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Summary Documentation Describing Adopted Procedures

Flood Risk Management Plan (FRM Plan)

for the Weiße Elster in Thuringia, Germany

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Contents

CONTENTS 2

1 INTRODUCTION 3

2 PRELIMINARY FLOOD RISK ASSESSMENT 4

3 FLOOD HAZARD MAPS AND FLOOD RISK MAPS 10

4 THE OBJECTIVES OF FLOOD RISK MANAGEMENT 13

5 FLOOD RISK MANAGEMENT PLAN MEASURES 20

6 SUMMARY 25

7 BIBLIOGRAPHY 29

1 Introduction

Directive 2007/60/EU of the European Parliament and the Council on the assessment and management of flood risks [1], dated 23 October 2007, represents the first comprehensive set of European regulations in the field of flood defence.

The aim of the flood risk management directive (FRMD) is to clarify flood risks and improve flood prevention and risk management. In terms of reducing or preventing the adverse consequences of floods the central protection objectives are considered to be human health, the environment, cultural heritage and economic activities.

The FRMD is implemented in three stages:

1. Preliminary assessment of flood risk zones.
2. Compilation of flood hazard and flood risk maps.
3. Compilation of management plans.

The flood hazards are described, the flood risks assessed and, based on these, the measures compiled and coordinated in a river basin flood risk management plan (FRM plan).

The FRM plans do not contain any directly obligatory specifications or plans for individual measures to be performed by those with a duty of care. Rather, it should specify the foundations for river basin planning and, where necessary, international planning, taking all sets of measures and priorities into consideration. This then provides the basis for any technical, financial and political decisions. The focus is not on achieving a given level of flood defence, but on establishing risk management processes, i.e. on recording, evaluating and controlling the hazards and preventing potential damage, including targeted post-event evaluation.

The international nature of any measures and their coordination are elements of integrated management and in combination with the European Water Framework Directive (EU-WFD) [2] lead to a river basin-focussed approach.

In 2009 the flood risk management directive (FRMD) was implemented in full in federal German law by the amended Water Management Act. The amended Water Management Act came into force on 01 March 2010.

This project applies the requirements of the FRMD exhaustively to the *Weiße Elster* project area where it passes through the state of Thuringia, and coordinates them with the neighbouring states of Saxony and Saxony-Anhalt in order to compile an example of interstate implementation of the directive and to clarify any difficulties in that implementation.

2 Preliminary Flood Risk Assessment

Preliminary flood risk assessment is carried out in line with Article 4 FRMD. This specifies that the flood risk should be estimated based on existing or easily derivable data.

According to Article 4 FRMD a preliminary flood risk assessment comprises at least:

- Maps, including topography and land use, and a description of the cause of flooding in the river basin.
- A description of any floods with significant adverse effects on protected assets, where a probability of return in similar form is given.
- A description of significant past floods and an evaluation of the anticipated effects under today's conditions (incorporating any implemented flood defence measures).
- An evaluation of the potential adverse effects of future flood events on protected assets.
- An estimation of the existence of any potential, significant flood risk.

In the course of detailed planning flood hazard and flood risk maps, as well as an FRM plan, must be compiled for the at-risk zones identified in this process.

Description of past floods

The location on the leeward side of the *Thüringer Wald* (Thuringian Forest) results in a moderate specific surface runoff of less then 10 l/s/km² [3]. These specific surface runoffs continue to decrease downstream. The crystalline rocks of the *Thüringer Wald* and *Thüringer Schiefergebirge* prevent rapid infiltration of surface water, resulting in a dense network of watercourses. The low storage volume of the geological subsurface impacts particularly on the *Weiße Elster* and leads to a very rapid runoff concentration into water bodies. Although occasional winter floods still occur in the *Weiße Elster*, the runoff regime in the *Pleiße* is almost completely characterised by hydrometeorological conditions and summer floods.

The occurrence of summer floods is predominantly initiated by unusual, very extreme precipitation events and/or regional characteristics favouring floods, such as high initial soil moisture content.

Description of any floods with significant adverse effects on protected assets

In addition to information generally available in various archives and on the internet, the basis for determining and describing historical flood events includes records held by TLUG Jena and the former state environment agency in Gera (e.g. records of the 1954 flood and analyses of the May 1978 flood) and the publication:

[3] Deutsch, M.; Pörtge, K.-H.: *Hochwasserereignisse in Thüringen* *TLUG Schriftenreihe* No. 63, 2nd revised edition, Jena 2003 [3]

Together with the unpublished archive research work:

[4] Eberle, H.: *Archivrecherche zu historischen Überschwemmungsflächenkarten für Fließgewässer Thüringens*, Halle, unpublished 2010.

Extreme precipitation events in the Thuringian *Weiße Elster* and *Pleiße* river basins, occasionally combined with ice jams or snow meltwater, have repeatedly caused both summer and winter floods, often associated with serious material and immaterial damage.

Research on historical flood events in the *Weiße Elster* and the *Pleiße* river basins revealed the following floods (selection):

1. *Weiße Elster*	• 1752, July and August • 1771, April and June • **1799, February (1)** • 1830, February • **1871, late June/early August (2)** • **1909, February (3)**
2. *Auma*	• 1661, August
3. *Weiße Elster* and all tributaries	• 1784, February • **1954, July (5)** • 1994, April
4. *Weiße Elster* (in part) *Erlbach*, *Saarbach*, *Brahme*	• **1981, August (6)**
5. *Weiße Elster* and *Pleiße*	• **1947, March (4)** • **1954, July (5)**
6. *Pleiße*	• 1661, August • 2002, August

Some more detailed descriptions exist in the literature [3], together with written documents on the causes and the courses of the events discussed. The following causes were identified for the above named flood events:

(1) Greiz on the *Weiße Elster*: snowmelt + ice drift + precipitation on frozen ground

(2) *Weiße Elster*: high yield + widespread precipitation falling on saturated soil (one of the worst summer floods in history)

(3) *Weiße Elster*: precipitation on frozen ground + snowmelt

(4) *Weiße Elster*, *Pleiße*: meteorological weather conditions with high precipitation

(5) *Weiße Elster* and all tributaries: Vb weather conditions with 75 h precipitation

(6) *Erlbach*, *Saarbach*, *Brahme* and in part *Weiße Elster*: strong low pressure area with high-yield precipitation, estimates speak about a HQ_{1300} event in *Saarbach*/*Erlbach*.

A description of any past floods with significant adverse effects on protected assets, where a probability of return in similar form is given.

Lessons from the recent past and the hydraulic calculations included in the *Weiße Elster* conceptual flood defence model [5] point to the conclusion that the flood defence measures implemented on the *Weiße Elster* do not provide complete protection against a HQ_{100} event. As a consequence, flood events of a magnitude comparable with historic events will continue to inflict great damage on protected assets. The more frequent and greater damage inflicted in the recent past is explained by an exponential increase in the development of assets in flood plains, e.g. shopping centres, residential buildings and recreational facilities.

Nineteenth century development led to severe changes in the discharge patterns of rivers. The eradication of retention areas in particular, together with changes in land use, led to higher peak discharges for the same runoff. River straightening and changes made during the translation and concentration period within the river basin in turn led to changes in the shape of the flood wave. This means that discharge patterns before and after development are only comparable to a limited degree.

Evaluation of significant past floods and evaluation of the anticipated effects under today's conditions

In term of the June 1954 event, which is regarded as a significant flood event, it should be noted that future floods involving similar runoff volumes will probably not achieve the full historical extent, due to the existing flood defence measures. However, because floods must continue to be anticipated in built up areas and considerably higher value assets have been created in flood zones, the possible negative impacts increase in line with the potential for damage.

Description of methodology for preliminary assessment of the flood risk

The information gained from historical flood event research was utilised in the preliminary flood risk assessment. It was also necessary to estimate the potential from available or easily derivable information based on specifications.

In order to carry out a uniform evaluation in Thuringia, a state-wide survey of flood damage potential was commissioned by TLUG Jena, and the risk zones subsequently specified, adopting coordinated significance criteria [6].

TMLFUN commissioned a survey of the approximate areas affected by flooding adopting a 200 year flood event [7] in preparation for the flood risk assessment for a total of approx. 3,400 km of watercourse.

Based on the results a state-wide review of hazards to human life and potential damage similar to the 'Atlas of flood hazards and potential damage during extreme flood on the Rhine' (*Atlas der Überschwemmungs-gefährdung und möglichen Schäden bei Extremhochwasser am Rhein*), IKSR 2001 (*Rhein-Atlas*, IKSR [8]), was carried out. The damage potential identification methodology was also adapted for use on the River Elbe in the ELLA project. It provides a uniform foundation for identifying those sections of watercourses for which more than only minor flood damage is anticipated, or where a potentially significant risk exists, in line with the requirements of the Water Management Act (*WHG*) and the EU flood directive.

The scope includes all water bodies and watercourses listed in the 'Thuringian Regulations on the Identification of Water Bodies and Watercourses in Accordance With § 80 Para. 2 of the Thuringian Water Management Act (*Thüringer Verordnung über die Bestimmung der Gewässer und Gewässerabschnitte nach § 80 Abs. 2 Thüringer Wassergesetz*) and published in the *Thüringer Staatsanzeiger* [9].

Using a GIS-based overlay of the flood-prone areas and the processed land use data it was possible to identify the damage potentials for the watercourses and communities involved based on the harmonised damage functions.

The watercourses or sections of watercourses that meet the significance criteria and are therefore regarded as risk zones are determined in an analysis of the damage potential and by adopting other significance criteria agreed upon with the client.

The significance criteria adopted in Thuringia are summarised in the following table.

Significance criteria in Thuringia

Adverse flood effects	Criteria	Indicator	Significance limit	Remark
Human health	Affected population			Covered by damage potential
Environment	Impacted IPPC facilities	No. of facilities	**≥ 1**	Individual evaluation
	Water protection zone 1	No. of zones	**≥ 1**	Individual evaluation
Cultural heritage	Impacted world heritage sites	No. of sites	**≥ 1**	
Economic activities	Urban, commercial and infrastructure zones (community-related) based on ATKIS	Damage potential	≥ € 500,000 for 1st order water courses ≥ € 500,000 for 2nd order watercourses >10 km long ≥ € 2.0 million for 2nd order watercourses >10 km long	

The following risk zones are thus defined for the *Weiße Elster* and *Pleiße* river basins [6]:

- *Weiße Elster* with

  Schnauder, *Erlbach*, *Saarbach*, *Weida*, *Auma* and *Göltzsch*.

- *Pleiße* with
  Gerstenbach, *Blaue Flut* and *Sprotte*.

Identification of flood hotspots

Flood hotspots are generally regarded as locations or industrial/commercial enterprises at particular risk.

Appropriate measures, regarded as complex due to their spatial relationships, were identified for the flood hotspots in an analysis of the as-is condition.

The hotspots shown in the figure are studied in more detail in the specification of flood hotspot measures (*Maßnahmensteckbriefe zu den Hochwasser-Brennpunkten*) (Annex 1 of the results report).

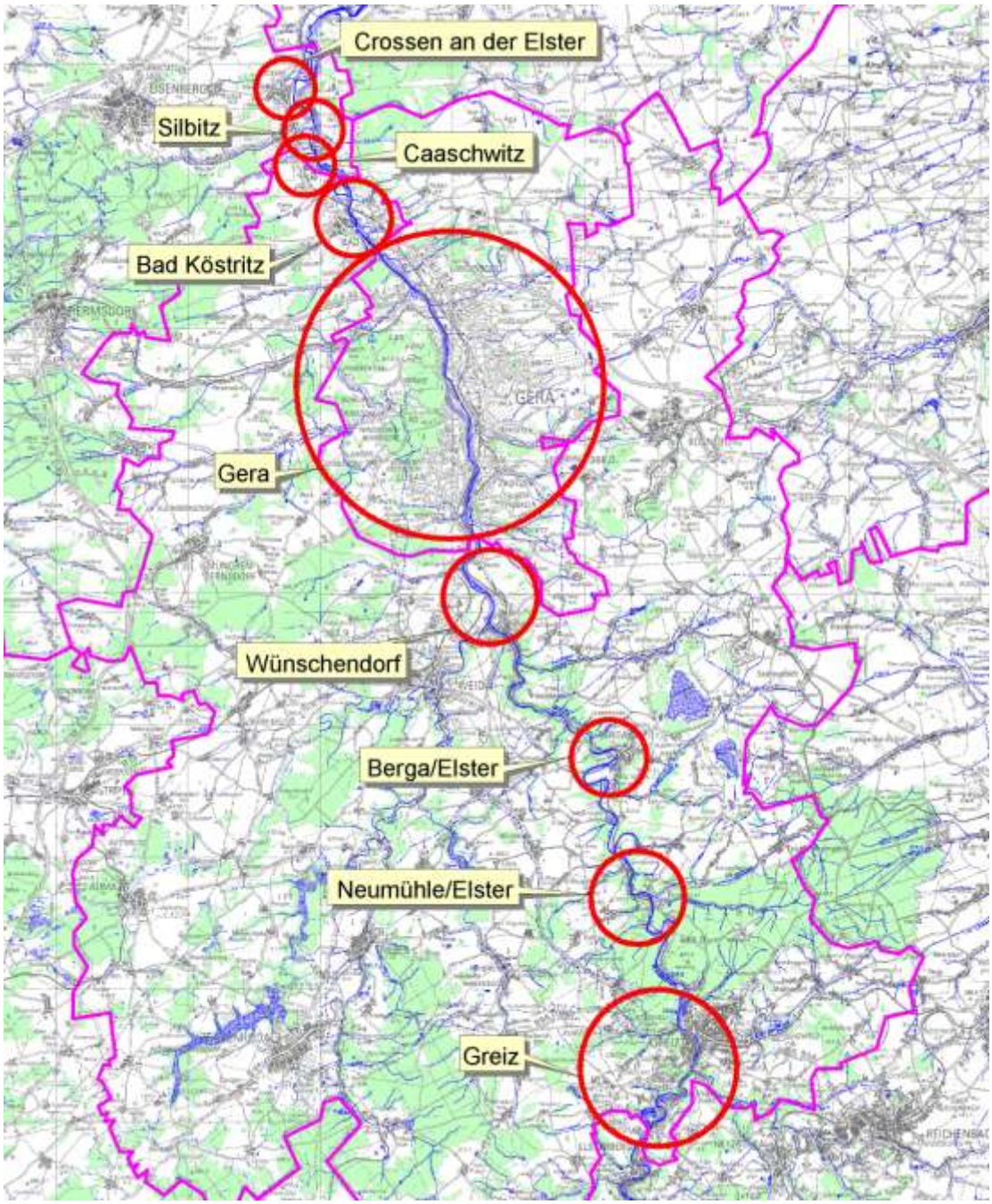


Figure: Overview of flood hotspots on the *Weiße Elster* river

3 Flood Hazard Maps and Flood Risk Maps

The second central point in the FRM plans after defining the risk zones is the verification and quantification of the flood hazard and the flood risk for the respective aquatic system. Using the compiled hazard and risk map sets and the currently assessed risk level (as-is condition), appropriate flood risk management objectives can be specified and prioritised, together with the measures required for achieving these objectives. The prerequisites for a continuous and comparable procedure are awareness of the baseline data and the methodology involved in map compilation for the current FRM plan. Only if these prerequisites are met is it possible to continue and compare the FRM plan every six years.

The flood hazard and flood risk maps for the *Weiße Elster* were compiled without taking the respective tributaries into consideration.

Flood hazard and flood risk maps comprise those geographic areas impacted by:

- Low-probability floods ($HQ_{extreme}$);
- Mid-probability floods (HQ_{100});
- High-probability floods (HQ_{20}).

Flood hazard maps

In the flood hazard maps the hazard zones are shown as classified water depths for the scenarios ($HQ_{extreme}$, HQ_{100} and HQ_{20}).

All data required for the compilation of flood hazard maps were clarified in the predecessor project '*Weiße Elster* Conceptual Flood Defence Model' (*Hochwasserschutzkonzept Weiße Elster*) [5].

$HQ_{extreme}$ was defined as HQ_{200}, but ignoring the control effect of existing flood defence embankments and walls. A peculiarity of the *Weiße Elster* is that the hydraulic calculations for HQ_{200} without existing flood defence measures provides a water level that is lower in some sections than the HQ_{100} water level, due to the long embankment lengths.

In order to display an extreme flood event on the maps it was agreed with the client to display the maximum resulting from the overlay of the HQ_{200} calculation **with** existing flood defence measures, and the HQ_{200} calculation **without** existing flood defence measures.

The map design is based on the LAWA guideline 'Recommendations for the Compilation of Flood Hazard Maps and Flood Risk Maps' (*Empfehlungen zur Aufstellung von Hochwassergefahrenkarten und Hochwasserrisikokarten*) [10].

In agreement with the participating federal states of Saxony and Saxony-Anhalt the following thematic fields are shown:

- Water depths HQ(T) in metres [m] with the classifications < 0.5; 0.5-1.0; 1.0-2.0; 2.0-4.0; > 4.0.
- Inundation boundary $HQ_{extreme}$ (for the HQ_{20} and HQ_{100} maps).
- Flood defence facilities (embankments, walls).
- Flowing waters (*Weiße Elster* and the tributaries classified as risk zones).
- Water course sectioning for the *Weiße Elster*.
- Administrative boundaries with name of administrative district.
- Local authority boundary with name.
- Gauges.

The hydrological and hydraulic parameters of the represented event are also displayed in the legend for the gauges shown on the map and/or for the two gauges immediately upstream. These parameters include the gauge name and number, the station, the water level at the gauge resulting from hydraulic calculations and the respective flow rate.

The relevant baseline data are listed in a separate window.

The hazard maps for the Thuringian section of the *Weiße Elster* respectively comprise sheets 16 to 23 of the annexes:

- G1 HQ_{20} flood hazard map.
- G2 HQ_{100} flood hazard map.
- G3 $HQ_{extreme}$ flood hazard map.

A uniform scale of 1 : 10 000 was used for the entire Thuringian section of the flood hazard maps.

The $HQ_{extreme}$ inundation boundary is also shown in the HQ_{20} und HQ_{100} flood hazard maps. An example map is included in the summary.

Flood risk maps

Flood risk maps are compiled for flood scenarios for which hazard maps have already been compiled. They show the flood risk as a function of land use or economic activity and the size of the affected population.

The same map base is used for flood risk maps as for the hazard maps.

In addition, the following baseline data is required:
- Land use information (from a state-wide overview (TLUG 2008) and ATKIS data).
- Population statistics data.
- Digital baseline data on IPPC facilities, protection zones and threatened objects.

The adverse effects caused by floods are shown in the flood risk maps.

The required information is specified in Article 6, Paragraph 5 FRMD:

- Number of potentially affected population (orientation value).
- Types of economic activities in the potentially affected area.
- Facilities in accordance with Annex I of Council Directive 96/61/EC dated 24 September 1996 on integrated prevention and control of pollution which may cause unintended environmental contamination in case of flooding, and potentially impacted protection zones in accordance with Annex IV, Number 1, Sections i, iii and v of Directive 2000/60/EC.
- Additional information considered useful by the member state, such as information on regions in which floodwater with a high level of sediment freight or rubble may occur and information on other prominent pollution sources.
- Optionally: the adverse effects on cultural heritage mentioned in the preliminary assessment and in the flood risk management plans are not given in Article 6, Para. 5 FRMD. However, because they are dealt with in the FRM plan, it may be useful to incorporate them in the risk maps.

The affected population was identified using the local authority population figures (December 2009 figures) and their allocation to residential zones and zones of mixed use. It was assumed that one third of the mixed use zone was used for residential purposes. The residential and mixed use zones were derived from ATKIS data for each local authority and a specific population figure (population per m²) determined from the total population figures.

The affected population per individual zone and scenario is given by multiplying the specific population figure by the area affected by HQ(T) for the respective use. By totalising the affected population of the individual zones of the local authority area it was possible to roughly determine the number of affected population for each local authority. This figure is for orientation purposes only and was rounded to the nearest ten.

The risk maps for the Thuringian section of the *Weiße Elster* respectively comprise sheets 16 to 23 of the annexes:

- R1 HQ_{20} flood risk map.
- R2 HQ_{100} flood risk map.
- R3 $HQ_{extreme}$ flood risk map.

An example flood risk map is included at the end of the summary.

4 The Objectives of Flood Risk Management

The central objective of the FRM plan is to reduce potential flood-related adverse effects on the four protected assets (human health, environment, cultural heritage and economic activity). The demands on the FRM plan and its components are described in Article 7 and Section A of the annex. Clause 75, Para. 3 Water Management Act, refers directly to these regulations. It must be emphasised that the FRM plan should include all aspects of flood risk management, and both specific and appropriate objectives and measures for the river basin involved.

The directive does not quantify any flood defence or specific risk management objectives. Article 7, Paragraph 2 FRMD states:

> 'Member States shall establish appropriate objectives for the management of flood risks for the areas identified under Article 5(1) and the areas covered by Article 13(1)(b), focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity and, if considered appropriate, on non-structural initiatives and/or on the reduction of the likelihood of flooding.'

The stipulations for the protected assets are only qualitatively specified, but not substantiated by quantitative flood defence objectives. No timelines for achieving objectives are given.

Components of the initial FRM plan and subsequent updates are differentiated.

Fields of action of flood risk management

Sustainable flood risk management planning comprises the entire cycle of prevention, defence and aftercare.

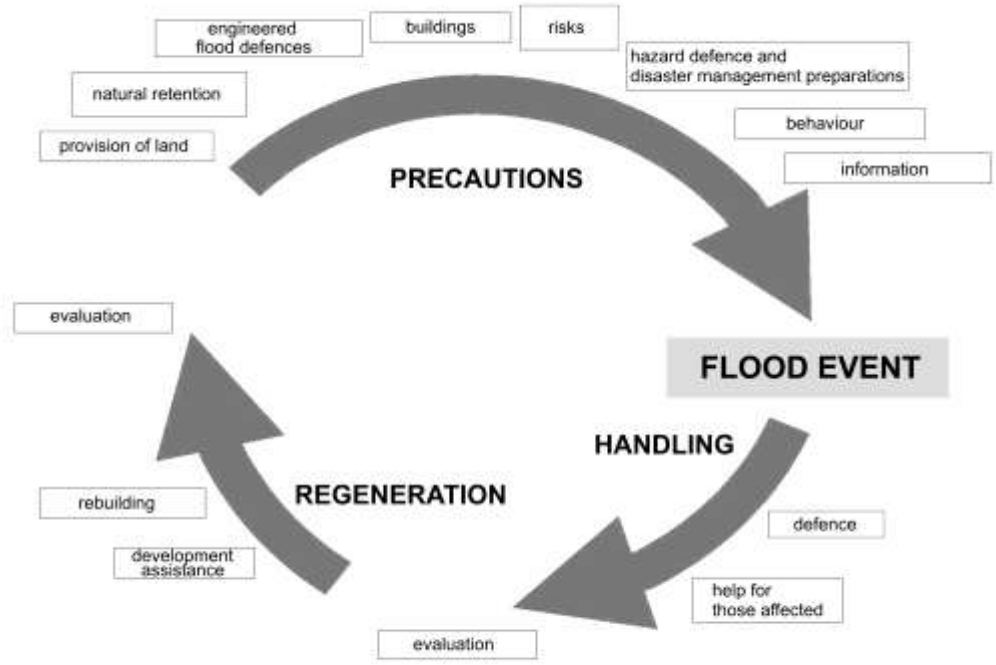


Figure: Flood risk management cycle (after LAWA [10])

In terms of the aims of flood risk management, different options are available for the protected assets human health, the environment, cultural heritage and economic activity. The possible fields of action are marked by a cross in the table below. Crosses in brackets indicate indirect influence options. For example, environmental flood damage may be smaller if the forecasting and information available on the flood situation are optimal, because the population and affected industry can protect themselves and contaminant inputs into the environment may be reduced as a consequence.

The interrelationships in the table represent the governing basis for planning measures. In this context it should be noted that the majority of the fields of action can apply to all four protected assets.

Table: Interrelationships between fields of action and protected assets. Crosses in brackets (x) represent indirect or secondary influence options (after LAWA)

Field of action		Human health	Environment	Cultural heritage	Economic activity
Provision of land	Administrative instruments	X	X	X	X
	Adapted land use	X	X	X	X
Natural retention	Natural retention measures (in particular on agricultural and forestry land)	X	X	X	X
	Reclamation of flood plains	X	X	X	X
Engineered flood defences	Water retaining structures for retaining water within the river basin	X	X	X	X
	Embankments, dams, flood defence walls, barrages and mobile flood defence	X	X	X	X
	Watercourse development (constructive measures for eradicating hydraulic bottlenecks and increasing the flood waterway)	X	X	X	X
	Clearance of flood waterways in urban areas	X	X	X	X
	Property protection	X	X	X	X
Precautionary flood defence: buildings	Flood-ready building and planning	X		X	X
	Flood-ready storage of substances hazardous to water	X	X	X	X
Precautionary flood defence: risks	Financial protection/precautions	(X)			X
Precautionary flood defence: behaviour	Education among the affected population and companies	X		(X)	X
	Preparation for flooding including operational preparation	X		(X)	X
Precautionary flood defence: information	Forecasts and information on flood situation	X	(X)	X	X
	Warning all affected	X	(X)	X	X
Precautionary flood defence: hazard defence and disaster management	Alarm and deployment plans	X	X	X	X
	Organisation of resources	X	X	X	X
	Carrying out exercises	X	X	X	X
	Training emergency personnel	X	X	X	X
	Civilian-military cooperation	X	X	X	X
Precautionary flood defence: flood handling	Defence	X	X	X	X
	Help for those affected	X	X	X	X
Precautionary flood defence: regeneration	Development assistance	X	X	X	X
	Rebuilding	X	X	X	X
	Preparation for flood evaluation and conclusions for improving flood precautions	X	X	X	X

In terms of the *Weiße Elster* FRM plan it is necessary to compile, formulate and coordinate appropriate objectives for reducing potential, flood-related adverse effects on the four protected assets in the project area.

The preliminary assessment of the potential flood risk in the river basin was performed as a first step. In the following section the principal deficits in terms of flood risk management can be clarified by an analysis of the as-is condition in the fields of action, based on the compilation and analysis of the flood hazard and flood risk maps.

As-is condition

Engineered flood defence efforts intensified between the 1930s and the 1980s. Following the devastating 1954 flood event in particular, hydraulic engineering flood defence measures were increasingly implemented. Additional flood defence pillars, especially flood zone management and flood precautions, have only increased in importance in recent years.

Since 2000, first the EU-WFD was incorporated in the Water Management Act at state level, followed by the FRMD in 2009. State-level development plans (*Landesentwicklungspläne* - LEP) have stipulated the use of flood zone management, together with the binding effect of these regulations, in regional and urban land use planning since 2004, based on the Thuringian State Planning Act (*ThürLPlG*). Overall, the discussion of securing open spaces includes all measures incorporated in modern flood defences, such as:

- Provision and management of land: marking and retaining flood plains and retention basins, consideration of flood defences in state and regional planning.
- Natural retention: renaturation of flowing waters and flood plains and synergy effects in terms of retention basin activation, pavement unsealing.
- Precautionary flood defence: buildings, risk, behaviour, information, hazard defence and disaster management preparations, flood handling, regeneration.
- Engineered flood defence: water retaining structures with flood retention basin, embankments and dams, clearance of flood waterways, watercourse development in urban areas, flood defence walls, property protection.

In summary, the following main points result for the fields of action in the as-is conditions:

Provision of land:

- Designation of flood area almost completely for *Weiße Elster*.
- Regional planning only takes part of flood area into consideration.
- East Thuringia urban land-use planning is out of date (1999).
- Consideration of and information on flood hazard areas ($HQ_{extreme}$) in planning.

Natural retention:

- Renaturation and relocation of embankments is planned or possible in accordance with *Weiße Elster* flood defence model.
- EU-WFD measures currently not implemented for *Weiße Elster*.
- Flood-ready agriculture and forestry previously only in line with management constraints for defined flood plain.

Engineered flood defence:

- Embankments without sufficient stability and predominantly without sufficient safety for the intended degree of defence (HQ_{100}).
- In places no defences in urban areas.
- Property protection only exists in individual cases or incompletely, e.g. Gera-Langenberg sewage treatment plant.
- Good watercourse management and clearance of flood waterway in urban areas.

Precautions:

- No flood forecast model exists for the Thuringia section.
- State-wide flood communications station exists.
- Flood signalling gauges exist but can be improved.
- No information on river basin-wide implementation of disaster management exercises.
- No information on fire-fighting/water defence services training status.
- No information on population alarm/flood warning.

Stipulation of appropriate objectives

To ensure coherent processes are adopted in FRM planning the fields of action are taken into consideration at the measures level when stipulating the objectives of flood risk management and are coordinated with the 'before', 'during' and 'after' flood event phases, in accordance with the FRM cycle.

The following principal objectives are defined for each of the four protected assets:

1. Prevention of new risks in the run up to a flood.
2. Reduction of existing risks in the run up to a flood.
3. Reduction in adverse effects during a flood.
4. Reduction in adverse effects following a flood.

The principal objectives for each protected asset are substantiated further in *action-related objectives*. Legal regulations and state-wide targets must be incorporated in the objectives of the continued FRM plan in six years time.

Appropriate flood risk management objectives are summarised in a table for the four protected assets.

As-is/target comparison

The deficits in terms of the fields of action

Provision of land	
Natural retention	
Engineered flood defence	
Precautionary flood defence:	buildings risks behaviour information hazard defence and disaster management flood handling regeneration

result from a comparison of the as-is condition with the compiled appropriate objectives.

In addition, concrete statements on local deficits can also be found in the flood hotspot specifications (Annex 1, result report).

Conclusions:

- Supraregional flow-regulating structures such as dams, are only of minor importance in the Thuringian section of the *Weiße Elster*.
- Flood hazards and flood risks for HQ_{100} are largely determined by the lack of stability of the embankments and the failure to achieve the planned protection objective. The predominantly engineered flood defence measures derived from this are dealt with in the *Weiße Elster* conceptual flood defence model [5].
- It will not always be possible to eradicate point flood hazards and risks identified over and above this by using higher ranking constructive/technical measures, meaning that precautionary measures and the measures for improving retention should preferentially be aimed for here. As a consequence a central focus of future flood risk management should lie in reinforcing centralised flood precautions and in education. This implies convincing provision of information both for the public and for the respective technical agencies. In addition to a possible website this may also include the production of an internal administrative management system, which considers all relevant aspects of flood risk management and supports the future continuation of planning.
- In addition to information on the internet and in printed media, this also includes distribution of the ***INGE*** software application (***In****teraktive* ***Ge****fahrenkarte für den kommunalen Hochwasserschutz* – Interactive hazard map for communal flood defence) and its integration in the activities of the proposed water defence forces (LABEL pilot activity in Berga/Elster).
- The identification of potential retention basins for improving flood retention in rural areas, as a principal measure in the fields of action of natural retention and provision of land, is only possible to a limited degree in the *Weiße Elster* region and was taken into consideration in the *Weiße Elster* conceptual flood defence model [5].

5 Flood Risk Management Plan Measures

After formulating the appropriate objectives for the protected assets, measures must be identified in the next step which positively influence the objectives by their modus operandi or lead to the objectives being achieved. Any measure can act on one or more objectives, but is uniquely allocated to a single, special field of action.

The measures are differentiated into regional and communal measures, described in the catalogue of measures and substantiated in the measures specifications.

The objectives and measures catalogues are allocated and listed based on the following considerations and procedures:

- Objectives: Oriented around the protected assets with reference to fields of action.
- Regional measures: Oriented around the protected assets with designation of field of action and all impacted protected assets.
- Communal measures: Oriented around the protected assets with designation of field of action and all impacted protected assets.

The fields of action are uniformly marked in line with the specified colour scheme in the measures catalogues and the measures specification:

- …. Precautions
- …. Engineered flood defence
- …. Natural retention
- …. Provision of land

The FRMD explicitly focuses on precautions and aftercare in flood risk management, together with flood handling. In terms of compiling measures these areas of the FRM cycle were concentrated on. Engineered flood defence measures, as core points of flood defence efforts to date, are incorporated in the FRM plan as a highly effective field of action (with reference to the *Weiße Elster* [5], *Wünschendorf* [11] and *Gera* conceptual flood defence models [12]).

Depending on the potential spatial effect and impact of measures ***regional and communal*** measures were differentiated in the *Weiße Elster* FRM plan. Clear delineation is often difficult in the precautions field of action, in particular, meaning that measures may listed as being both regional and communal. These cases are marked as such. Local peculiarities in the measures specifications are supplemented by additional, locally applied, communal measures.

These planned measures represent the current intermediate result for the *Weiße Elster* river basin. It is possible to include supplements and corrections in the selection and extent of measures in the continued

FRM plan. Current planning is limited to flood risks emanating from the *Weiße Elster* only, tributaries are not taken into consideration.

Selection of measures for achieving the stipulated appropriate objectives

The measures for achieving the stipulated objectives are differentiated into regional measures (the entire *Weiße Elster* region in Thuringia and beyond) and communal measures (implemented in local authorities and local hotspots). In addition to responsibility the principal differentiating characteristics are the conflict potential and the impacts on downstream areas and protected assets. Uniform measures for risk minimisation in IPPC facilities are possible, for example down to the level of river basin districts. This is similar to the case of cultural assets, where public discussions in terms of the importance of individual protected assets are predestined if no uniform rule is found at least at the federal state level.

To take this into consideration the risk management plan includes the regional measures catalogue for the *Weiße Elster* river basin in Thuringia. The measures are divided according to the protected asset they are primarily intended to protect. If additional protected assets are positively impacted by a measure, they are marked by crosses.

Showing the respective responsibility quickly provides information on possible options for action of the involved institutions.

All measures listed can be regarded as positive in terms of effectiveness, implementability, economy and ecological compatibility. No individual evaluation of the measures is therefore planned. In terms of prioritisation of measures it can be noted as a general rule of thumb that measures with a high anticipated financial cost have a lower priority than organisational and precautionary measures. Prioritisation therefore also conforms to FRMD regulations.

Measures planning at the level of sub-regions and flood hotspots is generally based on the local ***communal measures catalogue***. Possible measures in the river basin-wide, regional measures catalogue are not taken into consideration at this level.

In terms of achieving objectives in the precautions field in particular, the majority of the measures should be implemented in all local authorities and identified hotspots. A summary of all these general measures was compiled, because of the applicability to all measures specifications. In the measures specifications this list is supplemented by additional, specific communal measures by analysing the local deficit.

Assessment of measures in terms of effectiveness, implementability, economy and ecological compatibility

The FRMD requires that the evaluation of the effectiveness, implementability and economy of the measures be addressed. Uniform evaluation criteria are not specified in the first *Weiße Elster* FRM plan. The evaluation was carried out following technical appraisal and weighing up of the initial situation. The evaluation of the ecological compatibility forms a component of the SEA and is not assessed further at this point.

The following divisions were selected for the *Weiße Elster* river basin:

- Implementation: in terms of complexity
  - \+ easily implementable,
  - +/- moderately implementable,
  - \- implementable with difficulty
- Effectiveness: in terms of achieving objectives
  - \+ positive effect,
  - +/- little/no effect,
  - \- unfavourable effect
- Economy: in terms of financial burden
  - \+ low cost,
  - \- higher cost
- Ecological compatibility: component of SEA, currently being revised as part of the *Weiße Elster* flood defence model [5].

Implementation of measures

Implementation of the measures is associated with a more or less complex planning and monitoring effort and financial burden, depending on the field of action. The principal criteria decisive for short- or long-term implementation include: acceptance, practicality, land use, controllability, control effort and the long-term effect on the respective use, e.g. hydropower. Under optimum conditions the fields of action can be categorised as follows:

Short-term: Information, private buildings, behaviour, engineered flood defences (mobile flood defence, embankment refurbishment), natural retention (reactivation of retention basins).

Mid-term: Provision of land (flood-ready agriculture and forestry), precautions, engineered flood defences (embankment refurbishment, embankment heightening), natural retention (renaturation), risk prevention.

Long-term: Risk prevention, engineered flood defences (new embankments).

No information: No assessment possible.

Unfavourable prerequisites and conditions can lead to enormous loss of time and to increased use of resources, so these categorisations should serve as a guide only.

Prioritising measures

Very few targets are known with regard to the compilation of a measures implementation sequence. There is uncertainty about which criteria, reference quantities and comparison states should be adopted. For the first *Weiße Elster* FRM plan it was decided that measures for protecting human life would be given the highest priority. The economic activity, environmental and cultural assets were not differentiated further. The estimate of the anticipated cost-benefit ratio and the shortest implementation times were adopted for prioritisation as additional criteria.

The following sequence results for the regional and communal measures catalogue:

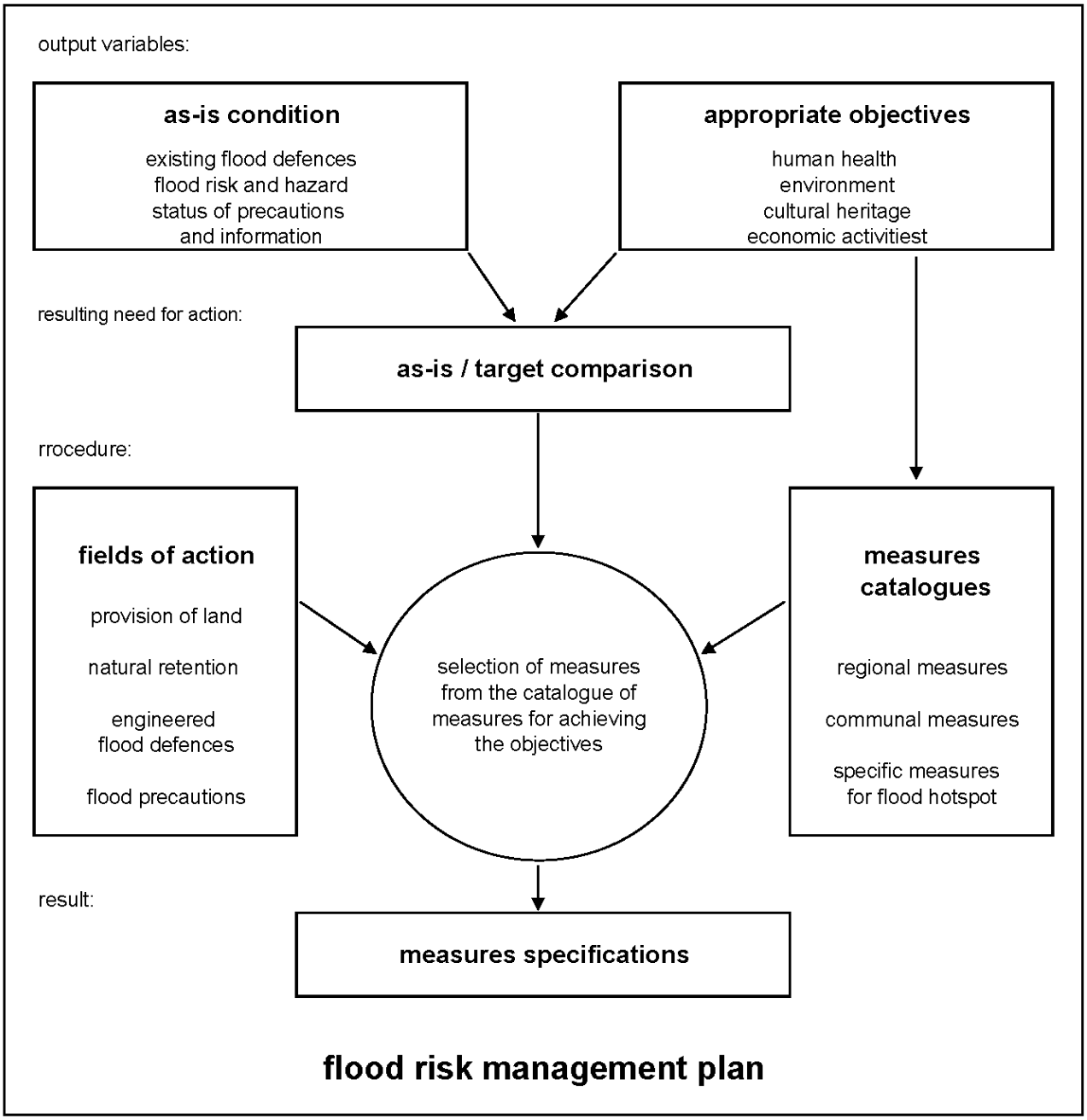
- Communal measures:
    1. Provision of land, information and organisational measures for preventing adverse effects in the run up to a flood event.
    2. Technical-organisational measures for reducing and preventing adverse effects during and after a flood event (e.g. providing reliable flood forecasts, providing reliable, functioning disaster management).
    3. Engineering measures for reducing and preventing the adverse effects of a flood event.
- Regional and supraregional measures priorities:
    1. Provision of land, information and organisational measures for preventing adverse effects in the run up to a flood event at a regional level.
    2. Technical-organisational measures for reducing and preventing adverse effects during and after a flood event (e.g. providing reliable flood forecasts, providing reliable, functioning disaster management).
    3. Regional engineered measures for reducing and preventing the adverse effects of a flood event (e.g. dams or flood retention basins acting on the river basin).

Measures from the 'enforcing legislative regulations' field also posses high priority.

6 Summary

The following figure exemplifies the fundamentals, the structure and the interactions between the components of the flood risk management plan.

The European flood risk management directive represents the start of new and modern handling of the hazards and risks emanating from natural flood events for humans, economic activities, built cultural assets and the environment. The integrated approach of the FRMD across administrative and political boundaries opens new perspectives and increases efficiency in dealing with floods and their consequences.



The adoption of the European FRMD in 2009 in the federal Water Management Act and from there in the legislation of the federal states formed the basis for implementing integrated flood risk management in Germany. Building on experience gained from the EU-WFD, the development of FRMD management plans from a hydrological perspective for national and international river basin districts (RBD, IRBD) has commenced in several European countries in the last two years. Initial flood risk management plan pilot projects have been put in place for the German IRBD *Rhein an der Murg* [13] and for the RBD *Weser an der Fulda* [14]. The efforts to implement the FRMD have intensified greatly since 2010.

International cooperation in the *Elbe* IRBD is guaranteed by the EU-INTERREG LABEL project. In the framework of this project and in cooperation between the three federal states of Saxony, Saxony-Anhalt and Thuringia, a pilot project was initiated for the *Weiße Elster* river as an important tributary of the *Saale* in the *Elbe* river basin. Taking country-specific baseline data and legal requirements into consideration the general procedures, the layout of the flood hazard maps and flood risk maps, and the structure of the FRM plan were exhaustively coordinated between the international partners. The pilot section of the Thuringian *Weiße Elster* is considered in the current FRM plan.

A prerequisite of the current *Weiße Elster* FRM plan on Thuringian territory was the preliminary flood risk assessment. After researching and evaluating historical flood events the 1954 flood event was identified as a significant event.

Using significance criteria such as the damage potential, affected population and IPPC facilities, the preliminary flood risk assessment was performed taking into further consideration a technical appraisal for the entire *Weiße Elster* sub-basin.

Following coordination between the participating federal states of Saxony and Saxony-Anhalt the contents of the flood hazard and flood risk maps were specified on the basis of the LAWA recommendations. The HQ_{20}, HQ_{100} and $HQ_{extreme}$ were adopted as the three characteristic flood events required by the FRMD with frequent, moderate and rare return intervals in Thuringia. The flood hazard and flood risk maps were compiled for each of these events. They were based on water level calculations using hydrodynamic, 2D modelling of the *Weiße Elster*.

It was possible to demonstrate, evaluate and describe the flood risks in the FRM plan for the determined flood areas of the three specified flood events, based on affected land uses, population figures, IPPC facilities and sewage treatment plants, economic activities, cultural heritage, and others, based on LAWA [10] and the FRMD [1].

Using these maps and an evaluation of the information contained in them it is possible to appraise the as-is condition in the flood area in terms of the protection objectives human health, economic activity, environment and cultural heritage.

For these protection objectives the FRMD formulates a variety of fields of action (precautions, engineered flood defences, provision of land and maintaining natural areas) for achieving as small an impairment of all protected assets as possible before, during and after a flood.

In order to more precisely address local peculiarities and extremes, flood hotspots were defined along the pilot section.

The current situation in terms of the flood hazard and the potential risk to the protection objectives, and the stage of development of the fields of action, are described in the FRM plan.

Based on the principal objectives named in the FRMD:

- prevention of new and existing risks in the run up to a flood;
- reduction of adverse effects during and following a flood;

it was possible to define appropriate objectives for each protection objective after examining the as-is situation in the *Weiße Elster* pilot area.

The deficit analysis (as-is/target comparison) identified deficits in the fields of action precautions (absent flood problem recognition, missing information material and private building precautions) and provision of land (insufficient consideration in regional and urban land use planning, incomplete identification of flood areas).

More advanced local deficits were also specified in the measures specifications for the identified flood hotspots.

The FRMD envisages the compilation of a management plan based on the combination of measures from the fields of action, which comprises precautions, handling and regeneration before, during and after a flood event. The measures can be directed at one or more protection objectives. They comprise:

1. Regional measures impacting the entire Thuringian watercourse.
2. Communal measures impacting neighbouring areas, but which are generally applicable to all flood hotspots, and
3. Communal measures listed in the flood hotspot measures specifications and impact on local, hotspot-specific deficits.

The focus of all *Weiße Elster* (Thuringia) FRM plan measures lies in the precautions field of action. This field of action has the highest priority in terms of an evaluation of the effectiveness, implementability and economy. In this report, ecological compatibility is not integrated in the evaluation, because it is discussed in the *Weiße Elster* conceptual flood defence model SEA in accordance with § 14f, Para. 4 Environmental Impact Assessment Act (*UVPG*), for all measures impacting on third parties. The communal precautionary measures are also strongly evaluated for the flood hotspots. Locally, measures from other fields such as the provision of land or engineered flood defences are more heavily integrated in achieving the objectives than on the regional level.

Calibrating the measures with the EU-WFD and Natura2000 is only possible in the continuation of the FRM plan, because currently the necessary baseline data is insufficient or concrete EU-WFD measures are not available.

The future progress of implementation should be studied before defining any purely quantitative objectives and potential measures without time frames. Similar to the EU-WFD, the FRMD defines new impulses and ways of thinking in dealing with natural flood events.

Recommendation:

The following general deliberations for compiling FRM plans and for revising the initial FRM plan are the result of compiling the *Weiße Elster* FRM plan for Thuringia:

- Federal or RBD-wide harmonisation of recurrence interval for frequent and extreme flood events (plus any additional representation of recurrence intervals).
- Federal or RBD-wide harmonisation of identification of affected population.
- Formulation of widespread (state-wide, national, RBD-wide, EU-wide), universal objectives and measures catalogues and an expandable, communal measures catalogue, offering the option of taking local conditions into consideration.
- Permanent continuation in terms of implementation of measures.
- Continuous improvement and adaptation of baseline data for the continuation of the FRM plan, in particular at the communal level (coordination with the responsible institutions).
- Provision of personnel capacities requisite to continuous advancement of the FRM plan, and implementation and coordination of measures.

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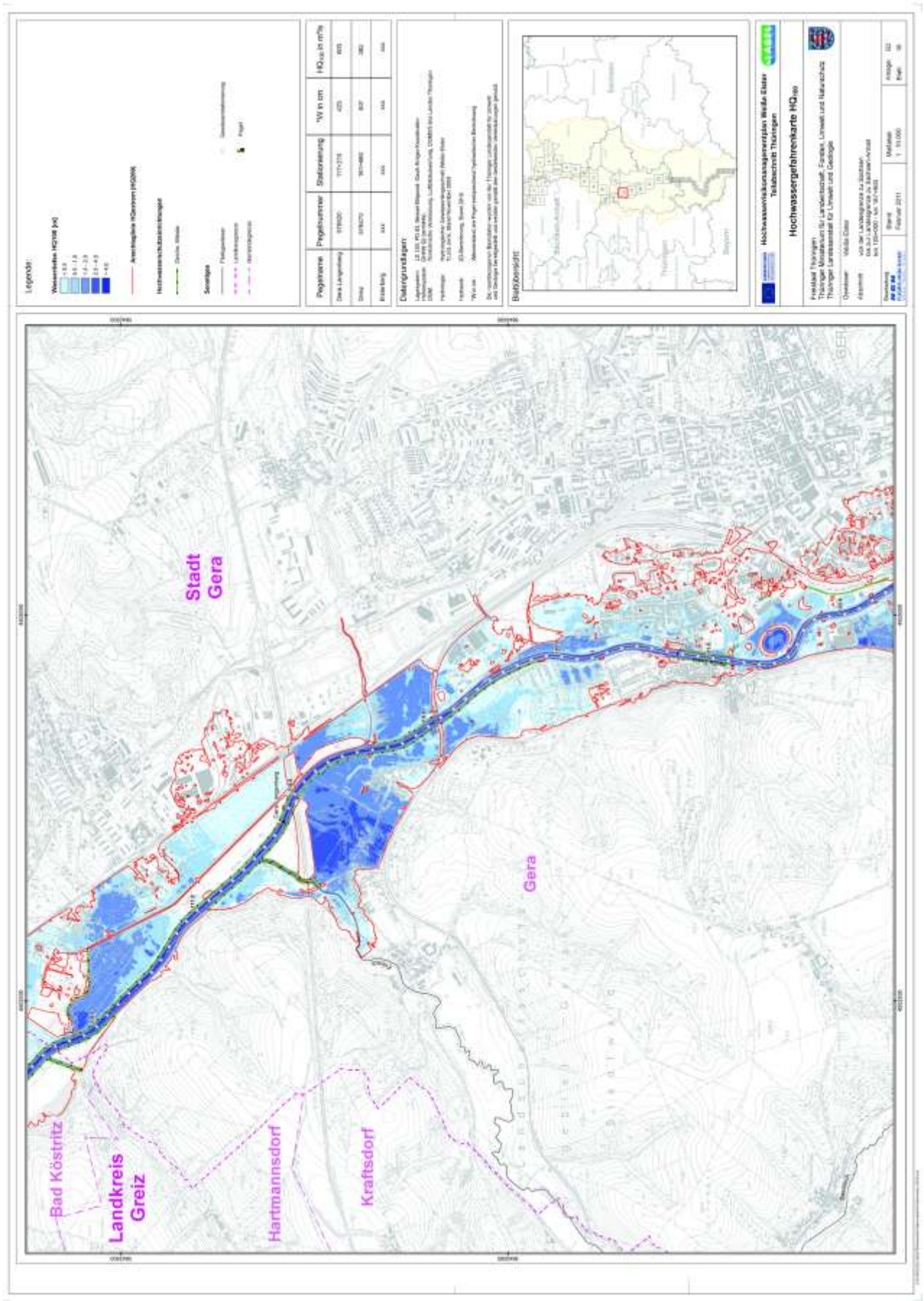
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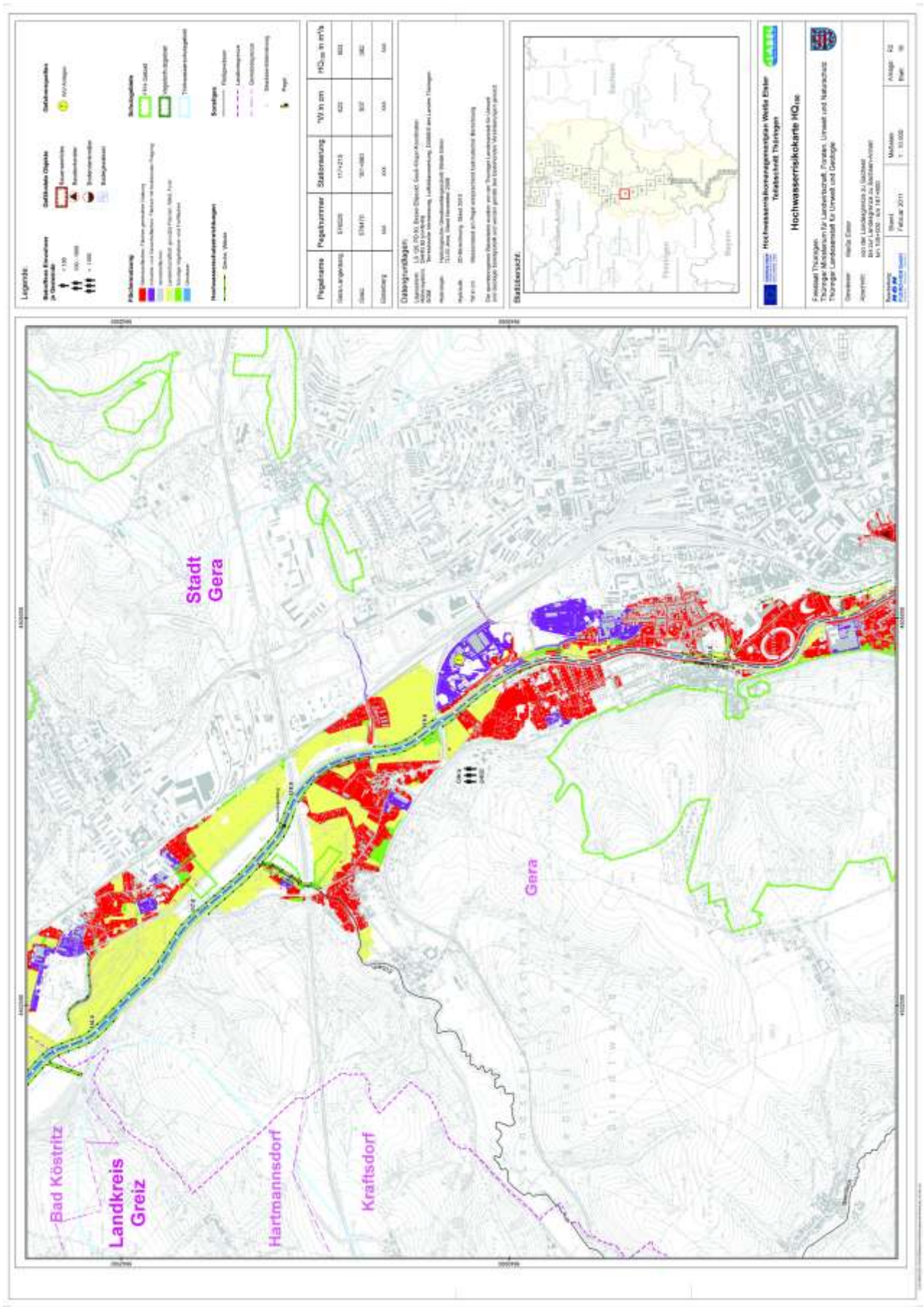
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