidity peak and pH peak). Although “expert judgement” classified the incident as an illegal discharge, it was only of local importance and was therefore not reported to the warning and emergency plan for the Elbe.

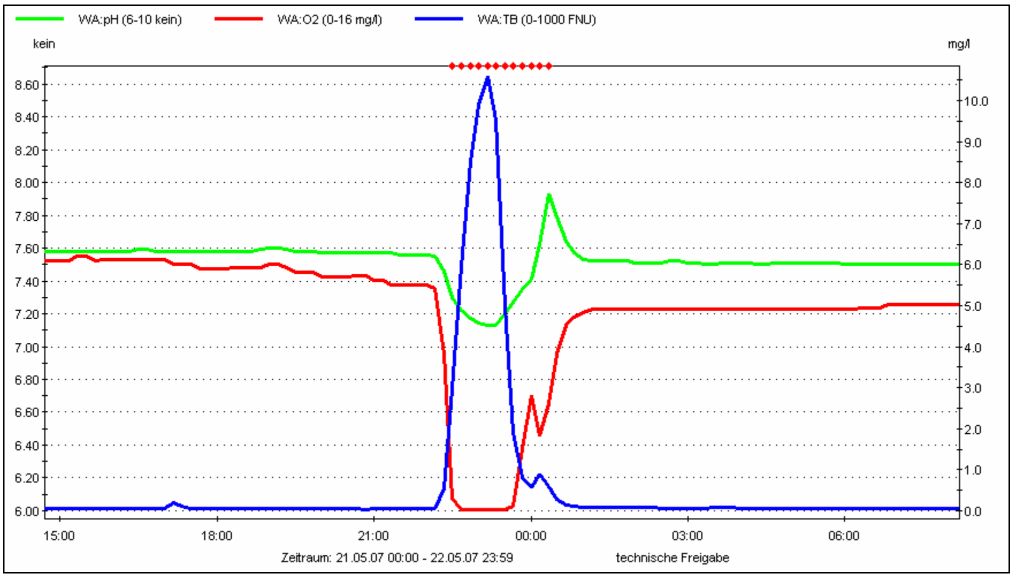

Figure 25 Changes in water properties due to an accidental discharge into the Wandse (green line: pH, red line: oxygen concentration, blue line: turbidity)

8.1.1.2.3 Monitoring points – Monitoring stations – Monitoring networks

Monitoring points for monitoring water body status pursuant to Article 8 WFD and Annex V to the WFD are points for taking samples at or in the water body, i.e. defined locations (measuring sites) at which samples are taken regularly (e.g. monthly) (Figure 26). Analysis of the samples – except for a few on-site parameter determinations – takes place in laboratories. The WFD does not require stationary facilities of any kind for this purpose.

Figure 26 Monitoring point Travehafen on the Elbe in the port of Hamburg

„In our opinion, *"systems for timely detection or early warning*" pursuant to Article 11 (3) I WFD also call for *immission oriented* detection and assessment of incidents requiring a warning. In Chapter 8.1.1.1 it was mentioned that there is a need for monitoring systems meaningfully distributed along the water body which are coupled with a technology that first detects "unusual events" by means of suitable *continuous measurements* in the water, then identifies them as "natural" or "accidental", and finally takes an alarm decision based on an evaluation of their "relevance". At least the actual measuring unit must be permanently present at the water body, and accordingly it is a stationary facility which is referred to here as a ***monitoring station***. Monitoring stations of the kind currently used on the Elbe and Rhine are typically housed in buildings or in containers on pontoons (Figure 27). As a rule they contain the actual measuring equipment with the associated sampling systems, a PC-based station computer which registers, processes and, where appropriate, assesses the measured data, and simultaneously forwards results to a central control room with the aid of suitable communication systems. Monitoring stations are usually unmanned, but depending on their functions and equipment they require regular maintenance by personnel. If its equipment consists of simple sensors anchored in the water body plus a wireless data transfer system, a station may merely be a floating buoy which does not require frequent visits. If, for example, it is equipped with biomonitors and event-controlled samplers for laboratory analysis, intensive regular attention is absolutely essential.

Figure 27 Bunthaus monitoring station on the Elbe in Hamburg

Automatic monitoring stations create the basis for continuous water quality monitoring, which is not possible with sampling and the established test programs. The continuous measurements in such stations make it possible to register changes over time for parameters which display great variability (usually also heavy seasonal and meteorological dependence) or which are important accompanying parameters for evaluating the results obtained from test on samples. And – monitoring stations lay the foundations for *immission oriented "systems for timely detection and early warning"* pursuant to Article 11 (3) I WFD.

Monitoring station locations on water bodies

The choice of locations for monitoring stations depends on the functions they are intended to perform. In most cases the underlying criteria, taking account of economic aspects as well, are identical to those for monitoring sites. In the document on the LAWA Study Programme Germany[211], the following typical locations were mentioned in the 1990s:

- before the point where rivers of water management importance flow into lakes and coastal waters,
- in the case of important transboundary rivers, close to the border,
- above and below urban agglomerations and major industrial settlements,
- within important sections of major rivers,
- on important tributaries, immediately above the confluence,
- on river sections unaffected by anthropogenic pollution ("zero measurement sites", reference measurement sites, background level sites).

The location should be basically representative of a river section and its cross-section, but it is permissible to depart from this principle in the event of specific emission-oriented monitoring functions. The location should take into account not only the measurement task, but also the logistical situation in the field. Installing the monitoring station in the middle of the river would be preferable from the point of view of measurement technology, but this is very rarely possible. The station should be as close as possible to the line of maximum velocity (from a flow point of view, the middle of the river), to ensure that the measurements and, where appropriate, the samples are as representative as possible. As a rule, this can most easily be achieved at a "cut-off bank". If the station is to observe particular "plumes", special provision must be made for this. This is the case at the Worms Rhine quality station, for example, which has to take in various sampling points in the cross-section of the BASF wastewater plume (site-appropriate measuring strategy).

The planning of monitoring stations should be preceded by preliminary studies making use of longitudinal, transverse and depth profiles. This is possible with the aid of mobile measurements. The results of previous monitoring programmes may also yield useful information for the choice of location.

When choosing the location it is also necessary to take account of problems originating from the catchment area itself. For example, floating objects may damage the water sampling facilities or the entire station, and finer flotsam may block the pipe system or affect the functioning of pumps and measuring systems. Sharply fluctuating water levels, floods or pack ice repeatedly result in station failures. This problem can be minimised by careful choice of location.

Monitoring networks

Monitoring networks connect several monitoring stations with each other and with a control centre. Various Länder in Germany operate monitoring networks for the purpose of constant water quality surveillance (see also Chapter 8.1.1.1.2).

The monitoring stations are coordinated by a ***monitoring network control centre***. Its functions include:

- data collection / data management / data preparation,
- data analysis and evaluation,
- coordination of and support for monitoring stations.

Equipment and control programs for monitoring network control centres are not yet available on the market as standard products. This also explains the high cost of setting up a network control centre. For recent development in the field of monitoring

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> *Continued from previous page* <

[211] LAWA (Joint Water Commission of the Federal States): Fließgewässer in der Bundesrepublik Deutschland - Empfehlung für die regelmäßige Untersuchung der Beschaffenheit der Fließgewässer in den Ländern der Bundesrepublik Deutschland (LAWA-Untersuchungsprogramm), 1997.

station control and monitoring network control, see Chapter *Equipment concepts for* monitoring stations/monitoring networks (8.1.1.2.4).

The Hamburg water surveillance system

As an example of the structure and equipment of a state-run regional monitoring network, this section gives a brief description of the Hamburg water surveillance system (WGMN Hamburg)[217].

The Hamburg water surveillance system with biological early warning system performs the following functions:

- early detection of accidents and illegal discharges,
- event-controlled sampling for accompanying laboratory tests,
- protection of drinking water abstraction areas with surface water enrichment,
- assessment of hazard potential arising from discharges,
- clues to authors of water body pollution,
- prevention: continuous water body monitoring acts as a deterrent and provides protection against illegal discharges or other water pollution,
- indication of short and long-term changes in water quality as a basis for water management measures (e.g. stop dredging in the event of oxygen deficiency),
- checking of heat load plans,
- progress review of water body measures (e.g. Elbe and Alster relief concept),
- safe accommodation for measuring equipment in the ICPER and WFD monitoring programmes (e.g. suspended solids samplers).

Figure 28 Automatic monitoring stations in Hamburg (green background – stations that also operate a biological early warning system)

The Hamburg water surveillance system has been operating since 1988 with ten monitoring stations on all important rivers (Figure 28).

All stations make automatic and continuous round-the-clock measurements of the chemo-physical parameters: oxygen concentration, pH, conductivity, turbidity and temperature. The Elbe stations Bunthaus and Seemannshöft (ICPER), which are also important for fulfilling international agreements, the Fischerhof station on the Bille (discharge of surface water into a drinking water abstraction area), and the Wands-beker Allee station on the Wandse also operate a biological early warning system which can register toxic effects in the water (station names on green background). These stations are equipped with automatic samplers, which supply samples for detailed laboratory analysis in the event of water accidents. In some cases the stations also use additional devices for oil detection and for measuring UV absorption (detection of organic impurities). The monitoring stations register the water body measurements as 10-minute means, save them temporarily in station computers, assess them and transfer them by ISDN to the central computer (including any unusual events identified/alarm notifications).

Great importance is attached to the biological effect monitoring methods, which are able to indicate acute toxic effects on a summary basis. For this reason, four Hamburg monitoring stations use automatic test systems with water fleas (*Daphnia magna*) and green algae (*Chlorella vulgaris*). The Daphnia toximeter uses a camera to observe the movements of Daphnia. If there are significant changes in behaviour, this is reason to suspect acute water pollution. The algal toximeter automatically registers harmful effects on algae as reflected by inhibition of photosynthesis activity.

The stations are equipped with the "dynamic unusual event detection" and "alarm index" technologies described above, and report any identified station alarms to the network control centre. An alarm reaching the control centre is automatically forwarded to the staff by mail or text message. At the same time the station automatically starts alarm sampling. Targeted chemical analysis of the samples taken makes it possible to identify the type of pollution and may permit conclusions about the identity of the polluter. In this way the water surveillance system ensures that sudden toxic pollution of the body of water is detected at an early stage, allowing prompt countermeasures to be taken. For example, an alarm at the Fischerhof station results in the discharge of surface water into the drinking water abstraction area being stopped.

8.1.1.2.4 Equipment concepts for monitoring stations/monitoring networks

For the monitoring stations themselves, largely complete station control systems are available from some manufacturers. To date, however, these have not succeeded in meeting the requirements for the functionality needed according to the results of the EASE[113] project. The technical description of alarm index and unusual events test makes for simple implementation of these modules.[212] Standardised (software) solutions for data management in the monitoring stations, with maintenance, archiving, presentation and export functions, are still in their infancy (see end of this chapter). Today the data transfer link between the control centre and the stations can take the form of a DSL connection for high transfer rates.

[212] See Chapter 8.2, EASE final report[113]

The equipment of monitoring stations and monitoring networks depends on what they are intended to investigate and on the local conditions, including human and financial resources. The preceding chapters have mentioned and in some cases described in more detail a number of equipment components which we consider important for a functioning early warning system. For various reasons (cost, accessibility, service intensity etc.), it will frequently be the case that not all these components can be implemented, which raises the question of a sensible and purpose-oriented equipment concept for measuring stations. In the context of the EASE project, a phased expandable modular concept was elaborated which compares various instrument options with the performance they offer and the costs involved.[213] A summary overview of costs for monitoring station/monitoring network equipment can be found in Table 21 at the end of this chapter.

The multi-stage concept has three equipment programmes, each building on the next:

- the *basic measurement programme*,
- the *extended basic measurement programme* and
- the *extended measurement programme*.

The equipment components listed in the individual programmes are examples and suggestions intended for guidance. They do not mean any ranking or preference for specific manufacturers or products. The more specialised the functions of the components, the smaller the supplier market. A certain amount of individual development or adaptation is bound to be necessary.

Basic Measurement Programme

The *Basic Measuring Program* describes the first – relatively inexpensive – steps in equipping a monitoring station with the devices and technology for detecting sudden changes in a water body. The equipment covers the main chemo-physical basic parameters and registration of the values measured by the equipment. This first stage permits subsequent manual evaluation of these water data items. Linking the measuring devices to a station computer considerably simplifies the management and analysis of the data. Timely automatic detection of events in the water body is not possible, or

[213] See EASE final report[113] – Chapter 9.3

only if the measurements are kept under continuous observation by operating personnel. The Basic Measuring Program is subdivided into 2 stages.

Stage 1 The first stage comprises measurement of the five “basic water indicators” (oxygen content, water temperature, pH, conductivity and turbidity), and registration of the data measured by the devices. With these five indicators it is frequently possible to register sudden changes in water quality. As a rule it is not possible, merely by using this combination of equipment, to make a clear and unambiguous distinction between accidental and natural changes in the water body (e.g. intense rainfall).

Stage 2 Equipment supplemented by a station computer for data acquisition, which considerably simplifies the comparative analysis and evaluation of the results by the personnel.

Extended basic measurement program

The *Extended Basic Measurement Program* permits both simultaneous automatic detection of unusual water conditions and event-controlled automatic taking of water samples. To increase the information value with regard to registration of accidents, the measurement program is supplemented by a further, relatively inexpensive parameter. The *Extended Basic Measurement Program* is divided into three stages (Stages 3 to 5).

Stage 3 The station computer is augmented by special software for automatic data analysis (dynamic unusual event test and alarm index). This ensures automatic and continuous monitoring of measured values. Direct detection and notification of sudden changes in water quality are now possible.

Stage 4 The monitoring station is equipped with an automatic sampler. Such samplers permit prompt, event-controlled automatic taking of relevant water samples for subsequent analysis in the laboratory. These tests provide information about the hazard potential of a change in the water, and may help to identify the party responsible for the water pollution. So-called self-emptying samplers have proved particularly useful for this purpose (Figure 29).

Stage 5 The station equipment is joined by a UV absorption measurement system. UV absorption measurement is used as a cumulative parameter for detecting certain types of dissolved organic contamination. The devices are an inexpensive and low-maintenance alternative to DOC and BOD devices, etc. When using such measurement systems, it is important to note that natural inputs of humic acids may also bring about a sudden rise in SAC values (e.g. in cases of heavy rainfall). In Stage 8 it is therefore recommended that humic acid measurements be made to confirm and distinguish the results of the measurements.

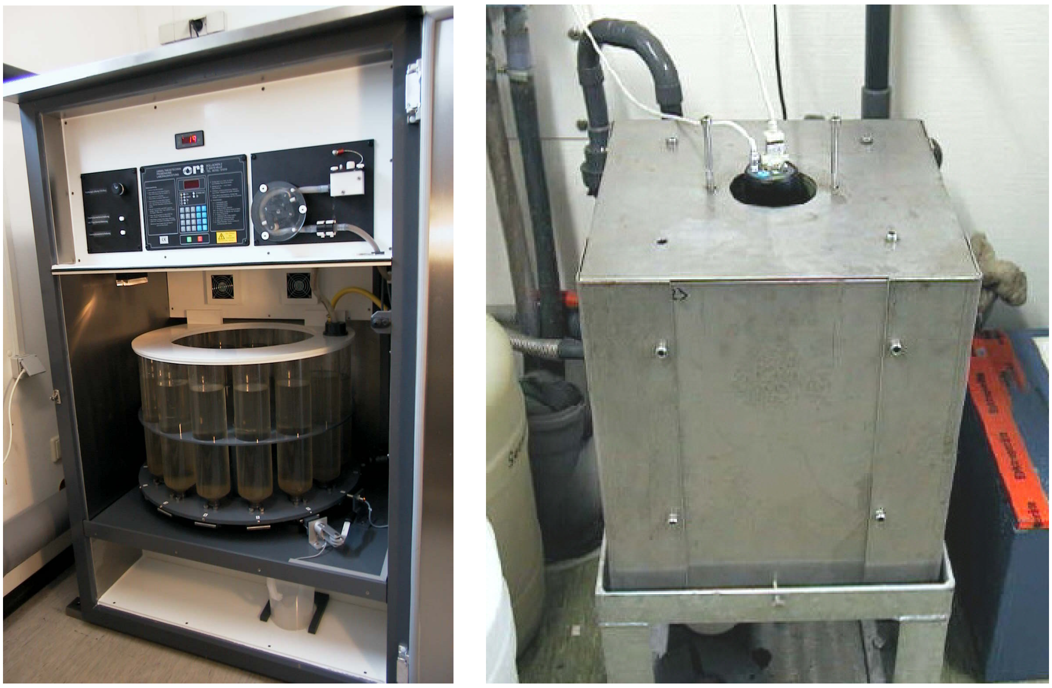

Figure 29 Left: Self-emptying sampler (ORI), right: Radioactivity recording in Hamburg monitoring station

<u>Extended measurement program</u>

The *Extended Measurement Program* supplements the measuring equipment with very powerful devices for detecting substances or mixtures dangerous to water. Owing to the complexity of these devices, the demands on the operating personnel are high, the devices are expensive in terms of both capital cost and running costs, and expenditure on operating and maintenance is usually considerable.

The *extended measurement program* includes a large proportion of the measuring systems commonly used in Europe, and is also broken down into several stages. The devices are divided into various categories. Unlike the Basic Measurement Program, it is not necessary here to integrate all devices from one stage in the monitoring station before starting to equip it with devices from the next stage. When choosing the devices from the Extended Measurement Program, one should instead make a selection based on the specific measurement tasks.

A large proportion of these devices can provide direct information on the hazard potential of the change in water condition. This applies primarily to the devices in Stages 6 and 7.

At the end of the equipment concept there are a number of devices and specialised sampling systems that cannot make a direct contribution to raising the alarm. These devices benefit above all from burglar-proof and weather-proof installation with power supply, and are used for specialised monitoring tasks, trend analyses, composite sampling over lengthy periods, suspended solids collection etc. The *Extended Measurement Program* is divided into four stages (Stages 6 to 9).

Figure 30 Algal toximeter in Hamburg monitoring station (bbe)

Stage 6 Here the station is equipped with continuous bio-testing methods (biomonitors). In view of the wide variety of potential pollutants originating from accidents, it is hardly possible to cover all individual substances by means of continuous chemo-physical or chemical monitoring. In biomonitoring, "standardised biological material" is exposed to river water under defined conditions in the monitoring station's test equipment. Biomonitoring, as effect monitoring, can give a timely indication of the effects of pollutants – especially in the case of acute, e.g. pollutant surges resulting from accidents – on organisms of various trophic stages in the food chain (examples of proven devices: algal toximeter (Figure 30), Daphnia toximeter (Figure 31), mollusc toximeter, fish toximeter, bacterial toximeter). [214, 215, 216] Since there are differences in the sensitivity of the various test organisms to pollutants, several tests can be used in parallel as a "test battery".

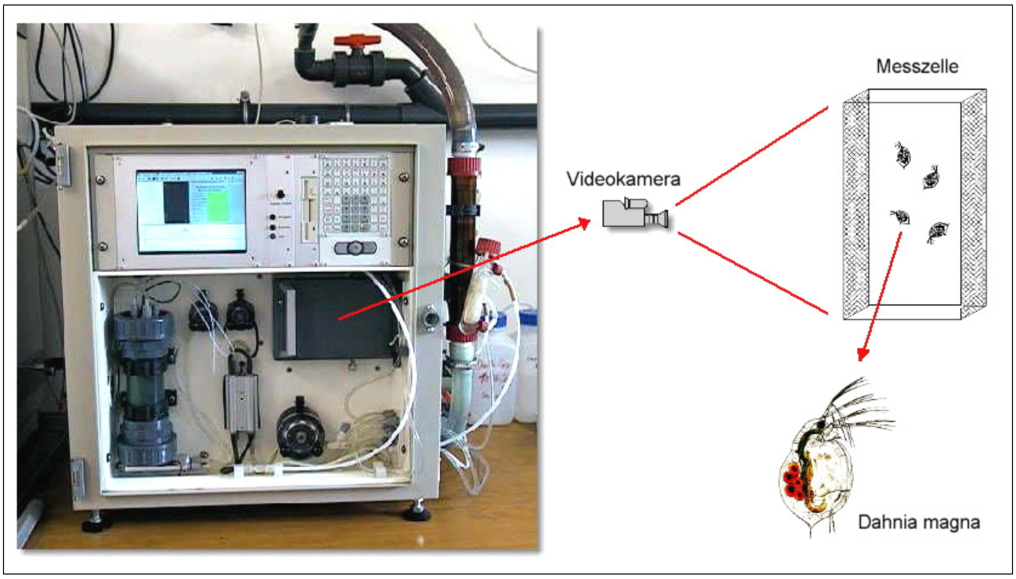

Figure 31 Daphnia toximeter in Hamburg monitoring station (bbe)

Stage 7 If it is known that an individual river has a specific problem regarding discharges of certain substances, the measurement systems in this stage can be used. Site-appropriate measuring systems are suitable for targeted registration of specific known pollution; examples proven in monitoring sta-

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214 LAWA (Joint Water Commission of the Federal States), *Empfehlungen zum Einsatz von kontinuierlichen Biotestverfahren für die Gewässerüberwachung*, 1996.

215 LAWA (Joint Water Commission of the Federal States): *Einsatzmöglichkeiten des Biomonitorings zur Überwachung von Langzeit-Wirkungen in Gewässern*, 2000.

216 In monitoring stations it is also possible to ensure protected housing of biomonitors for registration of long-term effects, bioaccumulation behaviour or bioavailability in genuine river water.

tions include radioactivity sensors, GC/MS, HPLC/DAD, oil detectors (Figure 29, Figure 32). Almost all devices permit direct statements to be made about the nature and hazard potential of the water pollution. Since such devices are also used in wastewater monitoring, e.g. in chemical factories, they are less exotic than one might think.

Figure 32 Left: GC/MS Rhine quality station Worms, right: HPLC/DAD monitoring station Bimmen

Stage 8 Various measurement methods for determining cumulative parameters can be used to supplement the analyses at the monitoring stations. As a rule, these devices do not make it possible to draw definite conclusions that a case of water pollution is harmful. These devices are also used in numerous other monitoring fields (e.g. production control, wastewater monitoring) and are suitable for targeted site-appropriate monitoring (emission-oriented, production-specific, plant-specific) of certain potential pollution sources with the aid of "indicator parameters". Examples include humic substance photometers (humic acid determination to supplement the UV sensor in Stage 5), nutrient analysers, TOC monitors, water level gauges for detecting rainfall events etc.

Stage 9 Various samplers are listed in this stage. These devices can be used to take various samples over long periods in order to obtain additional information about water pollution (including pollutant accumulation behaviour, long-term pollution, trend analysis of suspended solids collection). Pollution levels in various materials (water, suspended solids) can be investigated in the laboratory. This yields additional monitoring data, and also information for evaluating events.

As a *system for timely detection and early warning"* in accordance with the requirements of Article 11 (3) I WFD, the authors recommend a minimum set corresponding to Stage 3, or preferably Stage 4 of the equipment concept, in other words:

- continuous measurement of at least the 5 basic parameters, central acquisition and storage of measured data,
- dynamic unusual events test,
- "alarm index" for automatic event assessment,
- event-controlled sampling.

With Stage 3 (basic parameters / dynamic unusual events test / alarm index) it is possible to achieve reasonably reliable event identification, but it is only with "genuine" substance analysis that one can make substance-specific forecasts and take substance specific action. If there are no analysis systems in the monitoring station, there should at least be an event-controlled sampling system (Stage 4; for tabular overview see Table 20).

Further measuring equipment for plausibility checking and improving information reliability should be chosen to suit the specific situation and site. Notification through the reporting system of the International Warning and Alarm Plan should be made on the basis of "expert judgement". It is recommended that the measurement data be continuously made available online via web-based information systems to all parties concerned. Using the example of the Rhine quality station in Koblenz, Figure 33 provides a schematic overview of the measuring equipment of a station run by the Federal Institute of Hydrology (BfG), which is equipped primarily for quality monitoring. The equipment in the measuring field is largely that of an early warning station. To equip such a station for early warning tasks, it would only be necessary to upgrade it in the field of process control (event identification, alert management etc.), i.e. software and computer system (PC), as described in the following example.

New developments in the field of monitoring station/monitoring network control

The Institute for Hygiene and Environment is currently working on the third expansion stage of the Hamburg Water Surveillance System[217] (WGMN 3). The core item is the establishment of new monitoring network software and the necessary IT structure in cooperation with the firm of AJ Blomesystem[218]. The central server, station computers and clients (e.g. workstations) are to be linked in modular fashion so that this system can be adapted to any monitoring network and expanded; the central server can also be located in the Internet. Standardised systems of this kind would make it much easier than at present to optimise monitoring networks to cater for early warning requirements.

The future EASE-compatible basic structure, an application called "**ajb Environment Monitor**", consists of three components:

1. **ajb EnMo Server**
   The ajb EnMo Server handles central storage and processing of all data from the ajb EnMo application. It receives the measurements from the connected monitoring stations (ajb EnMo Site) at regular intervals and processes them. The results obtained at the monitoring stations are continuously analysed in the station computer. If deviations from the situation regarded as normal are detected, messages can be sent to scheduled recipients.

2. **ajb EnMo Site**
   This part of the application is run on a computer within the monitoring station and processes the values measured by the measuring equipment. It calculates mean values from the continuous measurements. The evaluation software IT-Sees can be used within the station to analyse the measurements for unusual events. If an unusual event is detected, a fully automated response to such an event is possible. For example, an unusual event could trigger an alarm and an automatic sampling system. These actions are triggered on a completely self-sufficient basis, i.e. even without a connection to the central server – which can be important in the event of power failure. In regular cycles the measured data and evaluations are transmitted to the central ajb EnMo Server.

217 WGMN Hamburg, Free and Hanseatic City of Hamburg, Institute for Hygiene and Environment, www.hamburg.de/wasserguetemessnetz.

218 AJ Blomesystem GmbH, Konrad-Zuse-Straße 1, 07745 Jena, www.aj-blomesystem.de .

3. **ajb EnMo Client**

   This is the graphic user interface (GUI) of the application, which enables a user to access the data and functions of the ajb EnMo application. Here data can be entered and retrieved. It also provides access to the functions needed for processing/evaluating the data.

Communication with the individual software components requires an infrastructure of the kind needed for a browser to communicate with the Internet (HTTP; Port 80). To ensure secure communications, it is necessary to log in to the system with user name and password. This is the case for clients logging in to the central *ajb EnMo Server* and for the *ajb EnMo Server* logging in to the monitoring stations (*ajb EnMo Site*). The application runs in a Microsoft Windows operating environment. The *ajb EnMo Application* needs additional software products to enable it to be used. These include a database and a reporting tool.

As equipment for a monitoring network with a central server and ten monitoring stations, the software package described costs in the region of €150,000. The PC and server technology used is conventional state of the art.

Table 20 Multi-stage program for equipping continuous monitoring stations

Programme	Stage		Equipment	Remarks
Basic Measurement Programme	1	No automatic assessment	**Multi-parameter measuring system** ♦ Water temperature ♦ Oxygen concentration ♦ pH ♦ Conductivity ♦ Turbidity	Central parameters for sudden changes in bodies of water, alarm can only be given if data under constant observation by expert personnel.
Basic Measurement Programme	2		**Data acquisition by station computer**	Simplifies data management and evaluation
Extended Basic Measurement Program	3	Automatic event detection and assessment, but no warning possible on the basis of substance data	**Dynamic unusual events detection and alarm index** Software implementation	By means of an unusual event test and alarm index it is possible to implement automatic and prompt recognition of events. **In our opinion minimum requirement of Article 11 (3) I WFD**
Extended Basic Measurement Program	4	Important for plausibility checks, warning with (laboratory) substance data and diffusion forecast	**Event-controlled sampling for laboratory analysis** ♦ Automatic sampling by means of self-emptying sampler	Taking of event-relevant water samples for ♦ assessment of scale ♦ determination of causes ♦ perpetuation of evidence ♦ database for substance spread modelling
Extended Basic Measurement Program	5	Stages 5-8 important for improving information reliability and plausibility	**UV absorption measurement (SAC 254 nm)**	Key parameter for dissolved organic substances. Inexpensive, low-maintenance alternative to DOC-, BOD- etc., information not always unambiguous
Extended Measurement Program	6	Toxicity tests, not substance-specific	**Continuous biotest methods (examples)** ♦ Daphnia toximeter ♦ Algal toximeter ♦ Mollusc toximeter ♦ Bacterial toximeter ♦ Fish toximeter	Indicators of toxic effects in water bodies, important for objects of protection such as drinking water abstraction
Extended Measurement Program	7	Substance-specific analysis especially for known potential contaminants	**Site-appropriate measuring systems (examples)** ♦ Radioactivity measurements ♦ GC/MS ♦ HPLC/MS or HPLC/DAD ♦ Oil detectors ♦ Fluorescence measurement (tracers)	Special purpose analysis, high specific information value
Extended Measurement Program	8	Partly substance-specific analysis, improves information reliability and plausibility	**Other measuring methods (examples)** ♦ Photometric determination of humic acids ♦ Nutrient analysers (ammonia/nitrate) ♦ Chlorinated hydrocarbon monitors ♦ TOC monitors ♦ Water level (runoff)	Cumulative parameters may supplement analyses in the monitoring stations (e.g. humic acids: plausibility check on results of UV absorption measurement in Stage 5).
Extended Measurement Program	9	Perpetuation of evidence, other quality monitoring, long-term and trend monitoring	**Samplers (examples)** ♦ Combination samplers ♦ Centrifuges ♦ Settling tanks ♦ Mollusc basins ♦ Artificial membranes for bioaccumulation	Supplementary programs for monitoring, long-term measurements, trend analysis, impact measurement Safe housing of measuring equipment in station

Table 21 Equipment for automatic monitoring stations – approximate costs (2009)

	Stage	Equipment	Costs [€]
Basic Measurement Program	1	**Multi-parameter measuring system** **Stationary, with internal data registration** ♦ Water temperature ♦ Oxygen concentration ♦ pH ♦ Conductivity ♦ Turbidity **Mobile, complete with data registration for 1-2 weeks**	 **10.000 - 18.000** ♦ **usually integrated in devices** ♦ **2.500** ♦ **2.500** ♦ **2.500** ♦ **3.500** **8.000 – 18.000**
	2	**Data acquisition by station computer** (standard software) Optional: cost of monitoring network software, e.g. "WGMN 3", see Chapter 8.1.1.2.3)	**20.000** **150.000**
Extended Basic Measurement Program	3	**Dynamic unusual events detection and alarm index** Software implementation	**Programming input, additional 14 - 20 person days (approx.)**
	4	**Event-controlled sampling for laboratory analysis** ♦ Automatic sampling by means of self-emptying sampler	**17.000**
	5	**UV absorption measurement (SAC 254 nm)**	**10.000 – 16.000**
Extended Measurement Program	6	**Continuous biotest methods (examples)** ♦ Daphnia toximeter ♦ Algal toximeter ♦ Mollusc toximeter ♦ Bacterial toximeter ♦ Fish toximeter	 ♦ **17.000 - 40.000** ♦ **25.000 - 35.000** ♦ **30.000** ♦ **15.000 - 23.000** ♦ **15.000 - 40.000**
	7	**Site-appropriate measuring systems (examples)** ♦ Radioactivity measurements ♦ GC/MS ♦ HPLC/MS or HPLC/DAD ♦ Oil detectors ♦ Fluorescence measurement (tracers)	 ♦ **30.000** ♦ **80.000 - 150.000** ♦ **60.000 - 300.000** ♦ **10.000 - 14.000** ♦ **15.000**
	8	**Other measuring methods (examples)** ♦ Photometric determination of humic acids ♦ Nutrient analysers (ammonia/nitrate) ♦ Chlorinated hydrocarbon monitors ♦ TOC monitors	 Not known ♦ **5.000 - 10.000** ♦ **30.000** ♦ **50.000**
	9	**Samplers (examples)** ♦ Combination samplers ♦ Centrifuges ♦ Settling tanks ♦ Mollusc basins ♦ Artificial membranes for bioaccumulation	 ♦ **6.000 - 10.000** ♦ **40.000** ♦ **3.000** ♦ **5.000** Not known

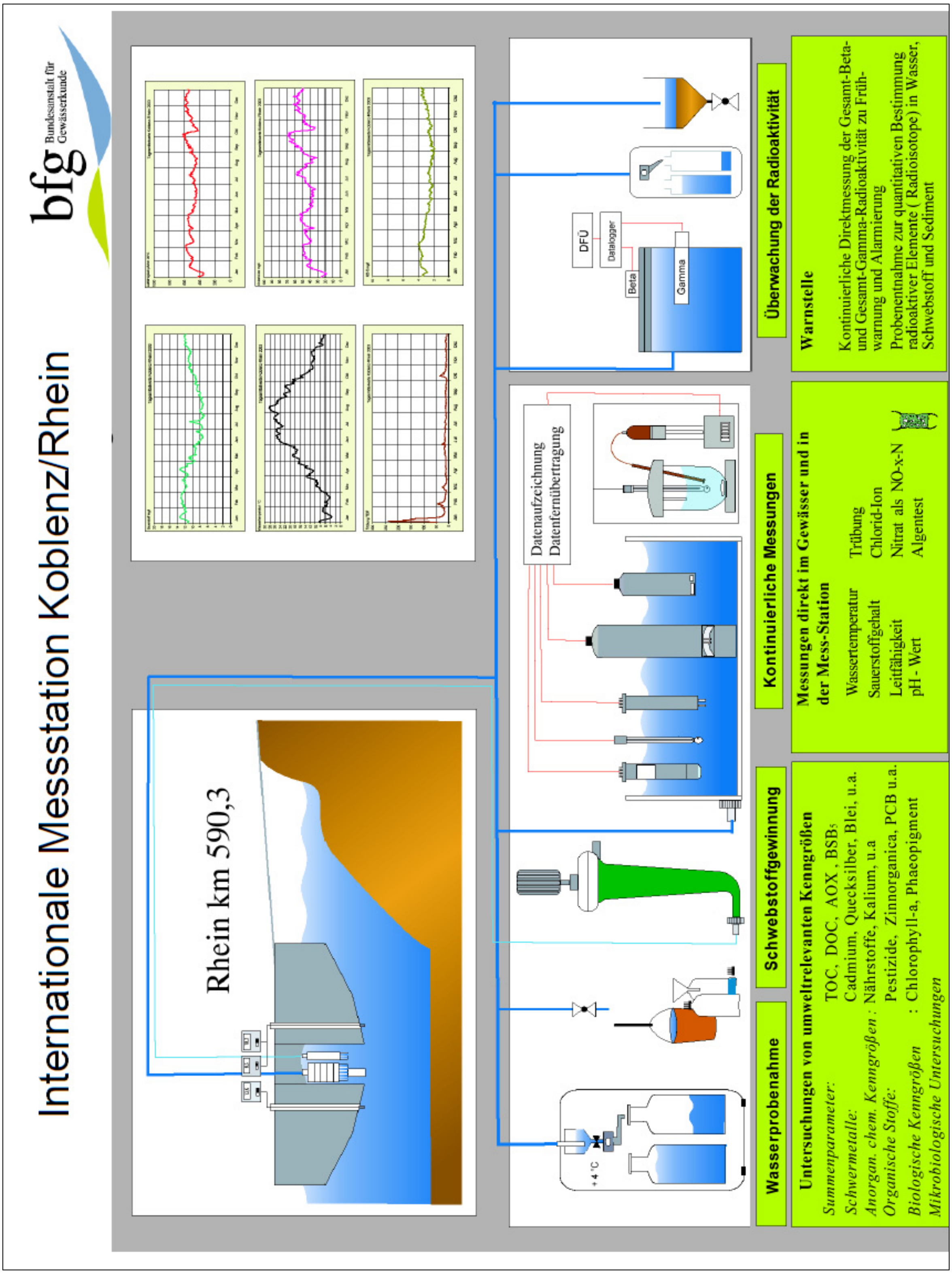

Figure 33 Example of a monitoring station equipped for quality monitoring and warning functions

8.1.1.2.5 Forecast and warning instruments – ALAMO

This section takes a more detailed look at the ALAMO program as an example of a well-functioning software for simulating pollutant waves with a view to speedy forecasting of the impacts of accidental pollution. Similar tools already exist for the Rhine and the Danube, for example. The precautionary planning software "VPS.system" for the German coastal regions, which is described in Chapter 8.1.3.1, also contains a module referred to as "drift model" to predict the spread of oil slicks. A prerequisite for good functioning of such mathematical models is a detailed knowledge of the hydrological conditions in the water bodies to be modelled. The lack of such data for many water bodies is probably a greater problem for the development of these tools than the actual programming work.

The simulation software ALAMO ("Alarm Model Elbe") developed by the Federal Institute of Hydrology[219] serves as a model for forecasting the spread of pollutants in the Elbe. It provides a quick and easy prediction of the distribution of dissolved substances in time and space (transport times and concentrations). The aim is to enable people downstream to take timely measures in the event of an emergency to minimise or prevent consequential damage. The software runs under Windows on conventional PC workstations.

In flowing waters the spread of the pollutant is largely determined by the flow rate. A hydraulic-numerical model was used to work out flow-rate/discharge relationships for the Elbe. The model takes in the stretch from Nemcice (CZ), 249.2 km upstream of the German-Czech border, to the weir at Geesthacht in Germany (just above Hamburg). This is a flow path of around 800 km. For the whole of this stretch it is possible to calculate flow rates and flow times for a discharge range from mean low water (MNQ) to mean high water (MHQ). ALAMO cannot model the conditions in the tidal Elbe downstream from the Geesthacht weir to where it enters the North Sea.

Given the input location, the quantity of substance input, the input time and the flow volume of the water body, ALAMO supports speedy accident appraisal.

[219] http://www.bafg.de

The transport and mixing processes of water-soluble substances in the Elbe are modelled by ALAMO using mathematical descriptions of these processes. The basis for this is an extended Taylor model, as a so-called still water zone model [39][220].

It is possible to obtain a tabular and a graphic description of the accident results. This contains the pollutant concentration results by place and time.

Several marker tests to identify the transport parameters were carried out in the Czech and German parts of the Elbe at different discharge levels. The hydrographic concentration curves generated also served to validate the model. As additional preparatory work for the calibration of the model, a one-dimensional water level calculation was used to re-determine the incomplete and relatively inaccurate water level-flow time relationships, which only then permit successful section-by-section quantification of the three transport parameters “longitudinal dispersion coefficient, still water zone component and still water zone coefficient”. For a total transport time of 250 hours and average discharge conditions, the modelled arrival times are found to show deviations of less than 6 hours from the tracer curves. Relatively large deviations are occasionally found in the follow-up calculations to the measured maximum concentrations, though in marker tests these depend to a large extent on the sampling position within the transverse profile.

It should be noted that at present ALAMO does not take account of specific substance properties; in other words, all substances input into the water display identical dispersion behaviour (e.g. they are completely soluble in water) and the quantity input remains unchanged over the entire distance of the modellable Elbe (i.e. no degradation, no evaporation, no sedimentation etc.). In this respect, the result of the calculation tends to be a worst case view.[221]

Input parameters (variable)

ALAMO performs model calculations on pollutant dispersion in the Elbe after accidents/discharges, provided the following parameters are known:

[220] Ettmer, B., Hanisch, H.H., Mende, M., “Fließgeschwindigkeit und Stofftransport der Elbe”, Die Elbe – neue Horizonte des Flussgebietsmanagements, 10. Magdeburger Gewässerschutzseminar, Teubner Verlag Stuttgart, Leipzig, Wiesbaden, October 2002, ISBN 3-519-00420-8.

[221] Of the two dispersion examples for hexachlorobenzene and a soluble mercury salt which were quoted in the foreword to this part of the report (Chapter 1), the forecasts for the latter were undoubtedly more accurate than those for hexachlorobenzene, which is very reluctant to dissolve and readily becomes attached to particles. The forecasts for the cyanide accident in 2006 were amazingly accurate (see end of this chapter).

- Input location
- Duration of input
- Quantity of substance released
- Current discharge conditions in the water body (alternatively one can fall back on three standard situations: *mean high water (MHQ), mean water level (MQ), mean low water (MNQ)).*

In other words, if all *emission data* are known, the effects of a water accident of known scale can be calculated in advance starting from the emission source, which means that people downstream can be warned if necessary. This is in line with the actual purpose of the software. What is not possible, however, is to perform calculations on the basis of *immission data* only – e.g. concentrations recorded in a monitoring station. Thus it is not possible – at present – either to work back from the individual concentration data and draw conclusions about the location and scale of an accident, or to model the further progress of the pollutant wave downstream from the monitoring site. As an approximation, however, it is possible, on the basis of the monitoring location and an arbitrary assumption about the pollutant quantity, to calculate the travel times of the pollutant maximum and make a rough forecast about the concentration figures, which can be improved by iterative calculations using measured data received from further downstream.

Accident simulations and alarm thresholds

By targeted simulation of accidents/releases, ALAMO permits convenient testing of the suitability and practicability of emission-oriented and immission-oriented alarm thresholds. An example of a simulation of this kind is explained below. We first take a graphic look at the spread of the pollutant wave. This is followed by distance calculations that show how far away water accidents can have effects and on what scale, and when alarm thresholds are exceeded.

Spread of a "pollutant wave"

ALAMO makes it possible to calculate individual concentration profiles for specific times after the occurrence of the accident and at predetermined monitoring sites. By chaining several such calculations it is possible to give a graphic demonstration of the passage of the “pollutant wave” along the Elbe.

The following three diagrams describe the development of the concentration wave after a two-hour release of a total of 100 kg of substance at river kilometre 0 (German-Czech border) under mean low water discharge conditions. (The area below the concentration profiles shown represents the pollutant quantity released, and – under the ALAMO system – remains constant along the entire modellable length of the Elbe.)

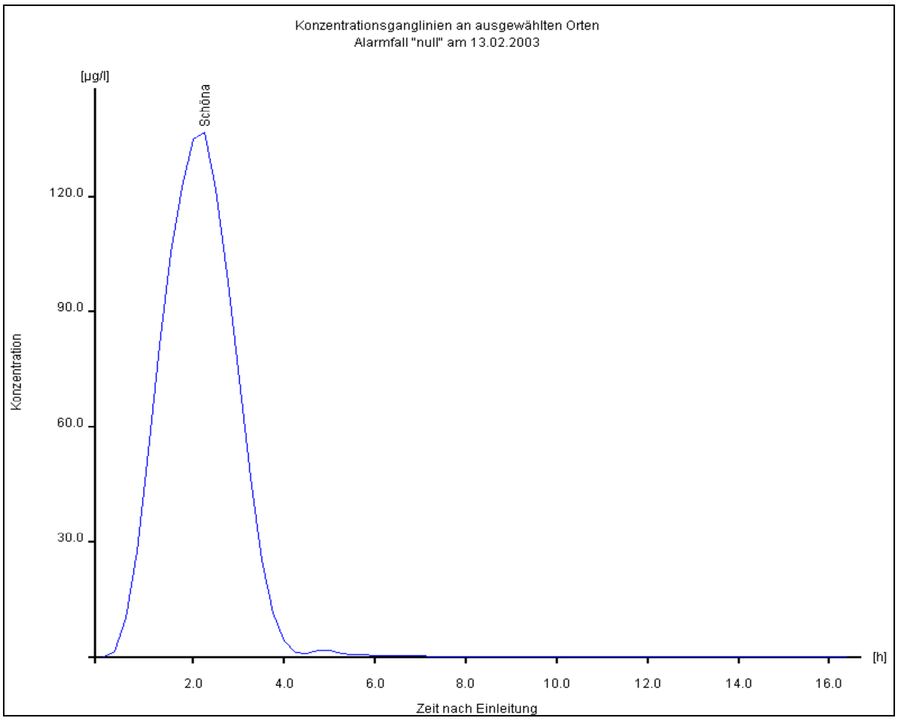

Figure 34 Concentration profile 2 km below the spill site (release quantity 100 kg, release duration 2 h)

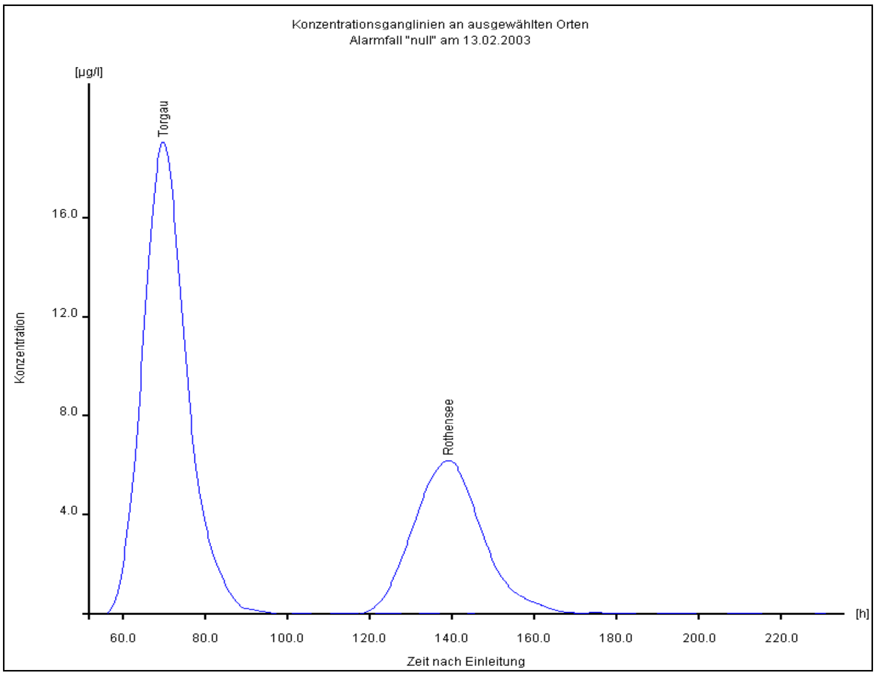

Figure 35 Concentration profiles 150 km and 330 km below the spill site (release quantity 100 kg, release duration 2 h)

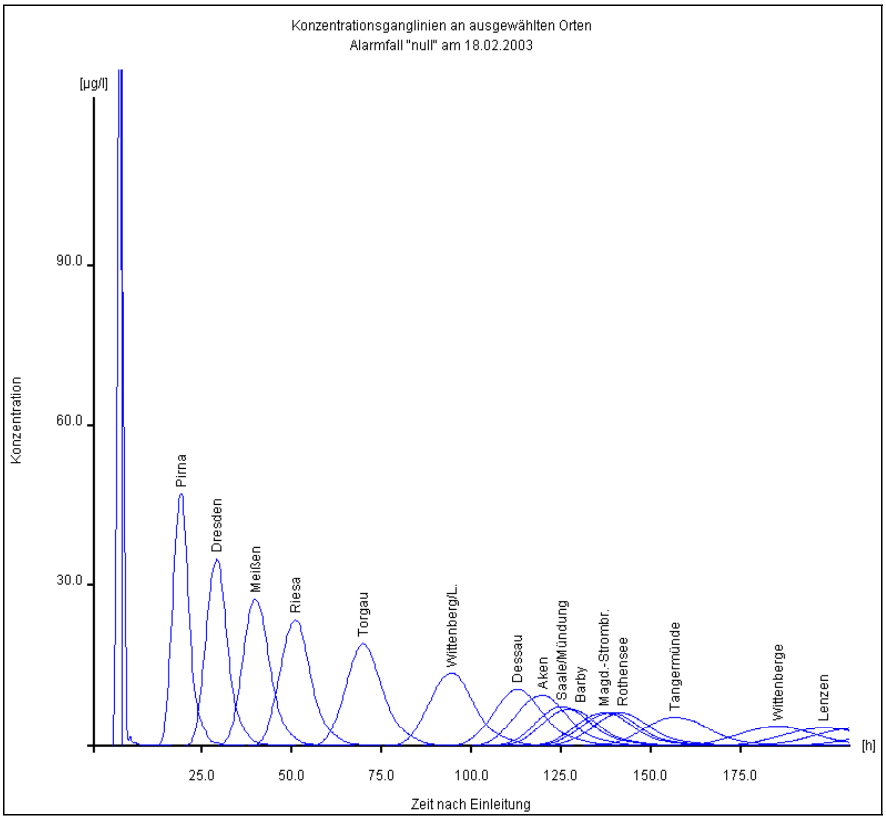

Figure 36 Development of concentration profiles over about one week (quantity 100 kg, release duration 2 h)

It will be seen that 2 km below the release site (at the Schöna monitoring station), the release which lasted for more than two hours has broadened to form a “pollutant mountain” which makes its effect felt on the water for 4 hours (Figure 34). On its way down river it gradually gets broader, and the maximum concentration decreases. After 150 km and 2 1/2 days the exposure time at the Torgau monitoring station is 30 hours, and at Rothensee, after 330 km, it is over 40 hours (Figure 35). After about a week and a further increase in exposure time, the concentration in the water – despite the relatively small quantity of 100 kg released – is still in the region of several µg/l (Figure 36). In relation to many quality standards (e.g. those of the WFD), this may – depending on the substance released – represent a considerable exceedance, even though it may be only temporary. On the basis of a scenario (e.g. Rhine/Maas (NL), Oder, Danube) where drinking water is produced from surface water in a river of comparable size to the Elbe, an accident involving a 100 kg batch of pesticide would have to result in several days’ interruption of the drinking water supply several hundred kilometres downstream from the scene of the accident (assuming EC drinking water limit values). It would seem worthwhile to attempt a more detailed quantification of the impacts of such accident scenarios.

ALAMO can be used to model the “effects” of accidents on the Elbe. In this context, “effects” means the concentration of a substance. Starting from an accident at a particular point on the Elbe, the program calculates the distance downstream until the value falls below a “specified substance concentration” . ALAMO basically allows a free choice of all parameters that are relevant here. The example here is intended to show what influence the release location has on the “effects” of a river accident.

Varying the release location

The range of the accident effects depends on the dilution due to the discharge. Since the discharge of a river increases from the source towards the mouth, accidents have different effects in different places. The red bars in the following table indicate the distance at which an accident involving a two-hour release of 10 kg of substance at the locations Melnik (Czech Republic, Moldau confluence), Schmilka (border CZ/D), Dresden or Torgau gives rise to a concentration of ≥ 1 µg/l in the water (see also Chapter 3.3.4).

Table 22 Distance (red) until concentration falls below 1 µg/l, for release at various locations; quantity released 10 kg, release duration 2 h; discharge: mean low water

Input location (river km)	**Thresh-old [µg/l]**	**Distance from release location in [km]**							
		50	100	145	220	260	300	320	400
Melnik (-105)	1								
Schmilka (0)	1								
Dresden (55)	1								
Torgau (155)	1								

The effect of the dependence on the release location is clearly visible here: whereas a release at Melnik in the Czech Republic means that the concentration does not fall below 1 µg/l until 320 km downstream (i.e. 60 km below Torgau), a release at Torgau has the same effect for “only” 145 km. However, it is striking to note that a release of only 10 kg in Torgau results in a concentration of ≥ 1 µg/l almost as far as Magdeburg, and that the fact that this distance is not longer is largely due to the large quantities of water brought in by the Mulde and Saale.

Appraisal of ALAMO

ALAMO is a useful instrument for estimated forecasts of the dispersion of substances in the Elbe as a result of water accidents at a known time and place and on a known scale. It offers the option of using standard discharge conditions, but also of including individual water level data from the monitoring sites along the Elbe for improved accuracy. It also provides a very “graphic” picture of pollutant dispersion in the Elbe and other comparable rivers. However, one should be aware of the limits that a simplified model of conditions on the Elbe entails with regard to the accuracy of flow times and the concentrations to be forecast. Furthermore, it does not take account of substance-specific properties such as solubility or the “disappearance” of a substance as it passes down the river as a result of degradation, sedimentation, evaporation etc. To this extent ALAMO tends to portray a worst-case scenario, though this does not by any means detract from its usefulness in alarm management.

There are systematic limits to the possibilities of “backtracking” to an upstream accident of unknown scale, location and timing on the basis of measured data. Even here, an iterative trial-and-error method could be used to calculate accidents in the upper reaches that would result in exactly the concentrations found at the monitoring station. However, the data obtainable from a single monitoring station are in principle not sufficient for precise clarification of the causes of the accident (place/time/quantity).

ALAMO application: the example of the cyanide accident in the Czech Republic in 2006

On Monday, 16 January 2006 the German authorities were informed by the Czech authorities about a case of water pollution that had taken place at Nymburk on 12 January 2006, in which cyanide (salt of prussic acid) at a concentration of 500 µg/l had entered the main stream of the Elbe. The report was apparently prompted by observations of fish mortality in the section of the Elbe near Nymburk about 70 km upstream of the confluence with the Moldau. The cause was later identified as a "technical hitch" that took place on 9 January 2006 about 30 km upstream at the chemical factory "LZ Draslovka" in the town of Kolin. No information was available on the total quantity of cyanide released, the maximum concentrations or the concentration profiles in Kolin or Nymburk.

On the basis of the small amount of data supplied by the Czech Republic, the Federal Institute of Hydrology used the modelling software ALAMO to calculate several scenarios for the concentration curve to be expected along the German Elbe. Even if the results calculated were still subject to considerable uncertainties, it quickly became clear that simply because of the considerable dilution due to the Moldau and Eger there was no reason to expect fish mortality or other serious ecological damage further down the Elbe. Various press reports on 17 January said that the pollutant wave was expected to arrive in Saxony starting on 17 January and reaching a maximum of up to 90 µg/l around 19 January. The wave would then reach Geesthacht, just above Hamburg, on 26/27 January with maximum concentrations of up to 15 µg/l. For comparison: the limit value for discharging wastewater is 200 µg/l, and the limit value for drinking water is 50 µg/l, though direct production of drinking water from the Elbe no longer takes place in Germany.

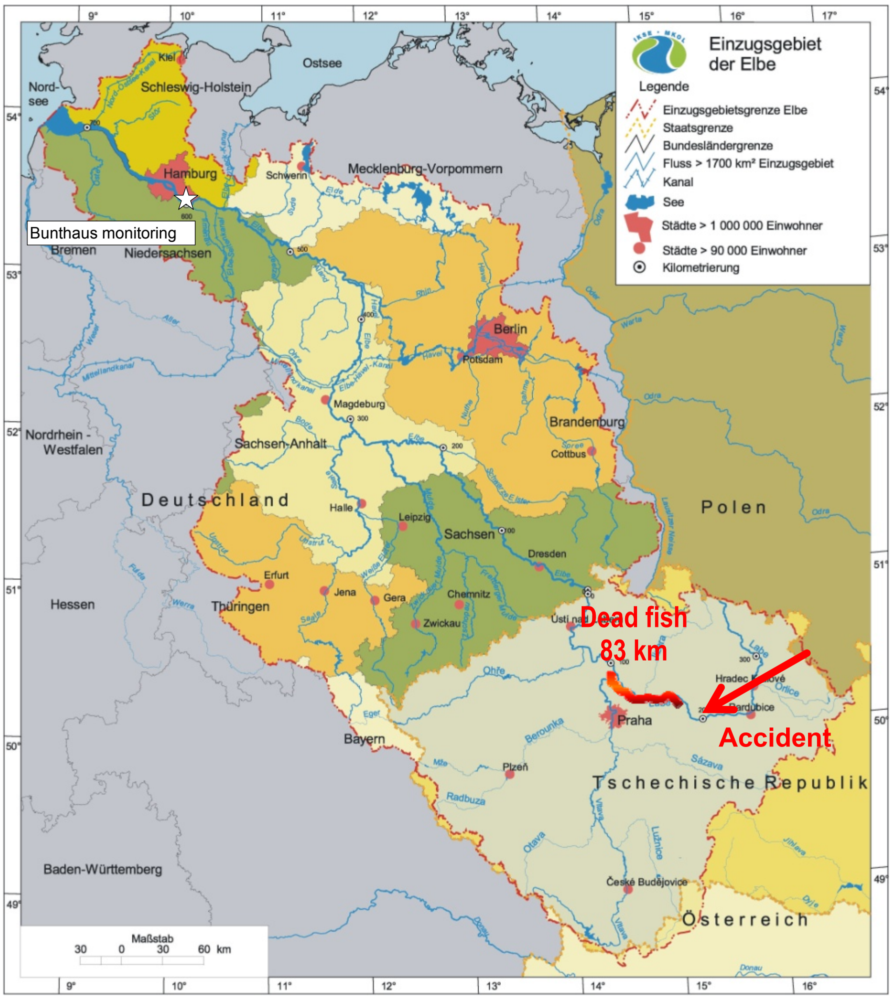

Figure 37 Accident site and Bunthaus monitoring point/Hamburg

However, the accident presented an opportunity to test the reporting channels of the International Warning and Alarm Plan Elbe (IWAE), the forecasting accuracy of ALAMO and the viability of the measuring technology installed along the Elbe.

At the Schmilka monitoring station, near Schöna, which is run by the Saxony State Agency for the Environment and Geology (LfUG Sachsen) and is the German water quality monitoring station closest to the Czech border, samples were taken from the Elbe at 4-hourly intervals on 16 January and tested for cyanide in the laboratory. A significant increase in the cyanide concentration was detected from midday onwards on 19 January and reached its maximum of 29 µg/l in the afternoon of 20 January. By the evening of 22 January the wave had passed through Schmilka. The cyanide concentrations had evidently caused no harm. The deviations from the forecast were explained by the imprecise data situation, especially since ALAMO is not capable of such precise modelling for the Czech part of the Elbe above the Moldau confluence (e.g. numerous weirs).

Fresh ALAMO calculations of the forecast arrival time and intensity of the pollutant wave expected in Hamburg were now made at the Hamburg Institute for Hygiene and Environment using the much more precise Schmilka data. These indicated that the cyanide concentration at Geesthacht, above Hamburg, would start to rise on 28 January and reach a maximum of around 4 µg/l on 29 January (see Figure 38)

These figures would not cause any problems from a toxicological point of view. There was however a problem regarding monitoring of the concentrations in Hamburg, in that the analytical detection limit for cyanide was in the region of the expected measurements, which meant that the passage of the pollutant wave might not even be registered.

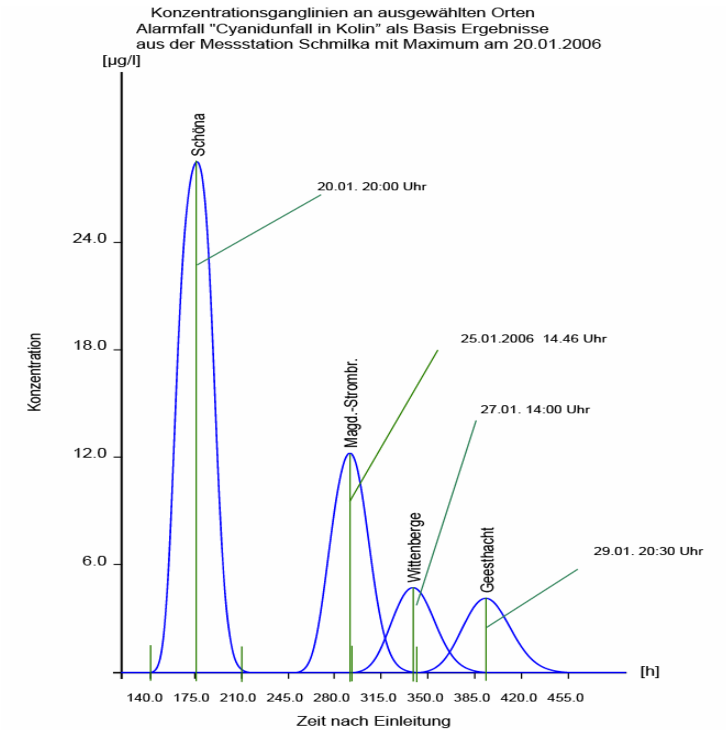

Figure 38 ALAMO calculation of pollutant wave on the basis of the Schmilka/Schöna measurements

At the Bunthaus monitoring station of the Hamburg Water Surveillance System, 25 km downstream from Geesthacht, an automatic sampler was used to take five-hour combined samples, which were examined at the Institute for Hygiene and the Environment. The results are shown in Figure 39.

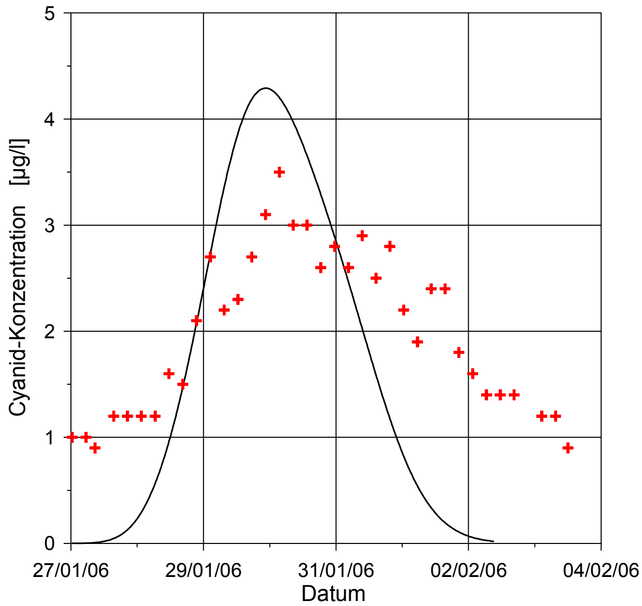

Figure 39 Measured (+) and calculated (line) concentrations at Bunthaus monitoring station/Hamburg

In the early hours of the morning of 28 January the cyanide concentration started to rise. During the night of 29-30 January the maximum of about 3.5 µg/l was reached, and by 4 February the wave had passed through. The asymmetrical curve (sharp rise, gradual fall = "tailing") was to be expected – unlike the model calculation: ALAMO does not represent this effect which is due to the flow movement. The rather "shaky" curve is due to the very low concentrations, close to the detection limit of the measurement method.

The agreement with the forecast is remarkably good – as regards both the timing and the size of the values. The results also demonstrate the high quality and usability of the water monitoring system.

8.1.2 Warning and alarm plans

As a result of conclusions drawn from the analysis of existing International Warning and Alarm Plans (IWAP) on the Rhine, Danube, Elbe and Oder in Chapter 4.3, this section presents suggestions for remedying some of the deficits identified. In particular, they set out to remedy the current lack of an immission-oriented component in the IWAPs. The methods presented here are largely based on developments of the proposals from the EASE project[113].

8.1.2.1 Warning and alarm criteria

Warning and alarm criteria in conjunction with "*significant losses of pollutants*" or "*unexpected water pollution*" (Article I WFD) ultimately mean defining substance-specific thresholds in the form of substance quantities, substance loads and substance concentrations which, if exceeded, give rise to emergency measures, or at least warnings. As an alternative to detecting the specific substances, detection of changes in other parameters or of effects may give rise to a warning. The subject is basically discussed in Chapters 3.2 and 3.3, and the deficits and possible methods of "*detecting such events*" (Article I WFD) are examined in Chapters 4.3 and 8.1.1. It is necessary to make a distinction between criteria that are valid for the potential emitter (*emission-oriented* warning and alarm criteria) and those which apply to water monitoring (*immission-oriented* warning and alarm criteria).

8.1.2.1.1 Emission-oriented warning and alarm criteria

Emission-oriented warning and alarm criteria exist for the Elbe, Oder and Danube on the basis of water hazard classes (WHC) and hence for a very large number of substances (see Chapter 3.3.2.1). The slightly different approach for the Rhine is described in Chapter 4.3. The method is in line with the principle consistently used in installation-oriented water conservation in Germany, namely to classify the water hazardousness of substance-specific installations on the basis of the water hazard classes, which in turn are based on the classification rules of Directive 67/548/EEC. The changes resulting from the enactment of GHS Regulation (EC) 1272/2008 do not conflict with this concept, so it is advocated that it should basically be retained in the (four-)three-stage form for warning and alarm plans as well.

A need for review is seen in two points:

1. It was shown in Chapter 3.3.4 that problems exist in connection with the water hazard classes for a number of substances regarding their compatibility with the immission-oriented environmental quality standards of the WFD. It would also be advisable to investigate whether it is merely a question of correcting a handful of values, or whether there are fundamental conceptual problems here.

2. "Input of a certain quantity of substances dangerous to water leads to different impacts depending on the river, because the effect of the substance depends on the concentration and not the load".[119] This statement dating from 1999 in the report by the Major Incidents Commission at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety led to a suggestion that a discharge-dependent factor be introduced when assessing the seriousness of an accident involving chemicals. Although the demand was no doubt technically correct, there is a danger of the discussion taking a turn which in the final analysis is probably not enforceable: the ultimate consequence of discharge-dependent thresholds is that the smaller the river on which they are located and the further upstream the location is, the more stringent the safety conditions that installation operators will have to satisfy. Nevertheless, the discharge effect should still be taken into account in view of its relevance to giving warning of an event.

8.1.2.1.2 Derivation of immission-oriented warning thresholds

In connection with the discussion of the basic requirements in Article 11 (3) I WFD it was shown that deriving immission-oriented warning thresholds from the established WHC-based emission thresholds is problematical (Chapter 3.3.4). It is therefore suggested that alarm thresholds be derived, with the aid of suitable factors, from generally recognised, preferably legally binding, norms that are based on *concentration details*. One major advantage lies in the ease of understanding the relationship of the alarm threshold to the measured value registered in the station on the one hand, and to the underlying generally recognised norm, which is related to the object of protection, on the other.

Water body and water quality norms lay down substance-specific or substance group specific concentration thresholds, guide values or limit values for the quality of surface waters or process water. Generally speaking, they are specific to the object of protection (e.g. ecology, aquatic communities, fishing, use of drinking water etc.) and are of varying legal relevance (recommendations, ordinances, acts, EC directives etc.). Chapter 3.3.2 mentions not only the WFD (plus “daughter directive” and implementation rules), but also a number of other regulations of differing legal character, such as the EC Fish Water Directive (Freshwater Directive), EC Bathing Water Directive, EC quality requirements for surface waters for drinking water purposes, EC Drinking Water Directive, or the LAWA quality objective figures. Attention is also drawn to various LAWA projects for the development of environmental quality standards.[222, 223]

When deriving warning thresholds from quality standards it must be borne in mind that the figures are usually based on the boundary condition that the object of protection in question will only suffer harm if the relevant quality objective is infringed with lasting effect (for a lengthy period). In the case of the AA-EQS of the WFD, assessment is on the basis of annual means. It is suggested that a factor be used to take this into account. No factor needs to be used if a MAC-EQS figure exists for the individual substance and this is used directly as a warning threshold.

On the basis of monitoring programmes run today and in the past on the rivers to be assessed, we possess a relatively good knowledge of the typical annual hydrographic concentration curves for a large number of relevant river-specific pollutants (and other parameters). If unambiguous identification of sudden events is required, practical considerations will make it necessary to work with warning thresholds that are higher than the kind of figures which normally occur on average for the year and in the “normal annual maximum”. This would also have to be taken into account if, for example, the resulting warning threshold for pollution known to be present in the river exceeded MAC-EQS values.

The path for deriving warning thresholds is outlined in the following basic steps:

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[222] Jahnel, Neamtu, Abbt-Braun, Haak, Gordalla: „*Entwicklung von Umweltqualitätsnormen zum Schutz aquatischer Biota in Oberflächengewässern” im Rahmen des Länderfinanzierungsprogramms “Wasser, Boden und Abfall*”, Länderfinanzierungsprogramm “Wasser, Boden und Abfall”, Engler-Bunte-Institut der Universität Karlsruhe 2003 www.laenderfinanzierungsprogramm.de.

[223] Ohlenbusch, Christian Münch, Jahnel, Abbt-Braun: „*Ableitung von Qualitätszielen für Kandidatenstoffe der prioritären Liste für die EU-Wasserrahmenrichtlinie*”, Engler-Bunte-Institut der Universität Karlsruhe 2001.

1. Selection of suitable concentration threshold or limit value systems for the relevant objects of protection; preferably the AA-EQS figures for the WFD (from "daughter directive" 2008/105/EC; from the river basin specific EQS for determining ecological status; possibly from proposals that are not yet legally binding, such as LAWA research projects[222]); if MAC-EQS values exist for the parameter, they are suitable and should be used as warning thresholds without applying any factors, unless other figures are necessary as a result of Items 2 or 3.

2. For each substance, selection of the "most sensitive" value for the relevant object of protection.

3. Review of the individual figures for "practicability" (e.g. river basin specific special features[224]) and adjustment if necessary; this yields the "<u>base value</u>" of the warning threshold to be derived.

4. Setting the warning threshold value by applying a factor (e.g. 100); <u>no factor</u> when using a <u>MAC-EQS value</u> as warning threshold (unless otherwise decided in Item 3).

The following are examples of how to derive immission-oriented alarm thresholds for a selection of parameters in accordance with the method described in principle above. To this end the legally relevant "water quality concentration standards" for the substances to be assessed are researched and listed. For this purpose the specific legal character of the values (limit value, guideline value, quality objective value, orientation value etc.) is initially immaterial. It is necessary to add data on the measured annual means, minima and maxima for the water body monitored (in this case the Elbe). In Table 24 this has been done for a selection of parameters, supplemented by the proposed alarm threshold values.

In the <u>first step</u>, the environmental quality standards for "good chemical status" and "good ecological status" under the Water Framework Directive (in accordance with Annex V to Directive 2000/60/EC and/or its implementing ordinances and "daughter directive" 2008/105/EC) are taken as a basis for the warning thresholds to be derived.

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224 Example: an alarm threshold value for TBT weighted with a factor of 100 on the basis of the "daughter directive on Priority Substances" (2008/105/EC) would trigger a permanent alarm in the tidal reaches of the Elbe, since the "normal" pollution level here is magnitudes above the figure for "good chemical status".

The second step is to investigate whether other objects of protection relevant to the alarm objective are catered for adequately by these values. In other words, do any protection goals exist which are more sensitive than the ecotoxicity covered by the WFD quality standards?[225] If this check reveals that a lower value is needed here, then this should be taken as the “base value” for deriving the alarm threshold. It may be possible to develop differentiated warning thresholds specific to individual objects of protection and to incorporate these in an appropriate warning and alarm plan with different addressees. It is important here to make critical use of expert knowledge, as lists of standards from different times, sometimes with different intentions, can only be compared to a very limited extent.

The third step is a comparison with the “normal” annual means and maxima occurring in the monitored river[226], to ensure that warnings only result from individual events which are genuine “warning candidates”, and to prevent situations where a “normal river status” that is known to be far from “good chemical/ecological status” results in permanent alarms. What (substance concentration) event counts as a “warning candidate” in this sense, requires critical discussion by experts from the river basin. For example, if the aim is targeted filtering of industrial incidents, the level of the base value may be different from when the alarm is to be triggered by impacts of extreme weather events. It is also possible that for individual parameters the “normal status” of a monitored river may be very much better than “good ecological status” within the meaning of the WFD – here one might consider setting a lower value as the basis for deriving the alarm threshold. The outcome of the considerations in this third step is the real “base value” for deriving the alarm threshold.

To prevent false alarms, the fourth step is to multiply the resulting base values by a safety factor. A safety factor of 100 is suggested. If clarity considerations make it preferable to use a system of alarm thresholds phased by powers of ten, for example, one could classify the base values in accordance with the following scheme and then assign the alarm threshold categories as suggested in Table 23. (Note: Since it is no longer the concrete base value that is weighted with a safety factor, but the lower limit of the base value category with the factor 100 {or the upper limit of the category with

225 For example, some of the ecotoxicological values for pesticides derived from the WFD-EQS are appreciably higher than the 0.1 µg/l limit which applies to pesticides in the drinking water sector regardless of specific toxicological considerations.

226 This data would have to be researched and, if necessary, measured; within the EU its acquisition and documentation was reported to the Commission in March 2005 as part of the “river status description“ in the first implementa-

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the factor 10}, the safety factor varies by one order of magnitude depending on the specific base value.)

Table 23 Suggested phasing of immission-oriented warning thresholds

Base value categories [µg/l]	Safety factor	Alarm threshold [µg/l]
> 0.0001 - 0.001	≥10 - 100	0.01
> 0.001 - 0.01	≥ 10 - 100	0.1
> 0.01 - 0.1	≥ 10 - 100	1
> 0.1 - 1	≥ 10 - 100	10
> 1 - 10	≥ 10 - 100	100
.... continued as appropriate	≥ 10 - 100	… > 1,000

Table 24 illustrates the procedure for deriving the immission-oriented alarm threshold for an arbitrary selection of substances (Column 1). Column 2 contains the relevant quality standards from the “Chem” and “Eco” lists of the Water Framework Directive (Table 6, p. 78 and Table 8, p. 82) as starting points for derivation (Step 1). Columns 3 - 5 contain a selection of other value lists that need to be taken into account – here the Drinking Water Ordinance (as an example of the decision in Step 2) and, from the water monitoring programmes, the minimum and maximum concentrations found in the Elbe in 2001 between the German/Czech border (Schmilka) and Hamburg (Seemannshöft) (for Step 3). To determine the base value (Column 6), the “WFD values” are taken as a basis for investigating whether all potential “water users” have been given sufficient consideration (Step 2). For example, if drinking water use is to be included in the alarm, one would have to select the value from Column 3 if it is less than the value in Column 2 (e.g. for benzene). Where the WFD does not (as yet) lay down a value, it would also be necessary to select from Column 3 a value for the specific object of protection (in this case, for example, the Drinking Water Ordinance for biocide products). A similar procedure would have to be adopted if other lists of values or measured data needed to be taken into account.

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tion phase of the WFD; in future, further data will result from the monitoring programmes which have been running

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Table 24 Procedure for deriving immission-oriented warning thresholds [µg/l]

Values in [µg/l]	Initial value	Other values to be taken into account (selection)			Base value	Alarm thresholds			Comparison with Rhine
Column No. ► 1	2	3	4	5	6	7	8	9	10
Parameter measured ▼	WFD Chem-/ Eco list	Drinking Water Ordinance	Elbe 2001 km 0 - 629 Minimum	Elbe 2001 km 0 - 629 Maximum		Factor 100	Factor 10	Phasing basis	Alarm warning Bimmen/ Lobith
Cadmium	0.45	5	< BG	0.2	0.45	50	5	**0.45**	3
Mercury	0.07	1	< BG	0.07	0.07	7	0.7	**0.07**	1
Benzene	50	1	< BG	1.2	1	100	10	**50**	3
1,2-dichloroethane	10	3	< BG	0.98	3	300	30	100	3
Hexachlorobenzene	0.05		< BG	0.019	0.05	5	0.5	**0.05**	0.5
Benzo-(a)-pyrene	0.05	0.01	0.001	0.039	0.01	1	0.1	0.1	3
Parathion-methyl	0.02	0.1	< BG	0.039	0.02	2	0.2	1	0.5
Other pesticides, per		0.1	< BG	0.2	0.1	10	1	1	0.5
Biocides, per		0.1			0.1	10	1	1	0.5
Σ [pesticides + biocides]		0.5	< BG	0.664	0.5	50	5	10	
Nitrate	50000	50000	8000	23500	50000	5000000	500000	1000000	

red figures: MAC-EQS under Dir. 2008/105/EC (see Table 6, p. 78)

The third step is concerned with testing practicability, and consists in comparing the value with the values actually occurring in the river in question. Here we can see in the maxima (Column 5) a slight exceedance of the Drinking Water Ordinance values for benzene and the WFD values for benzo-(a)-pyrene and parathion-methyl (grey fields), but in the weighing-up process this need not lead to a correction of the base value. Finally, the fourth step is to take the calculated base value from Column 6 and apply a safety factor to arrive at the actual warning threshold. This example shows the alarm thresholds that result from using the factors 100 (Column 7), 10 (Column 8) and phasing in accordance with the procedure in Table 23 (Column 9). MAC-EQS values are entered in red; no factor is applied to these. For comparison of the magnitudes involved, Column 10 shows the warning thresholds agreed for the Rhine at the German/Dutch border (monitoring station Bimmen/Lobith, see Table 12).

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since 2007 in accordance with Article 8 WFD.

8.1.2.2 "Three pillar model" – Immission-oriented and emission-oriented IWAP

In Chapter 4.3 it was pointed out that a major deficit of existing International Warning and Alarm Plans (IWAPs) was that they are (almost) entirely emission-oriented, i.e. they can only process notifications from polluters. The river basin commissions are well aware of this shortcoming; for example, the EASE project[113] has found its way into the work of the expert committees of the ICPER. The ICPR is also discussing the possibility of including the immission path in the IWAP (Figure 40). Implementation plans regularly fail because of the costs issue combined with the fact that this is not regarded as a mandatory legal requirement.

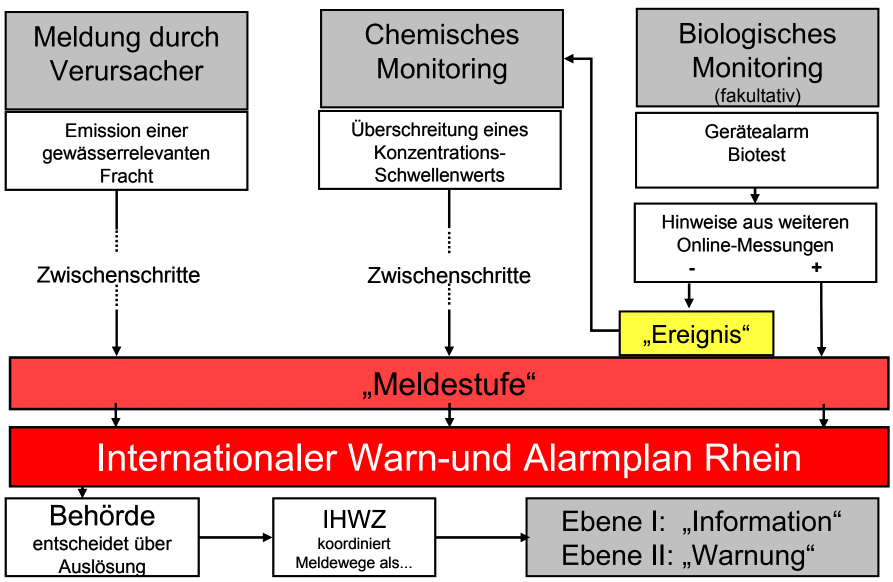

Figure 40 "Immission extension" under discussion for the Warning and Alarm Plan Rhine

In our opinion, the "*systems for timely detection and early warning*" referred to in Article 11 (3) l WFD definitely require the use of immission-oriented monitoring systems. Accordingly, they should be integrated in the IWAPs as additional "pillars":

1st "classic" pillar:	Notification by polluter
2nd pillar:	Chemical laboratory analysis
3rd pillar:	Monitoring by automatic measuring stations

The following figure shows a schematic “three-pillar model” for a warning and alarm plan taking account of both immission-oriented and emission-oriented criteria.

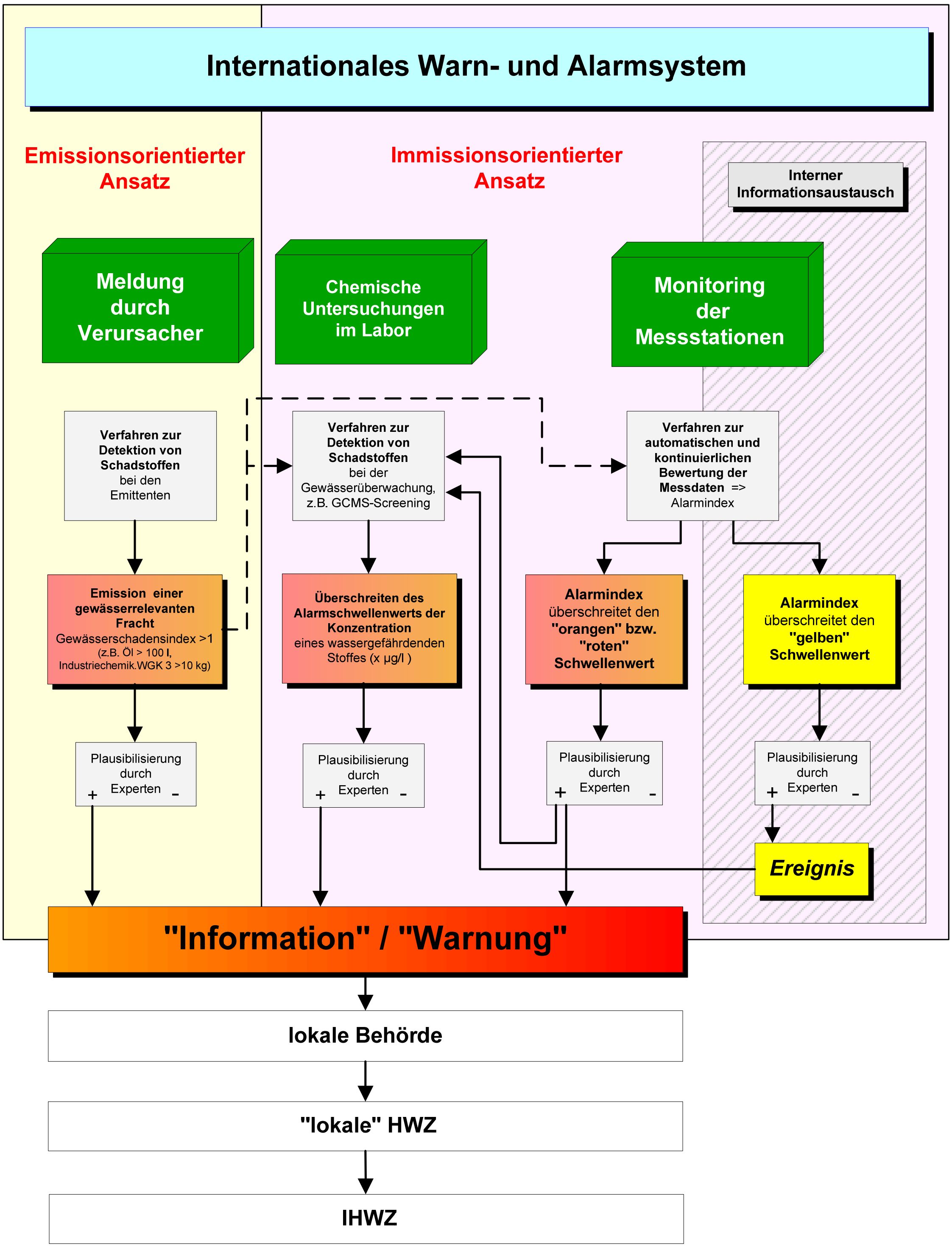

Figure 41 Three-pillar model for warning and alarm plans

Figure 41 provides a schematic description of the three ways to trigger warning and alarm messages within warning and alarm plans: On the left, on a yellow background, is the *emission-oriented* approach, which is based on notifications by the polluter. Here the alarm criteria are based on the quantities of substance emitted into the water body. On the right are the two *immission-oriented* paths. These take account of alarm criteria that are based on or derived from substance concentrations (pink background).

If water pollution or water changes due to substances dangerous to water are registered, the emission-oriented and the immission-oriented approach should be able to result in a message being sent to the reporting system. The criteria for triggering warning messages for all paths must be defined in the warning and alarm plans.

One major element of optimised warning and alarm plans is a modern communications management system.

8.1.2.2.1 First pillar – Notification by polluter

The first, “classic” pillar in Figure 42 gives a schematic outline of the existing emission-oriented model of the kind described in Chapter 4.3 for the Elbe, Oder, Danube and Rhine. Methods for detecting pollutants (or other incident-relevant parameters) at the emitter can be used to identify emissions of water-relevant pollution loads. These detection methods may be analytical methods, or simply individuals who have observed the discharge of a water-endangering substance.

If a substance dangerous to water enters the water in quantities of significance for notification, this information must be fed into the reporting path of the warning and alarm plan. The necessary alarm criteria must be defined and must be documented in the warning and alarm plan; e.g. on the basis of water hazard classes. In addition to the quantity of substance emitted, hazard assessment should also take the local river discharge situation into account as far as possible.

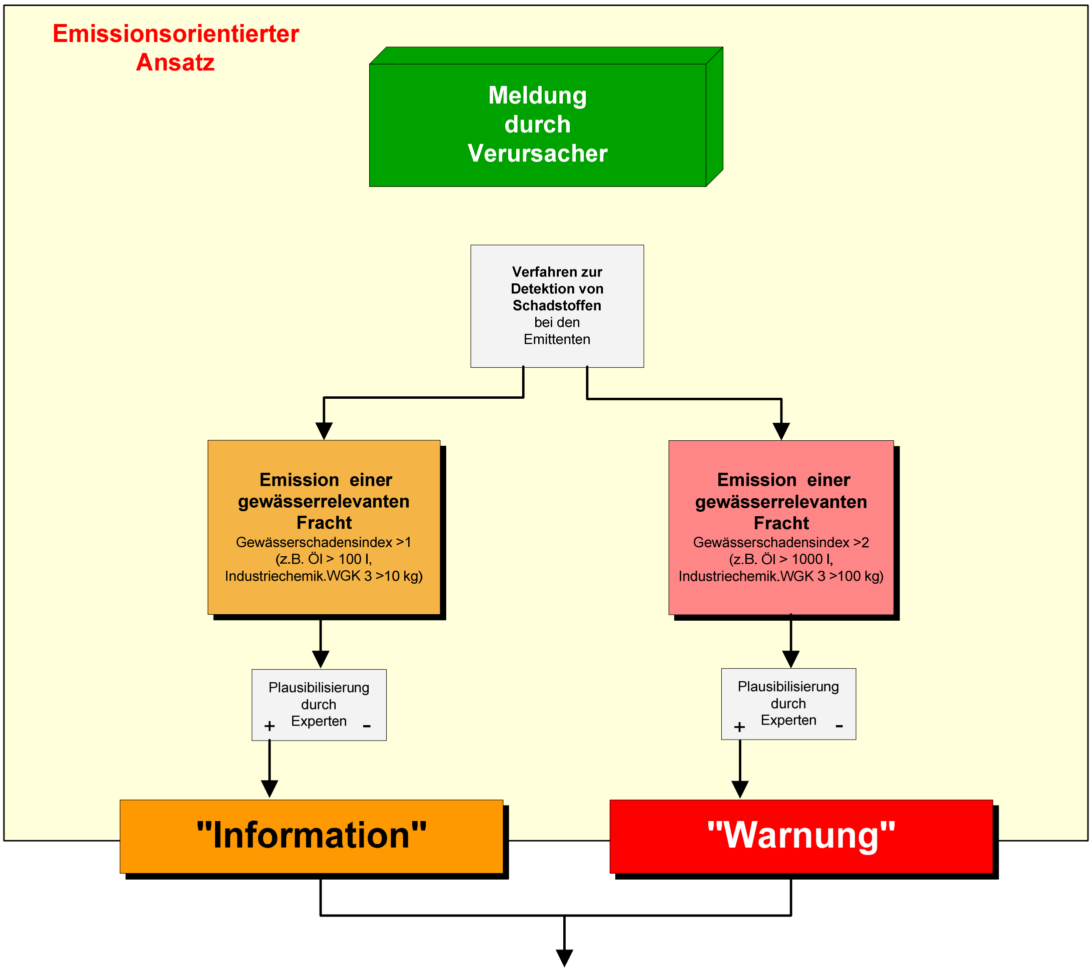

Figure 42 First pillar – Notification by polluter (example with information and warning stage)

8.1.2.2.2 Second pillar – Immission findings by laboratory

Following notification by the polluter, it is expedient to have laboratory tests made further downstream. On the basis of the findings it is possible to make detailed statements about the scale of water pollution and pollutant dispersion, permitting more precise risk assessment and targeted warnings.

The possibility of immission-oriented laboratory tests is the "second pillar" of the "three-pillar" warning and alarm plan. It can be triggered not only following notification by the polluter, but also in response to a finding from the "third pillar", the "systems for timely detection and early warning" that are also installed on the immission front, i.e. the automatic monitoring stations. “Chance findings” obtained in the course of quality monitoring may also result in a message.

The reporting criteria of the “immission-oriented pillars” are derived on the basis of substance concentrations (see Chapter 8.1.2.1.2) and must also be defined and documented in the warning and alarm plan.

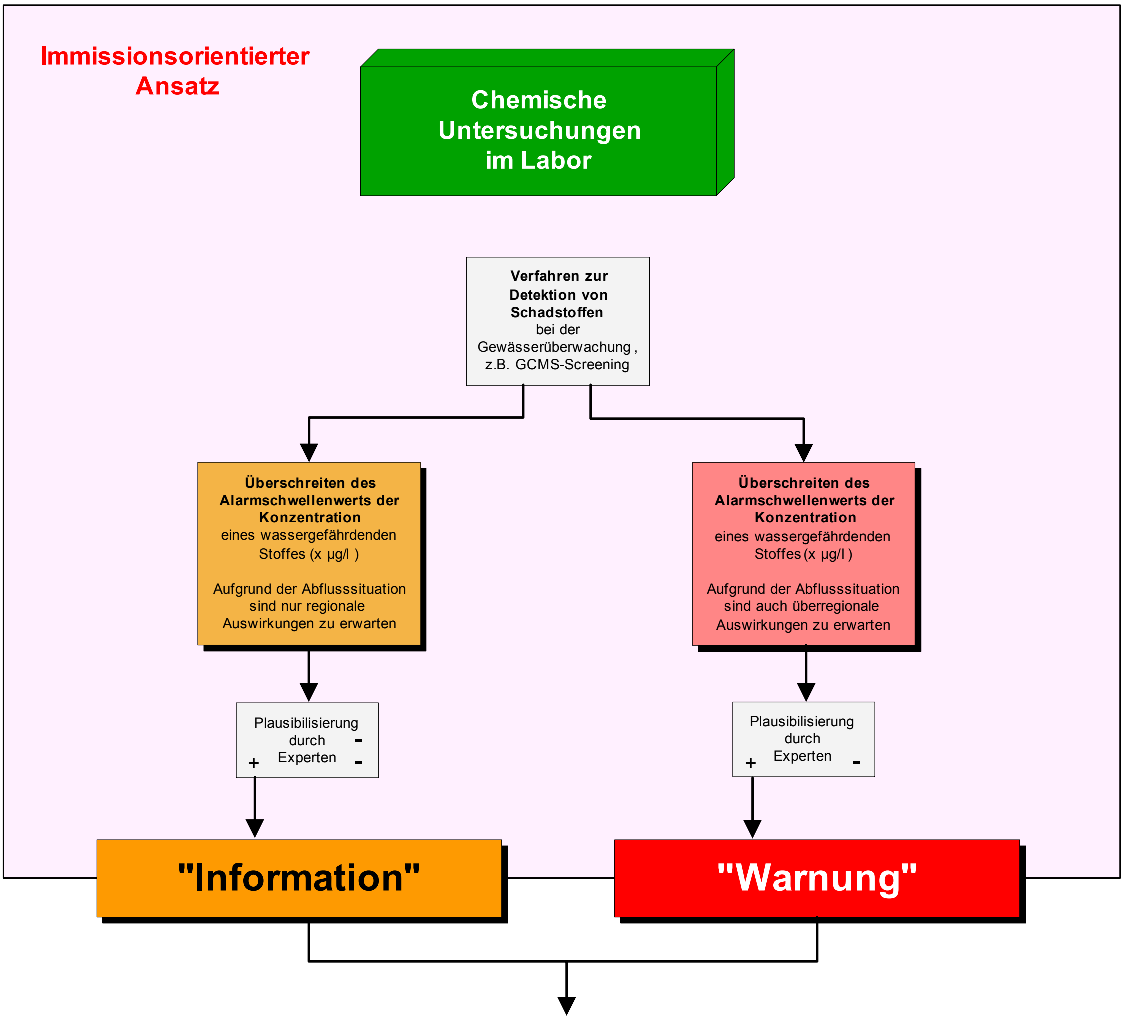

Figure 43 Second pillar – Immission findings by laboratory

8.1.2.2.3 Third pillar – Automatic monitoring stations

Continuously operating monitoring stations[227] can continuously ascertain measurands or quality criteria for determining the status of the water body. Permanent analysis and evaluation of the measured values makes it possible to identify unusual water levels or water pollution at a very early stage. The methodology of event identification using the dynamic unusual events test and alarm index (AI) was described in principle in Chapter 8.1.1.2.

A three-stage alarm system internal to the station or monitoring network is proposed for assessment of measured data by means of alarm index. The first stage would be a station-internal event identification message, and the next two – individually defined – warning stages would be for reporting to the IWAP (established IWAPs have two stages: “information” and “warning”). Depending on which of three phased alarm thresholds the alarm index exceeds, it may trigger a “yellow”, “orange” or “red” alarm.

“Yellow alarm”:

If the alarm index exceeds the “yellow alarm threshold”, the status “event” is reached after a plausibility check by the competent expert. The expert plausibility check is necessary to rule out the possibility that a malfunction or operating problem at the station has given rise to an erroneous reaction of the alarm index. In the first instance, “events” merely serve the purpose of internal exchange of information between the competent bodies. The “event” draws prompt attention to unusual changes in the body of water. As a rule, however, it is not yet possible to draw any concrete conclusions about the danger to water. An “event” should be followed by appropriate investigations into the cause of the accident (“Second pillar”); ideally, sampling should be triggered automatically by the station computer on an event-controlled basis. The results of the laboratory analysis (immission warning thresholds exceeded) may subsequently raise the message status to “information” or “warning”.

[227] “Continuously operating monitoring stations” will usually be “automatic monitoring stations” – in principle, they could also be implemented if permanently manned.

"Events" should be well documented and statistically recorded. Comparative scrutiny of "events" over long periods may reveal systematic connections, which may for example provide pointers to illegal discharges. The analysis of events can also make an important contribution to assessing the long-term development of the flowing body of water.

„**Orange alarm**":

If the alarm index also exceeds the "orange alarm threshold", the status "information" is reached after a plausibility check by the competent expert. In view of the kind of measuring equipment that resulted in the "orange alarm" (e.g. equipment in line with Stage 5 in Table 20), the probability of a hazard to the water body is great. The message status "orange" results in the message being passed on to the reporting system of the warning and alarm plan.

To clarify the origin of the water pollution, a subsequent follow-up analysis should also be performed in the laboratory ("Second pillar") to determine the nature and concentration of the substance input into the water.

"Red alarm": If the alarm index finally exceeds the "red alarm threshold", the status "warning" is reached after a plausibility check by the competent expert. In view of the kind of measuring equipment that resulted in the "orange alarm" (e.g. equipment in line with Stage 5 in Table 20, plus a biomonitor), it can be concluded that there is a hazard to the water body. This message status results in the message being passed on to the reporting system of the warning and alarm plan.

To clarify the origin of the water pollution, a subsequent follow-up analysis should also be performed in the laboratory ("Second pillar") to determine the nature and concentration of the substance input into the water.

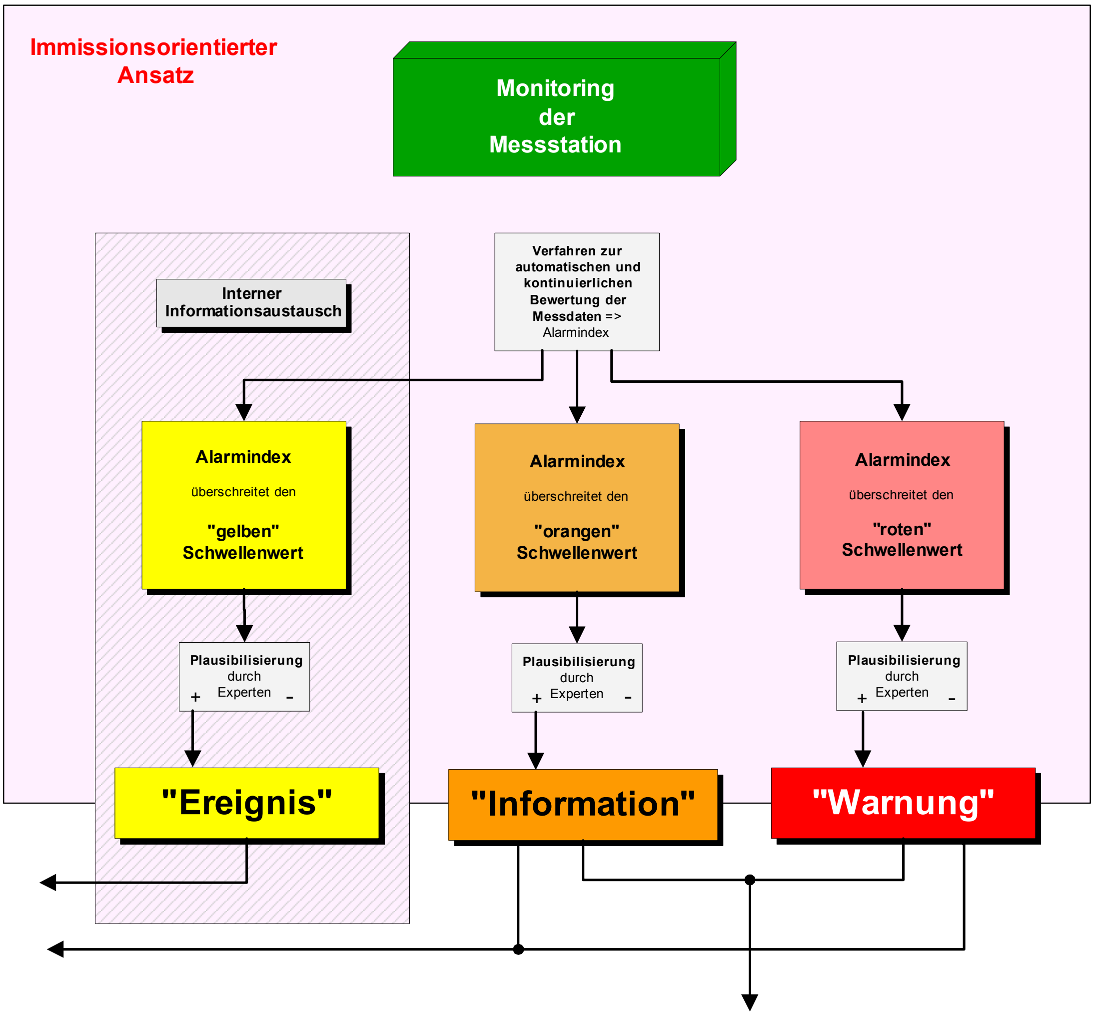

Figure 44 Third pillar – Messages from automatic monitoring stations

8.1.2.3 Warning and alarm communication

Once water pollution has be detected in accordance with the criteria defined in the warning and alarm plan, steps must be taken to ensure that the information about the danger is distributed so as to permit timely warning of water users and immediate initiation of response measures. The group of recipients must be clearly defined in the relevant warning and alarm plan.

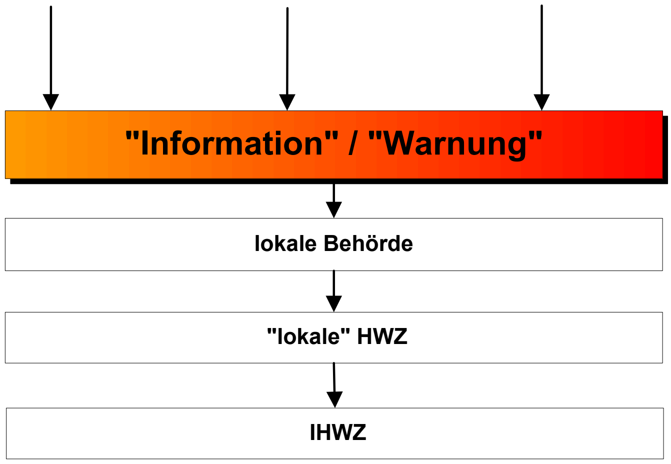

Figure 45 "Reporting chain" for passing on information

A basic requirement for the smooth flow of communications is the establishment of "alarm centres" at installation level, (regional) administrative level and river basin level. It must be ensured that all information of relevance to alarms is immediately forwarded to the appropriate group of recipients. Round-the-clock (24/7) alarm readiness is therefore essential.

In the Warning and Alarm Plans for the Elbe, Oder, Danube and Rhine, the forwarding of information from the competent local authority is coordinated by "warning centres" and "international warning centres" (Figure 45). Warning centres are typically located at police stations, because 24-hour manning is guaranteed here. The messages are mostly passed on using standardised fax messages which are sent successively to the various recipients in a "reporting chain".

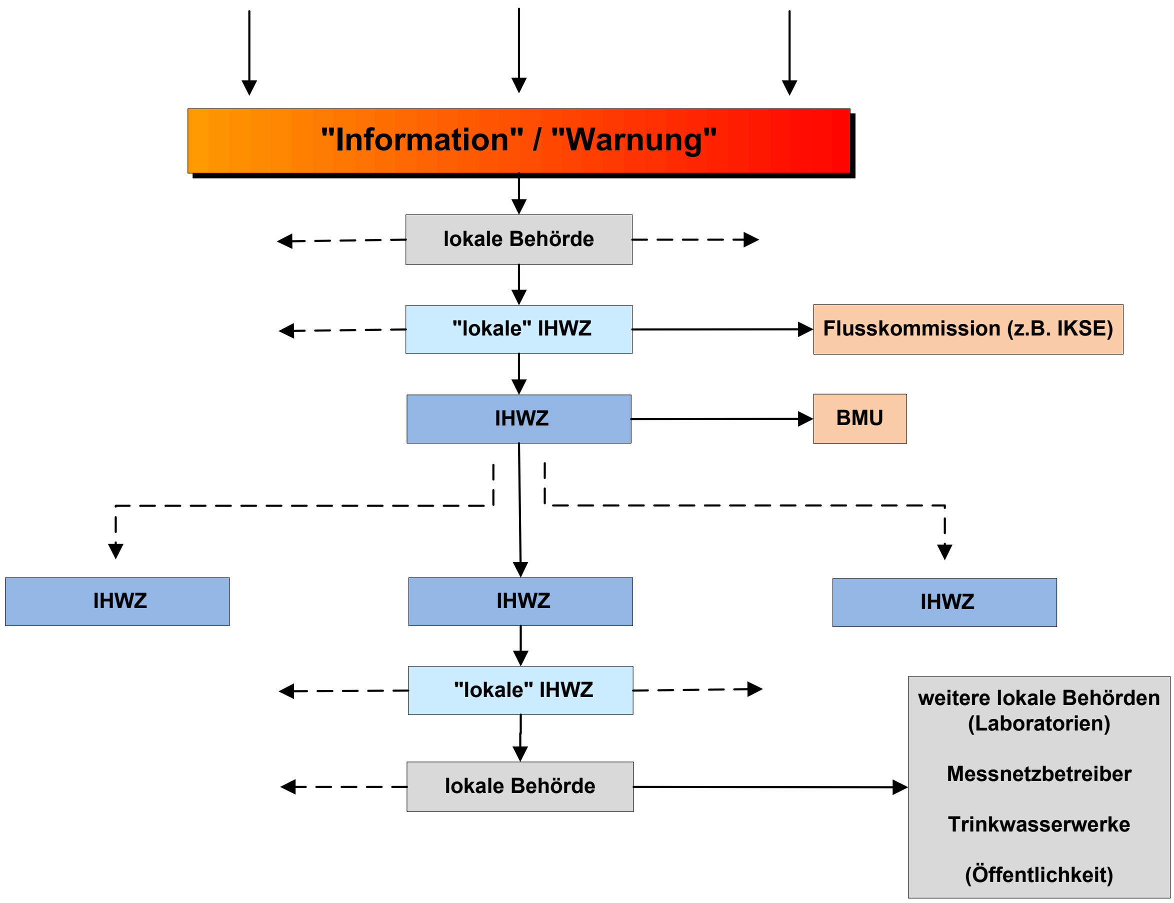

Figure 46 Possible communication paths for warning and alarm messages

Experience has shown that this kind of communication does not yield optimum results. Manual forwarding of individual faxes causes delays which increase with every additional recipient. The system presupposes that the fax machines are monitored by personnel on a round-the-clock basis. The visual quality of the faxes declines with every recipient; they may eventually become illegible. Queries are only possible on a one-dimensional basis back along the reporting chain. Answers and other information of importance to all concerned have to use the same reporting cascade, with the familiar delays it involves. With complex large-scale incidents, it is possible that very large numbers of faxes may be needed to communicate the state of events and integrate all concerned in the flow of information (Figure 46).

However, an ideal communication system needs to ensure a rapid, unbroken and largely simultaneous flow of information between all concerned. It therefore seems logical for alert management purposes to use modern web-based communications systems of the kind currently used in the Dutch system of water bodies in particular.[170] Messages can be entered in a web interface using an internet-based information system. The system then immediately informs all further competent bodies, e.g. by mobile phone text message, that there is a message waiting in the warning and alarm system, thereby ensuring speedy forwarding of the information. All following measures can be seen at all times and are visible at a central point. This makes it possible to ensure rapid and comprehensive alert management (Figure 47).

Web-based alert systems can therefore be recommended for all warning and alarm plans; they offer:

1. Speedy and simultaneous information for all parties concerned,
2. The ability for all parties concerned to enter information in the alert system,
3. Central collection of all information, which can be seen by all parties concerned at any time,
4. Optimum documentation of the incident,
5. Theoretically unlimited number of participants.

Trouble-free integration of additional tools is also possible, e.g. automatic translation of texts into multiple languages, which helps to avoid misunderstandings in the case of transboundary water pollution. Databases for dangerous chemicals can support hazard assessment; systems like the precautionary planning system described in Chapter 8.1.3.1 can be directly integrated.

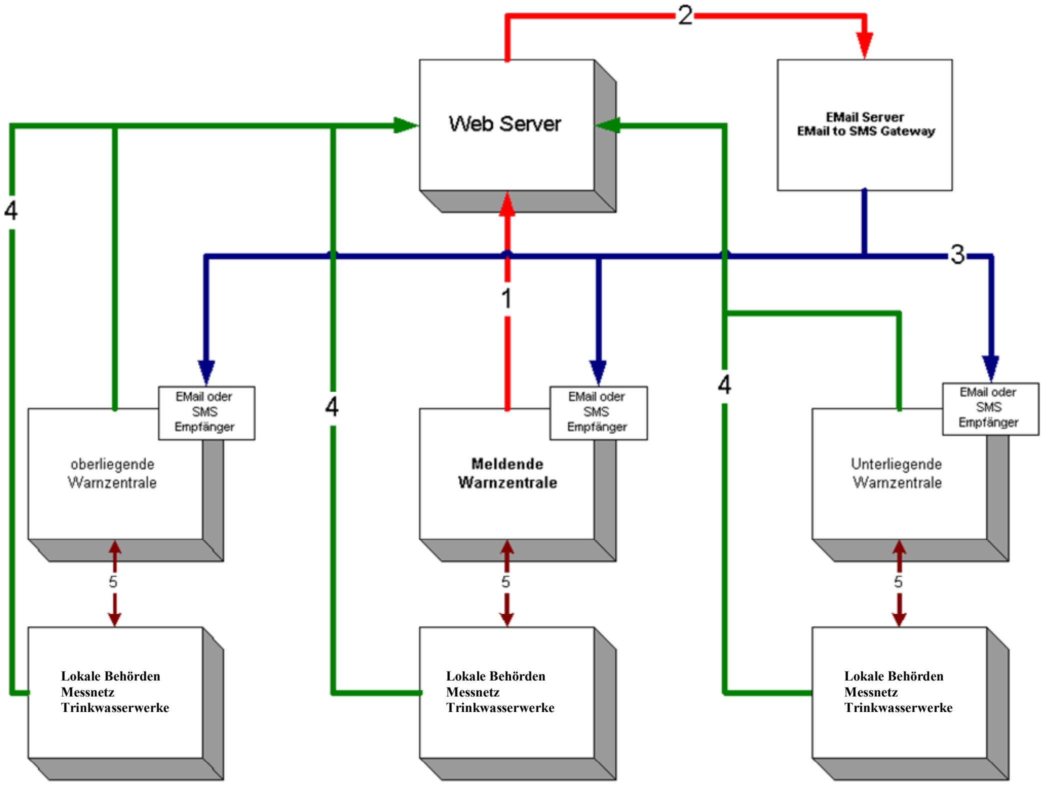

Figure 47 Web-based warning and alarm communication system

8.1.3 Protective planning

Protective planning embraces all organisational and technical measures that are necessary for a speedy and appropriate response in the event of an incident. It should be geared to the entire river basin, and also locally to (installation-related) safety hazards and objects of protection. Responsibilities, competencies and duties have to be regulated; the availability and readiness of technical facilities, equipment and emergency personnel must be ensured. Basically this is not a new requirement of the WFD, and it can be assumed that the Member States have made appropriate preparations at least in regions known to be critical. The legal basis was originally of largely national origin, even if corresponding obligations also have to be derived from the Seveso-II Directive[30] or the IPPC Directive[32]. To this extent the details of this topic are not the subject of this project. A new aspect is that Article 11 (3) I WFD and the WFD in general place the focus on the river basin as a whole. Whereas in the past there has tended to be a differentiation into more national measures and those that were specifically concerned with transboundary incidents, the WFD seeks to gear the management plans – and the associated protective planning – to the entire river basin regardless of national borders. To this end there is a need for improvements, not only in international networking, but also at national level when it comes to integrating authorities in the fields of installation safety/immission control with those in the fields of water conservation and also internal safety/disaster control.

As a example of *technical* networking of a wide variety of agencies, technologies and above all data, the next section describes the computer-aided precautionary planning system of the German coastal states – VPS.system – as a protective planning system that is up and running.[228] Other examples of highly integrated networked protective planning systems can be found in the Netherlands, for example, where the dependence of drinking water supplies on the surface water regime of the Rhine makes it necessary to rely on a very prompt, error-free response in the event of accidents etc.[170]

8.1.3.1 Precautionary planning system (VPS)

Some of the world's most frequented shipping routes run close to Germany's North Sea and Baltic coasts. The high density of shipping traffic calls for effective precautionary measures, particularly to protect the environment from the hazards that arise from this traffic.

Pollution of the sea and beaches with oil and chemicals is inevitable. For this reason the environment ministries of the German coastal states, in conjunction with the Federal Ministry of Transport, Building and Urban Affairs, have drawn up a plan for the entire German North Sea and Baltic coast which supports land-based measures to manage a pollutant accident.

The overall project 'Pollution Incident Control Plan' encompasses designing the content of the precautionary plan, creating the technical facilities for its implementation, and finally collecting all relevant technical data along the approximately 3600 km of Germany's North Sea and Baltic Coasts.

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[228] Hamburg Ministry for Urban Development and the Environment, Incident Management, *Vorsorgeplan Schadstoffunfallbekämpfung für die deutsche Nord- und Ostseeküste - vps09 - das elektronische Vorsorgeplanungssystem*, www.vps-web.de.

The software *VPS.system*, which is the electronic vehicle for implementing the precautionary plan, has been in operation since the year 2000. In 2009 it was repeatedly updated to take account of the changes in the organisational and technical conditions resulting, for example, from the needs of the Shipping Accident Command in Cuxhaven and the growing international interest in this software.

The creation, maintenance and use of VPS.system are part of the strategy of the coastal states and the federal authorities for meeting expectations with regard to sustainable precautions for disaster control, and also for "minor" pollution accidents near our sea coasts.

Following are some of the main specifications, but by no means all:

Data and information

One important function of VPS (**V**orsorge**P**lan **S**chadstoffunfallbekämpfung) is to collect, store and present information which is directly necessary or could be indirectly useful for controlling pollution incidents in coastal areas or ports and at sea. The data available includes:

- alphanumeric data,
- geodata,
- text, photos and graphics.

Alphanumeric data describe a broad spectrum of properties of sections of the coast, incident control equipment, protected areas, alarm plans etc. The information is stored in a database and displayed in a wide range of forms. Access to the data is via the convenient VPS.system (see Chapter 8.1.3.1).

The database includes the data on all technical equipment and vessels and their locations (equipment depots, berths, airfields). The following three figures show examples of screenshots from the vps equipment database for the oil spill vessel "Thor":

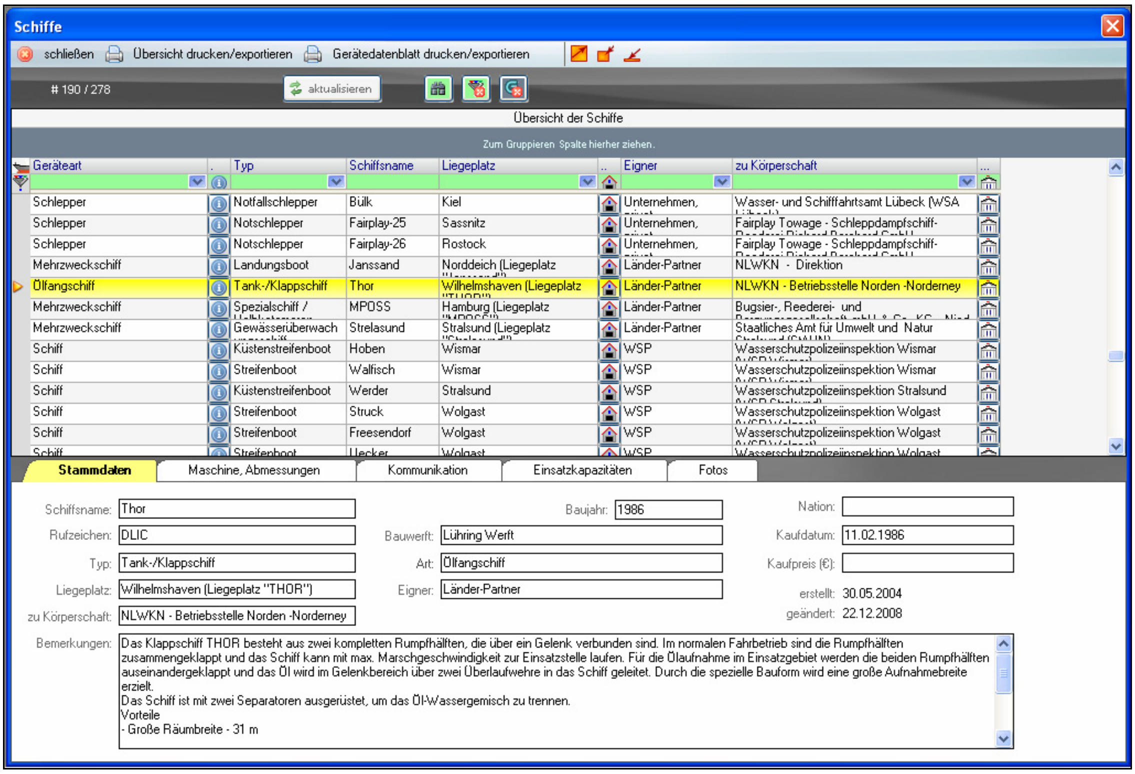


Figure 48 VPS screenshot – Equipment data master directory (excerpt)

Figure 49 VPS screenshot – Photo of oil spill vessel "Thor"

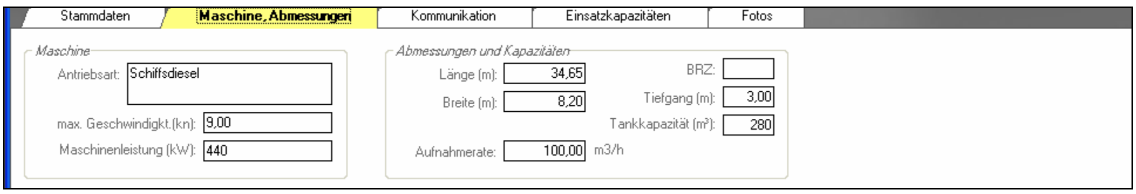


Figure 50 VPS screenshot – Data on oil spill vessel "Thor"

The VPS database also includes an extensive collection of addresses (with more than 3300 addresses, phone and fax numbers, e-mail addresses and other communication options) and detailed information on coastal and control sections.

The database user interface is organised by means of Explorers. The following figure shows the Explorer for coastal and control sections. By clicking on the desired coastal or control section, the user can access the full data record, a corresponding photo documentation, and the relevant protected areas for the control sections.

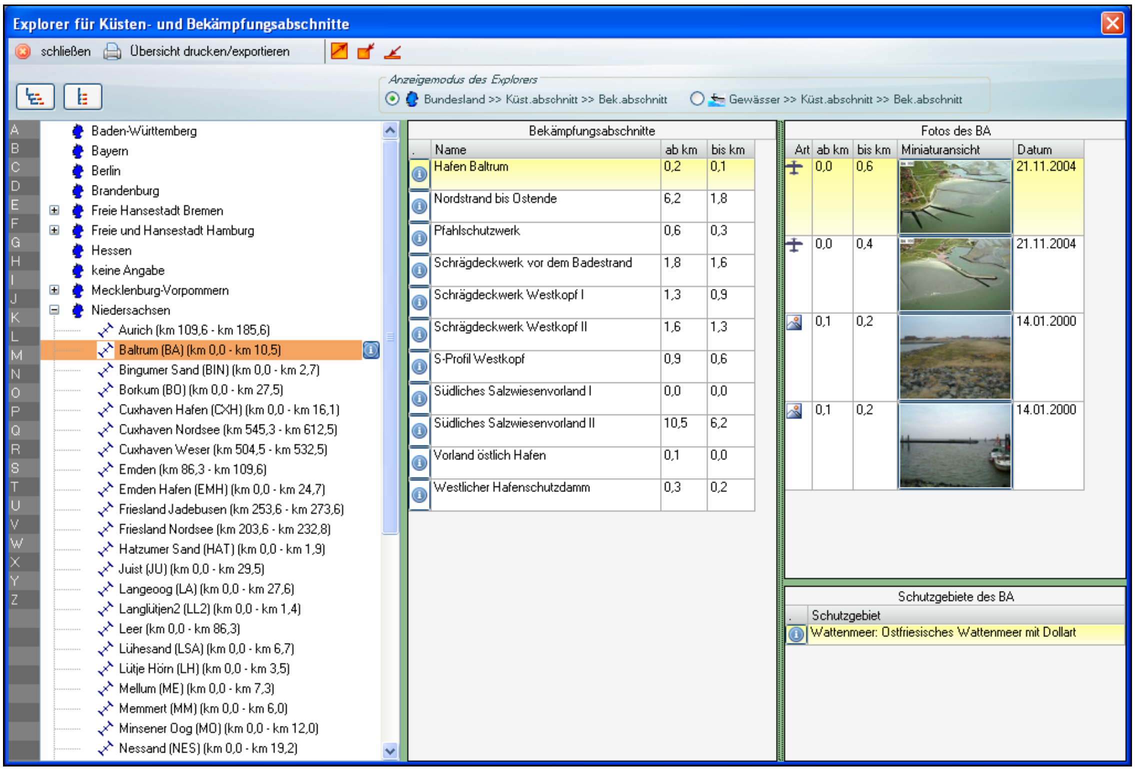


Figure 51 VPS screenshot – Explorer for coastal and control section – Lower Saxony/Baltrum

Geodata comprise the elements of the land map and sea chart, orthophotos and the geodata containing information of incident control relevance in coastal areas. The user is given access to the geodata by means of the GIS module in VPS.system, and also enabled to evaluate them.

The thematic map layer can be used to display a variety of data. In addition to the coastline kilometre geodata, this could for example be information on the competent authority for the relevant coastline section. To make it possible to visualise the great wealth of information, a special symbol set was developed for VPS.system.

To view the geodata for a specific coastline section, one starts with an overview map. The user can then zoom into this basic map to see a more detailed view of the data content. The following figure shows the North Sea coast near Bremerhaven. The symbols visible in this map view are explained on the right in the "dynamic legend".

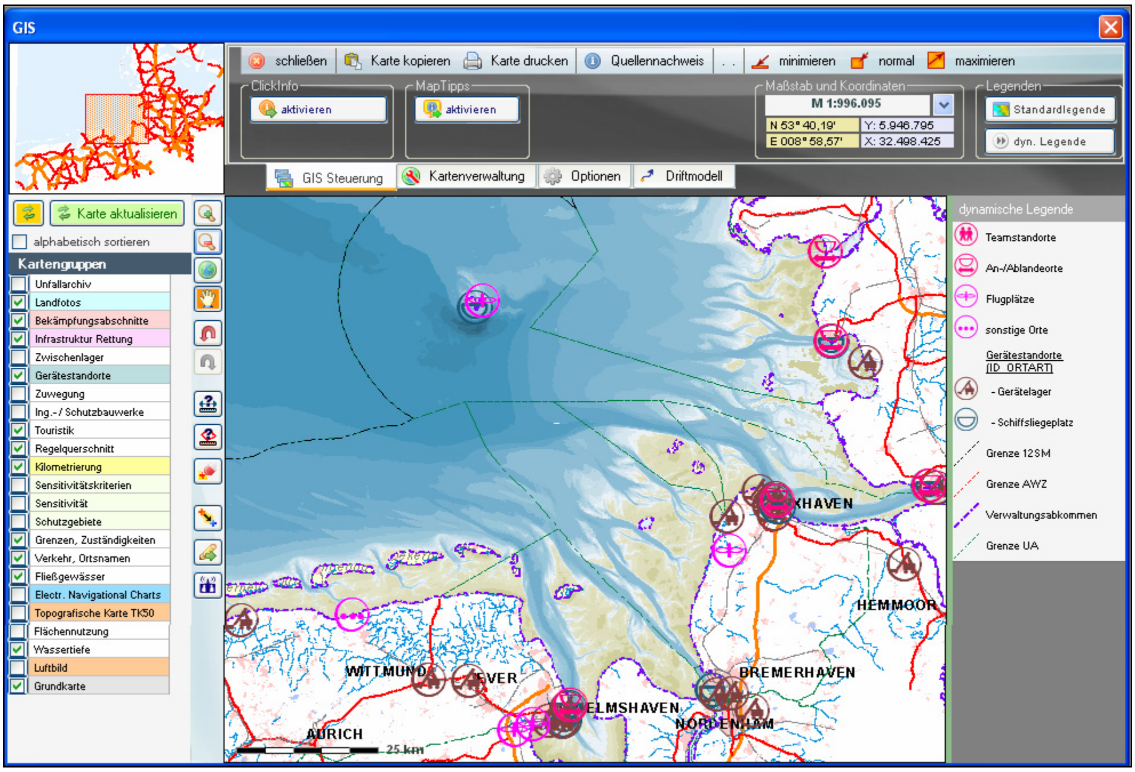


Figure 52 VPS screenshot – GIS control

By activating different layers it is possible to superimpose additional thematic information on the basic topographic map. Further information on each symbol is available. To be able to allocate information of control relevance to the individual coastline sections, the entire coast was broken down into control sections with a length of between 100 m and a maximum of 10 km. The database contains extensive information on each control section symbol (see next figure).

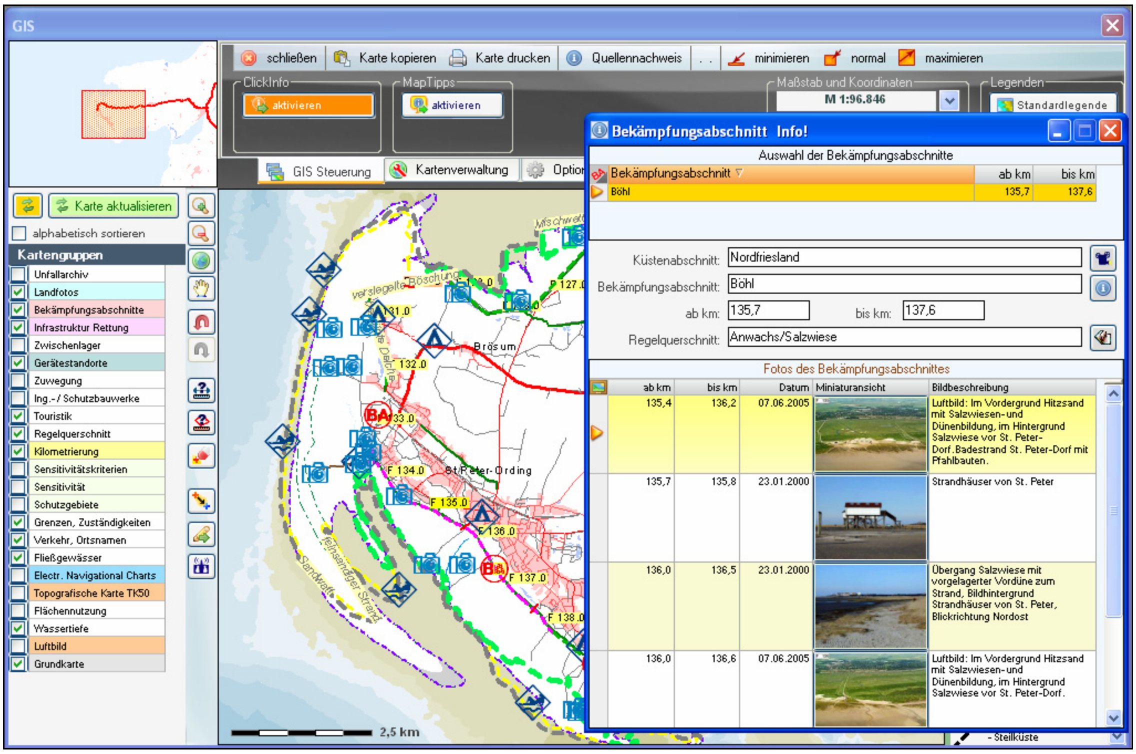


Figure 53 VPS screenshot – GIS control with information on selected control section Böhl/Nordfriesland

Numerous other database functions are also available. In addition to the usual map and layer control options, specific functions tailored to the current purpose are also available. For example, it is possible to measure any desired distance or area.

Texts, photos and graphics form the basis of the control manual. Since this manual contains the know-how on pollution incident control, rapid systematic access is essential in emergency. The text data is stored with the relevant graphics and photos as an ‘electronic book’, which is available in VPS.system.

The VPS database contains photos of the individual incident control sections. To this end, aerial photos were taken of the entire coastline. These can be supplemented by detailed shore-based photos of certain areas.

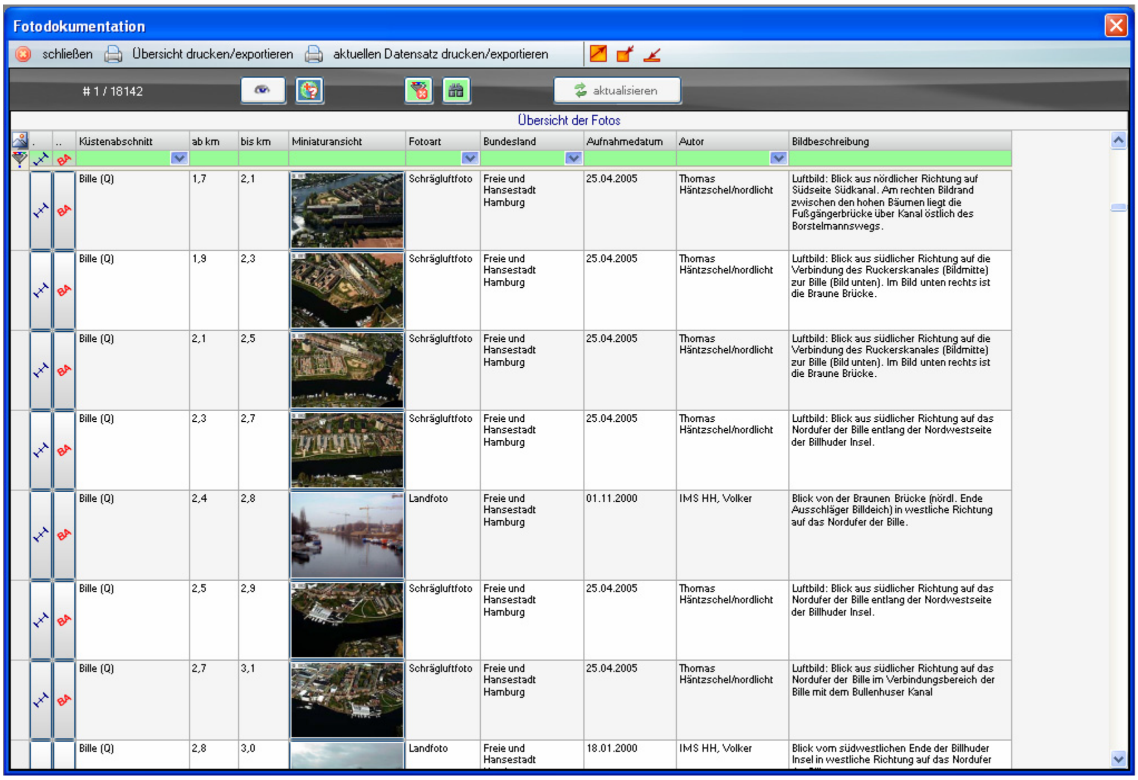


Figure 54 VPS screenshot – Photo documentation Hamburg / Bille

All photos in the photo documentation are linked to the coastline and incident control sections. Since the land-based photos are also assigned coordinates, a single click establishes a link from the photo documentation to the GIS .

Photos can also be displayed via the GIS user interface as “Map Tips” (see next figure).

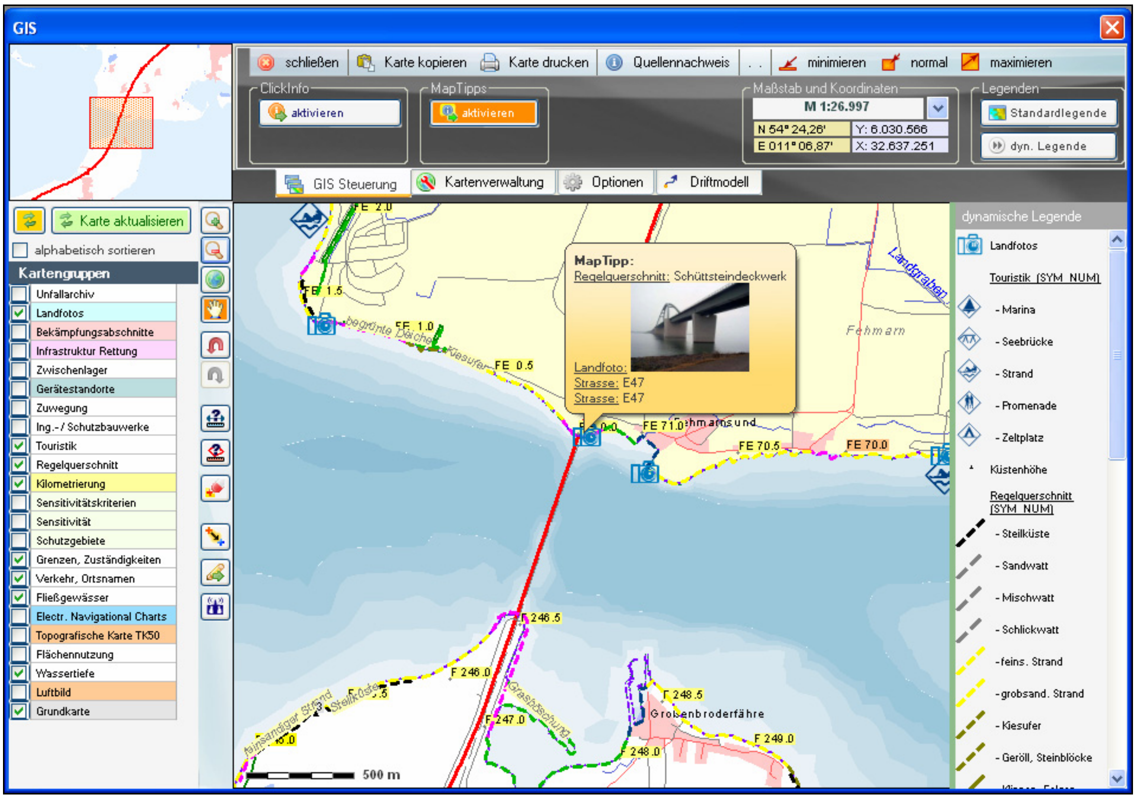


Figure 55 VPS database screenshot – Photo documentation via Map Tip

The nearly 14,000 oblique aerial photos of the entire German North Sea and Baltic coast provide a comprehensive store of information, enabling the trained user to find information on coastal structure, land-based and water-based access routes, sensitivity of shore areas, and practicable incident control strategies. The overlapping oblique aerial photos are also available in VPS as video files. This makes for a speedy overview of the existing structures in the relevant coastline section. The following example is an oblique aerial photo in the Bremen coastline section (coastal kilometre 0 to 0.1) with associated description:

Figure 56 VPS screenshot – Photo documentation, oblique aerial photo in Bremen coastline section

Various operational components (e.g. drift model and situation tracking) are integrated in VPS.system. These were implemented during ongoing development of the VPS software and its adaptation to the requirements of the Shipping Accident Command. Here we take a brief look at the drift model.

The drift model uses the mathematical core of the 'small drift model' of the Federal Institute for Navigation and Hydrography (BSH), Hamburg[229] and makes its calculations available in the convenient environment of VPS.system. This permits rapid estimates of drift paths for water pollution, containers and other flotsam in the German Bight.

After entering the incident-specific parameters such as spill location, information on wind and water conditions and the quantity of substance lost, the drift calculation can be started and the drift model results displayed. The next figures shows a screenshot of a drift model simulation of an oil spill off Cuxhaven.

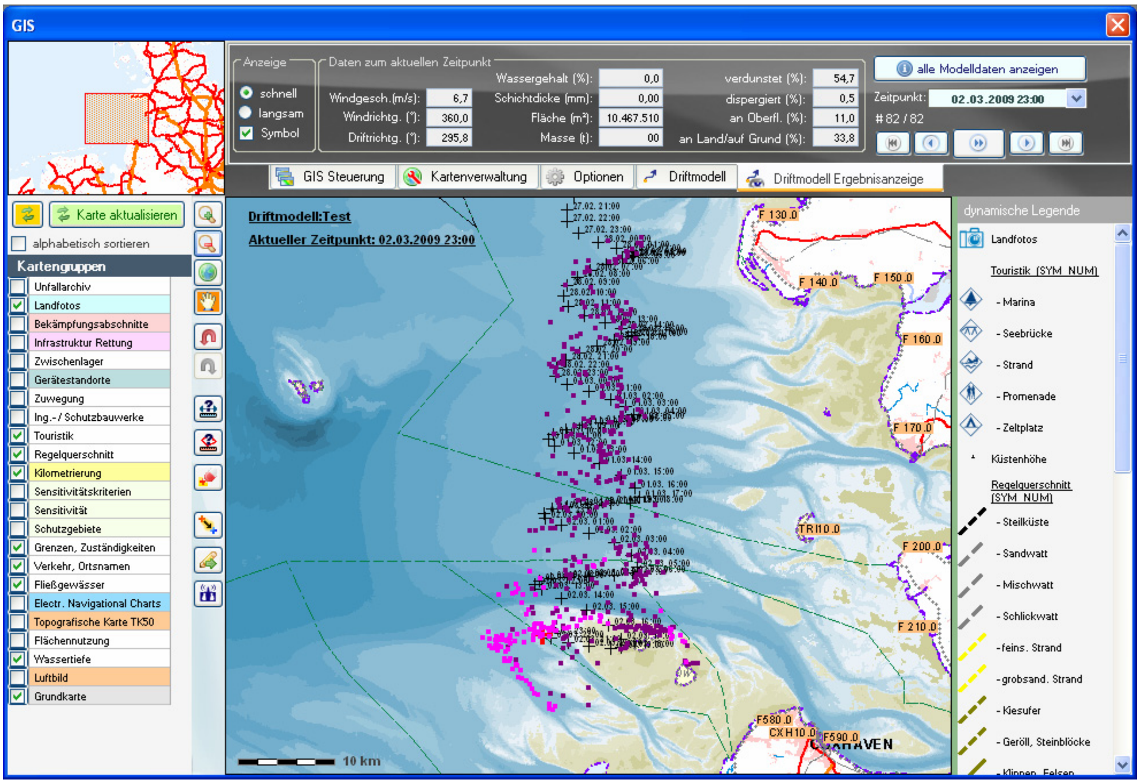
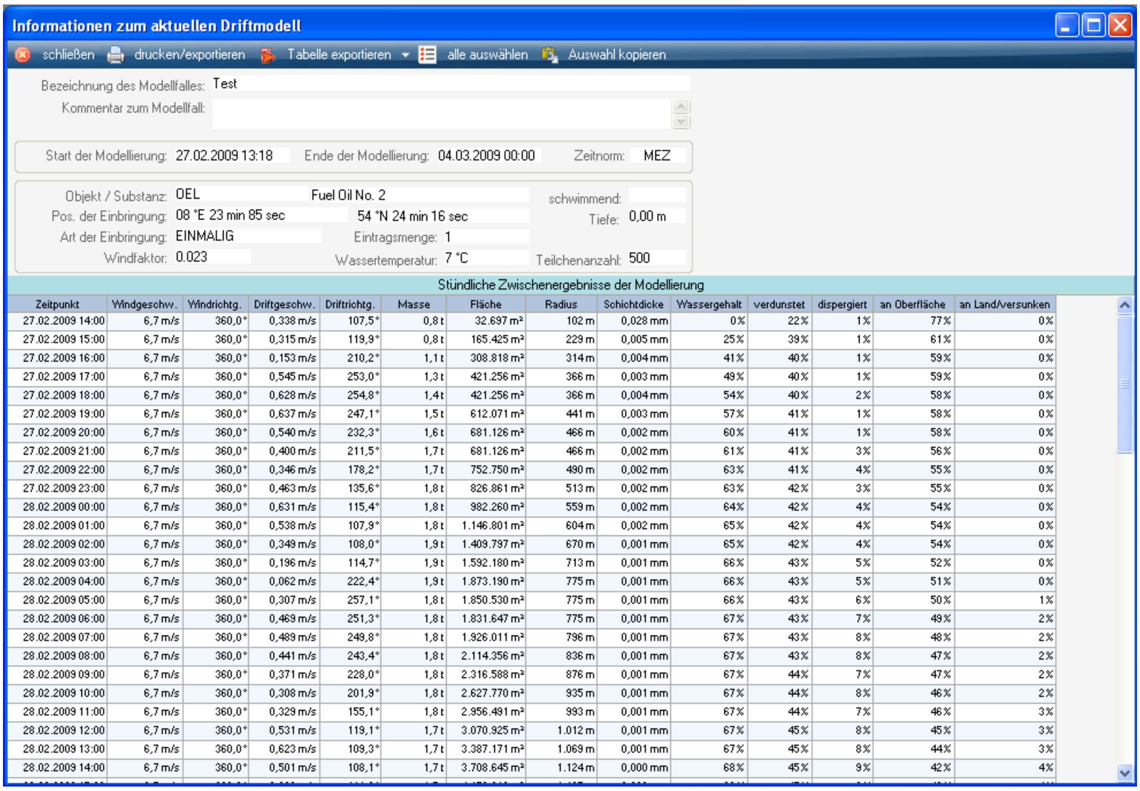


Figure 57 VPS screenshot – Drift model calculation of a simulated oil spill

The drifting oil slick is shown as a cloud of light purple dots. Oil particles that have sunk or been washed up are shown in deep purple. The modelled centre points of the oil slick at every full hour of the simulation are marked on the map, permitting a rapid overview of the drift path. The simulation can be run forward or back in one-hour steps, and it is also possible to select specific times. The legend above the map shows the calculated chemo-physical parameters of the oil slick at every time point in the model. The data calculated for the incident can be viewed in tabular form and exported to other analysis programs. The next figure shows the tabular summary of the hourly modelling results of the simulated oil spill. These include, for example, the calculated area, the radius and thickness of the oil slick.

> Continued from previous page <

229 Federal Institute for Navigation and Hydrography



Zeitpunkt	Windgeschw.	Windrichtg.	Driftgeschw.	Driftrichtg.	Masse	Fläche	Radius	Schichtdicke	Wassergehalt	verdunstet	dispergiert	an Oberfläche	an Land/versunken
27.02.2009 14:00	6,7 m/s	360,0°	0,338 m/s	107,5°	0,8 t	32.697 m²	102 m	0,028 mm	0%	22%	1%	77%	0%
27.02.2009 15:00	6,7 m/s	360,0°	0,315 m/s	119,9°	0,8 t	165.425 m²	229 m	0,005 mm	25%	39%	1%	61%	0%
27.02.2009 16:00	6,7 m/s	360,0°	0,153 m/s	210,2°	1,1 t	308.818 m²	314 m	0,004 mm	41%	40%	1%	59%	0%
27.02.2009 17:00	6,7 m/s	360,0°	0,545 m/s	253,0°	1,3 t	421.256 m²	366 m	0,003 mm	49%	40%	1%	59%	0%
27.02.2009 18:00	6,7 m/s	360,0°	0,628 m/s	254,8°	1,4 t	421.256 m²	366 m	0,004 mm	54%	40%	2%	58%	0%
27.02.2009 19:00	6,7 m/s	360,0°	0,637 m/s	247,1°	1,5 t	612.071 m²	441 m	0,003 mm	57%	41%	1%	58%	0%
27.02.2009 20:00	6,7 m/s	360,0°	0,540 m/s	232,3°	1,6 t	681.126 m²	466 m	0,002 mm	60%	41%	1%	58%	0%
27.02.2009 21:00	6,7 m/s	360,0°	0,400 m/s	211,5°	1,7 t	681.126 m²	466 m	0,002 mm	61%	41%	3%	56%	0%
27.02.2009 22:00	6,7 m/s	360,0°	0,346 m/s	178,2°	1,7 t	752.750 m²	490 m	0,002 mm	63%	41%	4%	55%	0%
27.02.2009 23:00	6,7 m/s	360,0°	0,463 m/s	135,6°	1,8 t	826.861 m²	513 m	0,002 mm	63%	42%	3%	55%	0%
28.02.2009 00:00	6,7 m/s	360,0°	0,631 m/s	115,4°	1,8 t	982.260 m²	559 m	0,002 mm	64%	42%	4%	54%	0%
28.02.2009 01:00	6,7 m/s	360,0°	0,538 m/s	107,9°	1,8 t	1.146.801 m²	604 m	0,002 mm	65%	42%	4%	54%	0%
28.02.2009 02:00	6,7 m/s	360,0°	0,349 m/s	108,0°	1,9 t	1.409.797 m²	670 m	0,001 mm	65%	42%	4%	54%	0%
28.02.2009 03:00	6,7 m/s	360,0°	0,196 m/s	114,7°	1,9 t	1.592.180 m²	713 m	0,001 mm	66%	43%	5%	52%	0%
28.02.2009 04:00	6,7 m/s	360,0°	0,062 m/s	222,4°	1,9 t	1.873.190 m²	775 m	0,001 mm	66%	43%	5%	51%	0%
28.02.2009 05:00	6,7 m/s	360,0°	0,307 m/s	257,1°	1,8 t	1.850.530 m²	775 m	0,001 mm	66%	43%	6%	50%	1%
28.02.2009 06:00	6,7 m/s	360,0°	0,469 m/s	251,3°	1,8 t	1.831.647 m²	775 m	0,001 mm	67%	43%	7%	49%	2%
28.02.2009 07:00	6,7 m/s	360,0°	0,489 m/s	249,8°	1,8 t	1.926.011 m²	796 m	0,001 mm	67%	43%	8%	48%	2%
28.02.2009 08:00	6,7 m/s	360,0°	0,441 m/s	243,4°	1,8 t	2.114.356 m²	836 m	0,001 mm	67%	43%	8%	47%	2%
28.02.2009 09:00	6,7 m/s	360,0°	0,371 m/s	228,0°	1,8 t	2.316.588 m²	876 m	0,001 mm	67%	44%	7%	47%	2%
28.02.2009 10:00	6,7 m/s	360,0°	0,308 m/s	201,9°	1,8 t	2.627.770 m²	935 m	0,001 mm	67%	44%	8%	46%	2%
28.02.2009 11:00	6,7 m/s	360,0°	0,329 m/s	155,1°	1,8 t	2.956.491 m²	993 m	0,001 mm	67%	44%	7%	46%	3%
28.02.2009 12:00	6,7 m/s	360,0°	0,531 m/s	119,1°	1,7 t	3.070.925 m²	1.012 m	0,001 mm	67%	45%	8%	45%	3%
28.02.2009 13:00	6,7 m/s	360,0°	0,623 m/s	109,3°	1,7 t	3.387.171 m²	1.069 m	0,001 mm	67%	45%	8%	44%	3%
28.02.2009 14:00	6,7 m/s	360,0°	0,501 m/s	108,1°	1,7 t	3.708.645 m²	1.124 m	0,000 mm	68%	45%	9%	42%	4%

Figure 58 VPS screenshot – Dataset of drift model calculations

Incident control manual

The former paper manual is now available as a convenient multimedia electronic book. It includes information on:

⇒ examples of incident control strategies,

⇒ parameters of pollutants transhipped in German ports,

⇒ available incident control equipment and its use, and many other topics.

The regularly updated manual, which can be downloaded from the VPS website, deals with precautions and incident control for oil pollution of the sea, beaches and shores, and the tidal rivers and seaports. It shows the organisational precautions and describes the necessary technical and logistical measures for an incident control operation. The incident control suggestions for the declared typical cross sections are also in the manual, linked to the database and GIS. Each incident control suggestion contains the headings:

⇒ Characteristics of shore type,

⇒ Expected oil behaviour,

⇒ What to do,

⇒ What not to do.

The final figure shows an excerpt from the incident control suggestions for sand flats.

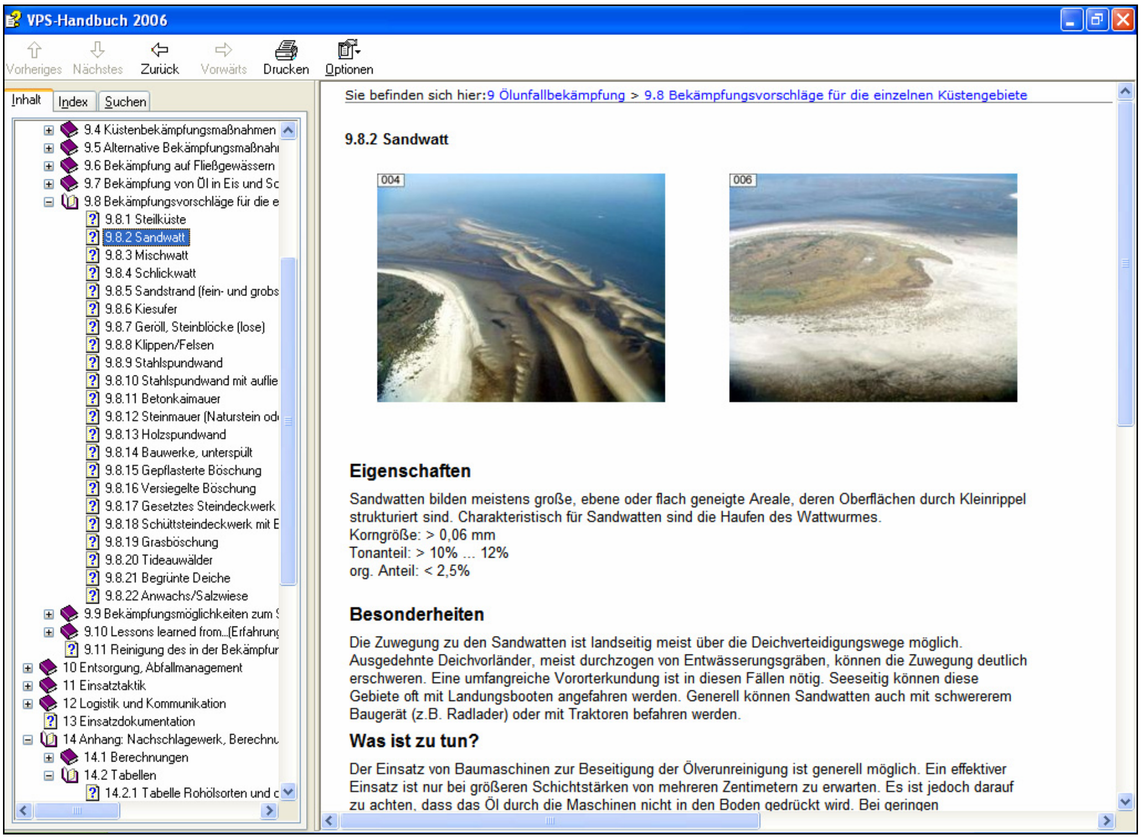


Figure 59 VPS screenshot – VPS manual, "Chapter 9.8: Incident control suggestions for the individual coastal areas"

8.1.4 Conclusions for the action concept

Table 25 provides a summary of suggested measures, with a selection of examples for implementation of Article 11 (3) I WFD for the action level "Preparedness".

Table 25 Suggested Measures – Preparedness

Crisis management – Crisis management instruments	
Measure	**Implementation examples**
Design and establishment of immission-related (river-related) early warning systems • Establishment of continuously operating monitoring stations • Establishment of monitoring and communication networks for entire river basin district • Development/implementation of event detection technology, evaluation and forecast instruments	EASE, Water Surveillance System Hamburg (WGMN Hamburg), Early warning system Netherlands (Rhine/Maas), UNDINE, VPS, ALAMO Aqualarm (NL) Guidance for Chemical Monitoring under the WFD (EU Draft)
Design and establishment of emission-related (plant-specific) early warning facilities linked to the measurement and communication network for the river basin	Seveso-II plants, e.g. Bayer, BASF
Design and implementation of warning and emergency plans for the entire river basin • Establishment of warning and emergency centres • Definition and technical realisation of warning and emergency paths • Definition of emission-related and immission-related warning and emergency thresholds	Infra-web (NL) International warning and emergency plans of the ICPER (Elbe), ICPDR (Danube), ICPR (Rhine) EASE
Design and implementation of disaster control plans, accident management plans etc. Provision of technical facilities and equipment for protective measures and damage containment • at public level • at plant level	Regional disaster control plans, Hamburg oil pollution control rules Police, plant fire brigade, THW (Federal Agency for Technical Relief), oil barriers, “Central provision, mutual assistance”
Ensuring readiness and functioning of crisis management instruments • at public level • at plant level • crisis communication (across all levels)	QM, training, exercises for entire river basin district BMI Guidelines on “Crisis Communications”[241]

8.2 Response measures

This link in the safety chain is concerned with the measures that are implemented or have to be implemented directly in the event of a specific incident. These measures include the process of giving the alert, plus the immediate responses such as damage containment, measures to protect humans and animals, uses and other objects of protection, and also immediate damage remediation.

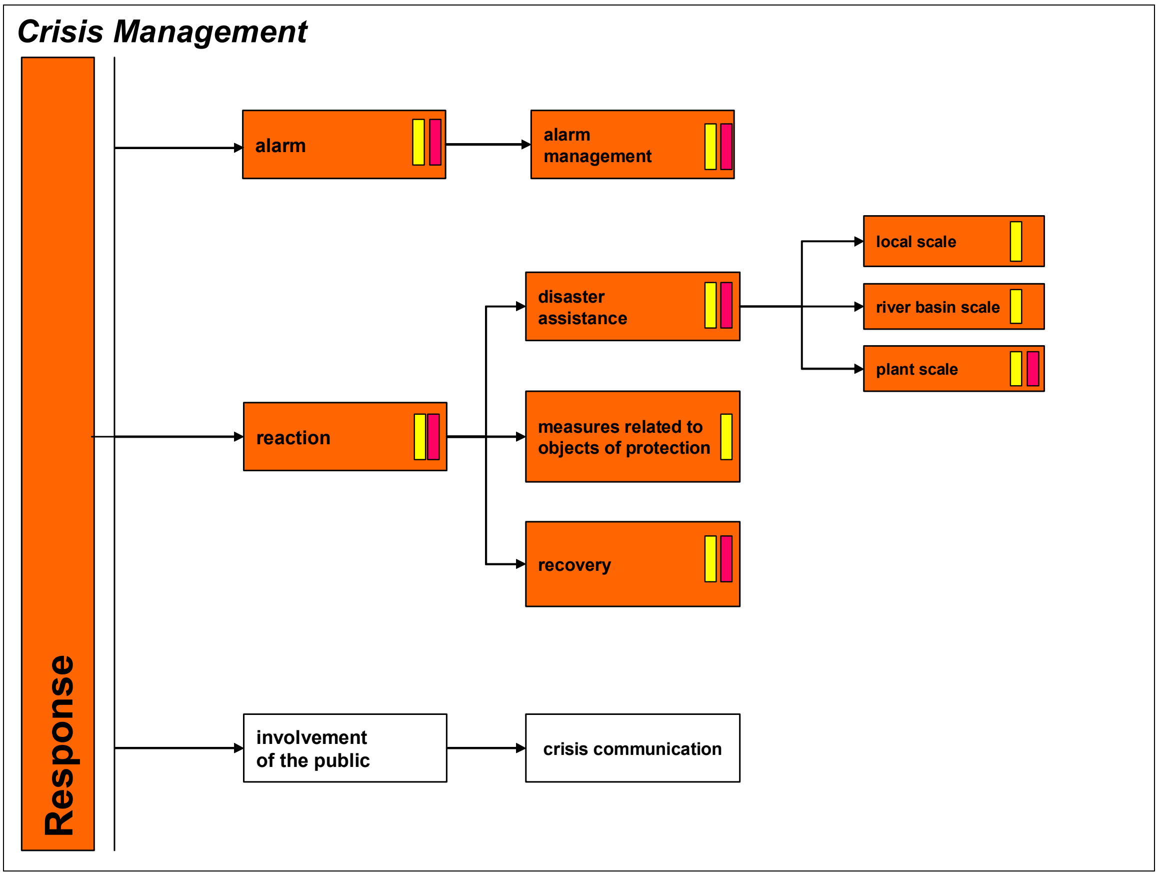


Figure 60 Crisis Management – Response Measures (Authority tasks, Operator tasks)

The measures that have to be set in motion for a specific incident may involve the mobilisation of massive human and material resources in the individual case. In the strict sense, they are not management planning measures. Their prospects of success do however depend to a very large extent on the quality of the design and implementation of the preceding packages of “hazard management” and “preparedness” measures. The measures immediately necessary if an incident occurs cannot be derived as measures simply from the requirements of Article 11 (3) I WFD; in other words, Article 11 (3) I WFD would not in this case demand any requirements different or additional to the tried-and-tested technical practice of accident and disaster control. It is undoubtedly not the intention of the WFD to bring about a reform of established structures in the field of disaster control. The fact that the WFD regards certain objects of protection as possibly more worthy of protecting and restoring than previous legislation is not due to Article 11 (3) I WFD, but to the general and environmental objectives of the WFD as a whole.

For this reason, this section only looks at the overall scheme of the Safety Chain without going into any further detail. The first level consist of three blocks (Figure 60):

⇒ Alert; i.e. controlled performance of all procedures laid down in warning and alarm plans,

⇒ Response; i.e. all short-term measures for

  - Incident control (regional, river basin oriented, installation-related),
  - Rescue/protection of uses and objects of protection,
  - Damage remediation (short-term measures until start of after-care measures)

⇒ Crisis communication (see Chapter 11)

9 After Care

The field of after care covers all measures that follow immediate damage remediation. A distinction is made between "Damage review" and "Follow-up measures". The focus is not only on evaluation of the incident at the level of all actors, but also on long-term remediation of the damage caused, targeted monitoring of this process, and reviewing the overall concept with regard to identified weaknesses and deficits.

After-care indisputably belongs to the continuous, integrated approach of the safety chain outlined here. However, it is only partly relevant to the field of application of Article 11 (3) I WFD. The "material" after-care measures in the safety chain, such as repairing damage (e.g. to buildings and dykes), restoring the original state (e.g. in contaminated protected areas) etc., are not covered by the precautionary provisions of Article 11 (3) I WFD. The focus here is on damage review in the sense of checking the quality of the Pro Action measures up to the response, and ensuring that any deficits identified are remedied in future (lessons learned).

In individual cases, after-care measures can also help to mitigate the effects of unexpected pollution. However, the interpretation of the legal requirements would seem to focus largely on immediate damage limitation measures (response) and not on long-term restoration measures. The approach could become important with regard to "*accidents which could not reasonably have been foreseen*". Following occurrence and control of such an event it is important to check whether the classification of "unforeseeability" can be sustained with regard to future events of the same type. If not, suitable measures must be taken.

In the event of confirmation the WFD, in connection with possible failure to achieve the environmental objectives, allows the exceptional situation of a temporary deterioration of status as a result of *"circumstances ... which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts and ... accidents"*[230]. However, the barriers to claiming exceptional situations are high:

- *All practicable steps* must be taken to prevent further deterioration in status in the water bodies affected. The purpose of this is to prevent or limit any spreading of the adverse effects to adjacent water bodies.[231]

[230] Cf. Article 4 (6) WFD

[231] Cf. Article 4 (6) a WFD.

- Furthermore, *all practicable steps* must be taken to restore the status of the water – as soon as *reasonably possible* – to what it was before the accident occurred.[232] According to this line of thinking, after-care measures are obligatory for precautionary strategies even if exceptional circumstances are claimed.

- Moreover, extensive justifications are required in the management plan. It is necessary to establish the conditions under which one can claim circumstances which are exceptional or which cannot reasonably be foreseen, and the indicators that are to be used for this purpose. The impacts must be reviewed regularly (annually).[233]

9.1 Damage review

In the course of an incident, damage review follows the immediate crisis management activities. The factors that led to the hazard situation have been counteracted or are under control, and the acute danger of the pollutant spreading has been stopped. In the course of events, there is now a need to analyse the factors and circumstances that led to these developments. It is also necessary to ascertain how serious the impacts and the damage caused actually were.

The purpose of the analytical damage review is

- ♦ to help the authorities and the plant operator to prevent future incidents of the same kind or at least mitigate the consequences, and

- ♦ to estimate and assess the extent of the damage.

Figure 61 illustrates these key points separately for the authority side and the operator side.

[232] Cf. Article 4 (6) d WFD.

[233] Cf. Article 4 (6) b WFD.

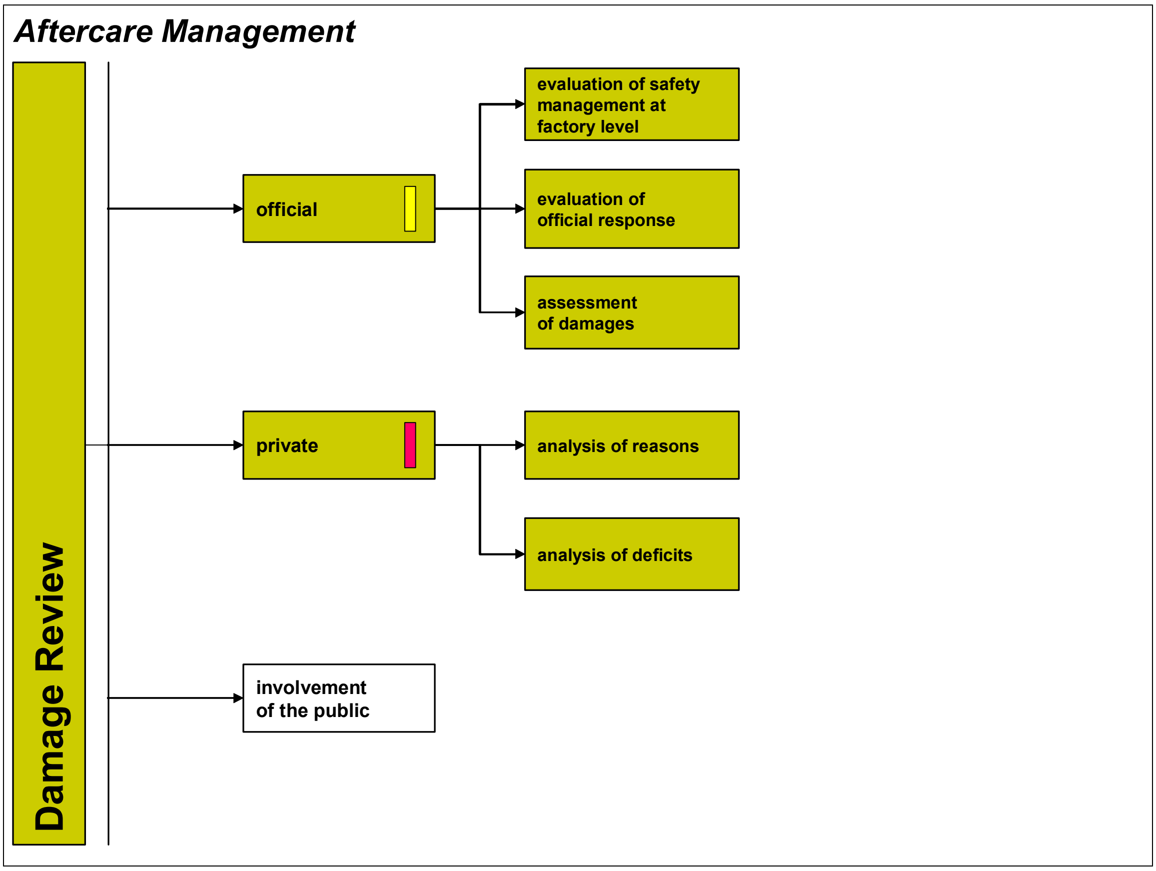


Figure 61 After Care – Damage Review (Authority tasks, Operator tasks)

9.1.1 Authority

The aim of damage review by the authorities is essentially to gather knowledge and experience regarding safe ways of dealing with safety hazards. This applies particularly to the operation of safety-relevant technical installations. Knowledge gained as a result of individual incidents is initially only available to the individual operator or local bodies. Central collection and evaluation creates a broader information base and makes it possible to generally integrate knowledge in structures and workflows in all relevant fields. This approach reduces the future probability of incidents of similar character and raises the safety level.

Here it is necessary to distinguish what kind of incidents are of interest at which levels. Of primary interest for the authorities are incidents with impacts that have adverse effects on human health and the environment beyond the operator's immediate sphere of influence. This includes all incidents that are relevant under Article 11 (3) I WFD, i.e.

- there are significant losses of pollutants from technical installations, or
- unexpected pollution takes place, and here it is necessary to analyse what the causes were and how they took effect.

In such cases there is reason to fear damage (to people/environment), and the authority is, jointly with the polluter (operator), responsible for analysing the incident. Not only aspects of operational safety management play a part here, but also the functioning of the official crisis management system and the registration of the damage actually caused.

9.1.1.1 Evaluation of plant-related safety management

The authority, in cooperation with the operator, registers the circumstances of an incident and analyses the extent to which operational safety management contributed to the commencement and spread of the incident through lack of measures, malfunctions or inappropriate action.

The focus here is on registering general data and circumstances which are associated with the incident and are of relevance to the damage review. It is also interesting to know whether the type of incident that occurred was to be expected in this form, and whether preventive safety measures were taken accordingly. The following aspects should therefore be considered when examining the operational safety management system[234]:

- Details of pollutant release: The main points of interest here are which pollutant was released under what circumstances (see Chapter 7.1.3.3.2) and what quantities were lost from the installation.
- Details of factors responsible: Since it is not uncommon for a chain of causes to have serious consequences, it is necessary to identify the individual causes and understand how they interacted.

Details of safety measures: If there were technical safety precautions which really ought to have counteracted the causes, it will be necessary to investigate why they failed or why they were insufficient.

9.1.1.2 Evaluation of official crisis management

The workflows planned and structures activated if an incident occurs are subject to similar preparatory mechanisms to site hazard precautions. After they have been used in connection with an incident, it is necessary to investigate whether the intended assignment of tasks and the effectiveness of the various instruments and bodies of crisis management functioned as planned. Here the focus is once again on identifying the deficits that occurred during the emergency. The findings of the analysis can subsequently be used to draw general conclusions for improving emergency plans or to plan changes in the use of crisis management instruments.

For evaluating crisis management there is a need to collect various items of data which represent the framework conditions for an emergency incident and thereby ensure subsequent use of the resulting information. The following individual aspects are relevant:

- Details of pollutant discovery: It is important to distinguish here whether an incident became known to the emergency personnel as a result of a report/alert by the polluter or by third parties, and what time elapsed before it was discovered. Here too, possible notification paths are electronic systems of the operator with links to the emergency personnel, or detection by district-related monitoring systems.

- Emergency personnel involved: What emergency personnel were involved in incident control? (Fire brigade, police, rescue services, technical auxiliaries, technical authorities, relevant experts, etc.) Who managed and coordinated the operation? Were the necessary personnel available on time?

- Crisis communication: What actors (public, industry, agriculture, etc.) were at risk of adverse impacts during the course of the incident? What measures were taken to prevent this? (Evacuation, emergency supplies, warning and alarm, etc.)

- Details of incident containment: What active crisis management measures succeeded in dealing with the causes of the incident and stopped it spreading?

> Continued from previous page <

[234] Cf. LAI (2002). This contains a detailed list of the factors to be investigated.

Were initial measures taken in addition to remedy or contain damage (damage to property, environmental damage)?

9.1.1.3 Scale of damage

Finally, the inventory of damage caused is the last step in damage review. Since this is a holistic registration of the scale of the damage, it is not confined to impacts of relevance for WFD purposes. On the contrary, the environmental damage of relevance to water conservation must be regarded as an integral part of incident analysis along with damage to persons and property.

In the present context, however, we focus here on factors that prove critical in relation to environmental damage resulting from incidents, especially in lakes and rivers:

- Pollutant dispersion: This analyses the media and paths by which escaped pollutants spread (cf. Chapter 7.1.3.3.3) and whether in this context measures were taken to contain them. Among other things, this real data yields information about the forecast radius of impact of a safety hazard.
- Areas of risk: Which objects of protection identified during the basic preparations (cf. Chapter 7.1.3.3.4) are located within the area at risk from pollutant dispersion? Is there reason to expect that the object of protection will react sensitively to the expected impact?
- Scale and direct consequences of the environmental damage: What form does the environmental damage take (contamination, extinction of species etc.)? Is the natural function of an object of protection endangered by the adverse effects, and can one expect regeneration without intervention? Is it necessary to discontinue uses (e.g. drinking water abstraction) either temporarily or permanently?
- Expected long-term impacts: Is there reason to fear that other water bodies in addition to the one directly affected will be adversely affected via the dispersion path “water”? Can such spreading be prevented or contained? Apart from temporary adverse effects, are long-term impacts of the relevant substance to be expected?

The findings of the damage scale assessment are of interest for selecting appropriate follow-up measures in particular (see Chapter 9.2.1.4). Especially if the damage already caused gives rise to dangers for water bodies not yet affected, it is necessary to take protective precautions to avoid further adverse effects and restore the original status.

9.1.2 Operator

At the operator level, monitoring and analysis can be more detailed than in the overarching view taken by the competent authority. Reasons for this include:

- Clear definition of sphere of responsibilities, which is manageable for the operator; workflows and structures are known in detail;
- Operator has a general interest in the proper functioning of operations processes; in addition to safety considerations, eliminating malfunctions plays a role for functionality and productivity reasons.

At operator level one can therefore expect a broader spectrum of safety relevant data and knowledge, since such investigations do not take place solely when incidents have adverse impacts outside the limits of the operational site. A wider range of events is covered here; in addition to the events registered in cooperation with the competent authorities, they include the following:

- Operating errors
- Individual technical malfunctions or failure of parts of installation
- *Near-miss* events, in which it was just possible to stop things developing to the point where damage could spread beyond the site structures)

This is intended to make it clear that incidents with serious impacts on people and the environment are frequently due to a succession of causes which, if they had only acted on their own, would probably have caused little or no damage. However, knowledge about the individual causes is often of great importance for the selection of precautionary measures, with a view to reducing or excluding the possibility of their occurrence. Thus detailed knowledge is of great importance, especially for ongoing development of the state of technical safety know-how. However, its collection by the operator, although a certain self-interest can be assumed to exist, is a largely voluntary process, since the quantity of information accumulating at the overarching level would be difficult to handle, and also since it is at the operator's discretion to decide how intensive his safety quality control is to be. Moreover, it is not always certain that the operator has an interest in open external communication of the internal findings for improving installation safety, especially if this would result in disclosing details of confidential internal structures and workflows.

9.1.2.1 Analysis of causes

Although installation-related analysis of causes can essentially be regarded as the operator's contribution to evaluating site safety management, it can also be used independently as an internal check when investigating internal errors which have not on their own led to serious and external consequences.

The operator's task here is to identify the cause of relevant events within the installation. The main focus is on pinpointing errors that can be attributed to either technical or human failure. If safety measures already existed in connection with the triggering factor, it is also necessary to investigate what role these played in the course of the incident and why they failed to provide adequate protection.

9.1.2.2 Deficit analysis

Deficit analysis follows on directly from the analysis of causes. If safety measures were already in place in an installation, the question arises as to whether they were intended to deal with the causes identified. If this was not the case, it is important to investigate whether there would have been suitable measures which would have prevented the cause of the incident, and why these were not previously regarded as relevant. If technical safety precautions already existed, there is a need to examine how it was possible, despite their conceptual integration in the structure of the installation, for the triggering factor to arise, what circumstances led to this, and whether such a case has to be regarded as probable in the future.

9.2 Follow-up measures

Within the concept of the safety chain, the key area of damage review lays the foundations for learning lessons from the conclusions that can be drawn from occurrence of the incident. This may result in follow-up measures for the field of hazard prevention and/or crisis management, with the aim of reducing the probability of such events occurring in the future and improving the efficiency of action taken in response to an incident. With regard to the damage caused, it will be necessary to consider how long this requires permanent observation and whether measures are needed to restore the original status of the water body in the long term. Figure 62 shows the key follow-up measures in the after-care field.

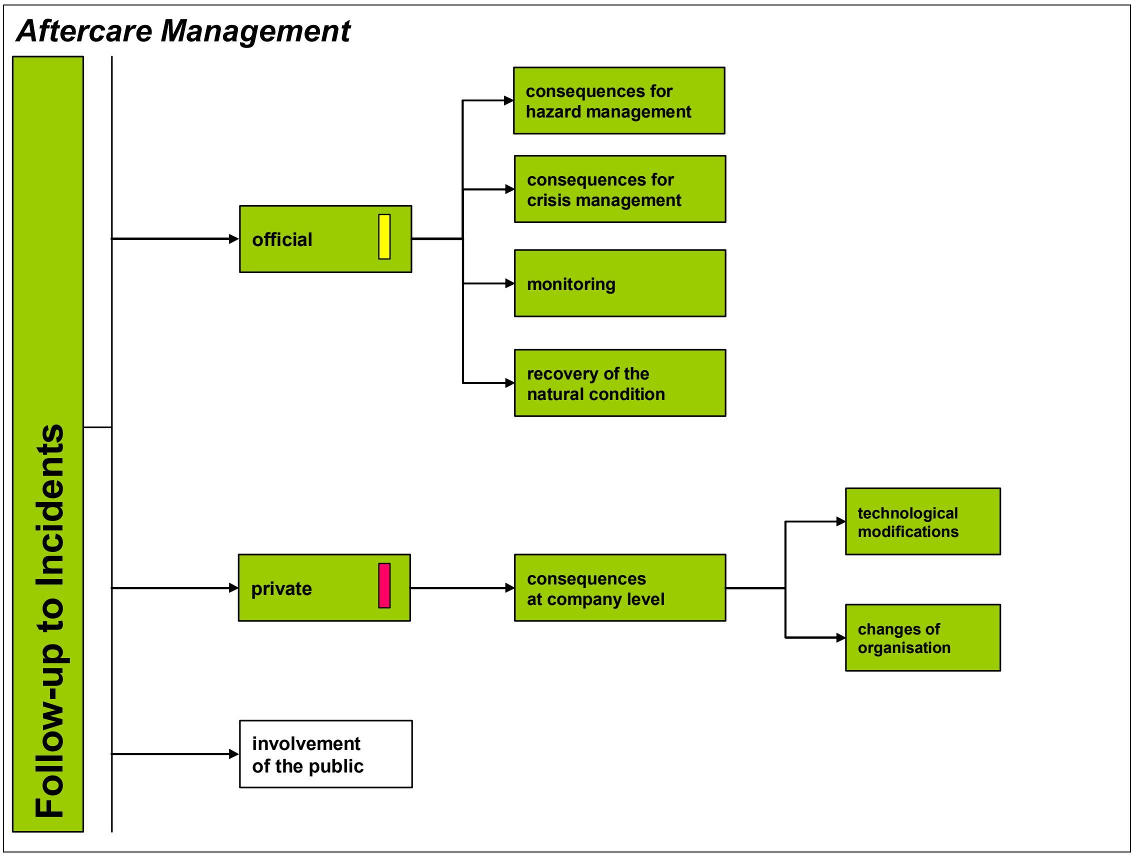


Figure 62 After Care – Follow-up Measures (Authority tasks, Operator tasks)

9.2.1 Authority

The authorities' responsibilities include not only evaluating incidents of "relevant" importance, but also ensuring that information from different incidents is registered in comparable ways. Despite the individual circumstances that can be expected to be associated with a crisis situation, there is a need for standardised models for registering the data. The aim of this approach is then to examine whether the information obtained might be useful as a basis for an extended area of application, i.e. outside the limits of the specific installation involved. Here it is important to establish whether the incident in question is a special case with characteristics that do not allow it to be transferred to a more general field of application, or whether the findings make it possible to draw conclusions for a large number of applications.

Thus the damage review at the level of the competent authority gathers data and evaluates information that may imply a need for revision and potential for improvement for earlier elements in the safety chain. It should be remembered that the safety chain is to be understood as a methodological approach for an action concept that seeks to link the elements of hazard management and crisis management. There is not necessarily any reason to expect that findings arising from incidents and crisis situations will lead to significant changes in the structure of this approach. It is rather a matter of strengthening the information base that can be used to make further improvements in the design of individual areas in relation to specific fields of application and industries.

9.2.1.1 Conclusions for hazard prevention

The conceptual approach to implementing hazard management at a multi-actor level was outlined in Chapter 7. Damage review findings may give rise to a need in various areas to make specific changes to the detailed design of individual points. Examples include the following points of attack for incorporating conclusions relating to hazard prevention:

- Conclusions for hazard analysis: The course that incidents take may result in knowledge about the release of pollutants, the dispersion behaviour of escaped pollutants, or their impacts on objects of protection. This may confirm or disprove existing assumptions.
- This may give rise to follow-up measures for more effective prevention of incident causes. Where do future technical and organisational safety measures need to be applied in order to exclude the causes identified or reduce their probability even further? This concerns not only causes against which no precau-

tions have been taken to date, but also causes where the existing safety standard has proved inadequate.

Above and beyond the prevention of causes, one could conceivably draw conclusions about ways of mitigating the impacts of incidents. A possible example is changes of strategy in relation to land-use planning.

9.2.1.2 Conclusions for crisis management

The elements required for crisis management were described in detail in Chapter 8. The review of incidents and the associated crisis management makes it possible to draw conclusions with a view to improving crisis preparations and management. The following are a few potential areas for applying such conclusions:

- Evaluation of information about the time taken to notify an incident to the competent bodies permits conclusions about reducing the time taken to initiate the emergency and alert the necessary emergency personnel.
- Experience and identification of organisational errors makes it possible to improve the deployment of emergency personnel. Who is responsible for managing the operation? Who plays which role and what are they needed for?

Experience gained from dealing with crisis situations may lead to modifications for future emergency exercises and crisis management operations, and provide indications of how to improve crisis communication.

9.2.1.3 Monitoring

The damage caused in the water body affected may in the individual case make it necessary to keep the further course of events under observation. Such monitoring provides information on how long the water body remains affected by the incident, whether the original status is restored by natural regeneration processes, or whether in the long term it will be necessary to take additional measures to remedy the damage suffered.

9.2.1.4 Restoring original status

Measures designed to restore the water body to its original status are a specific reaction to the environmental damage caused by an incident. To a certain extent they are difficult to plan, because one cannot predict the exact circumstances. The strategic character of the basic measures envisaged in Article 11 (3) I WFD does not, on the face of it, involve addressing aspects relating to restoration of the original status after an incident. Why this is nevertheless discussed in the safety chain and is of great importance from the point of view of the Directive as a whole, especially with regard to the environmental objectives and in conjunction with Article 4 (6) WFD, has already been examined (cf. Chapter 9).

In this context, “basic measures” means at best that there is a strategic definition of who bears responsibility for restoration after an incident. To this extent it is the Member State, as the party responsible for implementing the directive, that has the task of assigning such responsibility. Either this can be a competent authority which bears responsibility for restoration or, in cases where the role of polluter can be assigned clearly, the polluter-pays principle must be implemented appropriately.

At this point it is nevertheless worth taking a brief look at possible strategies that are available for restoring a water body to its original status after it has suffered adverse effects due to an incident:

⇒ *Passive strategy:* The restoration of a water body to its original status depends on the natural regenerative capacity of the water body, if it is indeed capable of regenerating itself at all in the face of the damage suffered. The passive strategy may be an option if no “practicable” active restoration measures are available, i.e. no technical solutions are known, natural conditions do not call for or permit any intervention, or the measures available involve unreasonably high costs.[235]

⇒ *Active strategy:* If measures for restoring the original status are known and practicable, an active strategy is to be pursued to remedy the long-term damage caused to water bodies and the area directly affected by them. Examples of such measures include the reintroduction of flora and fauna, replacement or decontamination of polluted sediments, or remediation of groundwater bodies.

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235 If none of these points applies, a passive strategy may conflict with Art. 4 (6) d WFD.

9.2.2 Operator

The findings resulting from the authorities' follow-up measures imply a need for revision of the operator's safety strategies. In addition, each individual operator needs to perform regular reviews to see whether changes in the state of safety technology over time give rise to changes in the requirements for his own installation.

The detailed analysis of operational structures and workflows going beyond an examination of events relevant to the damage provides a broader basis for possible improvements relating to technical and organisational safety aspects, with a view to taking more precise measures to prevent the occurrence of triggering factors in the future.

9.2.2.1 Follow-up measures for operational workflows

Whether there are changes in the site-specific hazard situation as a result of installation-related or general findings, is in principle a secondary consideration. What is important is that both sources of knowledge should form part of operational safety planning. Depending on the situation, follow-up measures for the following aspects of operational workflows may be necessary:

- ⇒ Susceptibility of individual safety-relevant components to malfunctions; changes in service intervals and operating workflows,
- ⇒ Modifications to operating instructions as a result of previous operating errors,
- ⇒ Regular review and revision of conceptual site-specific hazard prevention; can lessons be learned from previous incidents for the individual installation? (Broaden scenarios viewed, modify or enlarge package of measures),
- ⇒ Regular review and revision of internal emergency plans in the light of new findings and identified deficits,
- ⇒ Updating educational, training and information measures.

Responsibility for this individual "quality management" initiative must be assigned to the operator. At the same time, however, it must be assumed that as the hazard potential of an installation decreases and the standardisation of operational structures increases, there will be a decline in the operator's own sense of responsibility and inclination to innovate in the interests of continuous improvement. The competent authorities and bodies therefore bear increased responsibility in the field of access to information and updating of technical safety standards.

9.3 Conclusions for the action concept

The ideas in the section on after care, in conjunction with the requirements of Article 11 (3) I WFD with regard to damage review and follow-up measures, give rise to the action recommendations listed in Table 26. The table includes only measures which in view of their strategic character are capable of being part of the WFD programme of measures and which ensure controlled implementation of the after-care structures. For the reasons already explained, it does not list operational measures taken in response to a specific incident.

Table 26 Aftercare Management

After Care – Damage Review + Follow-up Measures	
Measure	**Implementation examples**
Creation of structures that ensure the following after an incident: • Official evaluation of plant-related safety management • Evaluation of official crisis management • Evaluation of impacts suffered • Analysis of plant-related causes and deficits	Guideline for registration, clarification and analysis of major accidents and disturbances of normal operation within the meaning of the Major Accidents Ordinance (LAI 2002)[236], Concept for registration and analysis of safety-relevant incidents (KAS/SFK 1998)[237]
Creation of structures that ensure incorporation of the analytical results ("lessons learned") in the fields of • Hazard prevention • Crisis management Database creation	Incident working groups in the international river basin commissions (Zentrale Melde- und Auswertestelle (ZEMA/UBA) (Registration and analysis centre) Major Accident Reporting System (MARS/EU)

[236] LAI, Guideline for registration, clarification and analysis of major accidents and disturbances of normal operation within the meaning of the Major Accidents Ordinance, 2002, http://www.umweltbundesamt.de/zema/LAI_Storfallmeldung_Leitfaden.pdf .

[237] KAS/SFK, *Concept for documenting and analysing safety relevant incidents*, 1998, http://www.sfk-taa.de/publikationen/publ.htm .

10 Quality management in the safety chain

While the importance of a quality management (QM) system for the functioning of the entire safety chain is not an essential theme of this project, it is certainly worth considering. A few remarks on this subject are in place here.

1. Quality management basically denotes all organised measures for the purpose of improving products, processes or services of all kinds.[238]
2. QM is a core task of management.[238]

These core statements on quality management expressed more or less in this form in text books prove in this particular case to be a very complex area that really deserves special treatment in itself. Whereas it may be possible to achieve a relatively precise definition of the "product" of the safety chain with the related "processes" and "services", practical implementation raises problems because in the multinational river basins – at least at present – there is no such thing as a joint "management" with core tasks that include QM. This would be the province of the river basin commissions, but their competencies and resources are probably not sufficient to enforce a comprehensive QM system.

This quality management is more far-reaching than the "feedback loop" in Figure 12 (p. 168), which is intended to ensure that the lessons learned from after-care following an incident of relevance to Article 11 (3) I WFD are fed into the optimisation of all planning, organisational and technical measures in the safety chain ("lessons learned", Chapter 9). The "lessons learned" in the "feedback loop" comprise the systematic collection, evaluation, aggregation and written documentation of experience, developments, useful information, errors, risks etc. which have been acquired in connection with an *incident that has actually occurred* (chemical accident, floods etc.) and which it might be useful to observe/avoid in connection with future incidents. Although in principle the "quality assurance loop" has the same "points of contact" as the feedback loop, QM is an ongoing process which has to be permanently maintained (Figure 63), and which must include all parties concerned, from the planning authorities through the warning centres to the safety personnel, and must be centrally controlled.

238 Brunner, Franz J., Wagner, Karl W.: Taschenbuch Qualitätsmanagement - Leitfaden für Studium und Praxis. Hanser, Munich 2008, ISBN 13: 978-3-446-41666-6.

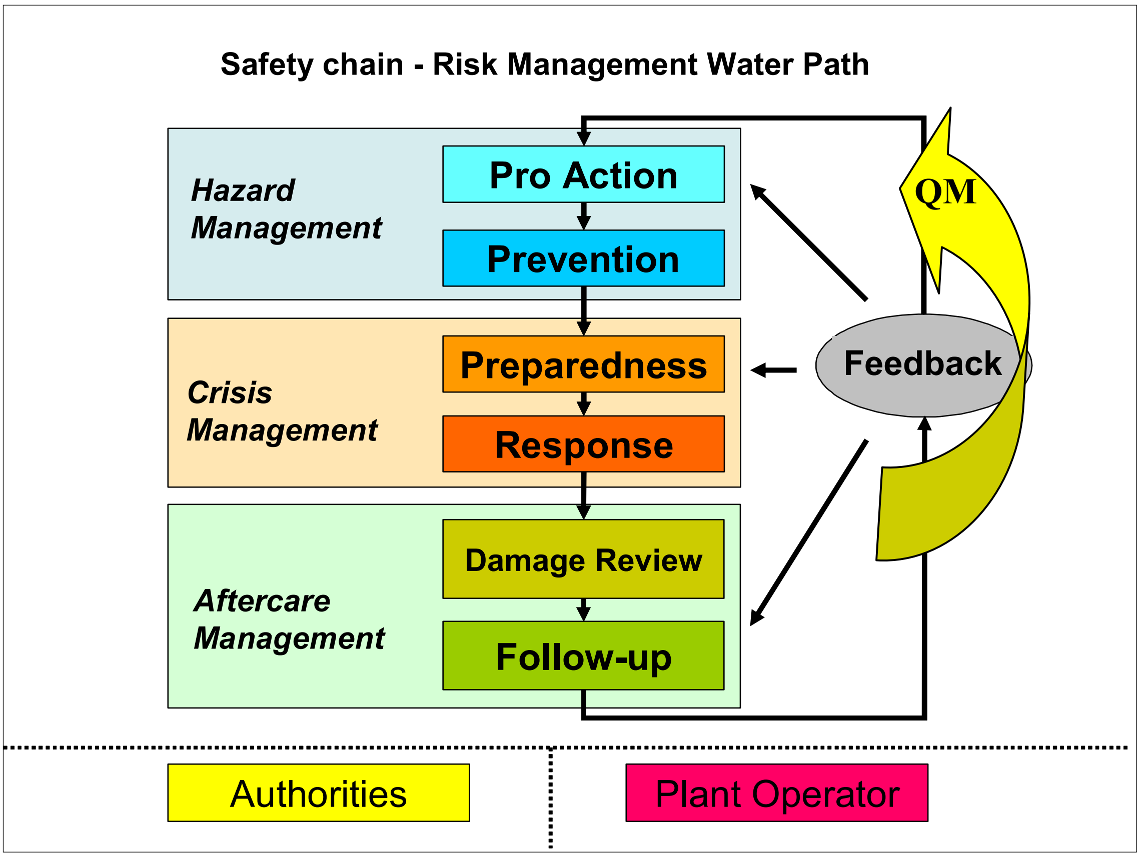

Figure 63 Quality management in the safety chain

For the implementation of the quality management system, the coordinating agency (e.g. the river basin commission) requires from every Member State in the river basin an authorisation endowed with appropriate powers, or at the least an explicit declaration of intent, plus the necessary human and material resources. Otherwise there will be little or no progress beyond exercises that confirm the functioning of fax forwarding between a number of warning centres, but reveal little about the effectiveness of the overall system in the event of serious accidents.

10.1 Suggested QM measures

The following are four – relatively abstract – suggestions for QM measures:

1. Develop for the safety chain at river basin level a quality management concept which takes account of the special characteristics of the river basin districts while having regard to the accepted rules of professional quality management. A concept of this kind specified to a degree that makes it capable of implementation is by no means trivial. Its preparation should be scheduled as a basic task in accordance with Article 11 (3) WFD for the first management period. Aspects to be taken into account include: the management and hierarchy structures, which do not correspond to those of a "company"; the presence/absence of different, possibly incompatible QM elements in individual sections of the safety chain; and the necessary human and material resources.

2. The implementation of a suitable QM concept throughout the river basin on an iterative, "learning by doing" basis should be scheduled for the second management period.

3. Before the implementation of the QM concept it could be agreed that individual technical links in the safety chain comply with existing established QM standards. At least technical requirements in the field of installation safety exist on the operator side in the form of the BREF documents (Best Available Technique Reference Document, Chapter 4.1.4), the individual recommendations of the river basin commissions or, in Germany, the ordinances on installations for handling substances dangerous to water (VAwS) or the future (federal) "Ordinance on the handling of substances dangerous to water" (VUmwS). Further QM requirements can be satisfied via the ISO 9000 standards, for example. Measuring equipment (both state-owned and operator-owned) can also be made subject to QM measures, e.g. accreditations are possible under the ISO 17000 standards. A number of the test methods used in the Hamburg Water Surveillance System are accredited (under DIN EN ISO/IEC 17025 *Test Laboratories*). Appendix 1 contains "*Recommendations on Quality Assurance of Analytical Results and Data in Automated River Water Monitoring Networks"* developed here.

4. Also before implementation of the QM concept, there could be an intensification of tests in the context of the International Warning and Alarm Plans, including

other links in the safety chain, such as the regional warning and alarm facilities, monitoring networks, rescue service establishments etc. Experience from these exercises could be fed into the development of the QN concept on an iterative basis.

11 Public involvement

Public involvement is basically an important concern of the WFD (Recital 46[239] and Article 14[240]). In relation to Article 11 (3) I WFD, public involvement is required in three intertwined fields of action:

1. In the preparation of management plans,
2. in the strategic environmental assessment,
3. in risk communication and crisis communication.

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[239] Recital 46 to the WFD

To ensure the participation of the general public including users of water in the establishment and updating of river basin management plans, it is necessary to provide proper information of planned measures and to report on progress with their implementation with a view to the involvement of the general public before final decisions on the necessary measures are adopted.

[240] Article 14 WFD

Public information and consultation

1 Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users:

a) a timetable and work programme for the production of the plan, including a statement of the consultation measures to be taken, at least three years before the beginning of the period to which the plan refers;

b) an interim overview of the significant water management issues identified in the river basin, at least two years before the beginning of the period to which the plan refers;

c) draft copies of the river basin management plan, at least one year before the beginning of the period to which the plan refers. On request, access shall be given to background documents and information used for the development of the draft river basin management plan.

2 Member States shall allow at least six months to comment in writing on those documents in order to allow active involvement and consultation.

3 Paragraphs 1 and 2 shall apply equally to updated river basin management plans.

11.1 Management plans

Management plans contain a summary of the programmes of measures including information on how they are to permit achievement of the objectives in Article 4 (Annex VII WFD A 7.). Annex VII also draws explicit attention to the measures for preventing the consequences of unintentional pollution (Annex VII WFD A 7.8.).

Management plans and, on request, background documents must be made available at an early stage, i.e. at the start of planning (periods of 1-3 years in the different stages of specification) and periods of 6 months must be granted for written comments on the documents.

This requirement, however, does not arise specifically from Article 11 (3) I WFD, but from the WFD as a whole. In other words, public involvement in the programmes of measures pursuant to Article 11 (3) I WFD does not differ either substantively or from a timing point of view from public involvement in other programmes of measures stated in the management plan.

11.2 Strategic Environmental Assessment (SEA)

Under Directive 2001/42/EC, plans and programmes that could potentially have environmental impacts must be subjected to a strategic environmental assessment (SEA)[54], which also prescribes formal information of the public and opportunities for comment by the public. This applies to all programmes of measures pursuant to Article 11 WFD, in other words including, but not confined to Article 11 (3) I WFD.

11.3 Risk communication and crisis communication

<u>Risk communication</u> is the "exchange of opinions and information on risks between the persons responsible for risk assessment, risk management, scientists and other parties concerned (industry, consumers, media and other interested groups)". In the context of crisis management the term needs a broader interpretation. It also includes pro-active information of the public and the media, and comes into play even before a crisis has arisen. <u>Crisis communication</u> is a management strategy which is employed in an acute

crisis, and thus forms part of crisis management. One aim of crisis communication is to ensure that despite the great pressure of time during the crisis the necessary communication between the parties involved in crisis management can take place. [241]

Successful risk management requires a functioning risk communication system along the entire length of the safety chain, i.e. the sharing of opinions and information on risks between the persons responsible for risk assessment and risk management, industry, the workforce, scientific circles, the public, the media and other groups affected. Involvement of the public in the event of a specific crisis (crisis communication) is one of several aspects. While the term "risk communication" does not usually occur as such in past legislation, such legislation frequently contains individual provisions that can be classified under this heading. In the field of containment of accident-induced hazards involving dangerous substances, the requirement can be deduced from the Seveso II Directive, for example, and also from the UNECE Accidents Convention, and it has been implemented in the member states in – sometimes differing – individual provisions. To this extent Article 11 (3) I WFD is directly concerned, but it cannot be regarded as the root source of the call for implementation of risk communication mechanisms. Thus Article 11 (3) I WFD does not give rise to any additional basic requirements in this respect than other areas of law. The preparation of management plans should however include a check for the existence of a functioning risk and crisis communication system. The inventory did not reveal any comprehensive concrete communications concepts at river basin level (apart from such items as notification forms for passing on damage notifications to administrative bodies in the warning and emergency plans).

As an example of risk communication guidelines, the reader's attention is drawn to *"Bericht Risikokommunikation – Anforderungen nach Störfallverordnung, Praxis und Empfehlungen"*[242] and to the report *"Risikokommunikation im Anwendungsbereich der Störfall-Verordnung"*[243], which also look at practices in other countries. The field of risk communication is the – sometimes controversial – subject of numerous publications. An in-depth discussion is beyond the scope of this project.

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241 Bundesministerium des Innern, Referat KM 1, Alt-Moabit 101 D, 10559 Berlin, *Krisenkommunikation - Leitfaden für Behörden und Unternehmen.*, www.bmi.bund.de, Berlin 2008.

242 AK Risikokommunikation „Bericht Risikokommunikation – Anforderungen nach Störfallverordnung, Praxis und Empfehlungen", Kommission für Anlagensicherheit beim BMU (KAS), June 2008, KAS-5, http://www.kas-bmu.de/publikationen/kas_pub.htm.

One guide to *communication in emergencies* and preparing for such communication was recently published by the German Federal Ministry of the Interior: *"Krisenkommunikation - Leitfaden für Behörden und Unternehmen".* This specific and clearly written guideline is discussed briefly below:[241]

11.3.1 Crisis communication – A guide for authorities and companies

Crisis communication comprises all communicative activities that take place in connection with a crisis situation, to prevent or limit loss of confidence, loss of image etc. It is an important part of crisis management and, like crisis management itself, requires clear structures and prepared strategies. Crisis communication has to be reviewed regularly to make sure it is up to date. It needs to be revised and updated *ad hoc* and in justified cases, especially on the basis of new findings ("lessons learned").

In practice, crisis communication means clear allocation of competencies and responsibilities, and a clear line of communication for a presentation that is consistent in content and arguments. To this end there is a need for agreement on how the media are to be integrated in dealing with the crisis.

In crises it is absolutely essential to ensure that all responsible parties have the same level of information and knowledge, and that the media and the public are supplied as far as possible with comprehensive, up-to-date, consistent and truthful information.

For this purpose the processes for coordinating information with a public impact must be agreed in advance between the authorities, since experience shows that when an incident is in progress there is no time to introduce new procedures or to optimise existing procedures and processes at short notice. Crisis communication calls for the elaboration of communicative strategies to prepare for crisis situations and for communication management (communicative behaviour during and after the crisis). [244]

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243 Anton; Claus; Bouteiller; Schrader; Kroll; Wiedemann; Eitzinger „Risikokommunikation im Anwendungsbereich der Störfall-Verordnung", Bericht zum F+E-Vorhaben 205 48 329 des Umweltbundesamtes, UBA-Text 31/2006, Dessau 2006, http://www.umweltbundesamt.de.

244 The actual line of communication is only decided in the crisis itself, because otherwise it would not be possible to take account of certain realities. External crisis communication, in other words communication with the media and

> Continued on next page <

In 2008 the Federal Ministry of the Interior published the guide *"Crisis communication – A Guide for Authorities and Companies"*[241], on which this section is based to a large extent.

The 70-page guide gives a clearly structured description of the main definitions, requirements and action recommendations (including check lists etc.). The guide – as stressed in the title – is intended to be equally suitable for authorities and companies. In fact it is largely concerned with administrative workflows – but companies can benefit from it if they imagine themselves in the position of one of the authorities involved in the events. The theories, definitions, action recommendations, planning models and check lists are undoubtedly just as useful for companies as for public authorities.

The guide puts a broader interpretation on the term "crisis communication" than the classification in the scheme in Figure 60 which is used in this report. This makes sense, because it addresses the subject here in parallel with the entire safety chain, from preparation through the crisis itself to after care with the lessons learned and need for changes. Figure 60 shows only the crisis part – in other words the actual "implementation" of the elaborated concept.

The guide is made up of three thematic areas:

⇒ Part A Crisis and crisis communication: Systematic overview,

⇒ Part B Instructions and action recommendations/checklists,

⇒ Part C Crisis communication plan (organisation-specific / sector-specific),

a fourth Part D "Personal Notes" contains blank forms that the owner of the guide can use in a crisis situation (personal To-Do list, phone numbers and contacts).

> Continued from previous page <

the public, cannot be squeezed into a fixed scheme. However, many things can be prepared and initiated or planned at an early stage (e.g: information material, media partnerships etc.) and have to be cultivated (regular communication with the media, press and public relations work).

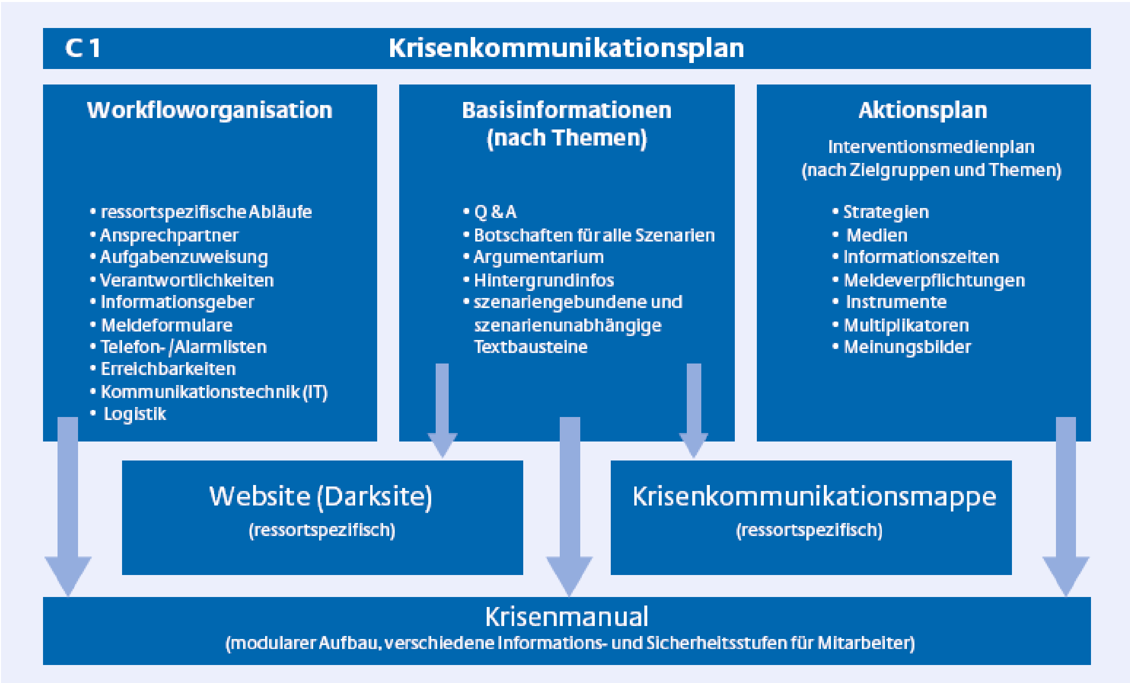


Figure 64 Structure of a crisis communication plan according to BMI guide

The systematic overview in Part A provides an introduction to crisis theory – definitions, manifestations, causes, characteristics, course of events, differentiation. It discusses the challenges during the crisis and the role of crisis communication; also communication strategies and the phases of activity in crisis communication. This information demonstrates the need for timely elaboration of a crisis communication plan (see Figure 64).

The crisis communication plan gives a detailed description of the PR-relevant procedures during a crisis in a company, organisation or authority. It describes crises with the aid of a scenario approach and runs through the sequence of events. This includes making clear definitions of competencies and responsibilities, laying down (as far as possible) a line of communication, and reaching agreement on a PR approach that is consistent in content and arguments. Detailed planning of how the media are to be integrated in dealing with the crisis also helps to ensure homogeneous communication to the public.

Part B Instructions and action recommendations/checklists presents instructions and action recommendations in the form of checklists. Six blocks of checklists cover the topics:

⇒ Instructions and action recommendations for analysing and assessing crisis communication and crisis communication structures,

⇒ Instruments of crisis communication,

⇒ Principles of and rules for (crisis) communication,

⇒ Checklist for communication strategies – Identifying and assessing possible factors,

⇒ Checklist for press releases – From the alert to the first press release,

⇒ Checklist for media observation and media analysis during the crisis.

Part C Crisis communication plan (organisation-specific / sector-specific) provides a model for the structure of a crisis communication plan. This systematically checks the key points in the structures shown in Figure 64.

12 Appendices

Appendix 1 Quality assurance in river monitoring networks

Michael Lechelt, Stephan Anke, Werner Blohm

Recommendations on Quality Assurance of Analytical Results and Data in Automated River Water Monitoring Networks

Contents

Page

1 Scope

These recommendations are intended to provide information on implementing quality assurance within automated river water monitoring networks. Detailed descriptions of many aspects of the items dealt with here are already available in general form in instruction sheets and standards. Examples include:

- DIN ENV ISO 13530, Water quality – Guide to analytical quality control for water analysis (October 1999)

- DIN EN ISO/ICE 17025:2005 General requirements for the competence of testing and calibration laboratories

The following recommendations are therefore only of a supplementary nature. They provide specific information on the operation of automated monitoring networks.

2 Introduction

Important decisions and measures in the field of environmental protection and environmental policy are based on measurements obtained using methods of chemical, physical and biological analysis. Environmental data are important indicators of adverse impacts on ecosystems and possible health risks for the population, and give politicians the opportunity to take timely countermeasures.

The analytical results therefore have to meet very high requirements with regard to quality and reliability. To ensure error-free analyses it is thus a fundamental requirement that a quality assurance system be in place for every monitoring station. This means it is also necessary to undertake quality assurance within river water monitoring networks [1]. Only in this way is it possible to detect operating problems at an early stage and take timely action.

3 Quality assurance

Quality assurance is a collective term for all measures taken to facilitate information about the quality of measurements and to ensure the quality of such measurements.

The most important measures are [2]:

- Clearly identifiable spheres of responsibility in the organisation
- Appropriate constructional facilities that take account of the requirements of the analytical methods
- Appropriate equipment that is regularly kept in line with the state of the art. For automated monitoring networks in particular, this includes the measuring equipment at the monitoring stations, the data transfer systems and the complex IT field.
- Qualified staff who receive regular and appropriate training and upgrading
- Use of procedures and methods appropriate to requirements
- Regular implementation of targeted and effective quality assurance measures
- Appropriate documentation of all results and quality assurance measures.

3.1 Staff and organisational requirements

Central coordination of the individual measures by a quality assurance officer (QA Officer) is essential. The duties of the QA Officer should be performed by a technically qualified person with several years' experience in the field of water analysis. A suitably qualified deputy should be available to stand in for the QA Officer if the need arises.
It is the QA Officer's duty to ensure that written documentation of the organisation of the QA system and the responsibilities within it is prepared (Quality Assurance Manual) and kept constantly up to date.

Quality assurance must be organised such that every member of staff knows the extent and limits of his or her own sphere of responsibility. To this end staff must be given appropriate instruction in their tasks and duties, especially with regard to quality assurance. Staff are required to carry out appropriate testing of new analytical methods and to practise adequate quality assurance.

One important aspect of maintaining competence is staff training and upgrading, with a view to keeping up with advances in measuring and calibration and improving work quality.

Dealing with quality management tasks ties up a considerable proportion of staff capacity.

3.2 Technical equipment

Continuously operating automatic monitoring stations are equipped with a wide range of technical devices. These monitoring stations are connected with the centre of the relevant network by data transfer systems. Complex IT applications are necessary to evaluate and manage the large quantities of data.

All items of equipment are maintained by the individual staff members responsible and serviced in accordance with the equipment instructions and, where appropriate, the maintenance plan. Device log books must be kept by the persons responsible for quality-relevant devices. The log book must clearly identify the device in question and must include a maintenance plan (where appropriate), and a historical record of calibrations, servicing, problems, repairs, performance tests etc. These records, along with manuals and servicing instructions, should be directly available to personnel at their workplace.

The impact of errors on earlier tests or calibrations must be investigated.

Measuring devices are calibrated by means of standards. The management of the monitoring network must ensure traceability of details such as composition, origin, preparation date, service life etc.

All standards must have a unique identification and, as a minimum, their service life date. Details of the use of standards are regulated by individually prepared standard operating procedures (SOPs).

3.3 Documentation

The documentation within a quality assurance system comprises both internal and external documents. Internal documents include the QM Manual, procedural instructions, standard operating procedures (SOPs), QM lists, control charts etc. These are explained in greater detail below.
The external documentation includes a wide variety of standards, rules, operating instructions etc.

Internal documents
The content of all documents must be checked regularly and revised if necessary, to ensure that they are always fit for the intended purpose and constantly in accordance with the applicable rules.

External documents
Device documentation and operating instructions etc. relate to individual devices and are therefore managed, updated and archived by the staff member responsible for the device in question. An up-to-date version should always be kept close to the device.
Relevant standards and rules are filed in a suitable place so that they are always accessible for inspection by those concerned.

3.3.1 Quality Management Manual

The elements of the quality assurance system are to be set out in a Quality Management Manual (QM Manual). The aim of the QM Manual is to bring together all quality assurance workflows, thereby streamlining them and making them more transparent. Internally, it is thus intended as an aid to the staff members concerned with the measurement tasks it describes. Externally, the QM Manual serves to document the quality assurance efforts vis-à-vis the client and the public and all institutions that are technically affected [1].

The QM Manual also documents responsibilities within the monitoring station. This includes at least one organisation chart, plus a description of the quality assurance tasks and competences assigned to the individual staff members. The monitoring station must keep information about qualifications, experience and continuing education of technical personnel up to date and must document it in suitable form. Measures must be taken to protect person-related data.

The QM Manual should be kept as a loose-leaf work, to make it easy to add and change pages. The Manual must be kept up to date by a responsible staff member appointed by the management of the monitoring network [1].

3.3.2 Procedural instructions

Procedural instructions are documents describing general or cross-sectoral workflows. They contain instructions on how to handle over-arching workflows. Procedural instructions also regulate competences.

In automatic monitoring networks it is helpful, for example, to describe the competences of the entire IT sector in a procedural instruction. Procedural instructions also lay down which SOPs are to be used in the individual procedures.

All persons working on a procedure are called upon to keep thinking about potential sources of error or possible improvements .

The staff should talk to the management of their work area about suggested improvements and possible preventive measures. Together they should examine whether the suggestion is useful and practicable.

If the decision is positive, the management of the work area and the originator of the idea, together with other persons affected (where appropriate), decide how the measure is to be implemented and documented. They must of course take suitable account of framework conditions such as the available human and financial resources.

3.3.3 Standard operating practices (SOPs)

As a fundamental principle, analytical methods etc. that are described in standards should form a basis for performing certain tasks and measurements and for complying with the quality assurance requirements. However, practical experience shows that

- the descriptions of certain process steps in standards are inevitably incomplete and are not always transferable to the operation of monitoring stations and their automated measuring methods,
- there may be technical reasons for deviating from procedures described in the literature.

There is therefore a need to ensure that the measurement methods used and the necessary work with the individual devices are described in a way that reflects their practical use. Moreover, it is also important to set down what items of equipment are to be used and what quality assurance measures must be implemented.

A description of the individual steps in the analytical methods must therefore be laid down in standard operating procedures (SOPs) and made available to the staff. Care must be taken to write these SOPs in a clear and easily understood form.

3.3.3.1 Content of SOPs

Standard operating procedures may have the following structure and must contain at least:

1. Contents
2. Scope, sphere of activity, measurement method, responsibility
3. Chemicals, calibrating solutions, service life
4. Equipment (exact designation, device parameters, special features)
5. Equipment servicing, service intervals
6. Measurement, evaluation, results, documentation
7. Quality assurance measures
   a. Calibration
   b. Plausibility check
   c. Internal comparison
   d. Data backup
   e. Control charts
   f. Device log book
8. Troubleshooting information
9. OSH information (optional)
10. Disposal of reagents (optional)
11. Flow chart (optional)
12. List of changes
13. Appendix

Content of the individual chapters

The following section provides a number of hints for compiling the individual chapters.
Generally speaking, where instructions keep on appearing in different SOPs it can be helpful to bring them together in a separate SOP that is merely referred to in the appropriate places.

Chapter 2: *Scope, sphere of activity, measurement method, responsibility*
This describes the work area and measurement method the SOP applies to. It makes reference to the underlying procedure in the standard, and describes any deviations of relevance to the results. It specifies the measuring range and the key data for the method.
It also documents who is responsible for performing the analytical method. This can also be done by referring to a separate list (in the QM Manual).

Chapter 3: *Chemicals, calibrating solutions, service life*
This chapter lists the chemicals and calibrating solutions required for the method. It should also list storage details and keepability. Where appropriate, the required purity must be specified for chemicals. Suppliers and order numbers should also be quoted, as this can simplify follow-up orders.

Chapter 4: *Equipment*
This describes the devices/equipment used and their precise names. All important device settings and special points to be observed when using the devices must be documented. References to the operating instructions may be useful here. A description of the measurement method may also be useful to make it easier to understand the necessary work.

Chapter 5: *Equipment servicing, service intervals*
All regular servicing requirements and their frequency are listed here (e.g. "change tube every 2 months"). A detailed description of the individual operations is provided.

Chapter 6: *Evaluation, results, documentation*
This chapter describes how the data are evaluated and checked. It specifies where and how the data are stored and how they can be evaluated. In this case it is advisable to write a separate SOP, which is merely referred to at this point.

Chapter 7: *Quality assurance measures*

a. Calibration
b. Plausibility check
c. Control charts
d. Internal comparison
e. Supervision of test resources
f. Data backup
g. Device log book

This section lists the quality assurance measures that are to be performed, with details of frequency and of the quality targets to be achieved. Suitable follow-up measures must be specified here for any out-of-control situations and for cases of failure to achieve stated quality targets. Routine analysis may not be resumed until steps have been taken to ensure that quality is not – or no longer – impaired. The entire procedure is documented.

a. Calibration: This section describes all work steps and also how calibration is performed. This item can if necessary be incorporated in the description of servicing work.
b. Control charts: This describes the procedure for preparing the control charts. The control charts make it easier to assess the accuracy of the methods and reveal any problems with the equipment at an early stage.
c. Internal comparison: This describes how the mobile measuring devices for checking the sensors in the monitoring stations are regularly synchronised, and where and how this is documented.
d. Plausibility check: This describes the work performed to check the plausibility of the data (stored online data in the database). It also explains the procedure for marking or deleting invalid data. A separate SOP on data maintenance should be prepared, and reference made to it here.
e. Supervision of test resources: Test resources are all equipment and reagents used for checking and operating a measurement method (e.g. refrigerators, pipettes, balances, reagents etc.). This section defines the test intervals, the relevant test methods and the way they are documented.

f. Data backup: This section describes all measures and the procedure for performing data backups. Special attention should be devoted to this point, since loss of data can render several years' work useless in a moment. Here too it is advisable to prepare a separate SOP which is referred to here.
g. Device log book: This describes how the device log books are to be kept. It defines what entries are to be made and when.

Chapter 8: *Troubleshooting information*
This section must explain potential problems and describe measures for avoiding and remedying such problems.

Chapter 9: *OSH information (optional)*
All work detailed in the SOP must comply with the OSH regulations currently in force. This chapter draws attention, if necessary, to any special risks and lists the relevant protective measures (e.g. safety glasses, protective gloves).

Chapter 10: *Disposal of reagents (optional)*
This specifies how to dispose of residual reagents (e.g. collecting toxic reagents in special containers for subsequent central disposal). It is important to ensure that the arrangements are as environmentally sound as possible.

Chapter 11: *Flow chart (optional)*
For some methods it is useful to present the workflow in the form of a flow chart.

Chapter 12: *List of changes*
This list serves to keep a record of ongoing changes to the procedure. Changes made during the period until the next revision of the SOP are entered in handwriting. (The period from the creation of a version until the next revision is usually one year.) These changes are then initialled by the manager of the work area. When the SOP is revised, relevant changes remain in this list, thereby making it possible to document the historical development of a procedure.

Chapter 13: *Appendix*
This is where documents such as printouts of measurement conditions, evaluation forms, control cards etc. are attached to the SOP.

3.3.3.2 Creating SOPs

As a rule, the first draft of a SOP is drawn up by the staff who operate the measurement method, usually in cooperation with the management of the monitoring network. The latter scrutinises the draft from a technical point of view and calls for redrafting where necessary.
After scrutiny by the management of the work area, the draft SOP is passed to the QA Officer, who checks it for completeness and plausibility, and with regard to the QA measures to be performed.
After successful checking, the SOP is stored in a specified location and the requisite number of copies are printed. The working copies are signed by all concerned to put them into force, and distributed. The precise procedure for creating and maintaining SOPs should be described in separate procedural instructions.

3.3.3.3 Maintaining and updating SOPs

Alterations to the SOP are to be made in the working copy without delay, by handwritten insertion in the list of alterations and, if appropriate, in the text itself. Major changes affecting the workflow are to be initialled by the management of the work area.
SOPs are reviewed annually. As a rule, this review is undertaken by the operating staff for the relevant method (or the author), mostly in cooperation with the management of the monitoring network.
If the review reveals that little or no change is necessary, the management of the work area enters the review in the list of changes in the working copy, with date and signature, and passes this information on to the QA Officer.
If major changes are necessary, the author and the management of the monitoring network draw up a revised SOP.
When the new version is distributed, the old versions of the SOP are collected in.

3.3.4 Control charts

To assure the quality of analytical results it is necessary to assess the correctness and precision of methods and to monitor them on a routine basis. One very efficient means of monitoring accuracy in routine analysis is to keep control charts [1]. Separate procedural instructions should be used to describe how the control charts for the monitoring network are to be kept. Recommendations and information on preparing control charts can be found in Appendix 2. For further information, see the analytical quality assurance instruction sheet on “Control Charts”, published by LAWA (Joint Water Commission of the Federal States).

3.4 Information on input required

Implementing a qualified quality assurance system involves considerable input in terms of time, human, technical and financial resources [1]. On the other hand, such measures are indispensable for assuring a constant standard of quality.

Depending on the task, the proportion of quality assurance measures required may be very high. The advantages are also considerable, however:

- Great reliability of analytical results
- Traceability
- Greater acceptance in the event of legal disputes
- More efficient workflow design (productivity)
- Customer satisfaction (client)

4 Definitions and abbreviations

This document uses technical terms from DIN EN ISO/IEC 17025 and commonly used expressions and abbreviations. The following list provides more detailed explanations and specifications.

4.1 Terms and definitions

Out-of-control situation: Situation in which the analytical method is faulty from a statistical point of view.

Device supervisor: Person or persons who are responsible for a particular measuring device and who usually work with it

Test methods: are methods that are used for analyses

QA Officer: The QA Officer is the person responsible for implementing a quality assurance system

Standard operating practices (SOPs): contain specific instructions on how to use an analytical method or an item of equipment

Monitoring station: Establishment concerned with performing the analysis

Investigation: Implementation of sampling and/or analysis

4.2 Abbreviations

IT	Information technology
PI	Procedural instructions
QA	Quality assurance
QAO	Quality Assurance Officer
SOP	Standard operating practice

5 Bibliography

[1] AQS-Merkblatt „Kontrollkarten“ zu den Rahmenempfehlungen der (deutschen) Länderarbeitsgemeinschaft Wasser (LAWA) für die Qualitätssicherung bei Wasser-, Abwasser- und Schlammuntersuchungen

[2] Qualitätsmanagementhandbuch des Institutes für Hygiene und Umwelt in Hamburg, Teil HU4, VA HU4.12, Erstellung und Pflege von abteilungsinternen SOPs und VAs

[3] DIN ENV ISO 13530, Water quality - Guide to analytical quality control for water analysis (October 1999)

[4] DIN EN ISO/ICE 17025:2005, General requirements for the competence of testing and calibration laboratories

[5] Arbeitsblatt DWA-A 704, Betriebsmethoden für die Abwasseranalytik, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfälle e.V.

6 Appendix

Appendix 1: Example of preparation of a SOP
Appendix 2: Recommendations and information on preparing control charts and lists

Appendix 1: Example of preparation of a SOP

FREE AND HANSEATIC CITY OF HAMBURG Department of Science and Health	**Hamburg Institute for Hygiene and Environment** Hamburg State Institute for Food Safety, Health Protection and Environmental Studies
Quality Management Manual – Monitoring Network	
SOP No.	**Determining conductivity in water samples, monitoring device**
Page …	**Version: 01** **Valid from: 01.01.2006**

Determination of conductivity in water samples with mobile monitoring device for checking online sensors

Working copy for

- ☐ **Workplace**
- ☐ Central QM
- ☐ SOP Collection Monitoring Network
- ☐ Record Office

☒ **Information copy** (not subject to change service)

	Name	Date	Signature
Created:			
Checked: QAO			
Approved: Management			

Contents

Page

1 Scope, work area, measuring method

This SOP applies to conductivity analysis of water samples within the work area of the monitoring network. It provides detailed information about use of the mobile monitoring device for regular checking of online conductivity sensors in the monitoring stations. The work is performed by the staff members “Tester 1” and “Tester 2”.
Responsibility rests with the management of the monitoring system. which is to be consulted in the event of irregularities or questions about the procedure.

Conductivity is determined by electrometric means in accordance with **DIN EN 27888 C8** (Version November 1993).

The conductivity of water samples depends on their temperature. In order to compare figures for different samples, conductivity is determined for a specified reference temperature. According to DIN the reference temperature is set at 25°C.

2 Chemicals and equipment

2.1 Chemicals

- Potassium chloride, analytical grade, e.g. Merck No. 4936
- Dilute HCl, approx. 0.1 mol/l for cleaning the sensor

For all chemicals and all solutions of limited keepability, the expiry date is to be indicated on the container if it has not already been printed there by the manufacturer.

2.2 Equipment

- Conductivity meter WTW inoLab Cond Level 2 P
- Conductivity cell WTW TetraCon 325
- 1 glass beaker 500 ml for rinsing
- Wash bottle with ultrapure water

3 Sample preservation, sample storage

Conductivity measurements are performed directly in the monitoring station, i.e. in the river. There is therefore no need for preservation and storage.

4 Storage and handling of standard solutions

0.1 mol/l potassium chloride solution: Dissolve 3.728 g dried potassium chloride in demineralised water in a 500-ml measuring cylinder and fill up to the calibration mark. This solution is stored in a refrigerator at 4°C and can be kept for approx. 3 months.
0.01 mol/l potassium chloride solution: This solution is always freshly prepared from the 0.1 mol/l solution by dilution in the ratio 1:10.

5 Test sequence

5.1 Calibration and testing of equipment

The functioning of the equipment is tested in the laboratory with a 0.01 molar KCl solution.

- Switch on device, red indicator
- Rinse cell with demineralised water, dry and immerse in the measuring solution (0.01 mol KCl).
- Press **<CAL>** key until æ **CELL** appears in the display
- Press **<RUN/ENTER>**, press **<RUN/ENTER>** again, **"AR"** flashes until calibration is complete.
- Measurement is continuous, conductivity and current temperature are shown.
- The measured value and the cell constant are entered in the relevant control chart.

After calibration, the measuring device assesses the calibration status:

Display	Cell constant [cm^{-1}]
three dashes	0.450 ... 0.500 cm^{-1}
E 3	Faulty calibration

The measured value for the 0.01 mol KCl solution must be 1413 ± 15µS/cm. If it is not, first repeat the measurement. Clean the electrode if necessary, then readjust cell constant until a conductivity reading of 1413 µS/cm is obtained.
Cleaning electrode and resetting the cell constant: see operating instructions (TetraCon 325, pages 2 and 6).

5.2 On-site measurement

Switch on device, **<red indicator>**. Measurements are made in accordance with DIN using the non-linear temperature function (nLF). "nLF" must appear in the lower part of the display. The reference temperature must be set at 25°C, the display shows "TREF 25".
Before starting measurement, activate the AutoRead function, press **<AR>** and hold the electrode in the basin or river, then press **<RUN/ENTER>** to start the measurement. **"AR"** flashes. Wait until **"AR"** stops flashing, which means the measurement is complete. Read off the conductivity and enter it in the relevant control log for the online conductivity sensor. Further details of the procedure for testing the online sensor can be found in SOP No. X "Measurements with the WTW online multiparameter sensor".

5.3 End of measurement

- Switch off conductivity meter

6 Analytical quality assurance measures

The following analytical quality assurance measures are performed weekly:
Measurement of the 0.1 mol/l KCl solution to check the sensor cell (see 6.1). The measurement is entered in the relevant mean control chart. The individual cell constant is entered in the relevant field.
If the control charts reveal unusual aspects or if the limit values are exceeded, the reason must be found and documented without delay; the management of the monitoring system or the QA Officer must be consulted. This device must not be used again until the responsible person has once again given clearance for the procedure.

7 Servicing of equipment, regular function tests

Check electrode and storage container regularly for algal growth, and clean with demineralised water. Treat stubborn dirt with dilute HCl.

8 Troubleshooting information

Chapter 6 of the operating instructions contains a list of all possible error messages.

9 List of changes

Date	Type of change	Signature
15.02.2006	SOP was reviewed by Ms Tester, Additions were made to Chapter 9	QAO

Appendix 2: Recommendations and information on preparing control charts and lists

These recommendations are intended to provide instructions on documenting quality assurance measures. All aspects of the items dealt with here are already described very thoroughly in instruction sheets and rule books. Examples include:

- AQS-Merkblatt “Kontrollkarten” zu den Rahmenempfehlungen der (deutschen) Länderarbeitsgemeinschaft Wasser (LAWA) für die Qualitätssicherung bei Wasser-, Abwasser und Schlammuntersuchungen
  (Analytical QA instruction sheet on “Control Charts”, by the (German) Joint Water Commission of the Federal States (LAWA), for quality assurance in water, wastewater and sludge analysis)

- Arbeitsblatt DWA-A 704, Betriebsmethoden für die Abwasseranalytik, Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfälle e.V.
  (Work sheet DWA-A 704, Operating Methods for Wastewater Analysis, German Association for Water Resources Management, Wastewater and Waste)

The following recommendations are therefore only of a supplementary nature. They provide specific information on the operation of automated monitoring networks.

When operating a monitoring network, special attention must be paid to quality control measures (these are described in the relevant SOPs). This ensures regular checks on the methods employed, the reagents used and the measuring equipment. The following methods can be used for quality control:

- Measurement of standard solutions to check working methods and measuring equipment
- Comparisons with other measuring equipment within the work area or in the context of inter-laboratory tests
- Plausibility checking by means of dilution or upscaling tests
- Reproducibility checking by multiple measurement of a sample
- Checking and servicing of test resources (adjustment, calibration) in accordance with manufacturer’s specifications
- Checking service life of reagents

Compliance with these instructions is a precondition for proper analytical results of consistently high quality. However, the data obtained will only be of appropriate significance if the circumstances of their capture and other quality assurance measures are suitably documented, e.g. with the aid of control charts or lists [5].

Systematic documentation produces objective evidence of the quality of the measurements, and that means measurements that can bear close scrutiny in legal disputes.

In addition to the measurements themselves, all boundary conditions must be documented. These include time , place and type of measurement, for example. The documentation must also indicate who performed the individual activities and what result emerged from the assessment of the test.

In order to provide a transparent picture of all quality assurance measures for the monitoring network, it is advisable to create an “overview chart”. This lists all measures and test intervals and the persons responsible.

Individual definitions should be laid down for test frequency, tolerances, service intervals and quality targets, to form the basis for the entire quality assurance system.

1 Mean control charts

For many measurements in a quality control context it is advisable to keep “mean control charts”. These are used to document the results of the regular calibrations and control measurements and assess them with the aid of “warning limits” and “control limits”.

The measurements are entered in the mean control charts; they must normally cluster around a target value (value specified in the standard). Depending on the concentration, every measurement method displays a certain characteristic measurement uncertainty (scatter) that gives rise to a permissible tolerance bounded by warning limits and control limits. These can be determined experimentally (see also [1]), but are usually specified by the manufacturer.

The analytical method is statistically out of control (out-of-control situation) if the following criteria are satisfied:

- 1 measurement is outside the control limit
- 7 successive measurements are above the target value
- 7 successive measurements are below the target value
- 7 successive measurements show a downward trend,
- 7 successive measurements show an upward trend,
- 2 out of 3 successive measurements are outside a warning limit.

Once an out-of-control situation has arisen, the reason must be found and documented without delay; the management of the monitoring system or the QA Officer must be consulted. This device must not be used again until the responsible person has once again given clearance for the procedure.

A separate chart must be kept for each measurand and each parameter . The following Fig. 1 shows a mean control chart illustrating quality control for a mobile conductivity meter (monitoring device, see also Appendix 1).

Fig. 1: Mean control chart for quality control of a mobile conductivity meter

Institute for Water Analysis Department: Monitoring Network	Mean control chart – Calibration of mobile conductivity meter	No. 123

Device: WTW inoLab Cond Level 2 P No. 123

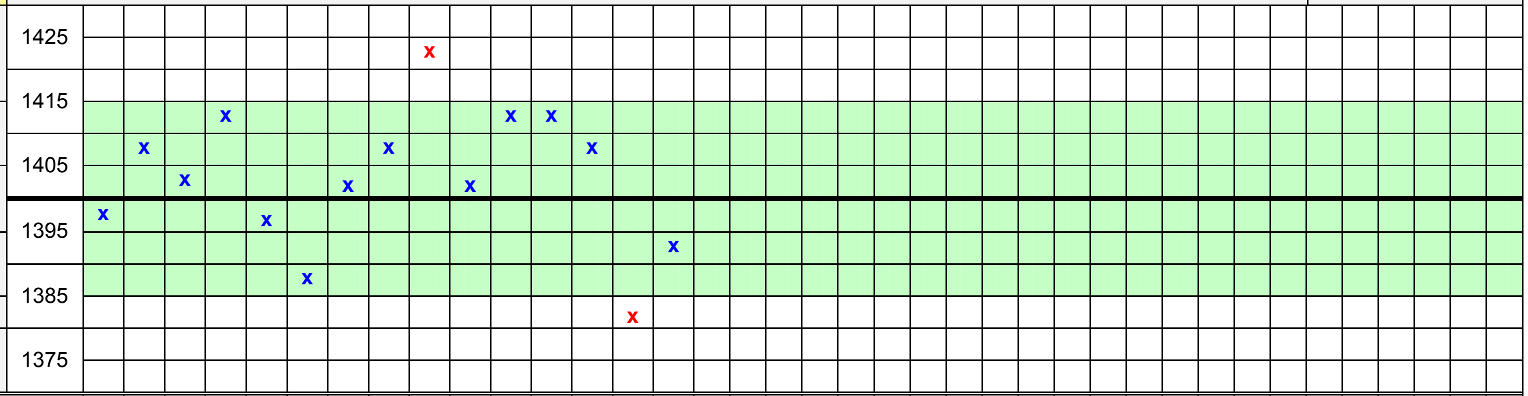
Measurand: Conductivity

Sensor cell: WTW TetraCon 325

Name of standard: Potassium chloride, Merck No. 4936

Target value: 1400 ± 15 µS/cm

Target value cell constant: 0.45 – 0.5 1/cm



Remarks	ok	ok	ok	ok	ok	ok	ok	ok	Not ok!	ok, standard new	ok	ok	ok	Not ok!	ok, new measurement
Measurand [µS/cm]	1398	1408	1403	1413	1397	1388	1402	1408	1423	1402	1413	1414	1408	1382	1393
Cell constant [1/cm]	0.456	0.458	0.457	0.456	0.456	0.456	0.455	0.455	0.457	0.456	0.455	0.454	0.454	0.457	0.456
Batch number, standard	123	123	123	123	123	123	123	123	123	456	456	456	456	456	456
Date	03.01.07	10.01.07	17.01.07	24.01.07	02.02.07	09.02.07	16.02.07	23.02.07	29.02.07	29.02.07	06.03.07	13.03.07	20.03.07	27.03.07	27.03.07
Name/Abbreviation	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 1	T 2	T 2	T 2	T 2	T 1	T 1	T 1

2 Control lists for comparative measurements

Comparative measurements are an important part of quality control within a monitoring network. In the operation of monitoring networks it has proved valuable to use “mobile monitoring devices” for quality control of measuring equipment in the monitoring stations. This has the great advantage that the mobile monitoring devices can be tested and if necessary calibrated under optimum conditions in the laboratory before every use. The devices at the stations are tested in their turn using the mobile monitoring devices. If several stations are checked with the same mobile monitoring device in a single day, this obviates the need for a large proportion of the steps necessary at the individual stations. Without the use of mobile monitoring devices it would be necessary to use the relevant standards to check the online sensors at the stations. Often, however, the conditions at the stations are not ideal for this work, and as a rule proper storage of the standard test solutions is not possible either.

If several mobile monitoring devices are used within the same network, the mobile devices themselves must be compared at regular intervals.

The following Table 1 shows an overview of the various quality controls for an online multi-parameter measuring device at a monitoring station.

Table 1: Overview of quality controls on an online multi-parameter sensor

Measuring device	Sensor	Measurand	Testing
WTW IQ Sensornet	pH	pH	Weekly comparative measurement with the mobile device before and after cleaning of the sensor
			Comparison of steepness of measuring chain with manufacturer's permitted specifications after every calibration
			Comparison of asymmetry with manufacturer's permitted specifications after every calibration
		Temperature	Weekly comparative measurement with a calibrated thermometer
	Oxygen	Oxygen concentration	Weekly comparative measurement with the mobile device before and after cleaning of the sensor
			Comparison of relative steepness with manufacturer's permitted specifications after every calibration
		Temperature	Weekly comparative measurement with a calibrated thermometer
	Conductivity	Conductivity	Weekly comparative measurement with the mobile device before and after cleaning of the sensor
			Comparison of cell constant with manufacturer's permitted specifications after every calibration
		Temperature	Weekly comparative measurement with a calibrated thermometer
	Turbidity		Six-monthly comparison of measurement with the systems at other stations

As already described, these operations must also be carefully documented. The following example (Table 2) shows the documentation of the comparative measurements between the mobile conductivity meter and an online conductivity sensor at a monitoring station.

Table 2: Example of documentation of comparative measurements, based on testing of conductivity measurements at a monitoring station

Sensor: Conductivity sensor No. 123					**Location:** Monitoring station Danube 3				**Mobile device:** WTW inoLab Cond Level 2 P, No. 123		
Parameter: Measurand: Conductivity					**Permissible deviation before cleaning:** ± 15% [otherwise clean more frequently]						
Permissible cell constant: 0.45 – 0.5 1/cm					**Permissible deviation after cleaning:** ± 5 %						
Date	**Reading, control** [µS/cm]	**Reading, online sensor before cleaning** [µS/cm]	**Δ1** [µS/cm]	**Δ1** [%]	**Reading, online sensor after cleaning** [µS/cm]	**Δ2** [µS/cm]	**Δ2** [%]	**Rating**	**Cell constant** [1/cm]	**Remarks**	**Tester**
13.01.07	523	499	24	4.6	535	12	2.3	ok	0.475	---	Tester 1
20.06.07	648	604	44	6.8	666	18	2.7	ok	0.475	---	Tester 2
27.06.07	687	577	110	16	698	11	1.6	Not ok	0.475	Currently strong growth, clean twice a week	Tester 2
30.07.07	587	487	100	17	605	18	3.0	ok	0.475	---	Tester 2
12.07.07	512	461	51	9.9	523	11	2.1	ok	0.475	---	Tester 1
17.07.07	756	711	45	6.0	804	48	6.4	Not ok	0.475	Calibrate sensor	Tester 2
17.07.07					776	10	1.3	ok	0.470	Sensor recalibrated	Tester 2
25.07.07	698	664	34	4.9	710	12	1.7	ok	0.470	---	Tester 2

3 Control lists for supervision of test resources

Test resources are all equipment and reagents used in connection with the measurements in the monitoring network. Test resources supervision plays an important role in quality assurance and can be as detailed as desired. Care should however be taken to ensure that this work does not exceed a reasonable level. The tests are made at defined intervals. These can be shown in the "Overview control chart". The tests may also be performed by the manufacturer in the course of servicing. Recommendations regarding control and monitoring frequencies are also often made by the manufacturers or may be taken from ISO standards.
Table 3 shows examples of possible test intervals for certain test resources.

Table 3: Examples of monitoring frequencies for test resources

Test resource	Testing
Refrigerators	every 6 months
Balances	every 12 months
Syringe pipettes	every 3 months
Thermometers	every 12 months

A separate chart must be kept for each test resource. The following Table 4 shows an example of a control list for quality control of a refrigerator for storing reagents.

Table 4: Control list for a refrigerator

Refrigerator: Siemens KT16RP20		**Location:** Laboratory No. 123		
Target value: 5°C ± 1°C				
Date	**Actual value**	**Rating**	**Remarks**	**Signature**
13.01.07	5°C	ok	---	Tester 1
16.06.07	6°C	ok	---	Tester 2
08.01.08	10°C	Not ok	Control out of adjustment	Tester 2
09.01.08	5°C	ok	Control corrected	Tester 2
03.06.08	4°C	ok	---	Tester 1

Appendix 2 Bibliography/Footnotes

Sources in the literature are cited in footnotes at the point where they are first mentioned. Repeat citations simply refer to the original footnote. The following list contains the sources cited, together with the relevant footnote number.

Reference	**Foot note**
POP Convention, Stockholm 22 May 2001, http://chm.pops.int/ .	1
Fiedler, Heidelore; Hub, Michael; Willner, Susanne et al., Landesanstalt für Umweltschutz Baden-Württemberg, Handbuch Altlastensanierung, Texte und Berichte zur Altlastenbearbeitung 18/95, Stoffbericht Hexachlorbenzol (HCB), Karlsruhe 1995. www.fachdokumente.lubw.baden-wuerttemberg.de .	2
Stockholm Declaration 1972, http://www.unep.org/Law/PDF/Stockholm_Declaration.pdf .	6
Rio Declaration 1992, http://www.unep.org/Law/PDF/Rio_Declaration.pdf	7
Convention on the Protection and Use of Transboundary Watercourses and International Lakes (“UNECE Water”), Helsinki, 17 March 1992, for text see http://www.unece.org/env/water/text/text.htm .	9
Convention on the Transboundary Effects of Industrial Accidents (“UNECE Accident”), Helsinki, 17 March 1992, for text see http://www.unece.org/env/teia/text.htm .	10
German-Dutch Boundary Waters Commission, Agreement of 29 April 1963 on the International Commission for the Protection of the Rhine against Pollution, Federal Law Gazette II 1963, p. 653; Federal Law Gazette II 1998, p. 1831.	11
Convention of 3 December 1976 on the Protection of the Rhine against Chemical Pollution, Federal Law Gazette II 1978, p. 369.	12
Convention of 3 December 1976 on the Protection of the Rhine against Chloride Pollution (Chloride Convention), Supplementary Convention 1991; Federal Law Gazette II 1987, p. 1065.	13
Convention of 12 April 1999 on the Protection of the Rhine, Bern, 12 April 1999, http://www.iksr.de/fileadmin/user_upload/Dokumente/uebereinkommen_zum_schutz_des__rheinsVers._12.04.99.pdf .	14

Reference	Foot note
Protocol of 20 December 1961 between the governments of the Federal Republic of Germany, the Republic of France and the Grand Duchy of Luxembourg on the establishment of an International Commission on the Protection of the Mosel against Pollution, Paris, 20 December 1961, for text see http://213.139.159.34/servlet/is/399/Moselprotokoll_d.pdf .	15
Convention on Co-operation for the Protection and Sustainable Use of the River Danube (Danube River Protection Convention) of 29 June 1994, Federal Law Gazette II 1996, p. 875, http://www.icpdr.org/icpdr-pages/about_us.htm .	16
Supplementary Protocol of 22 August 1996 to the Ems-Dollart Treaty regulating Cooperation on Water and Nature Conservation in the Ems Estuary, Federal Law Gazette 40 II of 23 September 1997.	17
Convention of 8 October 1990 on the International Commission for the Protection of the Elbe (CZ/D/EU), Magdeburg, 8 October 1990, Federal Law Gazette II 1992, p. 943.	18
Convention of 11 April 1996 on the International Commission for the Protection of the Oder, Federal Law Gazette 40 II of 23 September 1997.	19
Agreement of 19 May 1992 between the Federal Republic of Germany and the Republic of Poland on Cooperation in the field of Water Management of Boundary Waters, Federal Law Gazette 3 II of 15 January 1994.	20
Agreement between the Federal Republic of Germany and the European Economic Community, on the one hand, and the Republic of Austria, on the other, on cooperation on management of water resources in the Danube Basin – Statute of the Standing Committee on Management of Water Resources – Declaration, OJ L 90 of 05.04.1990, p. 20 - 25; Federal Law Gazette II 1990, p. 791.	21
Agreement of 12 December 1995 between the Federal Republic of Germany and the Czech Republic on Cooperation on Water Resources Management in Boundary Waters, Federal Law Gazette 17 II of 2 May 1997.	22
Treaty establishing the European Community, OJ C 224 of 31/08/1992, p. 0052 et seq. (Maastricht, consolidated version).	23
Treaty establishing the European Community, OJ C 325 of 24/12/2002, p. 0107 et seq. (Nice, consolidated version).	24
According to Art. 281 (ex. Art. 210) EC Treaty the EC (EU) possesses its own personality under international law, OJ C 340 of 10/11/1997, p. 0254 – consolidated version.	25
COUNCIL DECISION of 24 July 1995 on the conclusion, on behalf of the Community, of the Convention on the protection and use of transboundary watercourses and international lakes (95/308/EC), OJ L 186, 5.8.1995, p. 42.	26
Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Federal Law Gazette II 1994, p. 2334-2350.	27

Reference	Foot note
COUNCIL DECISION of 23 March 1998 concerning the conclusion of the Convention on the Transboundary Effects of Industrial Accidents (98/685/EC), OJ L 326, 03.12.1998.	28
COUNCIL DIRECTIVE 82/501/EEC of 24 June 1982 on the major-accident hazards of certain industrial activities, OJ L 230, 5.8.1982, p. 1 (Seveso Directive).	29
Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances; OJ L 010 of 14.01.1997, p. 13 (Seveso II Directive).	30
Council Directive of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (76/464/EEC), OJ L 129, 18.5.1976, p. 23, codified version: 2006/11/EC of 15 February 2006, OJ L 64, 4.3.2006, p. 52, and daughter directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC and 86/280/EEC.	31
Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control, OJ L 257, 10.10.1996, p. 26ff, codified: Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (codified version), OJ L 24, 29.01.2008, p. 8.	32
DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive, WFD), OJ L 327, 22.12.2000, p. 1.	33
Ginzky, H. (2008): Das Verschlechterungsverbot nach der Wasserrahmenrichtlinie. Natur und Recht, Vol. 30 (2008), p. 147-152, Springer Verlag.	43
Breuer, R. (2007): Praxisprobleme des deutschen Wasserrechts nach der Umsetzung der Wasserrahmenrichtlinie. Natur und Recht, Vol. 29 (2007), p. 503-513, Springer Verlag.	44
Consideration of cause-effect relationships, cf. European Commission (2002): Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document no. 3. Analysis of pressures and impacts. Working group 2.1 Impress, German translation.	45
Henneberg, S.C. (2006): Randbedingungen und Aspekte bei der Aufstellung des Maßnahmenprogramms für eine Flussgebietseinheit. KA Abwasser, Abfall, Vol. 53, No. 2, p. 140-145.	46
Görlach, B.; Kranz, N.; Interwies, E., Vorschlag für eine Methodik zur Auswahl der kosteneffizientesten Maßnahmenkombinationen für die Wasserrahmenrichtlinie. GWF Wasser, Abwasser, Vol. 146, No. 5, p. 412-417, 2005.	47

Reference	Foot note
Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC, OJ L 348, 24.12.2008, p. 91; entry into force 13 January 2009, to be transposed into national law by 13 July 2010.	48
Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks , OJ L 288, 6.11.2007, p. 27 et seq.	52
Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, OJ 175 of 05.07.1985, p. 40ff.	53
DIRECTIVE 2001/42/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, OJ L 197 of 27.06.2001, p. 30ff.	54
European Commission: Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance Document no. 3. Analysis of pressures and impacts. Working group 2.1 Impress, German translation, 2002.	61
Communication of 22.6.1982 from the Commission to the Council, OJ C 176, 14.7.1982, p. 3. (The Commission had proposed 129 (later extended to 132) substances as candidates for List I, and regarded 30 of them as “priority substances”.)	75
In Hamburg, for example: Ordinance concerning quality objectives for certain hazardous substances and programmes for reducing water pollution, of 20 March 2001 (Hamb.GVBl. No. 10 of 26.03.2001, p. 40), last amended on 29 June 2004 by Article 2 of the Ordinance on the implementation of Annexes II, III and V to Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Hamb.GVBl. No. 32 of 09.07.2004, p. 277).	78
In Hamburg, for example: Programme of the Free and Hanseatic City of Hamburg for reducing water pollution in accordance with Article 7 of Directive 76/464/EEC concerning the discharge of harmful substances into waters, November 2001.	79
Decision No. 2455/2001/EC of the European Parliament and of the Council of 20.11.2001 establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC, OJ L 331 of 15.12.2001, p. 1.	81
Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community, OJ L 64, 4.3.2006, p. 52.	84

Reference	**Foot note**
Joint Water Commission of the Federal States (LAWA): Model ordinance for the implementation of Annexes II and V of Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 02.07.2003, http://www.lawa.de/pub/kostenlos/wrrl/mustervo020703.pdf . taken as a guide by the relevant ordinances of the 16 Länder, e.g. for Hamburg: Ordinance for the implementation of Annexes II, III and V of Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, of 29 June 2004, HmbGVBl. 32 of 9.7.2004, p. 277,	87
Council Regulation (EEC) No. 793/93 of 23 March 1993 concerning the Evaluation and Control of the Environmental Risks of Existing Chemical Substances (OJ L 84 of 5.4.1993, p. 1 et seq.).	89
Directive 98/8/EC, OJ L 123 of 24.4.1998, p. 1 et seq.	90
Directive 91/414/EC, OJ L 230 of 19.8.1991, p. 1 et seq. Directive last amended by Directive 98/47/EC (OJ L 191 of 7.7.1998, p. 50).	91
Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC, OJ L 67 of 4.3.2006, p. 37 et seq.	93
Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life, OJ L 264 of 25.9.2006, p. 20 et seq.	94
Council Directive 75/440/EEC of 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking water in the Member States, OJ L 194 of 25.7.1975, p. 26–31.	95
Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330 of 05.12.1998, p. 32 et seq.	96
Recommendation by the Federal Environment Agency after hearing the Drinking Water Commission at the Federal Environment Agency: Bewertung der Anwesenheit teil- oder nicht bewertbarer Stoffe im Trinkwasser aus gesundheitlicher Sicht, Bundesgesundheitsbl - Gesundheitsforsch-Gesundheitsschutz 2003/46, p. 249–251.	97
LAWA (Joint Water Commission of the Federal States): Ableitung von Geringfügigkeitsschwellenwerten für das Grundwasser, http://www.lawa.de/pub/download.html , December 2004.	98
Administrative guideline on substances dangerous to water (VwVwS) of 17.05.1999, Federal Gazette 98a of 29 May 1999; For explanations, see also: Federal Environment Agency, Einstufung von Stoffen und Gemischen in Wassergefährdungsklassen gemäß Verwaltungsvorschrift wassergefährdende Stoffe (VwVwS) vom 17.05.1999 - Leitfaden für Selbsteinstufer -, Berlin, 1999.	100

Reference	Foot note
General administrative guideline concerning the amendment of the administrative guideline on substances dangerous to water (VwVwS) of 27.07.2005, Federal Gazette 142a of 30 July 2005.	101
Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, OJ L 396 of 30.12.2006, p. 1 et seq.	102
Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006, OJ L 353 of 31.12.2008, p. 1 et seq.	103
Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, OJ L 196, p. 1.	104
EINECS European Inventory of Existing Commercial Chemical Substances, http://ecb.jrc.it/existing-chemicals/ at the European Chemicals Bureau (ECB) in Ispra/Italy;	106
Based on BAuA/REACH Helpdesk: Brochure REACH-Info 1, http://www.reach-helpdesk.de/ .	109
Based on: Federal Environment Agency (UBA), brochure: Das neue Kennzeichnung- und Einstufungssystem für Chemikalien nach GHS, Forschungsvorhaben 206 67 460/06, Berlin 2007, http://www.umweltbundesamt.de/ .	111
Eisenträger, Adolf, Federal Environment Agency (UBA), first project workshop in Schkopau on 29 November 2007.	112
Hamburg Institute for Hygiene and Environment, “Entwicklung von Alarmkriterien und Störfallerfassung in Messstationen im Elbeeinzugsgebiet für die internationale Gefahrenabwehrplanung (EASE)”, final report on UBA research project FKZ -200 48 314/02 - Subproject 2, Hamburg 2004.	113
International Commission for the Protection of the Elbe River (ICPER), International Warning and Emergency Plan for the Elbe (IWAE) 2006, with updated address list 2008, http://www.ikse-mkol.org .	114
Störfall-Kommission SFK-GS-18, „Orientierende Beurteilung von Gewässerunfällen“, 1999, http://www.kas-bmu.de/publikationen/sfk/sfk_gs_18.pdf .	119
IKSD/ICPDR, Schwerpunkte der Vorsorge unfallbedingter Gewässerverschmutzungen, http://www.icpdr.org/icpdr-pages/accidental_pollution.htm.	120

Reference	Foot note
Inventory of Potential Accidental Risk Spots in the Danube River Basin. ARS ad-hoc Expert Panel of the AEPWS EG, 2001.	121
IKSD/ICPDR Recommendation Safety Requirements for Contaminated Sites in Flood-risk Areas. APC (Accident Prevention and Control) Expert Group, Final Draft (no year stated).	122
IKSD/ICPDR, Guidance Documents, http://www.icpdr.org/icpdr-pages/guidance_documents.htm.	123
Stand der Umsetzungen der Empfehlungen der Internationalen Kommission zum Schutz der Elbe (IKSE) für den Bereich der Störfallvorsorge, Anlagensicherheit und Störfallabwehr, 2007.	124
IKSE: Draft. Empfehlungen zur Ausrüstung von Tanks. Online at: http://www.umweltbundesamt.de/anlagen/Checklistenmethode/Entwurf-Empf-Ausrustung_von_Tanks.pd f Stand: 31.08.2008.	126
ICPO, mandate of working group G3 “Accidental Pollution“, http://www.mkoo.pl/index.php?mid=15&aid=231, Stand: 15.05.2006.	127
ICPO, Requirements for installations for handling substances dangerous to water in flood areas or areas at risk of ponding – Recommendations. Breslau, 2005.	128
IKSR, Anlagensicherheit und Störfallvorsorge, http://www.iksr.org/index.php?id=70, Stand 09.12.2005.	129
IKSR, Empfehlungen der Internationalen Kommission zum Schutz des Rheins (IKSR) zur Störfallvorsorge und Anlagensicherheit (no year stated).	130
ICPMS, mandate of group PS “Accident Precautions” of the ICPMS, http://213.139.159.34/servlet/is/1231/#.	133
ICPMS, Recommendations to the Member States of the ICPMS on precautionary measures for oil and hydrocarbon storage in areas at risk of ponding (1995).	134
Umweltbundesamt, Technologietransfer zum anlagenbezogenen Gewässerschutz in den Ländern Moldawien, Rumänien und Ukraine, 2005, http://www.umweltbundesamt.de/anlagen/Checklistenmethode/index.html.	135
Federal Environment Agency, Checklists for surveying and assessing industrial plant handling materials and substances which are hazardous to water. Overview and notes on using the checklists, 2006.	136
BMU/UBA, Technologietransfer zur Verbesserung der Anlagensicherheit und des Umweltschutzes in der russischen Zellulose- und Papierindustrie, 2004, http://www.umweltbundesamt.de/anlagen/Technologietransfer_Zellulose/.	137
R+D Industrie Consult, Checklists for Refineries. Second Draft. UNDP/GEF Danube regional project “Activities for Accident Prevention – Pilot Project – Refineries”, 2006.	138

Reference	Foot note
Federal Environment Agency, Report on preparation for the transboundary cooperation for hazard prevention in the Kura River basin, 2002, http://www.kura.iabg.de/.	139
UNECE, Water and industrial accidents, http://www.unece.org/env/teia/water.htm.	142
UNECE, Prevention of Accidental Water Pollution. Safety Guidelines and Good Practices for Pipelines, 2006.	143
UNECE, Draft Safety guidelines and good practices for cross border contingency planning, 2008.	144
UNECE, Draft Safety guidelines and good practices for tailing management facilities, 2008.	145
OECD, Chemical accidents, http://www.oecd.org.	147
OECD/BMU, OECD Guidelines for Chemical Accident Prevention, Preparedness and Response. Guidance for Industry (including Management and Labour), Public Authorities, Communities, and other Stakeholders. 2. edition, OECD publications Environment, Health and Safety, Chemical Accidents Series No. 10, 2003.	148
Federal Environment Agency, Integrierte Vermeidung und Verminderung der Umweltverschmutzung. BAT reference document on the best available technologies for the storage of bulk or dangerous materials. Dessau, 2005.	150
Federal Environment Agency (Ed.), Hinweise für Einsatzmaßnahmen nach Schadensfällen mit wassergefährdenden Stoffen. Vorsorgeplanung für die Ölwehr auf Binnengewässern. LTwS-Nr. 30, 2000.	152
Buncefield Major Incident Investigation Board, Recommendations on the emergency preparedness for, response to and recovery from incidents, 2007.	153
ICPR Expert Group ”Warning and Alarm Plan for the Rhine”, http://www.iksr.org , http://www.iksr.org/uploads/media/bericht_nr_137d.pdf	158
IKSD/ICPDR, AEWS (Accident Emergency Warning System) http://www.icpdr.org , http://www.icpdr.org/icpdr-pages/aews.htm	160
GSBL - Gemeinsamer Stoffdatenpool Bund / Länder, http://www.gsbl.de/	162
Stoffdatenbank für bodenschutz- /umweltrelevante Stoffe, http://www.stoffdaten-stars.de/	163
Gefahrstoffdatenbank der Länder, http://www.gefahrstoff-info.de/	164
Verzeichnis der potentiell gefährlichen Anlagen im Einzugsgebiet der Elbe, IKSE 1998.	166

Reference	Foot note
Maßnahmenkatalog zur Vermeidung unfallbedingter Gewässerbelastungen im Einzugsgebiet der Elbe, IKSE 1995, http://www.ikse-mkol.org/index.php?id=86&L=0	167
Blohm, Inst. f. Hygiene und Umwelt Hamburg, personal communication 2009.	168
Integrated measurement and information system (IMIS) for monitoring radioactivity in the environment with 40 stationary radiological warning stations. Legal basis: Radiological Protection Precautions Act *(Strahlenschutzvorsorgegesetz – StrVG)*, 1986 (EURATOM Treaty 1957, Art. 35 and 36); Radiation Protection Ordinance *(Strahlenschutzverordnung – StrlSchV)*; 1960 … 2001 (EURATOM Directives).	169
http://www.aqualarm.nl, Rijkswaterstaat, Center for Water Management Netherlands.	170
Informationsplattform „Datengrundlagen zur Einordnung und Bewertung hydrologischer Extreme“ (UNDINE), Bundesanstalt für Gewässerkunde (BfG), Koblenz, http://undine.bafg.de .	171
BASF, http://www.standort-ludwigshafen.basf.de/fileadmin/user_upload/BASF-Inhalte/umwelt/pdf/Im_Dialog_Januar_2006_d.pdf	172
Störfall-Kommission SFK-GS-18: Orientierende Beurteilung von Gewässerunfällen, 1999, http://www.kas-bmu.de/publikationen/sfk/sfk_gs_18.pdf .	174
van Engelen, D. et al., Cost-effectiveness analysis for the implementation of the EU Water Framework Directive. Water Policy, Vol. 10, p. 207-220; in conjunction with WATECO (2002): Economics and the Environment: The Implementation Challenge of the Water Framework Directive. EU Working Group guideline for WFD implementation, 2008.	175
Based on the fundamental examination by Artner & Sinabell. [Artner, A.; Sinabell, F.: Grundlegendes zur cost-effectiveness Analyse, Institut für Wirtschaft, Politik und Recht, Universität für Bodenkultur, Vienna 2003.]	176
[BAM, Bundesanstalt für Materialforschung und -prüfung, Untersuchung der Statistik “Unfälle mit wassergefährdenden Stoffen” des Statistischen Bundesamtes aus dem Jahr 2004 im Vergleich zu den Vorjahren. Study commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety], 2007.	179
Walter Ludwig Behälter- und Anlagenbau: price list August 2004.	180
Bavarian State Office for Statistics and Data Processing (Bayerisches Landesamt für Statistik und Datenverarbeitung, 2004): Unfälle beim Umgang mit und bei der Beförderung von wassergefährdenden Stoffen in Bayern 2003. Munich. AND Bavarian State Office for Statistics and Data Processing (Bayerisches Landesamt für Statistik und Datenverarbeitung, 2008): Unfälle beim Umgang mit und bei der Beförderung von wassergefährdenden Stoffen in Bayern 2006. Munich.	181

Reference	Foot note
Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2004): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2003. Statistische Berichte Umweltbelastungen, Schwerin. AND Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2005): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2004. Statistische Berichte Umweltbelastungen, Schwerin. AND Statistical Office Mecklenburg/W. Pomerania (Statistisches Amt Mecklenburg-Vorpommern, 2006): Unfälle beim Umgang und bei der Beförderung von wassergefährdenden Stoffen in Mecklenburg-Vorpommern 2005. Statistische Berichte Umweltbelastungen, Schwerin.	182
Federal Statistical Office (Statistisches Bundesamt, 2005): Anstieg des Umweltrisikos durch wassergefährdende Stoffe. Press release No. 134 of 21.03.2005.	183
Stadtverwaltung Ludwigshafen (2003): Umweltbericht 2003. Teil VI Gewässerschutz und Umgang mit wassergefährdenden Stoffen. Ludwigshafen, p. 95-112.	184
Cf. BMU (2004). Aid to enforcement of Hazardous Incident Ordinance of March 2004.	187
Cf. Münchner Rück (2006): Einschätzung von Umwelthaftungsrisiken. Casualty Risk Consulting, No. 22, Munich.	192
European Commission (2006): Land Use Planning Guidelines in the context of Article 12 of the Seveso II Directive 96/82/EC as amended by Directive 105/2003/EC.	196
Warm, H.-J.; Köppke, K.-E., Krätzig, W. B.; Beem, H.; Schutz von neuen und bestehenden Anlagen und Betriebsbereichen gegen natürliche, umgebungsbedingte Gefahrenquellen, insbesondere Hochwasser (Untersuchung vor- und nachsorgender Maßnahmen), F+E Vorhaben 203 48 362, UBA Texte 42/2007, http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php.	198
Betriebliche Gewässerschutzinspektion des Landes Hessen u.a.: Hofmann et al., Durchführung von betrieblichen Gewässerschutzinspektionen. Handbuch. 1. Fortschreibung; Hessisches Ministerium für Umwelt, ländlichen Raum und Verbraucherschutz (no year stated): Der gewässerschutzkonforme Betrieb. Hinweise für Unternehmen in Hessen, Wiesbaden, 2003.	201
Council Decision of 12 December 1977 establishing a common procedure for the exchange of information on the quality of surface fresh water in the Community (77/795/EEC), OJ L 334, 24.12.1977, p. 29.	202
Survey by the expert group on “Suspended solids” of the ad-hoc working group “AQS”, LAWA working group “OW”, ELBE River Basin Commission, status April 2009.	203
BASF, brochure on environmental monitoring, http://www.basf.com .	204

Reference	**Foot note**
LAWA (Joint Water Commission of the Federal States): Fließgewässer in der Bundesrepublik Deutschland - Empfehlung für die regelmäßige Untersuchung der Beschaffenheit der Fließgewässer in den Ländern der Bundesrepublik Deutschland (LAWA-Untersuchungsprogramm), 1997.	211
LAWA (Joint Water Commission of the Federal States), Empfehlungen zum Einsatz von kontinuierlichen Biotestverfahren für die Gewässerüberwachung, 1996.	214
LAWA (Joint Water Commission of the Federal States): Einsatzmöglichkeiten des Biomonitorings zur Überwachung von Langzeit-Wirkungen in Gewässern, 2000.	215
WGMN Hamburg, Free and Hanseatic City of Hamburg, Institute for Hygiene and Environment, www.hamburg.de/wasserguetemessnetz.	217
AJ Blomesystem GmbH, Konrad-Zuse-Straße 1, 07745 Jena, www.aj-blomesystem.de .	218
Ettmer, B., Hanisch, H.H., Mende, M., "Fließgeschwindigkeit und Stofftransport der Elbe", Die Elbe – neue Horizonte des Flussgebietsmanagements, 10. Magdeburger Gewässerschutzseminar, Teubner Verlag Stuttgart, Leipzig, Wiesbaden, October 2002, ISBN 3-519-00420-8.	220
Jahnel, Neamtu, Abbt-Braun, Haak, Gordalla: "Entwicklung von Umweltqualitätsnormen zum Schutz aquatischer Biota in Oberflächengewässern" im Rahmen des Länderfinanzierungsprogramms "Wasser, Boden und Abfall", Länderfinanzierungsprogramm "Wasser, Boden und Abfall", Engler-Bunte-Institut der Universität Karlsruhe 2003, www.laenderfinanzierungsprogramm.de.	222
Ohlenbusch, Christian Münch, Jahnel, Abbt-Braun: "Ableitung von Qualitätszielen für Kandidatenstoffe der prioritären Liste für die EU-Wasserrahmenrichtlinie", Engler-Bunte-Institut der Universität Karlsruhe 2001.	223
Hamburg Ministry for Urban Development and the Environment, Incident Management, *Vorsorgeplan Schadstoffunfallbekämpfung für die deutsche Nord- und Ostseeküste - vps09 - das elektronische Vorsorgeplanungssystem*, www.vps-web.de.	228
LAI, Guideline for registration, clarification and analysis of major accidents and disturbances of normal operation within the meaning of the Major Accidents Ordinance, 2002, http://www.umweltbundesamt.de/zema/LAI_Storfallmeldung_Leitfaden.pdf .	236
KAS/SFK, *Konzept zur Erfassung und Auswertung sicherheitsbedeutsamer Ereignisse*, 1998, http://www.sfk-taa.de/publikationen/publ.htm .	237
Brunner, Franz J., Wagner, Karl W.: Taschenbuch Qualitätsmanagement - Leitfaden für Studium und Praxis. Hanser, Munich 2008, ISBN 13: 978-3-446-41666-6.	238
Bundesministerium des Innern, Referat KM 1, Alt-Moabit 101 D, 10559 Berlin, Krisenkommunikation - Leitfaden für Behörden und Unternehmen, www.bmi.bund.de, Berlin 2008.	241

Reference	**Foot note**
AK Risikokommunikation „Bericht Risikokommunikation – Anforderungen nach Störfallverordnung, Praxis und Empfehlungen“, Kommission für Anlagensicherheit beim BMU (KAS), June 2008, KAS-5, http://www.kas-bmu.de/publikationen/kas_pub.htm.	242
Anton; Claus; Bouteiller; Schrader; Kroll; Wiedemann; Eitzinger “Risikokommunikation im Anwendungsbereich der Störfall-Verordnung”, Bericht zum F+E-Vorhaben 205 48 329 des Umweltbundesamtes, UBA-Text 31/2006, Dessau 2006, http://www.umweltbundesamt.de.	243

Appendix 3 Abbreviations

The following is a list of the abbreviations and acronyms used in the text (it does not list specialised technical terms, such as chemical parameters; neither is it a bibliography, though a number of links are included.)

Abbr.	**Meaning**
AA	Annual average
AEWS	Accident Emergency Warning System
ALAMO	Alarm Model Elbe, Federal Institute of Hydrology, Koblenz, www.bafg.de
Aqualarm	Netherlands alarm system for monitoring river water quality with the aid of collected measurements, www.aqualarm.nl
ARS	Accidental Risk Spots
BfG	Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology) http://www.bafg.de/cln_015
BGI	Betriebliche Gewässerschutzinspektion (in-plant water conservation inspection)
BMI	Bundesministerium des Innern (Federal Ministry of the Interior)
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BREF	Best Available Techniques Reference Document IPPC
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Institute for Navigation and Hydrography)
BvT / BAT	Beste verfügbare Technik / Best Available Techniques (► BREFs)
CHC	Chlorinated hydrocarbons
CKW	Chlorierte Kohlenwasserstoffe (chlorinated hydrocarbons, CHC)
CLP	Classification, Labelling and Packaging (Regulation 127
CORINE	CORINE Land Cover, EU Commission Coordinated Information on the European Environment, European Environment Agency, Copenhagen / EU Commission's land-use mapping programme at the European Environ-ment Agency in Copenhagen, http://reports.eea.europa.eu/COR0-landcover/en
DBAM	Danube Basin Alarm Modell
DeCheMa	Gesellschaft für Chemische Technik und Biotechnologie e.V., www.dechema.de
DVGW	Deutsche Vereinigung des Gas- und Wasserfachs (German Association of Gas and Water Experts), http://www.dvgw.de/

Abbr.	Meaning
EASE	Entwicklung von Alarmkriterien und Störfallerfassung in Messstationen im Elbeeinzugsgebiet (development of alarm criteria and registration of hazardous incidents at measuring stations in the Elbe catchment area for the international plan for averting dangers, UBA research project, FKZ 200 48 314/02 – Subproject 2), http://www.umweltbundesamt.de/anlagen/EASE
EC	European Community
EC Treaty	Treaty establishing the European Community
ECB	European Chemicals Bureau, http://ecb.jrc.ec.europa.eu/
ECHA	European Chemicals Agency, http://echa.europa.eu/
ECJ	European Court of Justice
EEC	European Economic Community
EIA	Environmental impact assessment
EINECS	European Inventory of Existing Commercial Substances
ELINCS	European List of Notified Chemical Substances
EQS	Environmental quality standard
FGG	Flussgebietsgemeinschaft (river basin association)
FGK	Flussgebietskommission (river basin commission)
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GIS	Geoinformation system or geographic information system
GMAG	Expert committee of the International Commission for the Meuse/Maas on “Equipment and resources for dealing with hazards to bodies of water”
GSBL	Gemeinsamer Stoffdatenpool Bund / Länder (Joint federal/Länder substance data pool), http://www.gsbl.de/
IHWZ	Internationale Hauptwarnzentrale (International warning centre)
IKSD / ICPDR	Internationale Kommission zum Schutz der Donau / International Commission for the Protection of the Danube River http://danubis.icpdr.org
IKSE / ICPER	Internationale Kommission zum Schutz der Elbe / International Commission for the Protection of the Elbe River www.ikse-mkol.org
IKSMS/ICPMS	International Commission for the Protection of the Mosel and the Saar against Pollution, www.iksms-cipms.org
IKSO / ICPOaP	Internationale Kommission zum Schutz der Oder / International Commission for the Protection of the Odra River against Pollution www.mkoo.pl
IKSR / ICPR	Internationale Kommission zum Schutz des Rheins / International Commission for the Protection of the Rhine www.iksr.org
IMK/IMC	Internationale Maas-Kommission (International Commission for the Meuse/Maas), www.cipm-icbm.be

Abbr.	Meaning
Infra-web	Web-based alarm communication system in the Netherlands, www.infra-web.nl
IPPC	Directive 96/61/EC concerning integrated pollution prevention and control (IPPC Directive)
IRBC	International river basin commission
IWAP	International warning and alarm plans
JD	Jahresdurchschnittskonzentration (annual average concentration)
JEG	Joint Ad Hoc Expert Group on Water and Industrial Accidents, UNECE expert group of UNECE Accident and UNECE Water http://www.unece.org/env/teia/water.htm
JRC	European Commission Joint Research Centre, http://ec.europa.eu/dgs/jrc/
KAS	Kommission für Anlagensicherheit (Plant Safety Commission at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety). www.sfk-taa.de
LAI	Bund-/Länderarbeitsgemeinschaft Immissionsschutz (Joint Immission Control Commission of the Federal States) www.lai-immissionsschutz.de
LöRüRL	Richtlinie zur Bemessung von Löschwasser-Rückhalteanlagen beim Lagern wassergefährdender Stoffe (Assessment Guideline for Fire-Fighting Water Retention in Storage Facilities for Substances Dangerous to Water)
MAC	Maximum allowable concentration
MARS/EU	Major Accident Reporting System - European Commission Joint Research Centre (JRC) (EU), http://mahbsrv.jrc.it/mars/default.html
MHQ	Mittleres Hochwasser (mean high water)
MNQ	Mittleres Niedrigwasser (mean low water)
MQ	Mittelwasser (mean water level)
nwgS	nicht wassergefährdende Stoffe (substances not dangerous to water)
PMS	Pipeline Management System
QM	Quality management
REACH	Registration, Evaluation, Authorisation of Chemical Substances
SDS	Safety Data Sheet
SEA	Strategic environmental assessment
SFK	Störfallkommission (Major Incidents Commission, now KAS)
SIEF	Substance Information Exchange Forum
TGD	Technical Guidance Document
THW	Bundesanstalt Technisches Hilfswerk (Federal Agency for Technical Relief), www.thw.bund.de
TrinkwV	Trinkwasserverordnung (Drinking Water Ordinance)
TUIS	Transport-Unfall-Informations- und Hilfeleistungssystem (transport accident and assistance system)
UBA	Umweltbundesamt (Federal Environment Agency), http://www.umweltbundesamt.de/
UGB	Umweltgesetzbuch (Environmental Code)

Abbr.	**Meaning**
UNDINE	Datengrundlagen zur Einordnung und Bewertung hydrologischer Extreme (database for classification and assessment of hydrological extremes), http://undine.bafg.de
UNECE	United Nations Economic Commission for Europe http://www.unece.org/
UNECE Accident	CONVENTION ON THE TRANSBOUNDARY EFFECTS OF INDUSTRIAL ACCIDENTS http://www.unece.org/env/teia/text.htm
UNECE Water	CONVENTION ON THE PROTECTION AND USE OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES http://www.unece.org/env/water/text/text.htm
UNO	United Nations Organization
UQN	Umweltqualitätsnormen (environmental quality standards, EQS)
UVP	Umweltverträglichkeitsprüfung (environmental impact assessment, EIA)
VAwS	Verordnungen zu Anlagen zum Umgang mit wassergefährdenden Stoffen (Länder ordinances on installations for handling substances dangerous to water)
VCI	Verband der chemischen Industrie (German Chemical Industry Association) www.vci.de
VDI	Verein Deutscher Ingenieure e.V. (German Engineer's Association) http://www.vdi.de/
VDMA	Verband Deutscher Maschinen- und Anlagenbau e.V. (German Engineering Federation), www.vdma.de
VPS	Vorsorge Plan Schadstoffunfallbekämpfung (precautionary planning system), www.vps-web.de
VUmwS	Future (federal) ordinance on the handling of substances dangerous to water, sub-statutory regulation under future Environmental Code (UGB)
VwVwS	Verwaltungsvorschrift wassergefährdende Stoffe (Administrative Guideline on Substances Dangerous to Water) http://www.umweltbundesamt.de/wgs/vwvws.htm
WAP	Warning and alarm plan
WFD	Water Framework Directive
WGK	Wassergefährdungsklassen (water hazard classes, WHC) http://www.umweltbundesamt.de/wgs/index.htm
WGMN Hamburg	Wasser-Güte-Mess-Netz Hamburg (Hamburg Water Surveillance System), www.hamburg.de/wasserguetemessnetz
WHC	Water hazard class
WRI	Water risk index
WRRL	Wasserrahmenrichtlinie (Water Framework Directive, WFD)
ZEMA	Zentrale Melde- und Auswertestelle für Störfälle und Störungen in Verfahrenstechnischen Anlagen beim Umweltbundesamt (Central Notification and Evaluation Unit at the Federal Environment Agency) http://www.umweltbundesamt.de/zema/
ZHK	Zulässige Höchstkonzentration (maximum allowable concentration, MAC)