Lessons Learned from the 2002 Disaster in the Elbe Region

Flood Risk Reduction
in Germany

Summary of the Study
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February 2004

German Committee for Disaster Reduction
Flood Risk Reduction in Germany

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Summary of the Study
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The Elbe floods in 2002 clearly emphasised that largescale disasters can afflict every country, even in Europe. The total damage costs of around 10 billion euros, the realisation that our infrastructure was so vulnerable and also the disruptions to the planning of many people’s livelihoods through natural disasters also placed the issue of disaster reduction on the daily agenda.

A great deal has happened since the 2002 Elbe floods:

The damage has been partly repaired, the affected Länder (states), rural districts and municipalities, as well as the organisations involved in overcoming the disaster, have each compiled the facts from their perspectives, have evaluated this material and, where necessary, have drawn their conclusions from this experience.

The German Committee for Disaster Reduction (DKKV) is the platform and coordinating point for the debate on disaster reduction, above all in an international context, but also in Germany. With this “Lessons Learned” study DKKV is for the first time providing a complete overview of flood risk reduction in Germany, using the example of the 2002 Elbe floods. An interdisciplinary team was set up, consisting of independent scientists, who evaluated the numerous reports available on the Elbe floods and – through supplementing these with their own surveys and analyses – drew up a comprehensive picture of what should be taken into consideration for the future of flood risk reduction in Germany. Above all this study underlines what we can do better in Germany.

The study does not provide an exact list of everything that happened or did not happen on the Elbe, but, instead, above all tries to work out structural failings using case studies and to use these to derive applicable statements.

I would like to express my great thanks to all participants who contributed information to this study. And I am particularly grateful to the German Red Cross, which financed this study in the knowledge that only frankness and transparency can enable us to recognise how to act better in the future – an awareness that we did not find everywhere during the preparation of this study. I hope that this study will find widespread public recognition and above all will provoke a lively debate amongst all those involved and between the various parties: citizens, the official authorities, science, industry, the media and not least policymakers at all levels.

Dr. Irmgard Schwaetzer
Ex Federal Minister
Chairperson of the German Committee for Disaster Reduction
Selected Recommendations for Improved Flood Risk Reduction in Germany

What our society needs is a transparent debate on risks. The basis for this is to disclose dangers and vulnerabilities, together with a consistent debate on protection objectives. This requires sufficiently precise data for planning, evaluation and cooperation as well as the weighing up of conflicting interests. Such flood risk management includes all aspects of flood risk reduction and disaster response. The previously prevalent separate view of precaution and response must be overcome.

In particular the following aspects have to be taken into consideration:

- The reduction of potential damage has top priority. Risk reduction through spatial planning as an important instrument for this purpose, has to be strengthened. In future statutory regulations on keeping floodplains undeveloped must be clearly defined. For better implementation of risk reduction through spatial planning synergy effects between flood risk reduction and other interests, above all nature protection, landscape conservation or drinking water protection should be sought and used. Financial and insurance incentives are required for rebuilding in another place or for resettlements, in order to achieve a reduction of damage potential in the flood plains rather than just stagnation.

- Measures and recommendations have to be comprehensively weighted in accordance with their importance for flood risk management, in particular in accordance with the effectiveness of the measures vis-à-vis space, time, and process intensity. Measures for evaluating effectiveness must be worked out, to be able to assess their importance. Measures for flood risk reduction and response must be assessed in accordance with specific catchment areas and with regard to their interaction. “Flood protection concepts” (for instance MÜLLER 2003) must take into consideration the broad range of flood risk reduction measures.

- Limits to natural retention, in particular its limited effectiveness in the case of extreme discharges, must be recognised and accepted. Demands for “climate protection” must be made in connection with flood risk reduction. However, both of these should not be allowed to serve as an alibi for preventing or reducing catchment area-related flood risk reduction and flood risk reduction covering different watercourses.

- Technical flood protection equipment is essential for reducing extreme flooding. However, their limitations and risks must be made transparent. Clear responsibilities must be created and the dimensioning of the equipment must be more closely related to the protection objectives. The equipment must be maintained: Here the dikes in particular are not up to standard. There must be frank information about existing weak points.

- Possibilities and limits for taking action must be emphasised. The usual HQ(100) observations must be also supplemented by further scenarios as well as by cases of failure. Presentations of danger situations should be intensified and should take place permanently and be linked with precautionary strategies and response possibilities.
LESSONS LEARNED — Flood Risk Reduction in Germany

SELECTED RECOMMENDATIONS

- Warning systems for specific dangers and regions, ranging from gathering data and forecasts right through to the reaction of affected persons should be expanded. Here, specific action must be incorporated in integrated concepts. Technical security and material and action-orientation of communication must be improved.

- For successfully implementing protection concepts, a discussion process must be introduced that involves the whole of society and involves the whole population. Here the principles of sustainability and objectivity have proved their value. Quick suppression and forgetting of negative situations must be countered.

- Flood risk reduction and flood response are cross-sectional tasks and require a great deal of communication, cooperation and management. All participants from different specialist and spatial areas must be better integrated with each other. Interfaces are weak points, and must be regularly tested for functionality and then updated.

- Own private precautions, constructional, behavioural and (insurance-aided) risk reduction should be systematically developed and stimulated as a component of flood risk reduction. Own precautions are neither encouraged nor rewarded sufficiently. It depends a great deal on whether flood dangers and limitations are recognised and whether possibilities for taking action are known. In the elementary damage insurance, insurance premiums and deductibles should be oriented not only to the risk but also the extent of own precautions, for instance to more intensely promote preventative building measures. To make sure that solidarity becomes more effective in individual cases, it must be ensured that private and commercial precautions can be integrated in (state) disaster response well before the disaster. How, for instance, private persons can be legally insured while carrying out relief work or how company fire brigades can be integrated if necessary, must be clarified.

- Under the primate of flood protection obligated to clear protection goals the interests of a broad range of political areas must be integrated in the drawing up of flood risk reduction concepts at an early stage. Impacts not only on nature and the landscape but also on industry and settlement development caused by flooding and flood protection measures requires an interdisciplinary space-oriented risk management (KARL AND POHL 2003), which does not demand any competition but, rather, a stronger integration of water (resources) management, land (resources) management and spatial planning.

- Action covering whole river catchment areas and extending across borders is essential for “preventative flood protection” and for preventative flood risk reduction. Above all in achieving and implementing transnational programmes such as “INTERREG-Rhein-Maas-Aktivitäten” (IRMA - Interregional Rhine-Maas Activities), for which from 1997 to 2002 a total of 153 projects with a total budget of € 356 million were worked out (ERNST AND NAGEL 2003), the special problems of risk management and risk communication became evident (POHL 2003). But also in the case of such smaller transnational projects like ODRAREGIO, with a comparably small cost of € 235,000 during a period from December 1999 to June 2001, one-sided orientations, for instance towards developing “spatially-organising networks” (HEILLAND AND NEUMÜLLER 2003) are unmistakable. It is to be hoped that the Elbe-Labe-Initiative (ELLA), earmarked to begin 2004 within the framework of the INTERREG IIIb programme, will not only provide transnational but also usable results, for instance through “network-forming activities” (MALEK 2003).
Solidarity with subsequent generations requires decisions on flood risk reduction concepts despite great uncertainties. First of all this means that we must learn from disasters and above all design reconstruction, so that a higher level of disaster reduction is achieved. Today’s flood risk reduction should not be allowed to restrict future generations’ possibilities of taking action. Flexible systems and expandable concepts are therefore required.

“The notion that “everything should get better, but nothing should change” also does not achieve the objective in the case of flood protection.” (LAWA 1995, page 24).

In order that there are not just “improvements everywhere but also that something really changes”, all demands must be considered, weighed up against each other according to social, economic and ecological criteria and finally subordinated to the common good – and not to individual sectoral, regional or local interests.
The floods of August 2002 in Central Europe caused total damage of 21.1 billion euros and 37 fatalities (MÜNCHNER RÜCK [MUNICH RE] 2003, updated) and, in contrast to the Odra flooding in 1997 in the German-Polish border area (GRÜNEWALD ET AL. 1998) had a disastrous impact in the catchment areas of the Rivers Vlatava, Elbe and Danube (Tab. 1). It destroyed confidence - not only amongst those directly affected by the disaster — in the security of people’s living conditions and institutions responsible for protection against flooding, and clearly underlined just how susceptible our highly technical and highly organised society is to extreme natural dangers.

In particular the shortcomings of flood disaster management in Germany were once again clearly evident. We have to learn from such events in order to identify as many findings relevant to future disasters, compile this information and as far as possible come to specific conclusions and use these to create improved measures for preventative action.

### FROM SAFETY MENTALITY TO RISK CULTURE

The danger of damaging flood waters is also ever present in the river catchment areas of Central Europe, and cannot be absolutely ruled out, even by comprehensive protection measures. The traditional approach to flood protection is shaped by a safety mentality. That is, flood protection is frequently conceived in such a way that one appears to be safe if the event should occur once again. The protection is aimed at design values (for instance, the 100-year flood), without a detailed analysis and debate about other possible damage scenarios and other protection objectives. Such an approach is characterised by suppressing and ignoring the complete spectrum of dangers and by a sectoral way of looking at things.

This traditional safety mentality or promise of protection must be countered by a risk culture, which is aware of the threat posed by flooding and which enables risks and their changes as well as preventative measures to

### TABLE 1

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Czech Republic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Total damage: initially estimated at € 22.6 billion, revised to € 6 billion 9.2 in Nov. 2002. Saxony alone reported € 6 billion worth of damage to Brussels, on 12.09.2003 State Premier Prof. Milbradt increased estimate to € 8.6 billion</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Total damage approx. € 3 billion</td>
<td></td>
</tr>
<tr>
<td>337,000 people directly affected</td>
<td>Approx. 220,000 people evacuated</td>
<td></td>
</tr>
<tr>
<td>Approx. 35,000 evacuated in Dresden alone</td>
<td>Approx. 50,000 in Prague alone</td>
<td></td>
</tr>
<tr>
<td>Many cultural assets (Zwinger painting gallery, Semper Opera, Schlosspark Weesenstein ...) badly affected</td>
<td>All three Metro lines badly hit</td>
<td></td>
</tr>
</tbody>
</table>

Tab. 1: Damage caused by the August 2002 floods in Germany and the Czech Republic
be presented and evaluated transparently in an inter- 
disciplinary dialogue. This includes the ability to 
collectively deal with uncertainties. This requires risk 
competence, i.e. the ability to correctly assess the 
danger potential and to reduce it following an analysis 
of social considerations.

The word risk is used in different connotations in 
colloquial usage and the scientific community. In ever-
day language risk means the possibility of suffering 
damage. In safety science risk means two aspects, 
namely the probability of damage occurring and the 
magnitude of the damage (for instance PLATE AND MERZ 
2001). The risk arises from the interaction of danger and 
vulnerability (Fig. 1).

Such a risk culture is based on three sets of questions:

• What can happen? – Risk analysis –

• What should not be allowed to happen?

• What is the best way of dealing with the risk?
  – Dealing with the risk –

Common aspects can be identified for these three sets 
of questions:

• Constructive, public risk communication is 
necessary, and risks must be made public. Threats 
and their impacts and possibilities of disaster risk 
reduction should be made transparent and debated, 
integrated in political opinion forming and publicly 
communicated.

• Risks and possibilities of reducing them change over 
time. This is all the more reason for continuous 
(political, societal and financial) commitment. It is 
not sufficient to simply react to specific events, i.e. 
only take action after damage has been incurred.

• Ultimately the change of paradigm from safety 
mentality and promises of protection to a risk 
culture means closer cooperation between risk 
reduction and coping with risks. Concentration on 
the apparent controllability of flooding or protection 
against flooding is to be replaced by strategies to 
cope with flood waters. This would mean that the 
separation between those involved with flood risk 
reduction and those involved with coping with the 
floods, which is found in many places today, would 
become less important.

• Finally the debate on flood risk should be linked 
with the debate on other natural risks and 
technological risks. The objective would be the 
coherent management of all risks that people in a 
specific region are subjected to.

Fig. 1: Risk as the result of the interaction between danger and vulnerability
Flood risk management in Germany

The two main elements of flood risk management are flood risk reduction and coping with floods (Fig. 2).

These two elements are integrated in the cycle of disaster management. This means, for instance, that reconstruction after the disaster already has to contain the foundations for improved preventative measures.

Preventative measures against flooding above all means:

- Spatial measures: keeping constructional development out of floodplains as far as possible
- Constructional measures: ensuring appropriately adapted construction methods in areas prone to flooding
- Risk reduction measures: own financial provisions (backed by insurance)
- Behavioural measures: explaining, preparing for and practicing how to cope with flood-related danger situations
- Informational measures: alarming, warning and informing about impending events
- Increasing natural water retention in catchment areas
- Technical flood protection: constructional facilities for water retention (such as dams, storage reservoirs, polders).

Coping with flood disasters above all means:

- Averting disastrous impacts of flooding
- Help for victims
- Construction aid
- Reconstruction

Damage caused by extreme flooding can only be reduced through a sensible integration of reduction and coping measures.

Germany has a federal system, which means that governmental tasks are divided between the Federal Government and the State Governments of the Länder. As part of Germany’s environmental policy the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety deals with general policy matters affecting water management and cross-border cooperation in this area.

Beyond these basic policy matters flood reduction and prevention is the concern of the Länder or states. After the various Länder had for decades pursued a policy that involved developing flood plains, for instance by building enterprise zones and housing estates as well as authorising more and more building of dikes and extension of rivers, the Water Resources Act was amended in 1996.

Even before the amendment the Länderarbeitsgemeinschaft Wasser (Working Association of the Länder on Water), which represented all German Länder (states), formulated “Guidelines for a Future-Oriented Flood Protection” (LAWA 1995). This contains all the main elements of risk prevention and reduction similar to the above definitions. In addition individual German Länder (states) and river basin commissions formulated programmes of action for a sustainable flood protection that contained similar terms such as “spatial measures” and “technical flood protection”, but also the confusing term “further-reaching prevention” (Fig. 3). It suggests a “regulated sequence of measures” in the sense of “first one and then the other”, which is by no means correct in the case of flood risk reduction.
On the contrary, sustainable flood reduction requires a “balanced coexistence” for different levels of danger (small, medium and large-scale flooding, respectively with different recurrence intervals, in water catchment areas of varying sizes and regional characteristics) to be developed across sectoral areas and to be partly implemented on a flexible basis (Tab. 2).

This study indicates that there is not enough cooperation, communication and management in either reduction or in coping with flood disasters in Germany. In both cases there is a lack of interdisciplinary action across different specialist, administrative and spatial boundaries and in particular across the different state borders of the Länder (states).

![Fig. 3: The three-pillared concept for water protection in Bavaria (BSMLU 2002) and the Saxon flood protection strategy (SMUL 2003a)](image)

**TABLE 2**

<table>
<thead>
<tr>
<th>Frequent floods (&lt; 10 a)</th>
<th>“Soft”, structural measures</th>
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<tbody>
<tr>
<td></td>
<td>Renaturalisation</td>
</tr>
<tr>
<td></td>
<td>Improved infiltration, unsealing of sealed soils</td>
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<tr>
<td></td>
<td>Decentralised water retention</td>
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<td></td>
<td>Moving back of dikes, widening cross-sections</td>
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<td></td>
<td>Dikes</td>
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<thead>
<tr>
<th>Rare floods (T = 10 – 200 a)</th>
<th>Technical measures</th>
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<tr>
<td></td>
<td>Retention basins and areas</td>
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<tr>
<td></td>
<td>Dikes</td>
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<td></td>
<td>Polders</td>
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<td>Moving back of dikes, widening cross-sections</td>
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<tr>
<th>Very rare floods (&gt; 200 a)</th>
<th>Organisational measures</th>
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<tr>
<td></td>
<td>Emergency discharges</td>
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<tr>
<td></td>
<td>Disaster relief</td>
</tr>
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<td></td>
<td>Precautionary financial measures</td>
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</tbody>
</table>

Tab. 2: Examples of differentiated measures for flood risk reduction in the case of different flood recurrence intervals (T in years) (KRON 2003, altered)
Floods are part of the natural hydrological cycle, which is prone to extraordinary temporal and spatial variations. They are natural events, which mankind has always been subjected to and will also be subjected to in the future. Extreme floods are above all due to heavy precipitation, combined with unfavourable hydrological antecedent conditions in the water catchment areas. Although the anthropogenous influences that have prevailed in the waters and their catchment areas in recent decades have partly aggravated flood water discharge, particularly in small catchment areas, they do not trigger off flooding.

Unusually heavy and abundant rainfall across wide areas of the subbasin of the upper River Elbe, combined with soils that were already relatively saturated, caused extreme flooding on the River Elbe and its tributaries in August 2002. The flood situation intensified dramatically there within a few hours on 12 August and presented an unprecedented challenge to those responsible for dealing with the situation. Initially the tributaries of the River Elbe in the Ore Mountains and the River Mulde were affected, and then later the River Elbe itself. The alarm was raised in many rural districts and municipalities.

From a meteorological point of view this event can be explained as the result of the flooding-prone “large-scale weather patterns in Central European” TM “Low over Central Europe” and TRM “Trough over Central Europe”. Although the frequency of such flooding-prone large-scale weather patterns (TRM and TM) are relatively low in the months of June to September — less than 4 %, when they do occur they bring sustained and heavy precipitation over large areas, and throughout history
they have repeatedly caused extreme flooding in the affected river basins (GRÜNEWALD 2003).

With regard to the events that took place, initially a differentiation must be made between two flooding events: one with very quickly rising flood water discharges in the tributaries and valleys of the Upper River Elbe and the River Mulde and a separate event with much slower rising waters in the River Elbe itself. Finally there was a third event involving the subsequent rising of the ground water, which caused considerable problems in urban areas.

Extreme floods concentrated over a particular period of time are by no means new occurrences in Central Europe and in the basin of the River Elbe. Important historic floods when the river in Dresden exceeded a water level of 8 m also occurred in August 1501, in February 1655, in March 1784, in February 1799, in March 1845 (greatest known historic flood with $W = 877$ cm and $Q = 5,700$ $\text{m}^3/\text{s}$, ice flood) in February 1862 and in September 1890 (SMUL 2002). Heavy summer rainstorms have also repeatedly caused limited flooding in the Ore Mountains and the catchment of the River Mulde (Fig. 4). Widely known — particularly in Saxony — are the devastating and torrential floodings which appeared to occur exactly every 30 years in the catchments of the River Gottleuba and the River Müglitz in the years 1897, 1927 and 1957, and which in 1927 had a particularly disastrous impact, causing 152 deaths.

After initial speculations of 7,000 $\text{m}^3/\text{s}$ for the August 2002 floods, it is now estimated that the peak discharge in Dresden was 4,680 $\text{m}^3/\text{s}$ (BFG [GERMAN FEDERAL HYDROLOGY INSTITUTE] 2002), which is relatively close to the summer floods of September 1890, with a flow of 4,400 $\text{m}^3/\text{s}$ and the water flows in August 2002 in Prague, Decin and Usti fitted in with the long-term river flow patterns. Records indicate that this magnitude of discharge recurs every 150 to a maximum of 200 years (UMWELTATLAS [ENVIRONMENTAL ATLAS] 2002), but the peak water level of 940 cm was higher than all previously observed values. The apparent discrepancy between an (after all) “unusually large flow” and a water level in summer 2002 surpassing all previous records in the urban area of Dresden can be explained by a drastically reduced flood water transfer potential: Increasingly it has been confirmed that the causes for this reduction are pronounced alluvial deposits — for instance around the Carola, Augustus and Marien bridges — as well as vegetation cover. Also the construction of sports complexes as well as, for instance, the stacked container offices of the building site for the new congress hall considerably narrowed the inlet to the Ostra flood channel. Other weak points are the bridge profiles, which do not allow enough water flow through them or which have been subsequently altered in ways which reduce the amount of water that can flow through them (Fig. 5).

Because other priorities had been set (amongst others, for nature conservation, recreation) there were no measures undertaken to minimise flooding.
and bridge profiles and outlets were also not kept clear. Only after the end of October 2003, for instance, following “lengthy negotiations between nature conservation authorities and the Radebeul State Environment Office” (SÄCHSISCHE ZEITUNG, 22.10.2003, page 13) could measures be commenced to partly remove alluvial deposits that raised water levels and altered the flow of waters. This is complicated by the complexity and variety of competences governing the management of water bodies (Fig. 6).

Fig. 6: Responsibilities for the Federal Waterway River Elbe (drawn up with the cooperation of the State of Saxony, “MW” = mean water level)
Lessons Learned for evaluating results

Extreme precipitation of great intensity and concentrated on a specific area in the basin of the River Elbe together with almost saturated soils led to extreme discharges in August 2002.

A look at the past reveals that there had already been comparable extreme flooding in the basin of the River Elbe on previous occasions.

The unprecedented water level 9.40 m in the urban area of Dresden was apparently encouraged by a reduced flood water transfer potential. This was caused by the combined effects of alluvial deposits, vegetation cover in the flood profile, constructions in the flood channel, etc. Flood profiles, flood channels, forelands, water channels under bridges, etc. have to be more consistently designed to cope with floods than they have been up to now.

The splitting of responsibilities between the Federal Government, Government of the State of Saxony and the local authorities and the partly unclear designation of competence along (navigable) river reaches and the river catchments must be done away with, and instead clearly defined objectives and clear definitions of priorities are required.
The general increase in damage caused by natural disasters is related to the number of people who live in exposed areas and accumulate value there (MÜNCHENER RÜCK [MUNICH RE] 2003). This particularly applies to damage through flooding because, for instance, in Germany building land is often offered in attractive locations in flood plains.

Keeping constructional development out of flood plains is the task of risk reduction through spatial planning (LAWA 1995). However, even with the existing values in the flood plains susceptibility to damage can be reduced and prevented. Here preventative measures in construction and adapted behaviour come into play. If flood damage is incurred despite all preventative measures, risk reduction can provide financial compensation: Here in particular the possibility of insurance-backed risk reduction should be considered.

Risk reduction through spatial planning

Risk reduction through spatial planning influences the extent to which areas are used and for what purpose they are used. In areas prone to flooding preserving those areas that are still not built on is the most effective method of limiting an increase in potential damage (e.g. EGLI 2002).

International waters such as the River Elbe require cross-border cooperation in managing river basins. Commissions, such as the International Committee for the Protection of the River Elbe work on an interdisciplinary and cross-border basis, and make recommendations (IKSE 2003), which, however, are not binding for Germany or the Czech Republic. This means that although good work is carried out, the effectiveness of this work remains limited. The only binding Directive at European level is the EU Water Framework Directive (WFD). However, it primarily focuses on improving water quality. Preventative flood protection, amongst other things, is not specifically formulated as an objective or otherwise anchored in the Directive and therefore scarcely plays a role in the current version (EU 2000). A positive approach of the WFD is to deal with the entire natural catchment area as a whole. Because of its size the catchment area of the River Elbe was subdivided into coordination areas (Fig. 7), for each of which a Land (state) is allocated as responsible body. However, this constitutes a partial deviation from the approach of treating the entire catchment area as a whole, since the new coordination areas orient to the existing administrative borders (boundaries of the Länder (states). This makes it more difficult to

Fig. 7: Coordination zones in the catchment area of the River Elbe (source: IKSE basic map, Federal Institute for Hydrology Koblenz DLM 1000 of the Federal Institute for Hydrology. Czech Hydrological Institute (CHMI), Prague 2003)
deal with the catchment area on an interspatial and interdisciplinary basis.

In the Federal Republic of Germany the different administrative levels in the form of Land (state) planning, regional planning and urban development planning decide on how the areas are used. The Federal Government merely lays down the framework conditions. The Lände (states) hence independently decide upon implementation of plans within this framework, which means “each makes its own”. However, they leave enough room for manoeuvre for the actual implementation of the regulations. Since the regional spatial planning can hardly interfere with the existing building areas and also can only stipulate measures to be implemented at local level when they were deemed to be essentially regional, the communal level of administration is in charge of this area of regulations. The local authorities therefore play the key role in assigning the use of these areas. Here flood protection is only one point among many others and it often has financial disadvantages for the local authority, so that in reality risk reduction through spatial planning still remains a “strong instrument in weak hands”.

The various local authorities deal differently with the knowledge about the danger of flooding and building in the flood plain areas — usually, however, with too little emphasis placed on considerations with a view to changing land use.

In particular the development before the 2002 floods around the local authority of Röderau-Süd in Saxony reflects the extent to which awareness for the problem has abated. The experiences of previous floods were ignored and a housing estate as well as an enterprise zone were planned and approved, and then built in the floodplain of the River Elbe (Fig. 8). Now compensation has been and is being paid to the residents to move and settle in another area. There is no recognisable standard approach for similar situations or for the whole of Germany.

**FIGURE 8**

*Fig. 8: Röderau-Süd 16.8.2002 (photo: A. Schröter)*
In Dessau, in Saxony-Anhalt, no building areas have been designated since 1990 in the floodplains at the junction of the Mulde and Elbe rivers (STADTPLANUNGSAMT DESSAU [DESSAU TOWN PLANNING OFFICE] 2003, personal communication). The flood plain of the River Mulde covers various other protected areas. It appears that there are positive synergy effects here between risk reduction through spatial planning, urban reconstruction and landscape conservation. Together with preventative action this has meant that this area has been left undeveloped, thus preserving the remaining available water retention areas.

In several Länder (states) initiatives for risk reduction through spatial planning were carried out after the flood in 2002. One instrument used for this purpose is the set of modern danger maps, which are now, for instance also being drawn up in Brandenburg, Saxony and Saxony-Anhalt. Mostly flood areas for floods that recur every 100 years are shown, but also others with other flooding intervals. Sometimes these maps also indicate the flood levels and the flood waterflow velocities on the flooded areas. However, there are no standard national criteria for these maps. Also there is a great deal of scepticism regarding the publication of these maps because, for instance, there are worries that they could have a negative impact on land prices.

Following the flood events, the German Federal Government drew up a 5-point plan for improving preventative flood protection (BMU [FEDERAL MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY] 2003). On this basis a draft for an Artikelgesetz (a law that applies to several different laws or contains very different contents) was drawn up (BMU 2003a). This envisages amendments in the Water Resources Act, Town and Country Planning Code, Federal Regional Planning Act, Federal Waterways Act and in the Law governing the German Weather Service.

The Artikelgesetz proposes the correct approach towards strengthening risk reduction through spatial planning as an instrument for flood risk reduction. Above all the regulations for dealing with the issues of areas prone to flooding and the possibilities of minimising damage must be regarded as a positive initiative. Also the efforts of regional spatial planning authorities to define areas prone to flooding are simplified and supported on a nationwide basis. Another positive approach is the proposal to integrate flood protection, flood-related construction and flood risk reduction in one law (BDLA [FEDERATION OF GERMAN LANDSCAPE ARCHITECTS] 2003). Currently these are anchored in different laws independently of each other.

**Preventative building measures**

Where settlements already exist in areas prone to flooding, preventative building measures can reduce the existing danger potential in the short term and for a sustained period of time. Preventative building measures are most effective in areas with frequent flood events and low levels at which floods occur (IKSR [International Commission for the Protection of the Rhine] 2002). In particular when new settlements are being built or during extensive urban renewal, for instance an elevated configuration (Fig. 9) or also the construction of buildings without cellars should be considered.

Permanent or mobile barriers can be used to keep water out of whole urban areas or also out of individual buildings — such as those that have been repeatedly perfected in Cologne on the Rhine. Moveable constructions are stored on site or in special storage spaces. In Dresden, too, concepts were also developed after the 2002 floods, for instance for protecting the main railway station and city centre with the help of mobile walls (UMWELTAMT DRESDEN [DRESDEN ENVIRONMENTAL OFFICE] 2003, personal communication).

The improvement of the stability of a building counters the dangers caused by buoyancy, water pressure, flood pressure, erosion and washing out of free-standing elements. When groundwater rises above the foundations of the building, the walls and the foot of the building...
are subjected to buoyancy forces and water pressure (BMVBW [FEDERAL MINISTRY FOR TRANSPORT, CONSTRUCTION AND HOUSING] 2002). Counter measures that can be undertaken include anchoring the buildings or ensuring that the buildings themselves are very heavy.

To prevent penetration of surface water and groundwater, any openings in the buildings must be raised or sealing measures must be implemented. Backpressure preventers stop backpressure in the sewage networks and hence prevent water entering the buildings. Buildings are sealed using bitumen or strips of plastic (“black” basement waterproofing) or by constructing the foot and walls of buildings out of concrete that is almost non-permeable (“white” basement waterproofing) (BMVBW 2002). However, water should only be kept out of the buildings as long as they are still stable. If the water level continues to rise, they must be flooded with clean water or the outside water must be allowed to penetrate.

If the water cannot be prevented from penetrating into the building, the damage can be substantially reduced by building usage adapted to flooding, i.e. by only having low-value utilisation in the endangered storeys. Electrical connections, heating and energy, gas and water supply installations must be moved to the upper storeys. In addition water-repellent or waterproof building materials and internal finishing work, mobile interior fittings and compact furniture (MURL 2000) should be used. These measures have proved to be effective even in the floods of 2002: Flood-adapted utilisation and interior fittings reduced damage to household effects by 13—15 %, and damage to buildings by 8—9 %. Fig. 10 shows the result of a survey of 1,248 private households next to the River Elbe in Saxony and Saxony-Anhalt, the River Mulde and the rivers of the Ore Mountains, which were affected by the floods in 2002. (Project partner for the survey: GeoForschungsZentrum Potsdam, Deutsche Rück; Financing: Deutsche Rück, Federal Ministry of Education and Research).

Another possibility is the safe and secure storage of oil and other environmentally hazardous substances. Tanks can float when flood waters rise and can be damaged by the water pressure. Empty containers must therefore be tested to ensure that they are secured against buoyancy. Although the amount of private oil central heating systems in flooded areas in Saxony and in Saxony-Anhalt was relatively low, at 15 %, 44 % of those interviewed said that their buildings were polluted by oil or petrol. Oil contamination does merely affect people’s own buildings but also causes great damage to others. During the floods of 2002 an average of three to four buildings were contaminated by one defective oil tank, which increased the degree of impairment significantly.

The survey shows that the floods motivated a relatively large number of people to implement private risk reduction measures. With the exception of the

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**Fig. 10**: Reduction in damage to household effects through different strategies of “yielding”.

(column = average value, dot = median, lines = 25—75 % percentile, n = number of households interviewed)
adapted utilisation of the endangered storeys, a higher percentage of households with severe construction damage implemented risk reduction measures. It is apparent that these risk reduction measures are being implemented parallel to renovation. Generally increased and improved information and financial incentives should be used to encourage preventative building measures. Possibilities for self-protection are, for instance, presented in the following brochures:

- “Hochwasserschutzfibbel — Planen und Bauen von Gebäuden in hochwassergefährdeten Gebieten”, Bundesministerium für Verkehr-, Bau- und Wohnungswesen (Flood protection primer — Planning and constructing buildings in areas prone to flooding, published by the Federal Ministry of Transport, Building and Housing),
- “Hochwasserfibel — Bauvorsorge in hochwassergefährdeten Gebieten”, Ministerium für Umwelt, Raumordnung und Landwirtschaft des Landes Nordrhein-Westfalen (Flood primer — Preventative building measures in areas prone to flooding, published by the North Rhine-Westphalia Ministry for the Environment, Regional Planning and Agriculture),
- “Hochwasserhandbuch — Leben, Wohnen und Bauen in hochwassergefährdeten Gebieten”, Ministerium für Umwelt und Forsten Rheinland-Pfalz (Flood manual — Living, dwelling and building in areas prone to flooding, published by the Rhineland-Palatinate Ministry for the Environment and Forestry),
- “Hochwasser-Merkblatt für Bewohner gefährdeter Gebiete der Stadt Köln” (Flood leaflet for residents of endangered areas. Published by the City of Cologne).

Such information possibilities should be developed for all Länder (states) of Germany, should be constantly updated and then suitably presented to potentially affected persons.

**Behavioural risk prevention**

Behavioural risk prevention is the “basis for taking measures to minimise damage before the next event occurs” (IKSR 2002). It is the instrument that is used after natural disasters to prevent a common state of affairs, i.e. “today everyone is talking about it, tomorrow it is forgotten”. At an early enough stage potentially endangered people should be informed of the possibilities of behavioural risk prevention. Everyone should know what to do. For instance, a check list indicating which things should be available for an emergency or what should be done in the event of a flood.

An integral part of behavioural risk prevention is adequate and punctual flood warnings (see chapter 5), which still enable damage to be reduced shortly before the event occurs. According to a survey of private households covering the “River Elbe in Saxony and Saxony-Anhalt” and the “Ore Mountains and River Mulde”, 40—50 % of people affected by floods did not know what to do on the basis of warnings by the authorities. Here there is an urgent need to provide people with better information. This is particularly important in areas where flood waters appear after a short time. Communicating information about risks of flooding is an important requirement for increasing people’s own risk reduction in households and companies. Brochures, information tables and high water marks, as well as staging of disaster protection

![Fig. 11: High water marks on the Water Palace of Schloss Pillnitz, Saxony (photo: U. Grünewald 2003)](image)
exercises, comparison and updating of information chains, amongst other measures, complement the possibilities of behavioural risk prevention.

After the floods in 2002 the authorities worked on information and reaction chains to ensure that in the event of an emergency everyone knows what information can be obtained from whom and to whom this information should then be forwarded. These chains must be tested in regular exercises on the basis of “testing before it is too late” to determine that they are up to date and function properly.

High water marks are a reminder of past floods, and usually located on historical buildings, where they show the maximum flood levels of the past (Fig. 11). They are a possibility of heightening and maintaining awareness for the existing danger of flooding at the places where previous flooding occurred. It would be worthwhile putting such marks in the inner cities. But, for instance, the “Ostthüringer Zeitung” (30.8.2003) accurately describes the situation, when it notes that there is a great deal of scepticism regarding this. However, for today’s mobile society these are important sources of information for learning about a place’s history of flooding.

Risk reduction

Financial precautions are needed to prevent “the residual risk finishing us off” and to prevent a flood endangering people’s very livelihoods. Since 1991 in Germany a so-called “extended elementary insurance”, enables people to extend their household’s insurance or household and personal effects insurance to include insurance cover for damage caused by flooding. To prevent this insurance cover only being wanted by those who have a high risk, this product provides comprehensive cover against several natural dangers. Currently there is no insurance obligation, which means that the rare incidence of such events leads many endangered people to do without insurance protection (IKSR 2002).

According to information from the Gesamtverband der Deutschen Versicherungswirtschaft — GDV (Federation of German Insurance Industry) in Germany in the elementary damage sector there is currently an insurance density of approximately 10 % for household effects and 4 % for residential buildings. However, historically the insurance density in Baden-Württemberg and in the Länder (states) in Eastern Germany is considerably higher. Out of all private households interviewed in Saxony and Saxony-Anhalt 50 % of households prone to flooding were insured (i.e. considerably more than the German average).

Just because in principle elementary damage insurance is available does not mean that everyone can get insurance cover. In particular buildings that are particularly at risk are exempted from insurance cover or can only be insured if high risk surcharges are paid. The prerequisite for a plausible insurance rating for a building is a good zoning of the risk. Since up to now nationwide danger maps for flooding in Germany are not available, the insurance industry had a Zonierungs-system für Überschwemmung, Rückstau und Starkregen — ZÜRS (zoning system for flooding, backpressure and heavy rainfall) developed under the auspices of the GDV in 1999. In addition to the ZÜRS Zone the number of previous incidences of damage and the distance to waters plays an important role in risk assessment. According to our survey, following the floods of 2002 the risk was more conscientiously assessed, above all through using the ZÜRS.

Surveys carried out in April/May 2003 indicated that flood water damage was dealt with more quickly for insured private households than for non-insured households. They were also more satisfied with the compensation for damage.

Within the framework of flood risk reduction, insurance should be combined with other preventative measures. A common means of promoting own private precaution on the part of the insured party is to include a deductible in the policy: in the event of any damage the insured party has to pay for some of the damage himself, and it is therefore in his interest to keep the damage as low as possible. It would be ideal to link the deductible with the risk of danger, so that particularly risk-prone households had the highest incentive to take their own precautions, for instance in the form of building precautions and behavioural risk prevention.

The insurance conditions for risk reduction against flood damage were investigated, with surveys involving approximately 120 primary insurance companies and differentiating between private households and companies.
Out of the interviewed primary insurance companies only 14% of the companies had voluntarily rewarded policyholders for flood protection measures. There are many reasons for the limited stimulation of own precautions by the insurance industry: On the one hand the household and personal effects and the building insurance is a mass segment in which the elementary damage sector is not very important for the companies. The results of the survey gave the impression that policies for the extended elementary damage insurance, as a mass segment, are handled according to a relatively rigid formula that allows little room for manoeuvre for negotiating. On the other hand, it must be assumed that many primary insurance companies themselves are not adequately informed about damage risk and damage avoidance in the elementary sector. Here there are differences compared to the reinsurance industry. For instance, Munich Re already developed an accumulative model for the whole of Germany, which can be used for calculating numerous scenarios (KRON AND THUMERER 2001).

“When floods occur an insured person carries his television down into the cellar, while a person without insurance carries it upstairs!” Such comments insinuate that people with insurance cover are not willing to avoid flood damage. However, the results of our survey revealed that there is no significant difference between insured and non-insured private households regarding the emergency measures they implement, not only with regard to the type of measures but also regarding the amount of work they invest. Before the floods in 2002 insured people even tended to be better informed about private precautionary measures to reduce damage in the event of floods and were more likely to have taken long-term measures than those who were not insured.

After the floods of 2002 government emergency aid and private donations played a big role in providing compensation. However, this undermines incentives, to take out private insurance cover against elementary damage and implement measures to reduce damage (MECHLER AND WEICHSELGARTNER 2003). Since the current voluntary elementary damage insurance has up to now not led to a clear increase in insurance density, a more effective solution must be sought.

Currently a nationwide mandatory insurance against elementary damage is being debated for insuring private flood damage. The insurance industry has abandoned its reservations about a mandatory insurance policy and is taking part in negotiations through the GDV (2003, personal communication). A nationwide insurance cover for elementary damage and the inclusion of the risk of storm tides is envisaged (cf. SCHWARZE AND WAGNER 2003). To encourage precautionary measures against flood risk as a whole, the conditions should be designed to reward private flood protection measures.
SUMMARY

Lessons Learned regarding measures for damage reduction

Risk reduction through spatial planning measures has a chance if they are integrated in a comprehensive and convincing concept and precautionary measures against flooding are given more weight in comparison with other areas of interest.

Various maps are being drawn up for flood danger. It would be worthwhile using standard, national criteria here.

A public debate is required on the possible extreme events and their varying intensity depicted in these maps.

Precautionary building measures considerably reduce damage to household effects and buildings.

Since oil contamination does not remain restricted to the premises where damage is incurred, more attention has to be paid to securing tanks.

Insurance companies currently provide too little encouragement or reward for precautionary behaviour or private precautionary building measures. Nevertheless, the floods of 2002 revealed that insured persons had taken better precautionary measures than uninsured persons and implemented a similar amount of emergency measures. This contradicts the widespread notion that an insured person is not interested in reducing damage.

A very positive development is that private households increase their private precautionary measures after a flood.

There is a great need for information on how to provide protection against flooding in an emergency situation. Regular information events and thematic exhibitions heighten awareness about flooding.

According to surveys carried out in April/May 2003, flood damage was dealt with more quickly in the case of insured private households than for uninsured ones. The former were also more satisfied with the damage compensation.

A concept for a more effective risk reduction must be worked out for Germany. The introduction of a mandatory insurance is currently being debated.
Natural retention

The motto “More room for rivers” has become the governing principle for reducing discharge and flooding (for instance BMU [FEDERAL MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY] 2003a). Here the prime and general focus is on reversing human interference, for instance the impact caused by the settlement of flood plains, building of dikes along riverbanks, the sealing of the ground, “forest dieback” and the straightening of rivers.

In the draft of the Artikelgesetz of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU 2003a) the key objective is “to leave more room for rivers, particularly their natural flood plains, or to give this space back to them”. Accordingly in particular measures, for instance for moving dikes further away from river banks and conservation or restoration of flood plains, are to be included in the flood protection plans (ibid, Section 31d, sub-section 1). However, the effectiveness of these possibilities for flood risk reduction are still overestimated, particularly in the event of extreme flooding.

Natural water retention is primarily frequently associated with restoring flood plains. Here the positive impact is tangible even when the flood levels are low. Consequently these areas are frequently flooded, albeit for a short time, even when flood water levels are low. This makes these measures particularly important in an ecological sense for appropriately adapted valuable riparian woodlands. For instance, currently moving back the dike at Lenzen is creating approximately 300 hectares of natural flood plains, which, amongst other things, pro-

**FIGURE 12**

Fig. 12: View across the highlands in the upper catchment area of the River Muglitz (photo: S. Schümberg 2003)
vides a habitat for a large riparian woodland. However, from the point of view of flood protection these expanded flood plains can only provide a limited delay in the advance of the flood waters and a slight reduction of their peak flows.

Other natural water retention measures, such as reforestation through planting mixed forest, must be seen in a very similar light. For instance, mining operations carried out since the 15th Century in the upper reaches of the River Müglitz undoubtedly drastically reduced forest stand there (Fig. 12). Here a comprehensive reforestation programme (protective forest with different tree species) on the areas currently primarily used for arable farming can improve the water retention capability of the landscape.

There should also be a differentiated assessment of other measures aimed at increasing the natural storage capacity of the catchment areas, for instance ploughless technologies, conservational tillage techniques, altered crop rotation. Their prime advantage is that they provide a better local storage of water for the water management of the catchment area. Undoubtedly this can increase retention of flood water in the case of minor precipitation events. However, it is astonishing how confidently claims are made that such flood water discharges as those encountered in August 2002 in the River Elbe basin could have been drastically reduced.

The latest “DBU project for an innovative preventative flood protection”, costing € 3.5 million, can be regarded as symptomatic of this misconception (http://www.presseportal.de/story.htm?nr=508485). By proposing the solution “Reducing dangerous peaks of natural disasters with natural methods”, the public are led to believe that such measures would be able to reduce extreme discharges in the river catchment areas by more than just a few percent.

Technical flood protection

The important objective of reducing runoff and flooding is to minimise the runoff volume of flood water. In the case of extreme events it is too large to be completely retained in the natural or artificial storage zones in the catchment areas. However a targeted reduction of the peak flow level can be achieved through controlled water retention measures, such as polders, dams, etc. (Fig. 13), by initially letting most of the rising flood waters through and then storing water shortly before the peak water level is reached. The available storage volume and how accurately the progress of the flood waters is forecasted naturally limit the effectiveness of these...
measures. In contrast, the natural retention areas discussed above cannot be deliberately controlled. Their flood retention volume is used up at the beginning of the flooding and therefore only accounts for limited reductions in peak water levels or, in unfavourable circumstances, to no reductions at all.

At the time of the floods in 2002 the dams, retention basins and reservoirs managed by the state dam administration of Saxony had a total volume of approximately 576 million m³, with a usual flood protection volume of 121 million m³. It was reported that at the beginning of the floods in August 2002 all water retention facilities had the available capacities envisaged for flood retention (for instance VON KIRCHBACH ET AL. 2002). They could only be enlarged to a limited extent without damage to people downstream because of the short advance warning period for the ensuing heavy precipitation.

Nevertheless the flood protection volumes that existed in 2002 were able to reduce the peak flow and delay it. This not only won valuable time for emergency measures but also prevented a simultaneous confluence of peak flows from tributaries and main rivers.

The topography around the lower reaches of rivers means that dams cannot be built here to provide reservoir space for controlled water retention. Here it is possible and necessary to turn areas along the river-banks into polders. The effectiveness of these (flood) polders and the principle of their use are comparable with flood water retention basins. For instance, the better they can be controlled and the nearer they are to the objects they are intended to protect, the more effective they are.

This was impressively demonstrated in August 2002 as the peak flood level was reduced by more than half a metre on the River Elbe at Wittenberge when the Havel weirs and polders, which were erected as a preventative measure in 1955, were used for the first time. In addition this is a positive example of well prepared cooperation across the borders of Brandenburg and Saxony-Anhalt, which was also consistently implemented during the disaster.

A real lesson learned was the necessity for flood-adapted agriculture in the polder areas, that is, for instance, that the existing surface and underground biomass should be so limited that the oxygen consumption caused by biodegradation in the water in the flooded polders does not have an impact on the aquatic fauna and there is also no danger of negative consequences for the river when the disaerobic flood water drains off the polders.

In 2002 the flood protection, or more precisely, the security provided by the dikes proved to be a “weak link in the chain”. Problematic here is the increased accumulation of value behind dikes that are regarded as secure. During the flooding of the River Elbe in 2002 many stretches of these dikes proved to be insecure. For instance, in Saxony the dikes burst or the flood waters rose over the tops of them in 131 cases, mostly in the catchment area of the River Mulde. The main problem of the dikes, which had been built over the course of centuries, was their poor condition. This was above all caused by severe root penetration, inhomogeneous structure and weak points in the ground, lack of sealing and damage caused by burrowing animals, which combined to make the dikes far more permeable than they should have been.

Even before the floods in August 2002 it was estimated that in the entire German catchment area of the River Elbe only a small part of the 730 kilometres of dikes along the Elbe and 480 kilometres of reservoir dikes fulfilled the standards of the German industrial norm DIN 19712 (IKSE [INTERNATIONAL COMMISSION FOR THE PROTECTION OF THE ELBE] 2001). The enormous effort and expense for repairing the dikes — the International Commission for the Protection of the Elbe (IKSE 2001, page 42) estimated that DM 900 million was required to repair all installations along the Elbe in Germany — did not allow this situation to be quickly alleviated.

Despite the latest calls for action by specialists (e.g. HEERTEN 2003), a rapid and thorough improvement of the dikes’ condition is unlikely. It is therefore particularly important to keep the disaster protection authorities informed at all times on the state of the dikes in their respective areas of responsibility. This is the only way to be able to react better in the event of flooding.
Lessons Learned about reduction of runoff and flooding

Decentral natural retention measures have a compensating impact on the water balance. However, it only has a limited significance regarding flood risk reduction when extreme events occur.

Dams, flood water retention basins and controllable polders are particularly suitable for reducing peaks of extreme floods, and hence also for securing major protection objectives.

Agricultural land use on polders should be designed to suit the requirements of flood protection and keep subsequent damage to a minimum.

Time-consuming and expensive repairs to dikes should be supplemented by consistent dike maintenance and preventative planning and management, taking into consideration disaster reduction aspects. Further accumulation of damage potential behind higher and “safer dikes” should be avoided.

The implementation of the motto “More room for rivers” requires a “Flood risk reduction round table”, that is a more balanced approach and greater coordination. Programmatically it must above all orient towards a consistent flood risk reduction obligated to fulfilling protection objectives.
5

Flood warnings and early warning systems as elements for risk reduction through providing information

For a successful flood forecasting system, flood reporting and flood prevention system — internationally known as flood early warning system for short — five components must interact with each other: noting the situation, developing forecasts, warning helpers and affected people, taking the correct action and behaviour adapted to the situation (Tab. 3). However, the whole system is more than simply a series of individual components. Although each component should as far as possible be state-of-the-art, the decisive factor is their interaction. Often there is a one-sided investment in the development of flood forecasting systems without adequately taking into consideration the distribution of warnings and forecasts or their implementation (GRÜNEWALD, BRODERSEN ET AL. 2001).

What weaknesses in particular were apparent during the 2002 floods in the Elbe area?

Criticism was levelled from various sources that the weather warnings of the German Weather Service in August 2002 were too late or too imprecise. The reason for this was that although the models provided information about impending extreme weather situations, that in turn also led to increased awareness among the forecasting meteorologists, the accuracy was evidently not sufficient for an earlier warning (RUDOLPH AND RAPP 2003). Hence a preliminary warning of a rainstorm was only issued on 11 August 2002, at 13:59 CET and at 23:08 CET this was updated to a rainstorm warning. Further updated storm warnings were issued from 12 to 14 August 2002. However, the dramatic increase of runoff, for instance in the Rivers Müglitz and Weißeritz already occurred on 12 August 2002.

In the catchment area of the River Elbe there are 214 flood reports and forecasting gauges (IKSE 2001). In the case of the August floods of 2002 many automatic gauges failed because they were flooded or because of power blackouts.

During the floods of 2002 forecasts for the gauges of the River Elbe were complicated because the so-called “stage-discharge relations” for the water levels that were reached had often never existed before. However, the flood forecasting model used for the River Elbe requires discharges as input data that can be calculated from the water levels of the gauges upstream of the respective forecasted gauge. Hence, these stage-discharge relations first had to be extrapolated, which led to numerous error possibilities. In the reaches of the River Elbe in Mecklenburg-West Pomerania, for instance, water level forecasts were made that were almost half a metre higher than the actual water levels that were reached (INNENMINISTERIUM MECKLENBURG-VORPOMMERN [MINISTRY OF THE INTERIOR OF MECKLENBURG-WEST POMERANIA] 2002), which led to many complicated protection measures being implemented that were not really required.

In the tributaries of the Upper River Elbe, such the Rivers Gottleuba, Müglitz and Weißeritz with catchment areas of less than 300 km² only prompt precipitation forecasts in conjunction with suitable hydrological rainfall runoff models can contribute to an improvement of advance warning.

There was strong criticism regarding the flood reports and the forwarding of these reports. Examples are, for instance, cited by VON KIRCHBACH ET AL. (2002). For example, forecasts were issued that had long since been overtaken by a long mark where the event was actually taking place illustrating the poor feedback of the rural districts to the flood forecast centres. Reports were delayed at intermediate stations and reached the disaster protection staff too late. In addition, because of the responsibility of different flood forecast centres for the same river area (for instance the River Mulde) forecasts were not consistent with each other.
People did not receive information or received it too late, particularly on the tributaries of the River Elbe. Warnings did not contain any instructions on what to do, which meant that emergency measures were not implemented, even where they would have been possible. Furthermore, the non-existence of a working siren warning system was criticised. The cooperation of the individual disaster protection units with each other and with the help organisations and support units also proved to be poor (chapter 6).

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Table 3: Components and factors of a flood early warning system (source: altered according to PARKER ET AL. 1994)
What activities were introduced after the floods in 2002?

The German Weather Service (DWD) is further developing the numerical weather forecast models and meteorological processes. In particular, they are working on an improvement of the precipitation forecast, especially taking radar data into account. The monitoring network of the automatic online precipitation stations is being expanded to fulfill requirements here. This is intended to enable a better spatial differentiation in the forecasts of rainfall depths.

The warning management of the German Weather Service was improved (with 4 warning levels: Early warning — 48 to 120 hours, Advance warning — 12 to 48 hours, Weather warning and Storm warning — generally up to 12 hours before the event, as well as warning at rural district level). Weather warnings can be called up free of charge on the Internet.

Plans envisage that, in addition to the routine forecasts on expected precipitation, the German Weather Service will also provide Saxony’s Flood Centre with information about whether extreme precipitation events will occur and also the degree of their probability. “This warning is very important for the rivers in the Ore Mountains and for controlling the dams” (SMUL 2003).

Flood warning gauges should be designed to be flood-proof and be fitted with redundant data collection, transmission and power supply systems. The Länder (states) most severely affected have already begun to take suitable action. Flood reports, the latest water levels and discharges as well as alarm levels of flood warning gauges are available free of charge on the Internet in graphic form or as tables.

To enable a faster and more effective flood forecast to be drawn up for an area, in Saxony the four existing regional Land (state) Flood Centres were integrated in one Landeshochwasserzentrum — LHWZ (State Flood Centre) for all of Saxony’s rivers (SMUL 2003). This simplifies data compilation and shortens the message channels. The setting up of this LHWZ is planned to be complete in June 2004.

The European Flood Forecasting System (EFFS) is being supplemented for the River Elbe basin with EU funding provided by the EU Institute for the Environment and Sustainability (IES) in Ispra/Italy (SÄCHSISCHE STAATSRÉGIERUNG [SAXONY’S STATE GOVERNMENT] 2003b). Building on the EFFS the IES in Ispra has been working since 2003 on the development of a prototype for a European Flood Warning System EFAS. This is intended to enable a forecast for an impending flood up to 10 days in advance.

The flood routing model “ELBA” currently used in Germany is to be updated with new stage-discharge relations and supplemented with new components (for instance Pretziener Weir) by the end of 2003. In addition a new flood forecast model “WAVOS” (water level forecast system) is to be worked out for the River Elbe in Germany from the national border to the backwater area of the Geesthacht Weir on the basis of a hydrodynamic model (1st version by the beginning of 2005). Apart from enabling forecasts based at the gauges, this will also make it possible to make forecasts at any required cross-section of the River Elbe. The influence of dike breaches and the controlling of flood polders can be taken into consideration. The forecast period on the River Mulde is to be extended by an additional 6 to 12 hours on top of the current 6 to 12 hours, primarily through improved rainfall-runoff relations (IKSE 2003).

In October 2001 the Federal Government began operating the first set-up phase of a satellite-aided warning system (SatWas) to provide a nationwide warning of the population. In a further expansion phase of SatWas the control and monitoring centres of the Ministries of the Interior of the different Länder (states) were fitted with transmission systems by the end 2002. “In addition from 2002, following the success in integrating the public radio stations, the private radio stations were also included in this warning system” (SCHULZ 2003, page 6). “This makes it possible to issue warnings via the radio stations on a nationwide basis or limited to regions (SÄCHSISCHE STAATSRÉGIERUNG 2003a, page 36). Now in the implementation of decisions by the Conference of Interior Ministers of 6 June 2002 a Gemeinsames Melde- und Lagezentrum von Bund und Ländern — GMLZ (Joint Centre of the State Governments and the Federal Governments for Reporting and Assessing the Situation), aimed at “optimising crisis management in Germany” has been set up (MITSCHKE 2003).
Lessons Learned about flood warning and early warning systems

- Research is required for further improving the quantitative, area-specific precipitation forecasts.

- Action has to be taken regarding working out reliable gauge-discharge relations at flood forecast gauges. They have a decisive impact on the quality of forecasts and are the prerequisite for reasonably fixing design parameters.

- Simple reliable monitoring processes that can be quickly carried out have to be developed and used for discharge measurements during floods.

- Improving and expanding the existing flood forecasting models for the River Elbe and its tributaries as well as the development of new models must lead to an improvement of advance warning times, to a stable, user-friendly operation of models and ultimately to reliable forecasts.

- Combining decentralised flood forecasting centres in one Land (state) flood centre concentrates competence and personnel.

- Flood warnings should be issued in standard formulations, in particular in the neighbouring Länder (states) and in the same river catchment area, and should contain appropriate recommendations for action for the recipients. It is easier to quickly issue “Standard report texts” and these are also more easily understood.

- The message channels should be kept short and should, for instance, lead directly from the flood forecasting centres to the subordinate disaster protection authorities.

- Redundant transmission possibilities should be provided for transmitting flood level warnings and reports.

- Official warnings should be clearly recognisable as such and should be issued via as many information media as possible.

- An initial warning of the population via sirens is above all recommendable for regions with short warning times.

- The reaction of all those involved, including the affected population, should be improved through appropriate behavioural precaution (for instance informing the public, training, practice and information).
The “Elbe flood of 2002”, just like the “Odra flood of 1997”, was quite rightly regarded as proof of solidarity and help. In Saxony alone 2002 more than 23,000 members of the fire brigade and 11,000 personnel from the relief organisations Arbeiter-Samariter-Bund (ASB), German Red Cross (DRK), Deutscher Lebensrettungsgesellschaft (DLRG), Johanniter Unfallhilfe (JUH) and Malteser Hilfsdienst (MHD) provided help.

However, to really understand how disaster protection functions, one has to investigate how the vast numbers and broad variety of people helping is coordinated to form a single task-oriented entity. In methodical terms this is not a trivial undertaking. One could not directly watch the service “disaster protection” being provided, even if one had enough observers available at a sufficient number of suitable revealing places. Actually one would only see helpers working but not the more widespread processes of management, communication, cooperation and logistics, which come before and after their deployment.

The task was therefore to use a method that was able to take the great variety of selective operations taking place on site, as seen “at ground level” and then still reveal the “bird’s eye view”, for instance of the whole Elbe flood. A suitable instrument for this is the analysis of the available deployment reports. They are prepared at all levels and for all participants and also “aggregated”, i.e. compiled according to specific aspects and used with specific interest as arguments in the discourse of the subsequent analysis of the event.

Hence deployment reports not only indicate how the members of taskforces themselves assessed their deployment but also how they want this to be evaluated by their superiors, and by administrative bodies, policymakers, media and the public. In addition to the dimensions that can be analysed in terms of content, the so-called network analysis can be used to show which relations existed between the participants: The deployment reports indicate who communicated, cooperated with whom, in what circumstance, or had any other type of relation with another participant. The frequency and intensity of such relations allow conclusions to be made on how the participants interacted with each other, with their resources and the actual circumstances.

Detailed examination of the content and network analyses showed that the participants do not really cooperate but, rather, primarily act in an organisation-oriented and resource-oriented way. Primarily each participant gets involved with the others in his or her organisation, i.e., public authority to public authority, fire brigade to fire brigade, German Red Cross to German Red Cross, etc. However, this is far less because of better knowledge of their own system and far more because of the internal, personal structure of disaster protection itself. In principle disaster protection is keeping to the plan, which when required will have to be put into practice ad hoc by the planned responsible agencies. In order to avoid errors, each participant sticks to those people he or she knows and, even more so, personal acquaintances, i.e. sticks to comrades of their own organisations or the colleagues at the same level of hierarchy or administration. The greater the uncertainties are concerning an unknown situation, the greater the temptation is to informally clarify the issues in advance. The so-called “informal channel” is the most efficient medium in this situation. However, the tangible increase in shifting whole implementation steps to informal channels complicates the overall situation, because this means that not only a documentable grasp and presentation of the situation but also functionally structured communication is lost in the process.

On the basis of the key dimensions “communication”, “cooperation”, “use of resources” and “management process” the real interrelations during the Elbe flood in
2002 were analysed and four structural failings were identified:

- Poor coordination of corporate disaster protection participants
- Self-orientation with decreasing orientation to the situation as a whole and to superordinated protection objectives
- Weaknesses of value-setting official channels of disaster protection
- Isolation through increasing centralisation of the operative-tactical subsystem.

The self-orientation of the participants due to functional uncertainties explains the lack of real cooperation and failure of communication. Participants concentrate on their own area and sector of tasks, because they believe that there they have their own conditions more under control. This means that they lose sight of requirements for the overall situation, and things are overvalued from the ground-level view. Above all nobody believes in a neutral overall perspective, which could legitimise objectives for action that would imply disadvantages. All participants therefore try to “keep their own nests clean”, so that it cannot be proved that they acted wrongly. But this forces them into the isolation of self-orientation while the expert work and management becomes increasingly centralised, i.e. moves from the lowest to the highest disaster protection authority, so that real action on site and management become separated, and from time to time even purely fictional: what happens on site is not the same as that prescribed and presented by the staff.

SUMMARY

**Lessons Learned from the analysis of the disaster prevention**

The following recommendations are envisaged for overcoming these failings:

- In the long term the conflicts of interests between the regional and local authorities and disaster protection organisations have to be countered through standard national disaster protection regulations. This can be achieved by defining clear responsibilities and a protection investment policy that rules out overlapping tasks and distributes resources according to protection requirements.

- It has to be ensured that equipment is complementary throughout the whole of Germany. The relief organisations must guarantee the overview of qualifications and equipment of the task forces through obligations to provide nationwide, consistent, standard, internal statistics on disaster protection organisations, which preferably refers to predefined interfaces to geographical information systems which contain maps with protection related data.

- The so-called “soft” capabilities and skills (motivation, social and communicative competence, discipline, etc.) of task forces and management have to be trained. The legitimacy of regulations should be communicated to increase their acceptance.

- A procedure for taking into account the common overall goal of disaster protection should be developed to remove barriers. The basis for this would be a clear protection provision and the introduction of an objective measuring of “disaster”, for instance a scale of damage similar to the “Mercalli Scale” used for classifying earthquakes. This could help to overcome the existing problems of unclear facts of the case according to disaster protection laws of the Länder (states).

- The evaluation of approaches should be ensured through reliable and valid procedures.
References

B-D =


E-G =


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Summary of the Study

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