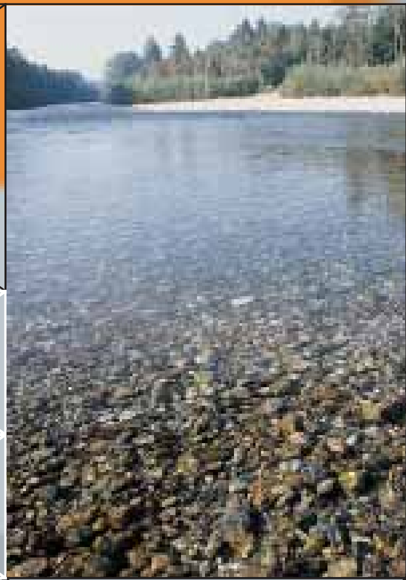


Flood Control at Rivers and Streams

Wegleitungen des BWG – Directives de l'OFEG – Direttive dell'UFAEG – Guidelines of the FOWG
Berne, 2001

Bundesamt für Wasser und Geologie **BWG**
Office fédéral des eaux et de la géologie **OFEG**
Ufficio federale delle acque e della geologia **UFAEG**
Uffizi federal per aua e geologia **UFAEG**
Federal Office for Water and Geology **FOWG**

Eidgenössisches Departement für Umwelt, Verkehr,
Energie und Kommunikation
Département fédéral de l'environnement, des transports,
de l'énergie et de la communication
Dipartimento federale dell'ambiente, dei trasporti,
dell'energia e delle comunicazioni
Federal Department of Environment, Transport, Energy
and Communication

Flood Control at Rivers and Streams

Wegleitungen des BWG – Directives de l'OFEG – Direttive dell'UFAEG – Guidelines of the FOWG
Berne, 2001

In cooperation with:
Federal Office for Spatial Development
Swiss Agency for the Environment, Forests and Landscape
Federal Office of Agriculture

Obtainable from: SFBOL, Distribution of Publications, CH-3003 Berne, www.bundespublikationen.ch
Order number: 804.801.eng

Bundesamt für Wasser und Geologie **BWG**
Office fédéral des eaux et de la géologie **OFEG**
Ufficio federale delle acque e della geologia **UFAEG**
Uffizi federal per aua e geologia **UFAEG**
Federal Office for Water and Geology **FOWG**

RDB; Keystone

Editor
Federal Office for Water and Geology **FOWG**
Ländtestrasse 20
Postfach
CH-2501 Biel

Editing Committee
Hans Peter Willi (FOWG)
Jean-Pierre Jordan (FOWG)
Ulrich Roth (Sigmaplan AG; Berne)
Bernhard Frei (Advokaturbüro Keller, Mesmer, Frei, Degiorgi; Berne)

Translation
Lyn Shepard, Filisur
Martin Jaeggi, Ebmatingen

Conception and Realization
Felix Frank, Berne

Quotation
Federal Office for Water and Geology:
Flood Control at Rivers and Streams.
Guidelines of the FOWG, 2001 (72 p.)

12.02 1000 84293

Contents

Strategy
- Where Do We Stand? 7
- What Do We Want? 8
- Principles for Flood Protection 9
- How Can These Demands Be Fulfilled? 10

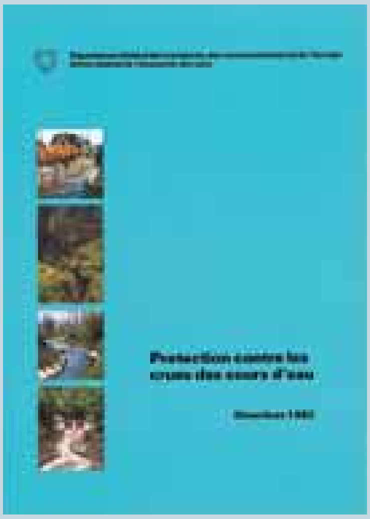
Action
- Recognizing the Need for Action 13
- Ascertaining the Hazard Situation and Damage Potential 14
- Assessing the State of a River or Stream 15
- Setting Protection Objectives 16
- Determining the Necessary River Space 18
- Defining the Need for Action 20

Procedure
- Responsibilities 23
- Legal Standards 24
- Framework Conditions 26
- Federal Subsidies 27
- Regular Procedure 28
- Accelerated Procedure 30
- Participation 32
- Overcoming Conflict 33

Project Design
- The Sequence of Project Design Work 35
- Conditions in the Catchment 36
- Uncertainties of Basic Data 38
- Hydraulic-Engineering Conditions 40
- Types of Hazard and Influencing Factors 42
- Assessing Hazards 44
- Graphical Presentation of Hazards 46

Measures
- Order of Priorities 49
- Appropriate Maintenance 50
- Forestry Aspects 52
- Alluvial Zones 53
- Land-Use Planning Measures 54
- Off-Limits Zones 56
- Object Protection 57
- Protective Structures 58
- Construction Methods 60
- Emergency Planning 62
- Emergency Organization 63

Appendix
- Glossary 65
- Checklists 68
- Contact 72



The first edition of the guidelines "Flood Control at Rivers and Streams" was edited in 1982. Since then the legal and professional framework has changed considerably. However, already then the federal counsellor Leon Schlumpf wrote in the preface, that "for interventions made for flood control reasons more attention has to be given the other functions of a river or stream. With their varied riparian vegetation they subdivide landscape and enhance its value. They offer habitats for animals and plants and their natural value makes them an ideal place for relaxation."

Comet (3); Keystone (1)

The disastrous floods of the year 1987 remain not only in the memory of those immediately hit by the events. For a new way of flood risk assessment as well, the year 1987 has become a milestone: the analysis of the causes of those events led to considerable new knowledge which in the meantime had a strong influence on the related legal bases.

Editorial

The strategy of the Federal Department of Environment, Transport, Energy and Communication is governed by the principle of **sustainability.** This results in the following objectives:

• to protect and maintain the **natural conditions and natural resource bases** for social well-being (ecological sustainability);

• to provide up-to-date services in transport, energy, **water resources,** postal service, telecommunications, and electronic media that benefit the population and the economy in such a way that the financial burden on the state and the economy is acceptable (economic sustainability);

• to ensure access to the natural resource base and to public services for the entire population and all parts of the country under equitable conditions and to **protect people from hazards** and health risks (social sustainability).

Basics

Flood protection plays a major role in sustainable development. Appropriate flood protection has been and continues to be a basic condition for a prosperous society. In their efforts to fulfil the common task of flood protection, the cantons and municipalities receive financial support from the federal government through the federal law on flood protection policy, dating from 1877.

The recent **Federal Law on Flood Control** (Wasserbaugesetz, WBG, 1991) provides a new basis for hazard assessment, differentiation of protection objectives, adequate planning of measures, and limitation of remaining risks (emergency planning). The respective **Ordinance on Flood Control** (Wasserbauverordnung, WBV), revised in 1999, regulates these general considerations.

Increased demands

In recent decades, stream and river training have contributed much to the general economic development of many areas in Switzerland. Only in recent years has flood protection policy been updated. The 1987 flood disasters in particular proved that there is no absolute safety from floods. These disasters triggered a complete **review** of flood protection policy, which concluded that a sustainable policy requires land-use practices that take account of existing natural hazards and minimize direct impacts on rivers and streams.

This is possible only when sufficient consideration is given to the multitude of functions fulfilled by rivers and streams. Reduction of damage following extreme events presupposes that these events be tackled in detail. The results have to be considered in emergency planning procedures as well as in structural and land-use planning.

Therefore, a modern flood protection policy will not only take account of safety aspects but consider other aspects of sustainable development as well. Environmental concerns and economic factors must be included in the planning process as early as possible.

The present **manual** is designed to contribute to the solution of complex tasks in this context. It was developed in a way that should allow the principles involved to remain valid for a long period of time. We hope that it will meet the expectations of all present and future readers. No standard solutions are presented, however. On the contrary, this manual is intended to help the authorities, associations and hydraulic experts concerned with flood protection schemes to ask the **right questions.**

Landowners and insurance companies are addressed as well; they can also contribute much to reducing damage potential. This should make it possible to approach flood protection in a way that satisfies all the parties concerned.

Christian Furrer
Director of the Federal Office
for Water and Geology FOWG*

* Former Federal Office for Water Management

Strategy

Streams and rivers not only cause floods. During an average 340 flood-free days per year they fulfil other functions that should also be considered in flood protection.

Hazard: Condition or process from which danger can arise for human beings, the environment, and/or property.

Risk: Size and probability of potential damage.

Residual or remaining risk: Risks that remain after completing all foreseen protective steps.

Where Do We Stand?

Numerous river training projects in Switzerland, including additional constructions, have considerably improved flood safety and contributed extensively to the economic development of large areas in floodplains.

Despite the efforts of many decades and large investments, there is no absolutely full protection against floods. This was definitely proven by the major flood disasters of 1987, 1993, 1999 and 2000. In addition, all the minor floods of recent years have indicated again and again that structural measures have a limited effect on exceptional natural events.

The need for concrete action

Reducing the impacts of floods on socio-economic life will require major efforts in future if the amount of economic damage is to be held in check. In particular, damage potential should be reduced. There are numerous reasons for rapid action:

- Economic development frequently takes place in hazardous areas, particularly in floodplains. Flood damage is steadily increasing in these areas.
- Flow is accelerated in canalized rivers and streams. The peak discharge increases in the downstream reaches.
- In general, there are not enough detention areas available for incoming water during extreme events.
- The maintenance of river channels is often neglected. Thus, hazardous conditions may suddenly change and new areas might be threatened.
- The risk of hazards could generally intensify in coming decades due to external influences (e.g. global climate change).

Loss of diversity

There are other deficiencies besides these safety aspects. In the past, the space allocated to rivers was limited to a narrow channel. From an ecological point of view, such rivers are deficient and can no longer fulfil various functions for the following reasons:

- Geometrically lined channels are monotonous landscape elements.
- Intense land use up to the border of a river or stream does not leave enough space for natural dynamic changes to happen.

A new orientation

These problems have been recognized and have led to a conceptual reorientation of flood protection. The 1987 flood events and subsequent **analysis of their causes** provided a decisive impulse for a basic reconsideration of flood protection and development of new strategies.

Safety for everyone and everything is not possible. This is not only a question of limited financial resources owing to budget constraints in the public sector. The value of the goods at risk has also increased enormously. Therefore, defence against hazards is no longer the only issue. What particular risks are accepted or may be expected to be accepted also needs to be discussed: What might happen, and where might it happen?

The legal framework

All of the above findings have had legal consequences. The new **Federal Law on Flood Control** (Wasserbaugesetz, WBG) came into effect on January 1, 1993. It provides a strategic basis for comprehensive hazard assessment, differentiation of protection objectives, adequate planning of measures, and limitation of remaining risk (emergency planning).

The **Ordinance on Flood Control** (Wasserbauverordnung, WBV) represents an additional cornerstone. It came into effect in 1994 and was revised in 1999. In accordance with these laws, the cantons delineate hazard zones and the necessary space to be allocated to rivers and streams for flood control reasons, but also in order that they can fulfil their ecological functions. This means that the areas in question must be included in structural and land-use planning and be considered in all land-use activities.

➜ Legal standards

Requirements

- Residential and commercial space should be protected properly.
- Comprehensive prevention should allow costs of damage not to continue to increase.
- Handling natural dangers should be improved and considered in flood protection concepts.
- Rivers and streams should be respected as vital and integrated parts of nature and the landscape.

What Do We Want?

Up-to-date flood protection is not limited to complete and maintain existing river training works. On the contrary, major efforts have to be made to include flood protection aspects in the planning and coordination of **all land-use activities.**

This includes the legitimate demands of all concerned partners and of activities such as water quality control, fishery, forestry, agriculture, protection of landscapes, water supply, and hydropower generation.

Flood protection today is facing numerous demands that reflect conflicts of interest. In order to devise good solutions, flood protection must fulfil a number of requirements:

- **Living space and the economic environment** must be adequately protected.
- Further economic damage must be limited by means of a comprehensive **prevention strategy.**
- Handling of **uncertainties** needs to be improved and included in flood protection concepts.
- Rivers and streams have to be regarded and respected as an essential link element in **nature and the landscape.**

Continuous process

The federal law and the federal ordinance on flood control clearly emphasize these requirements. Only a **minimum** of flood protection activities is allowed along rivers and streams. **Flood prevention** has a high priority. Despite preventive measures, functional **emergency planning** and **emergency organization** are indispensable.

On this basis a number of flood protection principles can be formulated (see p. 9).

Sustainable flood protection can only be achieved if these principles are put into **practice.** Consequently, the will to collaborate and achieve consensus among all participants in this process is indispensable.

In addition, federal policies pertaining to flood protection, water quality control, conservation of nature and landscape, fishery, forestry, hydropower generation, etc., are in a process aimed at better coordination.

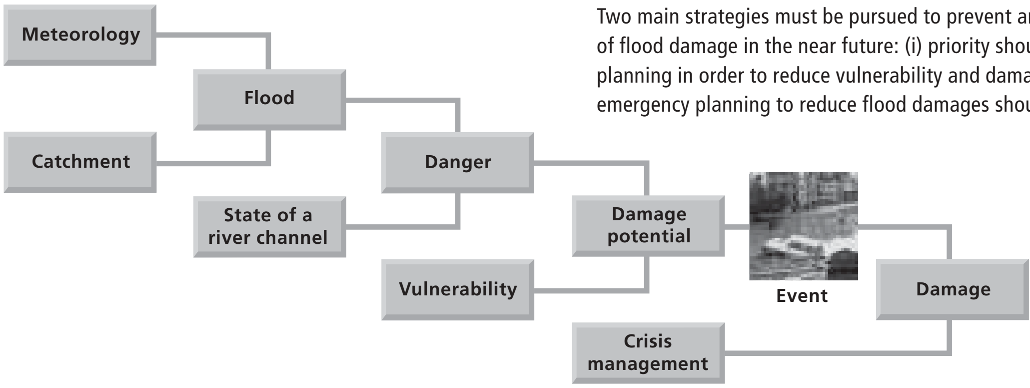
Step-by-step revision of the respective laws has a common aim that can be summarized under the heading of **sustainability:** Impacts on nature and landscape must not endanger living conditions for future generations.

Recommended reading

FOWG (flyer, 1995): Demands on Flood Protection

BWG (flyer, 2000): Raum den Fliessgewässern! [Space for Rivers!]

Frank



Two main strategies must be pursued to prevent an exponential increase of flood damage in the near future: (i) priority should be given to land-use planning in order to reduce vulnerability and damage potential, and (ii) emergency planning to reduce flood damages should also be undertaken.

Principles for Flood Protection

Analyse the hazards. Comprehensive knowledge of hydrological and hydraulic conditions and prevailing hazards within rivers is necessary if protection requirements are to be properly evaluated. Existing hazards and conflicts can be understood by documenting flood events, by making complete event inventories, and by establishing hazard-index maps. The hazard situation should be updated regularly. The existing hazards are to be considered in structural and land-use planning.

Assess and eliminate ecological deficiencies. Sustainable flood protection supports abundant riparian vegetation and provides ample space for the development of natural diversity in the aquatic, amphibian, and terrestrial ecosystems. It provides links between habitats.

Differentiate the protection objectives. Flood protection concepts are based on a clear differentiation among objectives. Areas and objects of high value require a greater degree of protection than those of lower value. According to this simple rule, agricultural land and individual buildings require less protection than towns, industrial plants, or infrastructure. Furthermore, no specific protection may be necessary for low-intensity agricultural areas. However, assessment of possible damage may result in different weightings. Thus, the measures taken have to be evaluated and judged according to their appropriateness.

Retain where possible, let pass where necessary. In order to dampen flood peaks, flood discharge should be retarded within detention areas wherever possible. Therefore, natural detention areas should not only be maintained but also re-established wherever appropriate. Flood waves should only be allowed to be passed downstream without dampening where the local situation requires it, e.g. in narrow settlements. Flood corridors should be established there or kept free in order to provide enough space for extreme events.

Minimize impact. Cross sections with sufficient flow capacity are a basic condition for securing flood protection, to keep the sediment regime in equilibrium, and to guarantee drainage of an area. Nevertheless, flood safety should be provided with minimum impact on natural habitats.

Check possible failure points. Natural uncertainties have to be considered carefully. In consequence, the safety of protection structures needs to be adapted and optimized. Moreover, their functioning and structural safety need to be checked for overstress during extreme events. Possible failure points might be recognized and eliminated in time through periodic checks of the fitness and usefulness of existing structures.

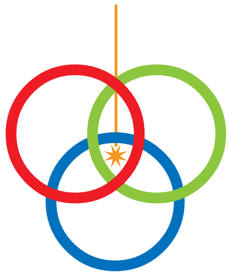
Guarantee maintenance. Appropriate maintenance of river and stream channels is a permanent task. It ensures maintenance of the substance of existing protection structures and of corresponding discharge capacity.

Secure the necessary space of a river. A stream must be more than a simple gutter and a river more than a canal. Land use in their vicinity requires respect of sufficient distance. The cantons are obliged to determine the necessary space for rivers, to establish it within the structural or land-use plan, and to consider it for all activities affecting land use.

Respect needs. For many people streams and rivers serve as recreational areas for leisure or relaxation. These demands have to be considered along with demand for sustainable use of water resources, particularly for hydropower generation.

Iseli

Area of sustainability



How Can These Demands Be Fulfilled?

Every flood protection project is biased according to **conditions** determined by (i) the prevailing natural hazards, (ii) existing or projected land use, and (iii) the hydraulic and ecological conditions of the river in question. On the other hand, the federal law on flood protection determines **priority** among respective measures. Sustainable measures have a clear priority:

• Flood protection is to be guaranteed through **proper maintenance** of the river or stream channel. This also includes the maintenance of **forests** with a protective function throughout the entire catchment.

• **Land-use planning measures** to preserve open space along rivers and prevent uncontrollable increase of damage potential on floodplains have the same priority as maintenance of river channels. Urban development that considers existing natural hazards is a better form of prevention than expensive protection works to protect thoughtlessly delineated building zones.

• **Structural measures** are only to be considered when maintenance work and planning measures cannot provide the necessary safety.

• Determination of priorities requires consideration of other measures such as **flood-proofing of buildings** and other existing structures.

➜ **http://www.bwg.admin.ch**

Guiding principles for flood protection

The particular need for concrete action must be determined with the cooperation of all parties concerned, based on a predetermined framework. This is only possible when (i) knowledge of the prevailing hazards is available, (ii) the hazards are properly assessed, (iii) the various interests are coordinated, (iv) the relevant laws are followed, and (v) the priorities are set:

• **Holistic planning** is necessary for tenable solutions. The result is a package of measures that considers all types of natural hazards and incorporates all land-use activities. These measures have to be adapted to existing development plans.*

• The current state of the river or stream must be preserved through maintenance works and land-use planning, provided that the **degree of safety** is sufficient from the point of view of flood protection and ecological conditions are acceptable.

• A plan for measures to be undertaken has to be established if **deficiencies** are revealed by a safety assessment. Measures have to be adapted to local conditions. In the process, flood safety as well as ecological deficiencies must be taken into account. These are of equal importance in guaranteeing appropriate flood safety and maintaining the ecological functions of the river or stream.

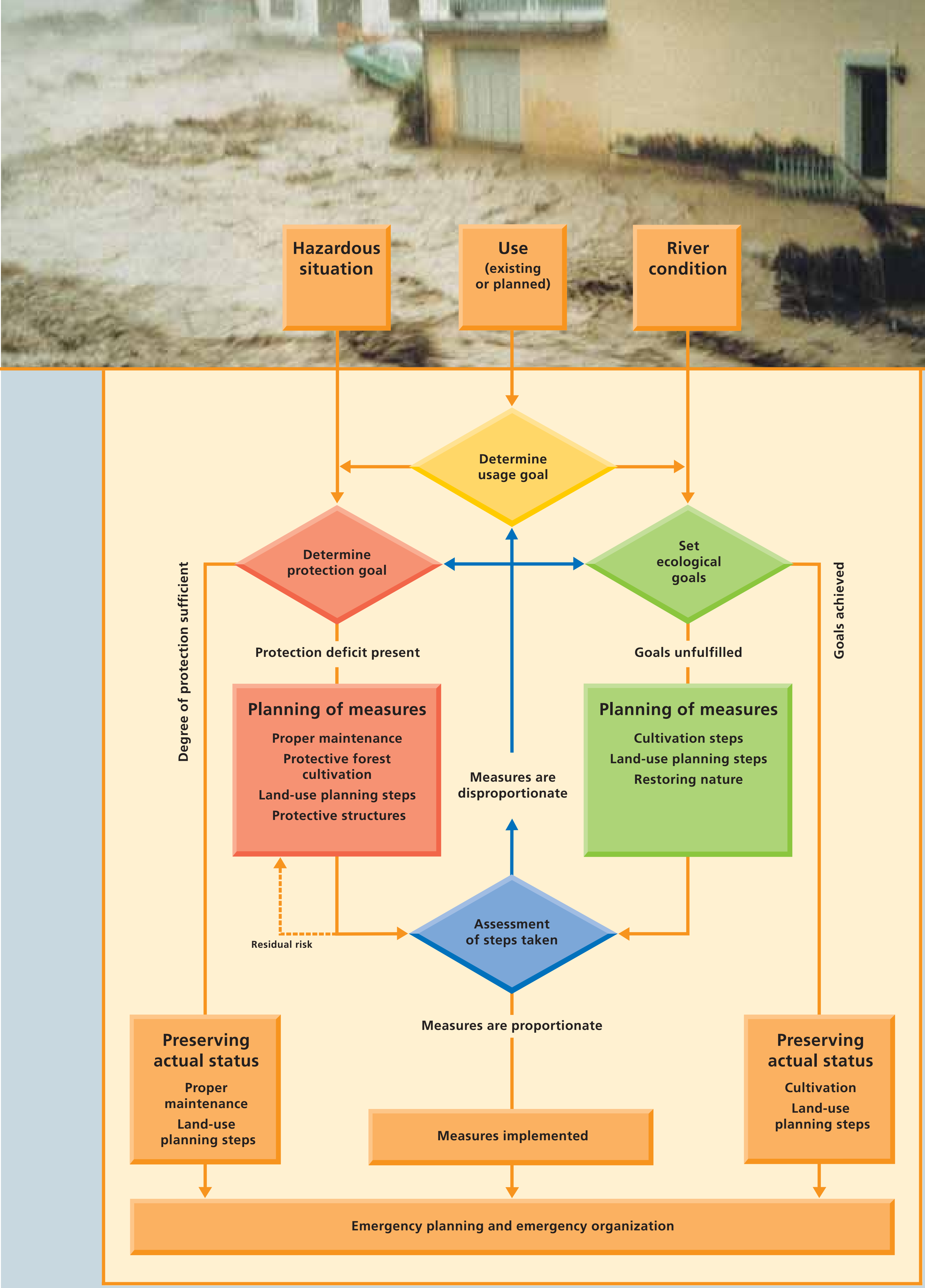
• Flood protection is no longer just limited to the prevention of overbank flooding and inundation by any means. Streams and rivers are ecosystems that host a variety of animals and plants, as well as excellent recreational sites. Therefore, up-to-date flood protection needs to show consideration for the **numerous functions** of the river or stream and must try to preserve and strengthen them wherever possible.

• Every flood prevention concept has to be assessed in terms of technical, economic and ecological **balance.** If a particular project is disproportionate in this respect, then land-use or protection objectives have to be reconsidered.

• A **detailed project** must be established if the measures are deemed proportionate.

• Residual risks always remain. These residual risks must therefore be assessed and the planned measures supplemented by **emergency planning** and related **emergency organization** (including warning concepts and evacuation plans). The efficacy of the measures in place needs to be examined in case of **overstress** during extreme events. This integral examination leads to living being conscious of possible hazards in the sense of a **global risk culture.**

* This procedure corresponds to the VSE Guideline (2000): Der regionale Entwässerungsplan REP [The Regional Drainage Plan REP].



Hazardous situation
Use (existing or planned)
River condition
Determine usage goal
Determine protection goal
Set ecological goals
Degree of protection sufficient
Goals achieved
Protection deficit present
Goals unfulfilled
Planning of measures
Proper maintenance
Protective forest cultivation
Land-use planning steps
Protective structures
Measures are disproportionate
Planning of measures
Cultivation steps
Land-use planning steps
Restoring nature
Residual risk
Assessment of steps taken
Measures are proportionate
Preserving actual status
Proper maintenance
Land-use planning steps
Measures implemented
Preserving actual status
Cultivation
Land-use planning steps
Emergency planning and emergency organization

Action

Many risks are obvious, but others can hardly be recognized without precise examination. Flood risk particularly falls into oblivion after long periods without threatening events.

Determining the need for action depends on the following points:
- Ascertaining the risk situation and damage potential.
- Assessing the state of a river.
- Setting protection objectives.
- Determining the necessary space for rivers and streams.
- Setting ecological development goals.
- Confirming existing or planned land use.

Recognizing the Need for Action

Weighing interests

Frank (2)

Flood control and ecological concerns are not in conflict, but are equal priorities in any flood control plan.

The need for action from a flood control standpoint

From a flood control standpoint, a **hazard assessment** must be made before assessing the need for action. One may recognize possible **protection deficits** by weighing the risk situation against the existing or planned land use.

If a deficit exists, the next step is to ascertain the degree of potential damage. If the existing risk is great, the protection deficit must be offset by **plans of measures.**

If no deficit exists, **maintenance** works have to be ensured. Suitable areas should be examined if they can be safeguarded as potential **flood detention areas** or **floodways.**

The need for action from an environmental standpoint

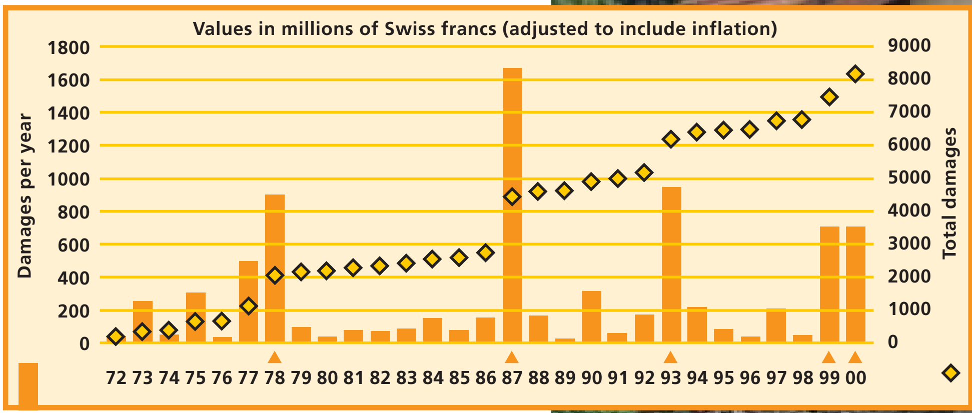
From an environmental standpoint, the stream or river reach in question must be checked for **ecological viability,** and the ecological development goals must be set in order to assess the need for action. Rivers and streams have multiple functions. They are not only **habitats** for local fauna and flora but also **network corridors.** Therefore, the situation at the upper and lower reaches must also be considered.

Monotonous, heavily trained river channels do not fulfill these functions (or only in a limited sense). Hence, maintenance or restoration of **conditions close to natural** also belongs to the flood control tasks: rivers should become evident as landscape-forming elements, and a water cycle close to natural should be maintained as much as possible. Moreover, greater attention should be given to the population’s recreation needs.

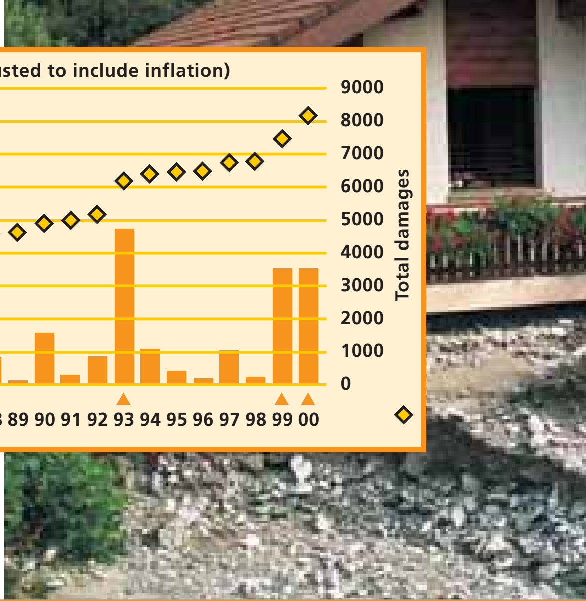
The key role of farming

When weighing the interests of land-use demands and environmental concerns, farming plays a key role. This is because ecological compensation measures demanded for infrastructure projects often use up agricultural areas. Yet solutions can still be found that serve both farming and flood protection. Thus, farmers affected must be involved in planning from the outset. They may take over maintenance works on the river in question, getting appropriate remuneration.

In addition, **financial incentives** reward nearly natural use of areas adjoining waterways. Ecological compensation areas are taken into account for a performance assessment, and areas of low intensity farming adjoining rivers are priority areas for which bonus payments may be received in keeping with the Eco-Quality Decree (EQD).



Flood and sediment disaster damage in Switzerland since 1972. The major events of 1978, 1987, 1993, 1999, and 2000 are crucial.



Ascertaining the Hazard Situation and Damage Potential

The effects of a flood in a specific area are basically determined by three factors:

- by the **processes** occurring,
- by their **intensity,**
- and by their **duration.**

Therefore, the degree of potential damage in a defined area is not a fixed amount but depends on a series of assumptions which often cannot easily be verified.

Wrong hypotheses obviously lead to misjudgments. Hence, a **variety of scenarios** have to be elaborated that are justified by the broad spectrum of potential flood processes. Only in this way is it possible to obtain usable results that allow objective and comprehensive **cost/benefit ratio** comparisons. All those involved – technical experts, design engineers, and representatives of municipalities, the cantons and the federal government – should debate those scenarios and agree on them.

The hazard situation ascertained in this manner enables assessment of a flood's potential consequences – i.e., the number of **people** at risk, the amount of **material damage,** the degree of **collateral damage** (interrupted production, product substitutions), and the degree of environmental damage.

Vulnerability

Water penetrates into buildings mainly through entrances, cellar openings, or garage doors. Therefore, building vulnerability to damage depends largely on the elevation of these potential weak points compared to the level of the surrounding terrain. The sealing of the external surfaces of a building, the supply equipment and elevator facilities are also potential weak points.

Ascertaining damage

A rough assessment of potential damage suffices generally. Basic data are particularly available in the case of material damage. It is often very difficult to assign money values for other categories. Usually damages for specific land-use categories are ascertained in costs per area unit. However, sensitive individual objects must be given special attention.

Special risks

Special risks include chemical and biological production plants, storage sites, rubbish incineration plants, dumps, switching centers, and production plants housing machinery of above-average cost. Special precautions are also necessary in **case of disaster** for important infrastructure sites such as command centers, hospitals, and emergency shelters.

Usually investigations of special risks have already been undertaken in connection with the ordinance on major accidents and may be used. Otherwise they must be ordered. Detailed studies are justified only if the **economic viability** of a flood control project becomes the focus of discussion.

Frank; Keystone

Rivers or streams imbedded in culverts present a special problem. Whenever possible, they should be opened and their channel transformed back into a state close to natural. New culverts should only be permitted in compelling cases, and their number ought to be restricted to an absolute minimum.

Assessing the State of a River or Stream

A natural stream and river landscape consists of a mosaic of different habitats. Flowing and still water, deep and shallow reaches, as well as periodically and episodically flooded bank areas are found close to each other on a narrow space in rivers or streams that have remained natural or have been laid out close to a natural state. Hence they provide a large habitat diversity for plants and animals.

Yet these **transitional areas** between water and land – areas that perform multiple functions – have disappeared in many regions due to the pressure of heavy land use. Therefore, all flood-control projects must take seasonal flow variation and variety of currents into greater account. In order to ascertain the need for action from the standpoint of both the ecology and flood control, three factors stand in the forefront:

- Does the river or stream have a **variety of structures?** Have existing migration obstacles or training works diminished this structure's variety?
- How much **room** does the stream or river need to fulfill its ecological functions?
- What **cross section** does the river need to evacuate flood flow?

Ecomorphological assessment

The need for action concerning a river's natural functions can be derived from an ecomorphological assessment. When planning flood control measures, this need for action should be considered in precisely the same way as protection objectives for land use.

The term "ecomorphology" covers the entirety of **structural conditions** in and at the river channel, i.e., both training works (e.g., bank protection, weirs, or bed stabilization structures) as well as the condition of nearby surroundings (cultures, land use, vegetation, and river or stream space).

The related assessment can be carried out with varying degrees of detail. In case of a regional assessment of rivers or streams (the so-called grade F), **five main characteristics** are sampled:

- average bed width;
- variation of the free surface width;
- bed stabilization structures (and stream migration barriers);
- bank toe protection works;
- bank width and bank characteristics.

Recommended reading

BUWAL (Mitteilungen zum Gewässerschutz Nr. 27): Methoden zur Untersuchung und Beurteilung der Fliessgewässer – Ökomorphologie Stufe F [Methods for Examining and Assessing Rivers and Streams – Ecomorphology Grade F]

Hold it back when you can, let it pass when necessary. The general use of one specific design flood no longer has any general validity. Instead, the protection objectives should focus on specific objects and the damage potential at hand. Yet the 100-year flood (Q_{100}) in settlement areas is now, as in the past, an important reference value. Higher protection should be the aim in case of very high damage values and special risks.

Setting Protection Objectives

Protection objectives are set differently, depending on the type of hazard that could endanger a specific location and what form of protection is needed: where human lives or high material damage values may be at stake, the protection rating is set higher than it may be in areas used for farming or forestry. Thus, a few objects may be flooded often, others seldom, still others as far as possible never.

This is a crucial innovation in comparison to past planning. In the past, flood control measures were often designed for a **specific event.** Hence, a 100-year event (Q_{100}) was usually selected. Almost full protection was guaranteed for this event. Yet this procedure led to disproportionately expensive solutions in many areas. And the effects of an event exceeding this design flood were usually not ascertained.

New planning

In the meantime the following procedure has proven its value: Defining protection objectives should occur in relation to land use and objects to be protected.

This has resulted in a so-called **protection objective matrix** that forms the basis of methodology and differentiation in setting protection objectives. Such a protection objective matrix was first graduated by object categories after the flood event in Uri canton of 1987. This example has also proved itself in other locations.

Differentiation of protection objectives

Flood control efforts concentrate on **reducing and preventing damage.** In case of high material values, the degree of protection is set higher than for low values. According to this principle, the protection objective is graduated by the value to protect, whereby the processes involved should be considered. The most important **object categories** are:

- **Closed settlements.** They should usually be protected against rare events.
- **Industry and trade.** The same principles apply for these facilities and installations as for closed settlements. They should usually be protected against rare events.
- **Infrastructure facilities.** Differentiation occurs here between installations of national, regional, or local importance. The protection objective will be higher or lower, depending on its value, as well as its vulnerability.
- **Cultivated areas.** It is better to protect intensively cultivated areas than low intensity cultivation areas. There is also a great difference to be made between the processes that reduce land fertility and those that lead to a one-time crop loss in the worst scenario.
- **Special objects.** These must be assessed individually, but again, the principle has to be used that the higher the potential for damage, the higher the protection goal.

Main parameters

The protection objective is basically linked to probability of occurrence, and this is characterized by specific parameters. The quantity parameter used most often is the **peak discharge Q** expected for a certain return period.

- The **damage limit Q_a** refers to a discharge that should run off without causing damage to objects requiring protection.
- The **hazard limit Q_b** refers to a discharge that, when exceeded, can lead to an uncontrolled flow situation. The security of objects to be protected is no longer guaranteed.
- Flood processes for flood discharge amounting between the damage limit Q_a and the hazard limit Q_b may cause **limited damage,** but neither objects to be protected nor flood control structures should normally be destroyed.
- For certain object categories, the design discharge must be raised from the damage limit Q_a to the hazard limit Q_b, if the process involved induces high danger.
- In case of differing object categories, the definitive protection objective should be ascertained by assessing the residual risks. If a project leads to disproportionate costs or impacts, the protection objectives or the land-use practice must normally be adapted.
- The concerns of **other domains affected** (e.g., farming, protection of nature and the landscape, settlement development, and energy production) must be considered when weighing interests.

Differentiating protection objectives permits suitable reaction to the flood hazard based on local danger factors. This cuts costs while enabling even extreme events to be handled. Such a **protection objective matrix** was used for the first time in Uri canton (after a devastating flood of the Reuss river in 1987).

Frank

Dependence on the processes involved

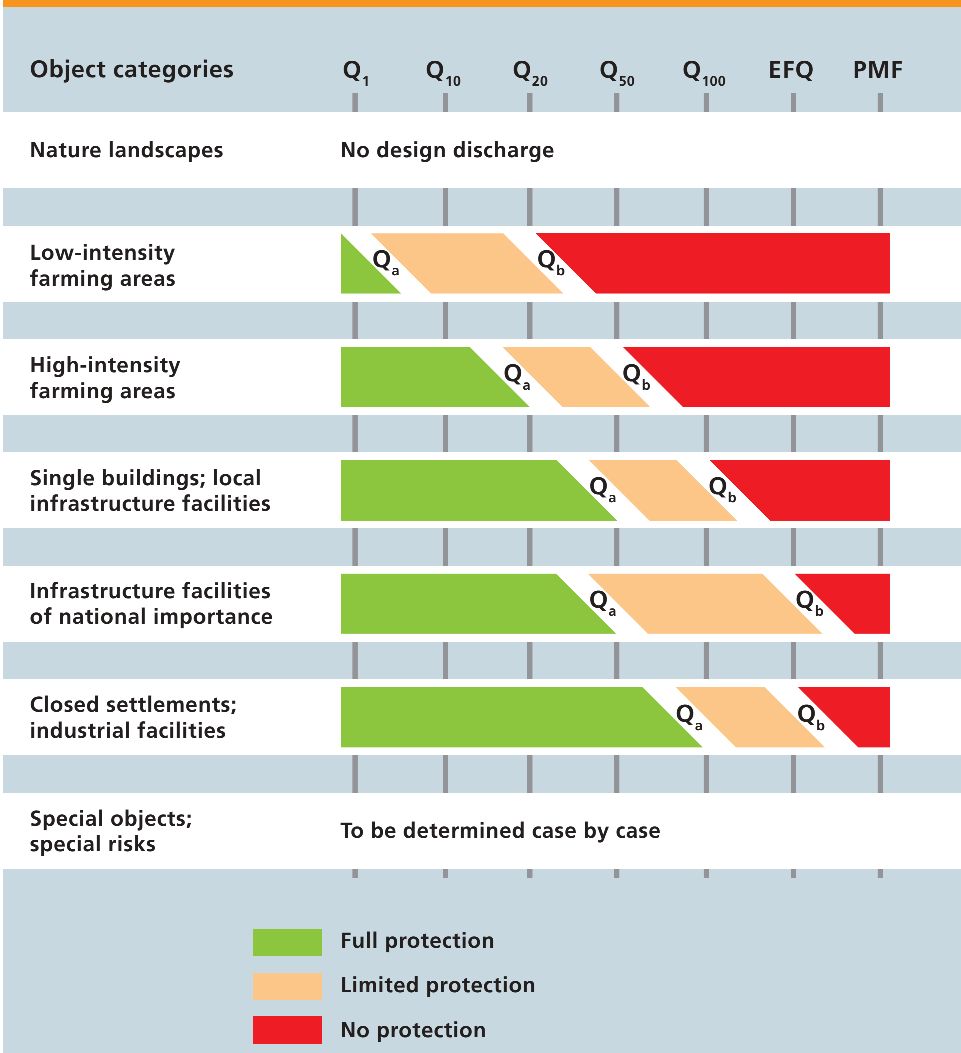
The protection objective not only depends on how a specific area is used (object categories) but also on the frequency and characteristics of floods occurring there. Therefore, important parameters beside peak flow must always be considered. In case of bank erosion or debris flow, the protection objectives must be increased according to the hazards of these dangers. Definitive parameters linked to the various processes can set for **the related scenarios:**

• In case of **inundation,** the main parameter is the volume of water flowing out of the channel and the duration of flooding.

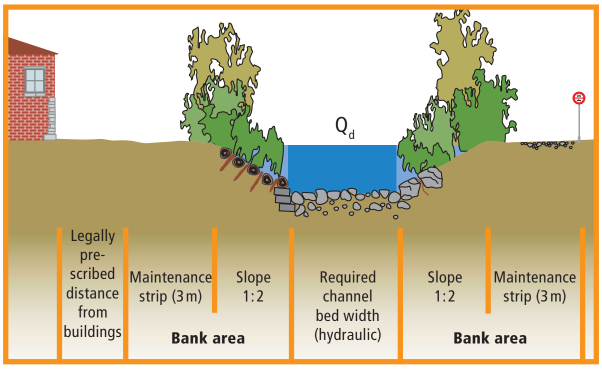
• In case of **erosion and deposition,** the decisive quantity is not so much the peak discharge, more the duration of the flood.

• In case of **debris flow,** the volume is often more crucial than the peak discharge.

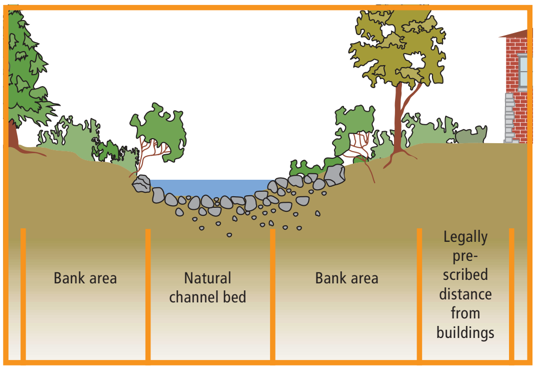
A proposal for a protection objective matrix



Q_a	Damage limit
Q_b	Hazard limit
FQ_1	Annual flood
FQ_{100}	Flooding occurring only once every 100 years (100-year flood)
EFQ	Flooding occurring for extreme in hydrological and meteorological situations
PMF	Probable maximum flood



Minimum space needed from flood protection standpoint.



Minimum space needed from an ecological standpoint.

Determining the Necessary River Space

Any project presents a crucial question: How much space does the stream or river need? Basically the minimum necessary river space includes the channel's bed and the bank area. The stream or river can rework this space. It makes itself available for flood flow, and it usually remains free of any kind of use (buildings and facilities may only restrict the minimum river space in well-justified exceptions). Moreover, the answer to the question about the necessary space can be derived from the following needs:

• **The flood control standpoint.** Given the hydrologic basics and the **protection objectives** set, a river space to be secured in the long-term must be defined. The corresponding design flood permits determining hydraulically the required theoretical bed width when considering local framework conditions. When considering a 1:2 bank slope and a maintenance strip of 3 m that ensures access, the minimum space required can be estimated from the flood control standpoint.

• **The ecological standpoint.** Streams and rivers are not only habitats of a varied flora and fauna native to the location. They are also a link in networking the habitats. They form the landscape, they contribute to self-purification of the water, and they provide a crucial contribution to regenerating groundwater. From the ecological standpoint, a simple method of calculation – a **key curve** – is available to set the minimal necessary space. It ascertains the width of the bank area. This working aid is applicable for small and medium-sized streams that comprise a major part of the water network.

Minimum necessary space
The larger of the two river spaces determined this way is finally definitive. Buildings and facilities should basically maintain the legally prescribed distance to the river space ascertained in this manner.

Other space requirements
Where leisure activities are expected, **recreational space** complements the space requirement of rivers and streams. In rarely used areas, necessary space can be expanded by the **meander** width of a natural channel. Setting up a buffer zone corresponding to the meander width makes space available for dynamic development of rivers that are close to nature.

Approach to secure space
A wide range of planning measures can assure the necessary space for rivers and streams to secure flood control and ecological functions:

• Acceptance in **cantonal guidelines or action plan** (imperative): it maintains the primary hydraulic engineering fundamentals valid in the long run and provides guidelines binding on the authorities.

• Consider in **cantonal or municipality land-use plans** (imperative): define flowing waterways space by clearly identified parcels and property lines (e.g., by related frontage lines).

• Consider in a municipality **structures ordinance** (optional): also define river space by clearly identified parcels and property lines.

• Define a municipality **planning zone** (optional): rapid temporary assurance of the required river space to prevent further restrictions.

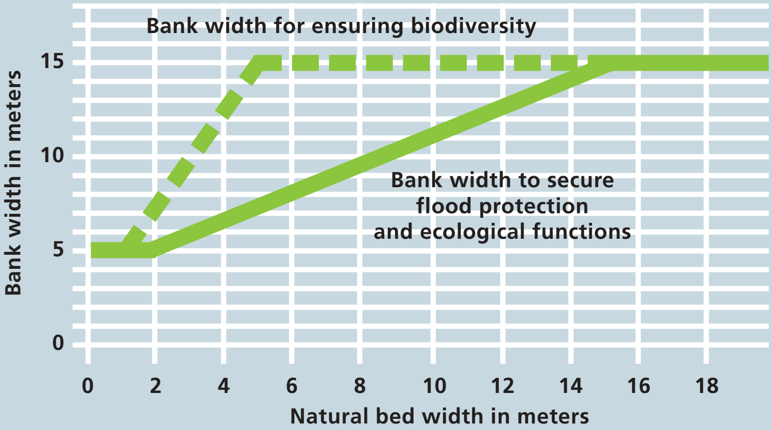
• **Acquire land through the public sector** (optional): assures space permanently for rivers and streams.

• **Transfer land** (optional): relieves property owners of disproportionate restrictions.

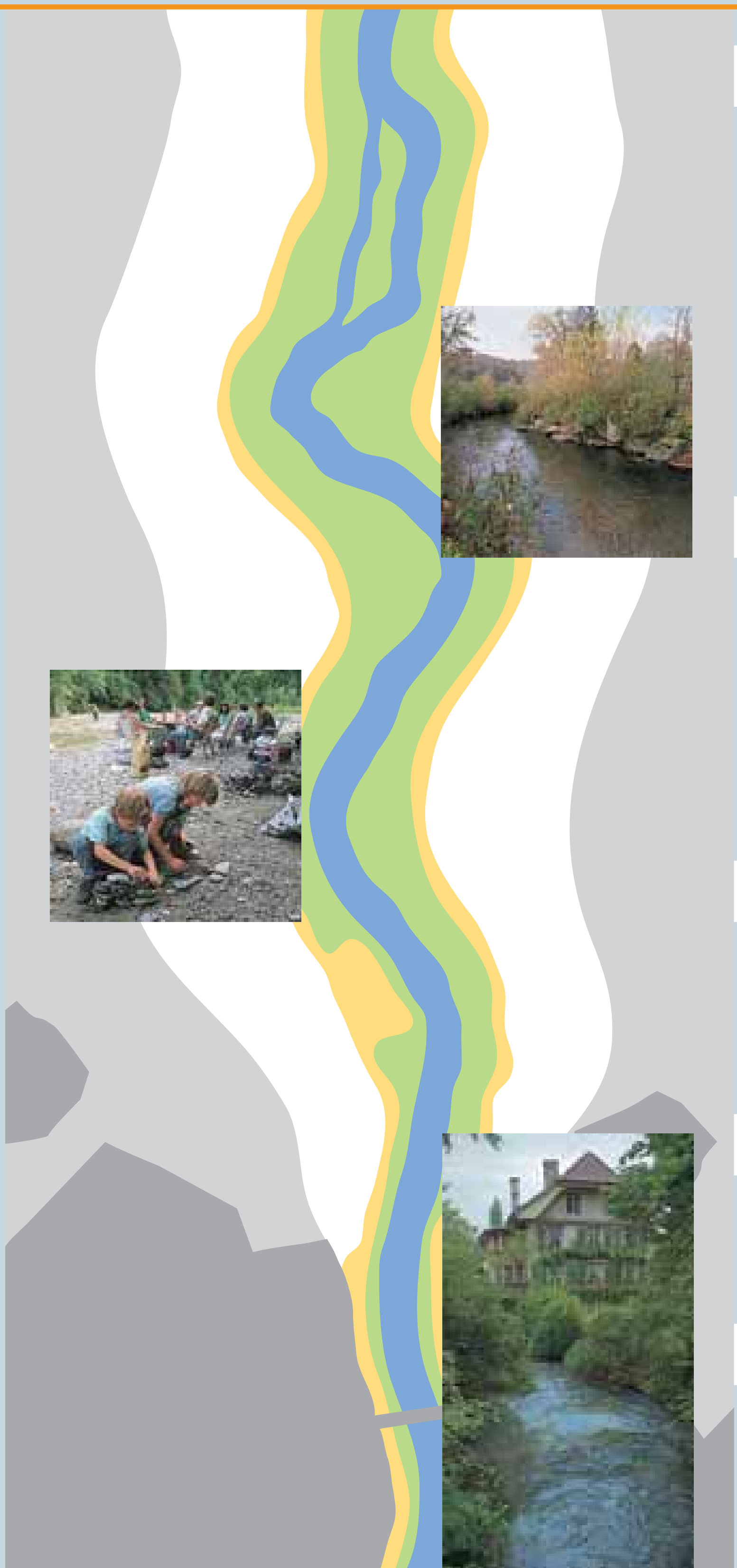
• **Resolve through contracts** (optional): governs management and care of bank areas as well as compensation for these ecological services.

• **Legally prescribe distance to buildings in urban areas** (recommended): In order to maintain leisure space in river areas, we recommend that the defined river space benefits from the usual legally prescribed distance to buildings (i.e., from the bank area onwards).

Recommended reading
BWG (flyer, 2000): Raum den Fliessgewässern! [Space for Rivers!]



Key curve. The decisive parameter in ascertaining the necessary space of a river is the natural bed width. The bank area's recommended **minimal width** can be derived from this: Even in case of brooks, it amounts to at least 5 m. At a width of 15 m, a bank strip can function as an independent biotope. In case of smaller streams in particular it makes sense to determine a wider bank area (hatched green line). This will promote **biodiversity** – the natural variety of plants and animals – along the stream.



Frank (2); Schäublin (1)

Natural channel bed. Corresponds at mean flow to the water level width and serves as the decisive parameter for calculating the bank area and meander width.

A natural channel bed indicates a marked variety in width. If natural comparative stretches are missing, the following **multipliers** apply:

- With limited variety in width
  Factor 1,5
- With lack of variety in width
  Factor 2,0

Bank area. The bank area required for river or stream functionality is determined by the key curve. Depending on the width of the channel bed on both sides of the river, it amounts to a **minimum of 5 m.** This consists of the **minimum nutrient buffer zone** that is set at 3 m according to the material decree. In areas with excessive nutrients input from neighboring farming regions, this buffer zone should be extended.

Leisure space. An additional space of **3 m** is recommended globally (e.g., for paths) near settlements and on traditional hiking and biking routes. Furthermore, enough room must be foreseen for rest areas and camp grounds.

Meander. In little used areas, a stripe corresponding to the meander width of a natural channel can be superimposed on the bank area, and it can be widened accordingly. Its width amounts to five or six times the width of the channel bed .

Settlement areas. Even under limited-space conditions, flood control and ecological networking should also be secured to the maximum.

Expansion of river space has a positive impact in a great variety of areas: It reduces risks of flood damage. It enables more cost-effective solutions for flood control structures. It protects rivers and streams from input of undesirable ingredients and improves water quality. It contributes to maintenance of natural habitats. And it upgrades recreation space.

Defining the Need for Action

After a hazard situation has been identified, the damage potential ascertained, the state of the river assessed, the protection objectives set, and the necessary space determined, the decision must be taken on the degree of planning measures necessary. Four individual cases or combinations of these individual cases can be distinguished.

Case A:
No flood control deficit
Current use is in harmony with the hazard situation posed by nature. This fortunate situation should be secured over the long term. Therefore, it is necessary to implement it in **structure and land-use planning.** The maintenance already guaranteed should be continued, and the functionality of protective structures on hand (and their susceptibility to hazards) should be checked periodically.

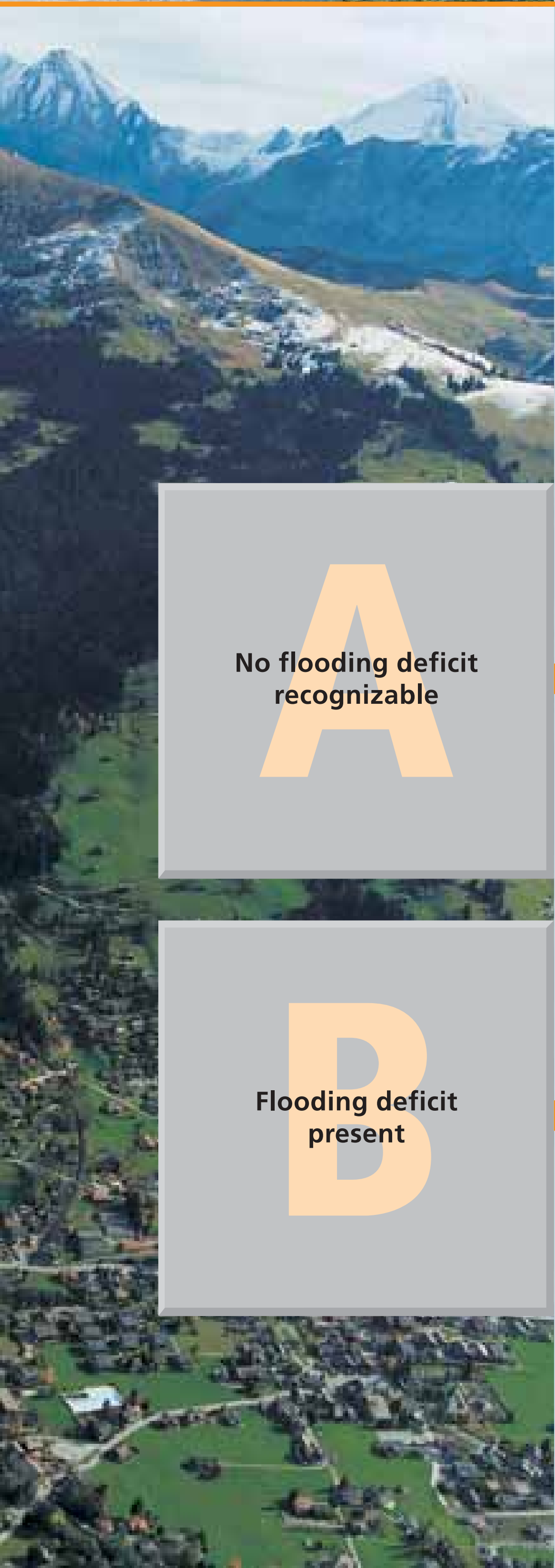
Case B:
Flood control deficit
If a flood-control deficit is identified, studies within planning corrective measures must determine how to eliminate or reduce it. Possible ecological deficits should be considered at the same time. After the measures have been realized, remaining hazards must be identified. A **hazard map** should be compiled for this purpose to be implemented in **structure and land-use planning.** Residual risks should be clarified and should be considered in emergency planning and organization. Maintenance of protective structures and of river channels must be secured over the long term.

Case C:
No ecological deficit
There are no land-use conflicts, and the river is in a condition close to natural. This should be assured in the long term through **structure and land-use planning.** The maintenance and care already carried out are to be guaranteed and continued.

Case D:
Ecological deficit
If ecological deficits are identified, within planning of corrective measures must also be determined how the situation can be improved. Flood control concerns must also be taken into account. After improvement of the situation has occurred, it must be secured for the long term. If deficits remain that cannot be eliminated immediately, the necessary land for it must at least be secured in a **land-use planning sense.**


Desair; Documenta Natura

Procedure for planning corrective measures and integrating ecological demands. A sustainable flood control project basically treats both aspects.



	C No ecological deficit recognizable	**D** Ecological deficit present
A No flooding deficit recognizable	Long-term guarantee	Need for action Planning measures in the environmental sector
B Flooding deficit present	Need for action Planning measures in the flood control sector	Need for action Planning measures in the flood control as well as environmental sectors

Procedure

All flood control measures – but especially planning and construction measures – lead to complex decision-making processes in which a number of standards should be noted.

The Federal Law on Flood Control (Wasserbaugesetz, WBG) sets the following **framework conditions:**

- the goals of flood control;
- the order of priorities in planning and when carrying out flood control measures;
- qualitative requirements in case of unavoidable interventions in the river space and maintenance.

Responsibilities

The **federal government** has broad sweeping legislative authority in the flood control sector. Yet each **canton** is responsible for related projects. This task is broad-ranging and includes both river channel maintenance and land-use planning as well as structural measures. The cantons are also responsible for emergency planning and emergency organization.

Accordingly, the cantons carry out federal flood control laws and enact **regulations** necessary to implement them. In particular, they regulate inner-cantonal responsibilities (task distribution between the canton, the districts, and the municipalities) and the applicable procedures for planning and realizing the measures needed.*

Distribution of tasks

The cornerstones of federal law mark out the **material framework** that the cantons fulfill on their own. For its part, the federal government must provide compensation regarding certain flood control measures and may give **financial aid** for river restoration (no legal claim). The federal government also promotes **training and continuing education** for people entrusted with flood control. And it carries out surveys of interest to all Switzerland on flood control matters and hydrologic conditions.

Furthermore, the responsible Federal Office for Water and Geology (FOWG) provides the basic data and manuals required for suitable and sustainable flood control. It also advises the cantons as well as other institutions. The FOWG's opinion is necessary (see below) for certain projects. In all other cases the cantons may opt to seek the FOWG's opinion.

But in case **subsidies** are sought, early contact with the FOWG is recommended.

Federal supervision

A central federal task is to supervise **cantonal enforcement** of federal law. The FOWG is also responsible in this area. It checks conformity of flood control projects with federal legislation – particularly environmental law – and looks after appropriate use of federal resources.

Before they make a **decision,** the cantons propose their flood control projects to the FOWG for federal **comment.** This applies especially in case of projects that:

- affect a river forming a national border,
- affect flood control measures of other cantons,
- require an environmental impact study,
- affect a protected area or an object on the national inventory.

Procedural coordination

All decisive cantonal and federal law procedures used in individual cases must be coordinated in a material and formal sense and then be brought into harmony with each other in terms of content. The **material agreement** and balancing of interests related to it permit integral treatment and assessment, even in complex projects. Two different approaches are possible in the **formal** respect:

- **Coordination model.** Several authorities remain responsible in various procedures and harmonize decisions in terms of content.
- **Concentration model.** A single authority carries out the various procedures. The FOWG coordinates the relevant procedures at the federal level.

* Due to the variety of federalist structures, these 2001 guidelines must be restricted to the collaboration between the federal government and the cantons.

Keystone

UFAEG–FOWG

Legal Standards

The **Federal Law on Flood Control** (Wasserbaugesetz, WBG; SR 721.100) and supplemental **Ordinance on Flood Control** (Wasserbauverordnung, WBV; SR 721.100.1) occupy center stage among federal legal tasks concerning flood control.

The federal legal outlook can be summarized as follows: Legislative attention focuses primarily on land use which recognizes existing natural hazards and maintains (or creates) the necessary buffer areas. Thus recognized hazards should not be punctually removed but imbedded in a global concept for the entire area.

As soon as structural protective measures become necessary, federal law makes qualitative demands that lie in the interest of a varied animal and plant world as well as river ecology. In each case a minimum space must be reserved for rivers and streams. Therefore, maintaining or creating floodplains while establishing and ensuring **floodways** also belongs to expedient planning of measures.

Other federal standards

Beside the WBG and the ordinance related to it (WBV), there is a series of other federal legal standards* that can relate to flood control. They often require special decisions or procedures:

• **Federal Law on Land-Use Planning (RPG).** Planning of flood control is a step in establishing a cantonal structure and land-use plan. It has to be coordinated with space requirements of other sectors by weighing interests. In particular, planners must consider the river's or stream's space requirements needed for flood control and to guarantee ecological functioning. Structural measures for flood control require a construction permit. A waiver permit must be obtained outside construction zones. Engineers must prove that the measure is bound to the location, and a preponderance of interests must not oppose it.

• **Federal Law on Water Quality (GSchG).** Hydraulic engineering projects must not cause water pollution. The implementation of such projects is only conditionally possible in water protection areas and groundwater protection zones. Hydraulic flood control measures need a legal permit for water quality control protection, in particular endangered water protection areas. The law basically forbids to cover rivers or streams by structures or to lay them into culverts. Extraction of sand, gravel and other material requires a federal law permit (it cannot be granted if the sediment regime in rivers or streams is adversely affected). The water quality law (like the hydraulic engineering law) requires maintenance or restoration of natural rivers.

• **Federal Law on Fisheries (BGF).** Interventions in rivers, their discharge regime, or their course as well as in bank and bed areas assume a legal fishery permit (to the extent that no permit is required in connection with the water quality law).

• **Federal Law on Protection of Nature and Landscape (NHG).** Objects listed as of national importance in the federal inventory of alluvial zones are of special importance. They are to be maintained undiminished (thus flood-control measures are only permitted in a restricted manner). In all other protection areas, according to the NHG, unavoidable interventions require compensation or restoration measures. Ecological compensation is also foreseen in intensively used areas (e.g., by restoring riparian vegetation) and by identifying ecological buffer zones to protect biotopes.

• **Federal Law on the Forests (WaG).** The law enacted a ban on clearing in principle. Waivers are only granted under strict conditions, especially if the envisioned structure or facility is confined to the loca-

***Other interfaces.** Flood control measures can also affect national treaties and other international agreements. There are also interfaces with other concerns of federal law. Those especially worth mentioning are:

- the decree on security precautions for pipeline facilities (in connection with safe distances);
- the decree on security of dam facilities (StaV, in connection with risks for riparians).

Already in 1874 the Swiss people through Article 24 of that era's federal constitution has given the federal government competence for hydraulic engineering and forest police. The related hydraulic police law was approved on 22 June 1877. At first it applied only to high mountain areas, but from 1897 on it affected other areas as well. This law was replaced in an updated constitutional version by a **water resources management** article in 1975 (in the revised federal constitution's Article 76 "Water"). However, the hydraulic police law was only replaced during the 1990s by the Federal Law on Flood Control (Wasserbaugesetz, WBG) and its related Ordinance on Flood Control (Wasserbauverordnung, WBV).

tion. Basically, property compensation is to be provided. But this can be waived in case of flood control measures. Nature and landscape protection measures can also be used for compensation instead of property. The clearing permit does not obviate the need for a construction permit waiver in regard to land-use planning. Training of streams by forestry engineering methods that serves to maintain forests is also ruled by the forest law. Details are derived from the hydraulic engineering law (if the situation arises, responsibility is to be coordinated between forestry management and hydraulic-engineering). Based on the WaG, the federal government grants subsidies in case of any other protective measures that supplement hydraulic engineering (avalanches, rockfalls, erosion zones, landslides not related to river activity).

• **Federal Law on Environmental Protection (USG).** The legally regulated precaution principle manifests itself in the environmental impact study that is to be carried out in case of important hydraulic engineering measures. USG regulations are also to be observed for noise control, soil pollution, and waste planning.

• **Federal Law on Hunting and Protection of Mammals and Fowl Living in the Wild (JSG).** The federal government declares reservations for water and migratory birds of national and international importance. The opinion of the responsible Federal Office for Environment, Forestry, and Landscape must be obtained in case of hydraulic engineering plans that impact protection areas.

• **Federal Law on Footpaths and Hiking Paths (FWG).** The cantons are concerned with planning footpaths and hiking networks. They coordinate them with their other space impact activities including the hydraulic engineering sector.

• **Federal Law on Hydropower Use (WRG).** Requires coordination of hydraulic engineering measures with concession rights (and vice versa). In particular, it concedes a right to compensation to the hydropower concessionaire if interventions in the river's course affect his previous use of it permanently (presuming adaptation of the plant is unreasonable). On the other hand, the concession can also envision the concessionaire's financial participation in maintenance costs and possible structural protection measures.

• **Federal Law on Agriculture (LwG).** The federal government can support subsidies for low intensity use of farmland. Moreover, cantons, communities, and hydraulic engineering associations can compensate for measures that serve flood control goals (e.g., inundation zones). Stream restoration (including land acquisition) can also be supported in connection with rural engineering. Basically, hydraulic and rural engineering projects should be coordinated.

• **Federal Law on Dispossession (EntG).** In implementing the law on hydraulic engineering law, the cantons can dispossess the rights in question or transfer the right to dispossess to third parties.

• **Federal Law on Financial Aid and Compensation (SuG).** This governs the federal government's guarantee of compensation and financial aid. In accord with it, among other features, possible participation of beneficiaries and those liable should be considered. Before receiving the contribution guarantee, those granted subsidies may only begin construction or make major acquisitions if the subsidizing authority gives its approval.

• **Federal Law on Use of a Special-Purpose Mineral Oil Tax (MinVG).** The federal government uses a portion of the mineral oil tax revenue earmarked for highway traffic for structures protecting against natural hazards along highways and particularly flood control measures.

• Minimum requirements for linking ecological compensation zones are set out in the **Ordinance on Ecological Quality (ÖQV).**

➜ **http://www.admin.ch/**

Protection objectives are to be examined (and adapted, if necessary) within a interest-weighing procedure concerning their economic and ecological proportionality.

Framework Conditions

Flood control cannot be planned or realized in a manner detached from other demands for space. Coordination and agreement with other space-impact **plans** (e.g., from the sectors of highway design, forestry management, farming, water quality control, water use, and river restoration) and other **intentions for land use** (e.g., development of building sites) are cogent in any case, and the related fundamentals should be considered.

Therefore, any flood control project should determine right from the start if other disciplines are affected. Only in this way will potential **conflicts** be recognized on time and considered properly in planning.

Proportionality

Basically every measure has to fulfill the following conditions in connection with flood-control: On one hand, the measures envisioned must achieve the **goal** desired. On the other, they should be as **unobtrusive** and cost as little as possible. Moreover, a reasonable ratio should exist between the desired goal and the intrusion into **protected legal goods** (e.g., private property). Therefore, any flood control measure should be examined from the viewpoint of its proportionality:

• **Costs.** Flood control projects must be economical and expedient. Thus, a balance is necessary between the cost of the protective measures and the potential damage expected. No claims for compensation or financial aid can be justified for uneconomical or inexpedient flood-control projects. If such a project involves not only the public interest but especially that of privileged third parties, the costs are to be apportioned among the participants.

• **Ecological claims.** Proportionality has also to be respected in case of claims lodged on behalf of nature and the landscape. Basically the existing conditions should not be worsened but improved as much as possible. In case of supplemental claims, the costs related to the "ecological benefit" (even if they cannot be determined monetarily) should be factored into the comparison.

• **Private interests.** Often hydraulic engineering needs and private interests fail to harmonize. Owner positions must bow whenever a sufficient public interest exists. Therefore, the cantons have the right to dispossess property in the interest of flood control. On the other hand, private parties affected may present their concerns through the procedures envisioned for them by the cantons and the federal government.

Frank; Keystone

Federal Subsidies

The crucial assumption for a subsidy issued by the federal government is **expedient planning** of the related flood-control project:

- Agreement and coordination with other interests and partners is secured.
- There is no dual subsidy (e.g., from hydraulic engineering and forestry management).
- The work is in the public interest.
- Cost participation corresponds to the interest situation ascertained.
- In case of conflicting goals, the verdicts are justified.
- The project fulfills the requirements of all federal laws (i.e., regulations on waterway protection, land-use planning, nature and landscape protection, environmental protection, etc.)

Documentation

In case of subsidy applications for structural measures, the natural hazards, possible damage, selected protection objectives, and impacts of measures envisioned should be identified, clarified, and understandable.

Another assumption for a federal subsidy application is that the responsible cantonal authorities have already made a **legally binding** decision on the related project.

Federal authorities also require **project documentation** in order to carry out a thorough examination of the project. This includes documentation on technical and cost factors as well as opinions and ascertainments of cantonal authorities.

Legitimization

Within approved loans, the federal government carries out settlements for:

- Preparation of basic data for assessing hazards (including concepts, hazard and event register, or hazard maps).
- Planning and building flood-control structures and flood control facilities (as well as restoring or replacing them).
- Clearing channel beds and restoring a sufficient flow section after the occurrence of extreme events.
- Setting up and operating gauging stations in the interest of flood control.
- Building up early-warning services.
- Acquiring land for protective structures.
- Restoring rivers when stressed by hydraulic engineering measures. There is no basis for legal claims. Priority is given to projects that enhance natural river dynamics and serve to network habitats (e.g., through culvert removal and by creating enough buffer zones and transition areas between land and water).

The step-by-step approach within procedural planning can identify an optimum solution for flood control balancing technology, ecology, and economics: maintenance as well as planning and structural measures often stand in close correlation, since they exercise a mutual influence on each other.

Luftbild Schweiz

Regular Procedure

The regular procedure for flood-control measures can be divided into four substeps.

Step 1: Laying out the project

Each canton usually has a **specialized office** responsible for flood control. This office has multiple tasks:

- It is responsible for handling and coordinating project applications.
- It advises local responsible persons or agencies, farming cooperatives, private landowners, and third parties on flood control issues and in connection with river restoration.
- It is the direct contact in the flood control sector for the Federal Office for Water and Geology (FOWG). The procedure can be simplified considerably if an early **information exchange** on the flood control project takes place between the cantonal office and the FOWG. This applies especially if important fundamentals (e.g., design parameters) are to be determined. Yet early agreement by all involved is also of great usefulness if other federal interests are involved (e.g., projects in areas with a claim for protection due to federal inventories).

Step 2: FOWG opinion

In case of important projects and in special cases (see also page 23), the responsible cantonal field office consults with the FOWG which issues a binding opinion. The FOWG can also express itself here on the amount of a possible federal contribution.

Step 3: Cantonal decision

The next step is the canton's legally binding decision on the hydraulic engineering plan and its financing. In case of plans requiring an environmental impact study (UVP), cantonal law determines the procedure definitively.

Step 4: Subsidy procedure

Based on the legally binding decision of the cantonal authorities, the cantonal office can submit applications for subsidies to the FOWG. The FOWG checks the project documentation and determines the amount of the federal contribution as well as related conditions. The project's harmonization with other federal laws is also checked in this connection.

➜ **Appendix: Checklists**

The first planning level is the **preliminary study** (in flood control also frequently referred to as the **concept**). All possible options (i.e., the "do nothing" approach, too) should be discussed, and the option worth pursuing should be defined. Important framework conditions should be considered here, and potential conflict points should be listed.

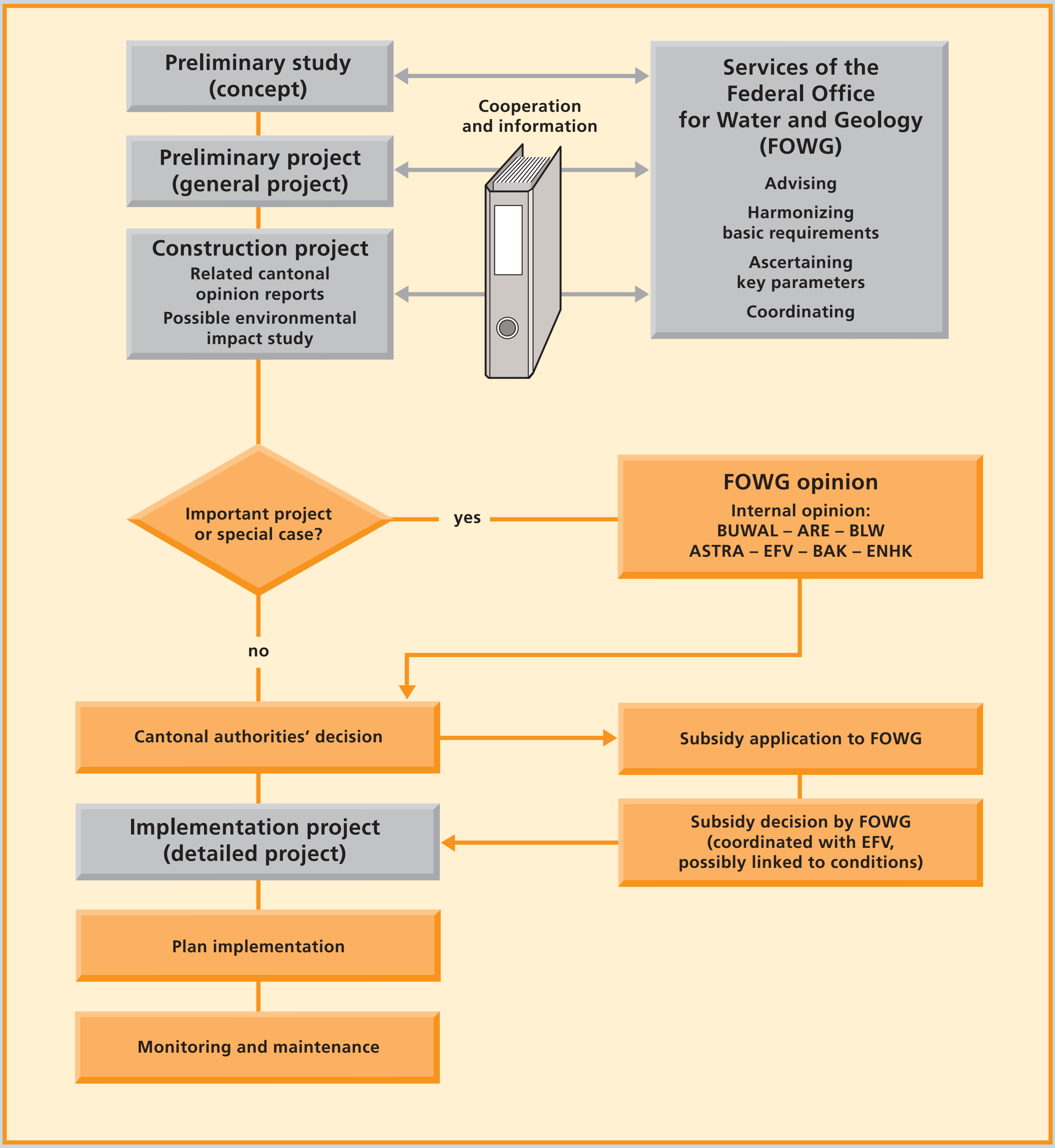
At the **preliminary project** planning level (often called the **general project** in flood control), planning measures for the elected options are detailed to the extent that (1) a rough cost estimate emerges, (2) major dimensions of potential structural measures are known, and (3) an overview of the hydraulic, economic, and ecological impacts of the related approaches can be provided.

The **construction project** includes the technical report, the project plans, and the cost estimate. It becomes the basis for the building permit procedure, the decision on subsidies, and the call for tenders. Those directly affected must be able to recognize the related impacts on each parcel precisely (except for urgent measures after floods and sediment disasters).

The **implementation project** (often also called the **detailed project** in flood control terminology) presents all calculations, dimensions, construction details, and instructions needed to realize the measures selected.

Procedural flow at the cantonal level

Procedural flow at the federal level



After a disastrous event, a canton can request support from the federal government, e.g., in preparing event documentation.

Accelerated Procedure

If obvious **security deficits** appear after floods and sediment disasters and immediate measures have to be taken, an accelerated procedure can be used to approve subsidies. To justify such an approach, **immediate measures** are defined as:

• work immediately after an event, i.e., clearing channels or restoration of ruined protective structures;

• anticipated measures that reduce existing security deficits as soon as possible.

Checkpoints to be noted

The following should be considered in planning and implementing immediate measures:

• Priority should be given to measures that reduce an existing risk or damage potential as quickly and effectively as possible. On the other hand, measures that affect security only marginally should be handled in connection with **regular procedure** (see page 28).

• Before starting any work, the canton's **specialized offices** should be consulted (and also third parties, if necessary).

• **Coordination** with other projects in the area affected should also be assured.

• If projects are **important,** coordination with the Federal Office of Water and Geology (FOWG) is also necessary. This especially applies for plans with important cost consequences or for work in an area that is protected by federal inventory.

• If necessary for security reasons, the FOWG can grant a **temporary building permit** based on subsidy law for urgent work before definitive funding approval. This allows work to be undertaken immediately without having to wait for completion of the subsidy procedure.

• Before restoring destroyed protective structures, investigation should confirm whether simple restoration of these structures makes sense. The **cause** of failure should be determined as far as possible, and structure security should be enhanced.

• Basically, space which the river has taken during the event should be secured as **river space.** New space restrictions should be avoided. Greater flexibility can be achieved for definitive measures in this manner.

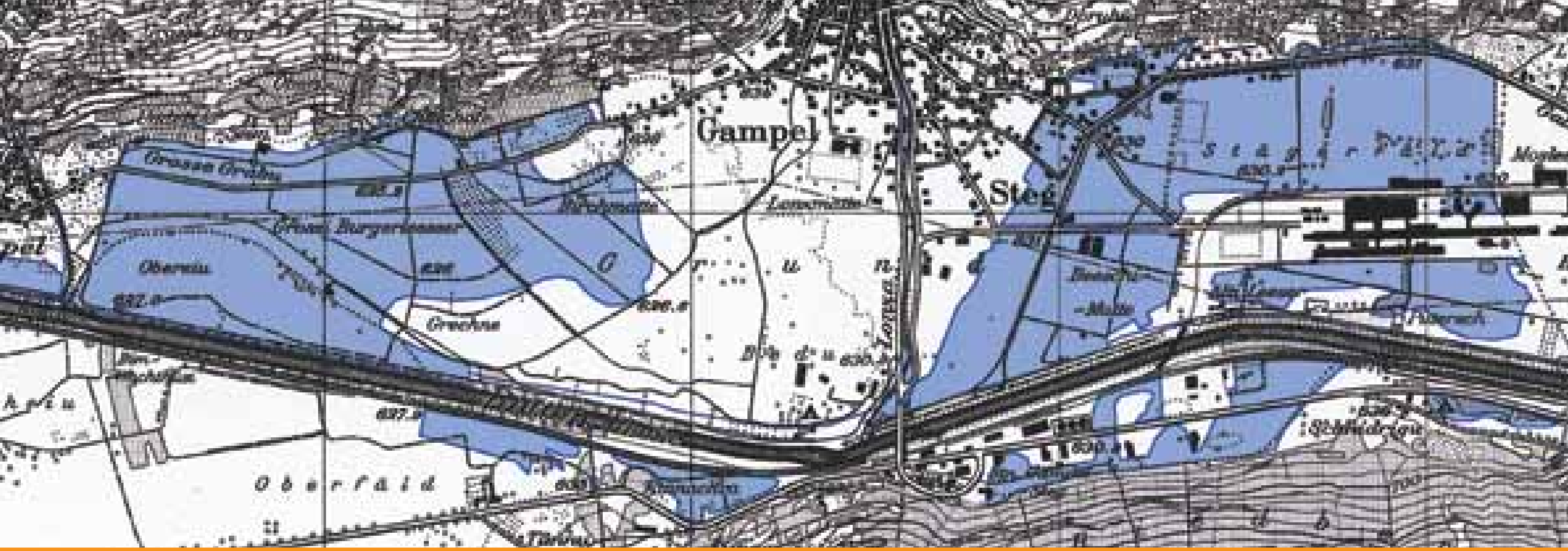
• **Definitive solutions** should be realized in case of local problems and clear framework conditions.

• On the other hand, in case of major planning that has to balance the various interests, **low-cost temporary structures** should be built. Hence, time can be saved for expedient project management.

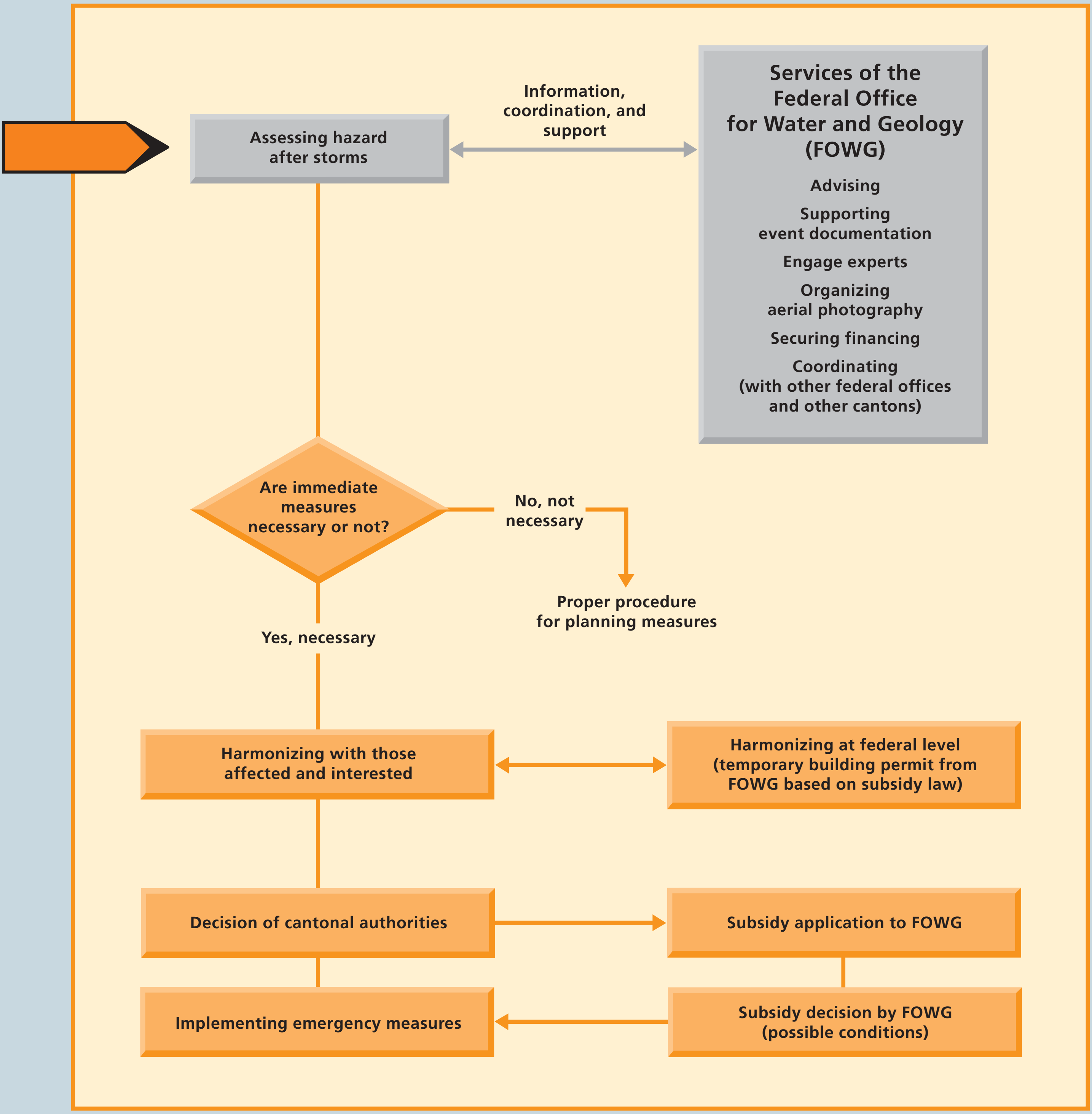
• Immediate measures and restoration steps should create no **prejudgments** about definitive solutions.

• Special fundamentals apply to **alluvial zones** (see page 53).

UFAEG-FOWG; Frank; Keystone



Procedural flow at cantonal level | **Procedural flow at federal level**



Conflicts in flood control plans are usually the result from differing interests concerning use in the planning area.

Participation

All flood control measures should be based on an understandable, transparent, and comprehensive weighing of interests. This means that a **compromise** satisfactory for all involved must be found through communication and discussion. It should be noted here that differing concerns should be rated in terms of the goals formulated and considered according to their importance.

Information

Landowners and farmers directly affected by the plan should be informed of the planning approach in a timely, understandable, and schedule-related manner.
Informing those affected should not occur only once but in an expedient ongoing manner at the right moments during the entire planning process.

Forms of participation

If concerns are raised from the public, a spirit of give-and-take should be promoted (to the extent that individual interests are compatible with the general welfare). Coordination of hydraulic engineering plans is also important for both **downstream riparians** along rivers and streams (since they are directly affected by the project's impact) and **those upstream** (e.g., hydropower plant operators).
The level at which participation begins depends on the project in question. Various forms of involvement are possible. The goal of this approach is to realize sound projects and thus improve **acceptance** of measures related to them. Public involvement also offers the opportunity to use know-how of local residents and to draw them into planning at an early date. Possible forms of involving the public and those affected are varied:

- Presentations by experts, public gatherings, or discussion evenings.
- Local visits or excursions to areas with similar situations.
- Exhibitions and public-information postings.
- Study groups or expert panels in which various interest groups discuss goals and optional solutions with a moderator.
- Interdisciplinary monitoring committees, e.g., one established with success along the River Thur.
- Information in local and regional news media.

Frank (3); Schäublin (1)

Overcoming Conflict

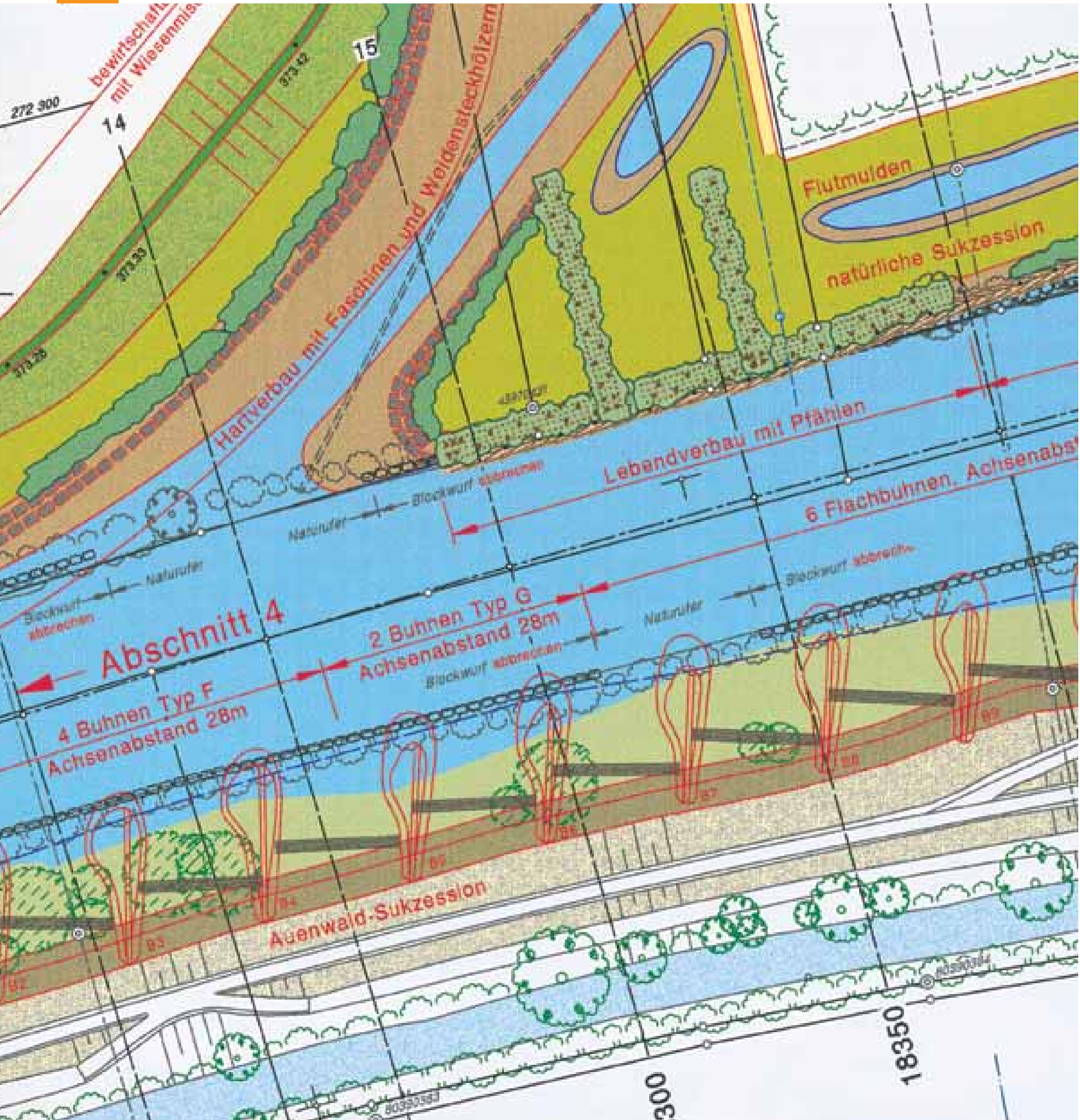
Planning's goal is to work out a project that wins consensus and can be realized within a reasonable period. Nonetheless: rivers and streams and their related flood problems are so closely bound to totally differing demands for use that planning flood control measures often leads to conflict. The reasons are varied. They may lie in divergent **claims for use.** Yet it is also conceivable that conflicts arise through **shortcomings of the planning process.** This applies, for example, if doubts, desires, or demands of collaborators and those affected are not assessed on time or taken seriously. Differences could thus arise that end up in objections (and thus postponements).

Recommendations

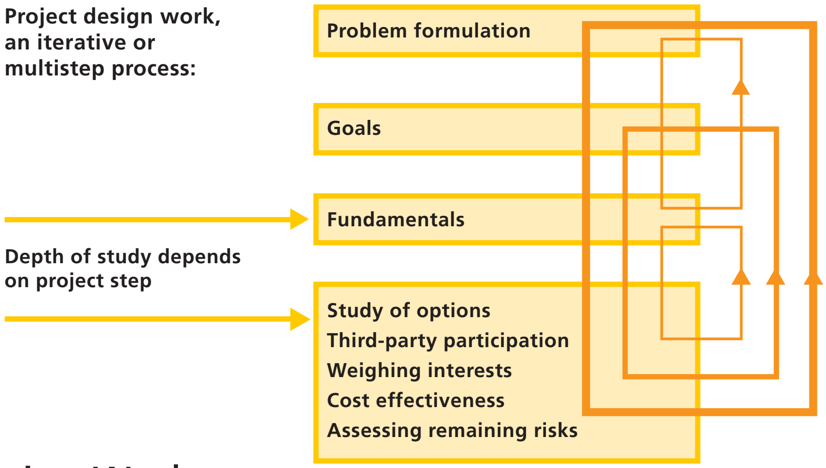
There are various recommendations on how conflicts can be recognized, avoided, and resolved. The most important are noted here: Before working out a project, involve all affected early and within the framework of an open and comprehensive information policy. Identification with the corresponding plans and understanding for the measures needed can be promoted in this way. The following points should be observed in addition:

- The **legal framework** and **space requirements** for natural habitats as well as procedural flow are expressed clearly at the beginning of planning.
- In case this framework cannot be considered, the **reasons** for it should be presented openly.
- Broad-based **discussion** of the draft project including local visits contributes to mutual understanding and early clarification of potential points of conflict.
- Conflict points that cannot be resolved immediately may be neutralized at times, if **improved decision-making bases** are made available through more detailed examination.
- If, despite all efforts, further conflicts cannot be overcome, responsible authorities at the cantonal level must **weigh the interests involved.**
- A **decision** by the responsible authority follows. It may be appealed, depending of the law involved.
- Finally, it is important that **decisions** made are explained and made known to all involved.

Project Design



In order that gaps never completely bridged between the natural framework and society's claims are not excessive, a **change in course** regarding flood control procedures may also be necessary: "Back away from pure flood control defense; advance to a culture aware of risks" is the thrust of the **new motto** that should be experienced at all levels – i.e., the federal government, the cantons, and municipalities – in the future.



The Sequence of Project Design Work

There are no standard recipes for solving flood-control problems. Yet recommendations can be made based on experiences from the recent past on how flood-control goals can be achieved in a timely and cost-effective manner:

- In any project the necessary should be separated from the desirable in order to keep **costs** within reason.
- The **depth of study** should be adapted to project requirements.
- The necessary **basis** for decision-making must be prepared early.
- **Basic data** needed for the project must be complete. There are enough examples to show that a single unclarified issue can delay a project for years (or even cause a failure).
- Expertise from various disciplines is usually required during a project's stages. It is therefore important that **partners** assigned special tasks be selected carefully. Those bidding for project tasks must be able to demonstrate their specialized technical skill, qualitative record, and business performance in managing the work envisioned. Furthermore, they must be able to work in a team.
- If the **interest-weighing process** established that economic, ecological, or even technical measures lack proportionality, adaptations must occur in the uses foreseen – and also the protection objectives selected (see also guiding principles, page 10).

Recommended reading
FEDRO/FOT/FOWG/SBB (1998/2002): Safety of Structures in Water. Recommendation for the Surveillance and Indications for the Construction of New Structures

Optimization by multistep approach

Once the need for action, the problem formulation and the necessary fundamentals are established, the goals to achieve with planning measures need to be defined. For their part, these goals influence the nature and quality of the basic data required, and the measures again lead to adaptations and supplemental steps. Project optimization through such a multistep approach is therefore an **iterative procedure.** Attention should be paid to:

- **Documentation of the original situation.** This includes documentation on the hazard situation and the state of the river or stream, as well as the question of an extreme flood's impact.
- **Estimate of possible damages.** This study provides information on the financial consequences of a certain event.
- **Planning measures.** A rule of thumb states that impact on rivers should be as small as possible. Another principle calls for upholding the priorities set by federal Law (maintenance and land-use planning measures have priority over structural protection measures). Important improvements for flood control may often be achieved at little cost, and finally comprehensive weighing of interests leads to better options.
- **Assessing the residual risks.** Clarifying residual risks belongs to a complete planning of corrective measures. This can be done only being aware of uncertainties linked to natural events.
- **Emergency planning and emergency organization.** Each flood control project also includes a catastrophe management plan oriented towards the current hazard situation.
- **Maintenance and monitoring.** An essential component of a flood control project is also to set up a maintenance concept (total security and use plan).

Implementing into land-use planning

The remaining danger situation after realizing protective measures should be presented in the form of a hazard map and considered in establishing the **structure and land-use planning.**

If the project is rejected, the responsible flood control authorities must work out the hazard map corresponding to the original situation and make sure that it is implemented into structure and land-use planning.

➜ Order of priorities

A phenomena map produced by field survey is a meaningful supplement to event documentation. It records characteristics and indicators observed in the field in map and text form. It also refers to the status, triggering mechanics, and impact of potential types of hazards.

Conditions in the Catchment

Processes occurring in rivers or streams will be determined largely by conditions in the corresponding catchment. Important parameters are:

- **topography** (surface, form, gradients, readiness of a zone in relation to a certain process);
- structure and distribution of various types of **soil;**
- **geology;**
- **geomorphology** (processes that have shaped the catchments);
- **precipitation conditions;**
- degree of **glaciation;**
- **forested area** (and its condition);
- **discharge regime;**
- **channel geometry** (longitude profile and cross sections) and **channel morphology** (grain size diameter of bed substrata).

Available basic data

Any flood-control project is based on numerous pieces of basic information on the river and its catchment. Part of these data is also available in **digital form** (e.g., topographic and topical maps as well as aerial photographs) or is integrated into geographic information systems (GIS). Various cantons as well as the federal government also operate coordinating offices. The following working and planning tools are of particular importance:

- **Precipitation data.** Governmental and private institutions collect this data. Evaluations of weather radar data are often valuable in assessing and classifying major precipitation events.
- **Discharge data.** Governmental and private institutions also collect this data; rated and made accessible to the public (e.g., in the form of the FOWG's "Hydrologisches Jahrbuch der Schweiz" [Hydrologic Yearbook of Switzerland] also on the Internet).
- **Registered events.** Those who want to foresee the future need to look back into the past. Therefore, experiences gained from earlier events are of great use in assessing and estimating future events. This assumes a comprehensive and accurate documentation of individual events. Besides noting the crucial processes and degree of damage, event documentation provides information on areas affected by the natural hazard involved as well as the meteorological, geological, geomorphologic, and hydrological conditions.
- **Basic data concerning geology.** Geological conditions influence runoff, the nature of sediment and its yield, as well as the sediment's physical characteristics. Stability calculations related to mass movement cannot be carried out without knowing the geological conditions. Moreover, when intervening in groundwater, drainage as well as measures near sources requires investigations of the hydrogeological situation.
- **Inventory.** The so-called federal inventory represents important tools for protecting nature and the landscape. It distinguishes between landscape and biotope inventories, because they differ in legal importance. Accepting an object of national importance in a **landscape inventory** in accord with Article 5 NHG mainly commits federal agencies themselves (as well as those that fulfil federal tasks or claim federal funds for their plans). Excepted is the inventory of moor landscapes, which is based on Article 23b NHG and is applied directly to property owners. Substantially more authority has been granted to the federal government since 1987 in the sector of biotope protection. The legal basis of the **biotope inventory** (including a federal inventory of nationally important alluvial zones) is Article 18a NHG. After hearing testimony from the cantons, the Federal Council identifies the biotope of national importance, determines its status, and sets protection goals.
- **Damage potential.** Based on their documents, cantonal building insurance can provide data on potential damage and **object protection measures.**

Recommended reading

BWW/BUWAL (1995 recommendations): Naturgefahren. Symbolbaukasten zur Kartierung der Phänomene [Natural Hazards. Symbol Toolbox for Mapping Phenomena]

PLANAT/BWG/BUWAL (2000 compendium): Vom Gelände zur Karte der Phänomene [From the Field to the Map of Phenomena]

Basic data	Contact/Sources
Precipitation data	• Heavy precipitation: Federal Research Institute for Water, Snow, and Landscape (WSL), Birmensdorf • Entire Switzerland surveys: SMA MeteoSwiss, Zurich • Radar weather assessments: SMA MeteoSwiss, Zurich • Local surveys: hydropower plants; private meteo offices
Discharge data	• Entire Switzerland surveys: FOWG-LHG, Biel and Berne • Local surveys: waterpower plants; cantonal flood control offices; cantonal water management offices
Structure plans	• Cantonal land-use planning offices
Land-use plans (local)	• Cantonal land-use planning offices • Municipality administrations
Landscape development concepts (LEK)	• Federal Office for the Environment, Forestry, and the Landscape (BUWAL), Berne • Cantonal land-use planning offices
Events register	• BUWAL, Berne (Forestry Directorate) • Cantonal flood control offices
Protection structures register	• Entire Switzerland documentation: FOWG, Biel; BUWAL, Berne • Regional and local surveys: cantonal flood control offices
Hazard index maps	• Cantonal flood control offices • Cantonal land-use planning offices • Municipality administrations
Hazard maps	• Cantonal flood control offices • Cantonal space planning offices • Municipality administrations
Project files (old)	• Cantonal flood control offices • FOWG, Biel
Damage potential	• Cantonal structure insurance
Inventory	• Federal inventory (landscape and biotope inventories): BUWAL, Berne • Regional and local inventories: cantonal nature protection offices • Red lists: BUWAL, Berne; cantonal nature protection offices; environmental associations
Basic data concerning geology	• Geological maps (however, the National Geology Atlas at a 1:25 000 scale is incomplete). • Geological studies that were carried out for other projects. The National Geology Division (FOWG) operates the Swiss Geology Documentation Center (SGD), which also collects unpublished documents. • Additional geological, geotechnical, or hydrogeological studies on reservoirs, check-dams, dams, and interventions into water regime (e.g., lowering groundwater).

Calculating return periods is quite tricky, as the example of the Reuss in Uri cantone shows. During the mid-1980s this river was designed for a flood discharge of 600 m^3/s, and that value was considered as a **100-year event** (Q_{100}). Yet a detailed hydrologic study after the 1987 flood showed that this design value only corresponded to a **30- to 40-year flood.** Thus the **probability** that a discharge of 600 m^3/s occurred during a 100-year period rose from about 64% to 90%.

Uncertainties of Basic Data

Discharge is an important parameter in any flood control project. It has a crucial influence on the design of corrective measures.

Discharge refers to the amount of volume that flows through a river cross section per second. Usually it cannot be measured directly and continuously but determined only sporadically (normally by measuring velocity distribution over the entire flow section, but in some cases by using tracers or by laboratory tests).

Fundamental relation

A correlation curve for stage/discharge (the so-called H/Q curve) can be determined discharges measured (Q) at differing water levels (H). It forms the basis for converting water levels into discharges. This correlation curve can change with time (especially through river channel deformation during floods). Hence, the measurement of discharge must be repeated periodically to test the curve and update it.

The H/Q curve must often be extrapolated mathematically for extreme values (this applies to both floods and draughts), since measurements are often lacking for these exceptional situations.

Recommended reading

LHG (1998): Ausgewählte Tätigkeiten und Leistungen [Selected Activities and Performances]

Return periods

The term "return period" refers to the long-term average interval or number of years within which an event will be equaled (or exceeded). The term "recurrence interval" is also used frequently for this value:

- $\mathbf{Q_1}$ is in the average expected once a year (the so-called annual event).
- $\mathbf{Q_{100}}$ is in the average expected every 100 years (the so-called hundred year event).
- $\mathbf{Q_{300}}$ is in the average expected every 300 years (the so-called 300-year event).

Conservative estimates

As for all natural processes, uncertainties are also great in determining probability. Viewed statistically, even very long records show great scatter. This condition must be taken into account when estimating design values. This usually leads to conservative estimates. Therefore, hydrological data used for flood control planning must indicate the prevailing uncertainties.

The design discharge $\mathbf{Q_d}$ corresponds to the discharge that can be evacuated without damage owing to the measures projected. In parallel to the determination of the design discharge, within the planning of protective measures the consequences of a flood exceeding this value must always be ascertained.

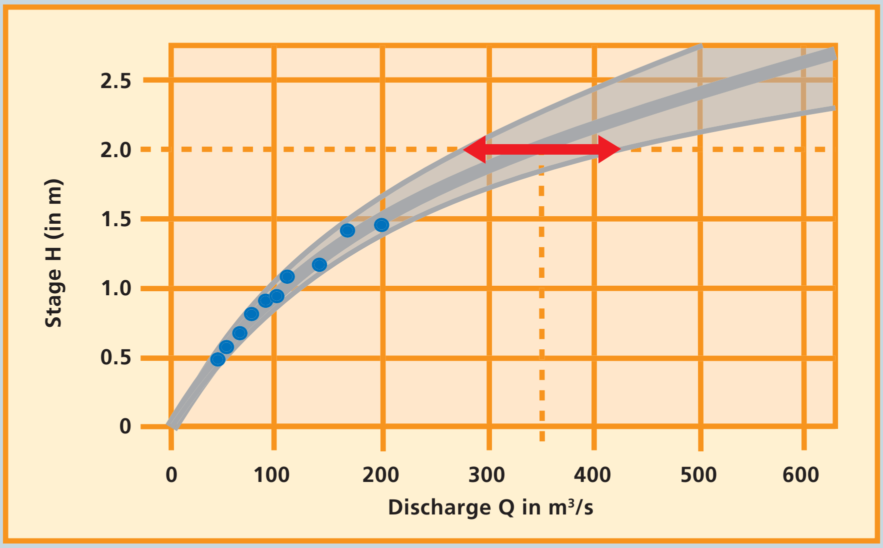
Event sediment yield

Uncertainties are already great when determining peak discharge values. They are even greater when determining sediment yields. This applies for **bed load transport** as well as assessing potential **debris flow.** A reason for these uncertainties is the lack of basic data. Yet the main reason is procedural complexity (and the great variability related to it). It is impossible to find a simple correlation between a characteristic parameter of observed debris flow and the easier-to-measure precipitation.

It is still more difficult to classify **probability of occurrence** (i.e., the possibility that such an event can occur during a certain observation period with a defined recurrence interval). Therefore, one must settle for a definition of plausible **scenarios** that can be classified qualitatively as a probability of occurrence: frequent, seldom, very seldom.

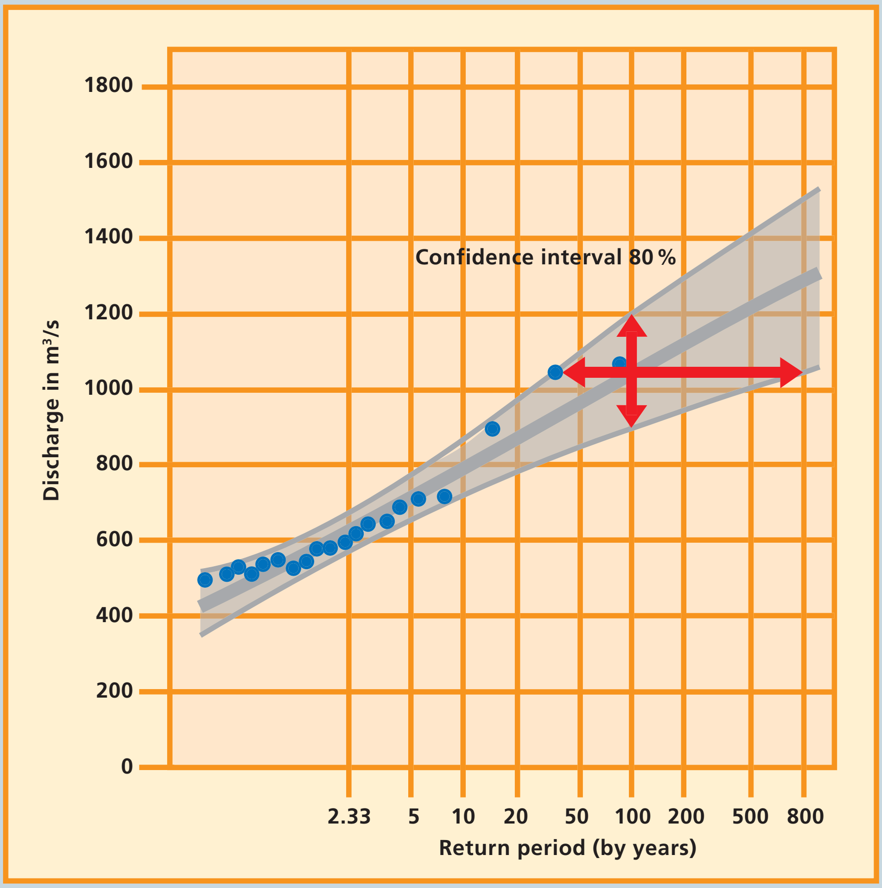
Moreover, it is practically impossible to produce a correlation between peak discharge of debris flow and its **volume.** Debris flow often occurs in surges. Model tests have also shown that addition of sediment at given velocities and channel slopes does not lead to an increase in the flow depth. It is rather the volume of debris flow that increases.

Discharge (Q) measured at varying water levels (H) can be plotted on the so-called H/Q stage-discharge correlation. The curve's imprecision rises with increasing discharge, as shown by this example of the Emme river at Burgdorf: This flood was ascertained at 350 m³/s with a confidence interval between 280 m³/s and 420 m³/s. Therefore, when determining the discharge, the margin of error for the respective water levels must be included in the indications for precision.

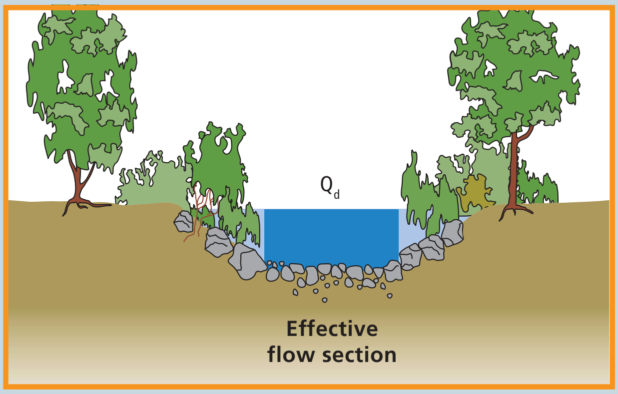


The example of the Rhone river at Sion shows how great the uncertainty in determining probability can be. A **return period** of 100 years can be attributed to the discharge of 1050 m³/s (without considering the hydropower storage impact).

Yet a confidence interval of 80 % also means that the corresponding recurrence interval can be classified as a 40-year event as well as an 800-year event. If these confidence limits are applied to discharge, the corresponding value varies between 900 m³/s and 1200 m³/s.



The mean roughness coefficient k_m in case of the simplified determination of flow capacity: $k_m = 20–25\,m^{1/3}/s$



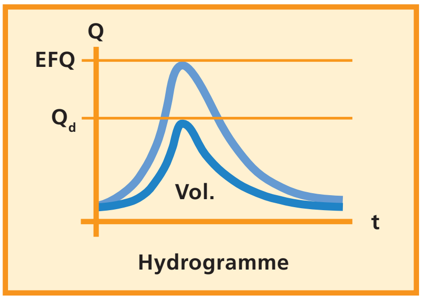
Hydraulic-Engineering Conditions

Every natural river or stream finds itself in a constant state of change. Normally, erosion occurs in the upper course, while deposition takes place in the lower course. Thus, special attention should be given to the following four points in hydraulic-engineering assessment:

- **hydrology** (discharge regime, type of flood);
- **hydraulics** (flow capacity):
- **sediment regime** (debris flow hazard, sediment yields; braiding; meander formation);
- **weak points** along the river course.

Regular checks

Hydraulic-engineering assessment allows to draw conclusions on both short-term processes during an event causing damage and long-term developments. The hazard situation can change over the course of time. This requires regular checks of the hydraulic-engineering situation.



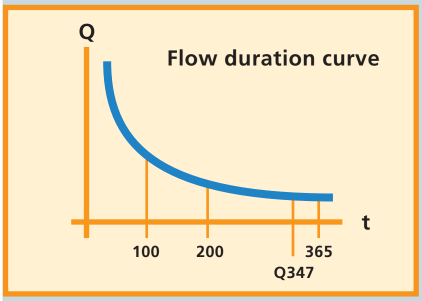
Hydrology

Hydrology records the occurrence and circulation of water resources and the water cycle at, above, and below the earth's surface (and is also concerned with water quality and material transported in the water).

In connection with flood control, the most interesting factors are potential **peak discharge** and **flow volumes.** They form a basis for assessing the degree of the existing flood protection (hydraulic basic data), evaluation of existing protective structures and the design of new structures, identifying inundation areas, investigating detention capacity, as well as assessing system behavior in case of overload (EFQ).

In recent years the methods to estimate flood discharge have been developed greatly, and old measurement records were checked for errors. Numerical methods (mathematical models and simulations) have provided a crucial contribution to this. Yet even these methods are affected with uncertainties. Therefore, flood estimates should be conducted with various methods: **sensitivity analyses** are useful, and **plausibility checks** are necessary.

Additional data are required to assess the **ecological condition** of a river or stream: flow duration curves, mean flow rates, low flow rates.



Hydraulics

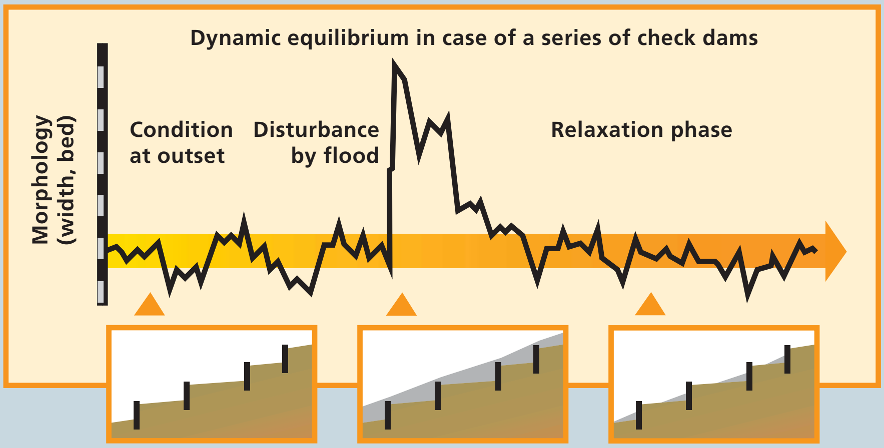
Hydraulics is concerned with the water's flow conditions and determines a **channel's flow capacity.**

The geometry of the river or stream channel (cross sections and longitudinal profile) and the dimensions of protective structures can be derived from the **design discharge Q_d.** Yet it should always be noted that rivers are **dynamic systems** that change their geometry over the course of time. The causes are varied and extend from the influence of riparian vegetation to bank and bed erosion and on to channel fills.

In case of variation of the cross section geometry or of the longitudinal profile, simple uniform flow calculations will not suffice. **Backwater curve calculations** must be made instead. The water level and energy lines are calculated systematically. In case of local problems, detailed calculations are necessary (e.g., at structures with a hydraulic effect as submersible dikes, culverts, or bridge piles).

Space-related flood danger is usually assessed by determining **inundation zones.** Various methods are available to determine this. Detailed mathematical model calculations to identify inundated surfaces require precise altitude in critical sections of between 10 and 20 cm.

Flow depths and velocity are the two determining factors for hazard assessment at a specific point. In case of complex issue formulations (e.g., for special structures), it is proper to check the hydraulics more precisely with the help of physical scale models.



Sediment regime

The destructive and at the same time formative power of water shapes a river or stream channel. On one hand, water is an effective solvent. On the other, it manages to transport weathered material and to deposit it at other points. Therefore, erosion and accumulation of **bed load** and other sediments are integrally bound to each other at any river or stream.

Flood events with a return period of two to ten years are particularly crucial for these **bed-forming processes,** which are also referred to as **morphology.** A dynamic equilibrium prevails over a longer period of time, and changes are small.

This **dynamic equilibrium** is disturbed as soon as extreme flood events induce widespread erosion and accumulation. Therefore, such processes must be taken into consideration in planning corrective measures. The most important thing to determine is whether a new equilibrium can be achieved, or if even a system collapse has occurred (or could occur).

The great significance of **sediment regime** was often neglected in hydraulic projects. Channel fill can lead to major problems – especially in case of knick points. This has proved to be case several times in recent years (e.g., at the Saltina river in Brig during 1993).

Mountain torrents (>15% slopes) are especially dangerous. Critical here is the size of the sediment potential available for **debris flow formation.**

Numerical simulation models are also available today that allow analysis of sediment transport and estimation of erosion and channel fill. These methods are usually based on data concerning bed material size distribution, channel geometry (cross section and longitudinal slope) as well as discharge hydrographs.

Scour processes in a river channel are closely linked to channel bed forms. Scours appear in river bends and confluences, at a change of bed roughness, and near special constructions such as drop structures, piles, and groynes. Quite important scour may develop in a channel with three-dimensional flow patterns and bed forms, compared to channels with nearly plane bed and one-dimensional flow conditions. New approaches allow to assess these scour depths and thus to design the foundations of bank protection works, for which this process has to be considered. Thus, morphological effects of interventions should be checked carefully at each flood-control project.

Weak points

Weak points are locations or stretches of a river course where a hazard can emerge. Classical weak points are too narrow culverts, bottlenecks, sharp curves, obstructions, or knick points in the longitudinal profile. Such weak points can be recorded and mapped in the field survey.

Scenarios are necessary to enable assessment of weak points. There are various means of recognizing them: **observations** (flood marks; remaining freeboard during a specific flood), **comparisons** (smaller culverts than upstream or downstream, **simple estimates,** and finally **numerical calculations** (e.g., for determination of flow capacity). Hence, indications on the **precision** of related assessments must always be made in the documentation.

In order to permit statements on the need for action, a periodic assessment of the protective structure's **functionality** is needed, including checking the hazard situation which has eventually changed, and also the overload case (EFQ)**.**

A databank on protective structures – a so-called **registry of protective works** – is therefore a useful aid in monitoring flood security. Good documentation also permits comparisons with earlier assessments.

Frank; RDB

Our highly networked industry, services, and leisure society is very vulnerable to disturbances that stem from uncontrolled water forces.

Types of Hazard and Influencing Factors

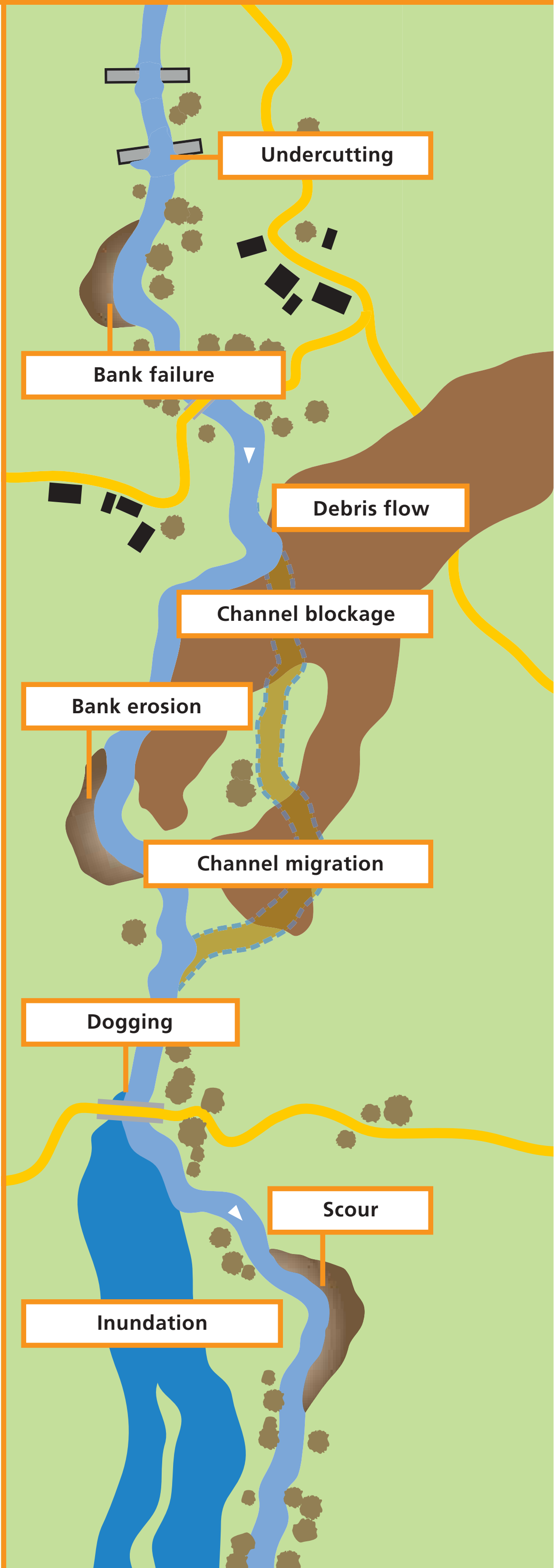
Floods repeatedly prove to be a serious hazard that cannot be averted by protective structures alone. Efforts are also necessary to prevent a continued rise in the sum of damages and to reduce the damage potential. Thus precise knowledge and correct estimates of **possible processes** take on major importance.

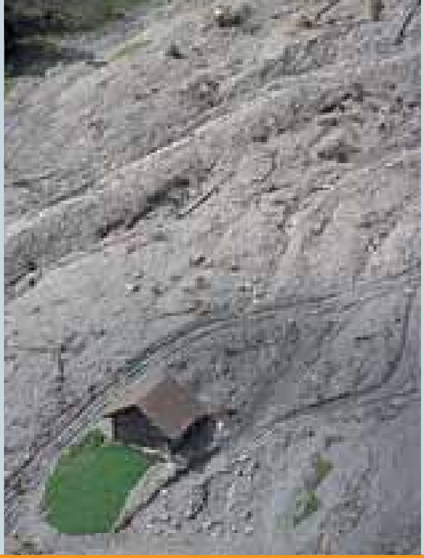
Floods are dangerous in several regards: They can overflow and damage cultivated land and structures through the sediment they transport. They can erode and thus undercut the foundations of existing structures. They can mobilize bed load and other sediment and destabilize protective structures through their dynamic impact, sweep away people and motor vehicles, and destroy buildings.

Depending on the prevailing impact of a flood, we distinguish between **inundation, bank erosion,** and **debris flow deposition.** Most events result in a **combination** of these three types of hazard. In addition, **overbank sedimentation** – i.e., a widespread sediment deposition outside the channel – often occurs. But this process is usually not entered as a hazard type in its own right, since it is always linked to a dynamic flooding.

Besides these basic types of hazard, there are other important **influencing factors:**

- **Clogging.** After avalanches, during violent winds, and in heavy storms, felled timber, driftwood, and other debris clog the flow section, especially at bottlenecks such as weirs, bridges, or ravine stretches. Behind such blockages the water level is raised. Resulting consequence: the water leaves the channel and searches for new flow outlets. If it suddenly breaks through, it may surge downstream in a dangerous gush of water (or in steep reaches, forming a debris flow containing wood and sediment).
- **Channel blockage.** Rock falls, landslides, avalanches, or debris flow can raise the bed level of a channel (or block it totally). Such blockages induce upstream flooding. For the downstream area, there is also a risk of breaking through (and a flood wave resulting with all its possible effects).
- **Dike failure by inner erosion.** If flood levels remain high for a long time, inside the dikes, seepage flow appears. Depending on permeability and homogeneity as well as on tunnels produced by roots and animals, fine-grained material along these pipes will be washed away (piping). This process can destroy older dikes, in particular, from inside (without them being overtopped).
- **Dike failure by overtopping.** Dikes can be overtopped because of a too high discharge, bed level raising, log jams, or blockages. A dike not specially protected against erosion usually does not resist for a long time against the overtopping water, what increases in a short time the danger of flooding a large surface.





BWG-OFEG (1); Frank (2); Keystone (1)

Inundation

Inundation (or flooding) describes when a land surface is **temporarily** covered with water outside the channel. Inundation is often related to other types of hazard – for instance, to bank erosion or of sediment deposition. We distinguish between two forms of inundation, which can arise in alternating form within a close distance during the same event:

- **Static inundation.** The water flows very slowly if at all in this case. The water depth increase outside the channel occurs gradually (except in field troughs). Static flooding occurs in flat fields and along lakes.
- **Dynamic inundation.** This is characterized by high flow velocity and occurs on sloped ground along mountain torrents and rivers. High dynamic stress can be expected in flat areas near bottlenecks and dike breaches.

Assessment criteria

For flooding **flow velocity** and **inundation depth** are the decisive parameters. Flow velocity normally depends directly on the slope. In case of great velocity, coarse-grained deposits are to be expected, and local erosion may occur.

Bank erosion

Erosion processes are the most damaging type of hazard in many cases, because they happen accidentally and uncontrollably.

Flowing water can erode laterally as well as vertically. Subsequently, when banks collapse or fail (bank failure), even buildings and infrastructure facilities are endangered **above** the flood level.

During extreme floods channel migration occurs, the eroded material is deposited in the immediately adjoining reach downstream.

Bed erosion, related to bank erosion, induces additional sediment input. Lowering of the bed can endanger building foundations. The determining shear stress for streambed erosion is mainly dependent on water depth and flow velocity. Local conditions – e.g., channel morphology or obstacles – can heavily influence bed shear stress. Resistance against erosion depends on bed and bank material grain size, bank vegetation as well as the types of protective structures.

Assessment criteria

The decisive assessment criteria are bank **stability** or stability of bank protections as well as **depth of erosion.**

Debris flow deposit

There are many terms for this type of hazard, but their meaning always suggests extensive amounts of debris shifted by great volumes of water in pulses. The **sediment concentration** amounts to between 30 and 70 %.

Debris flows are not triggered by accident. If the related topographic, geomorphologic, and geologic conditions are fulfilled, unstable material can liquefy in storms, during strong rain, or in case of snow melt. This surges into the valley as a mixture of water, silt, sand, and stones interspersed with boulders weighing tons and uprooted trees. And, depending on its composition, this occurs at a velocity of up to 60 km/h.

Part of the material relocated is often deposited at the side as **levees.** Yet damage occurs mainly because of the dynamic impact of the **debris flow front,** which may contain large boulders.

Assessment criteria

The dynamic impact of debris flows is usually estimated by observing the **height of deposits** and the **superelevation in curves** (as an index of flow velocity).

The actual degree of flood hazard can be derived from working and planning tools that are by now used routinely. **Hazard index maps** provide a first rough estimate on the hazardous situation; **intensity maps** show overflow depths and flow velocities; **hazard maps** form the technical basis for drafting community use plans (local planning).

Assessing Hazards

Correctly recognizing and estimating the types of hazard existing and their influencing factors is of central importance. In order to make statements about them, the following questions in particular must be answered in connection with flood hazards:

• How large is the channel's flow capacity (with and without sediment)?

• Where can water and sediment escape out of the stream or river channel – and how much?

• Where and to what degree are erosion and deposition possible?

• Where will material be eroded or deposited from debris flow and how much?

• Are there bottlenecks and obstacles in the channel?

• Do existing protective measures influence the course of potential processes?

• Where can potential weak points be identified at protective structures?

• Is it conceivable that a global climate change affects events and must be considered?

Recommended reading

PLANAT (2000): Empfehlungen zur Qualitätssicherung bei der Beurteilung von Naturgefahren im Sinne der Wald- und Wasserbaugesetzgebung [Recommendations on Quality Assurance in Assessing Natural Hazards as Envisioned in Forestry and Hydraulic Engineering Legislation]

Overall observation

Without assessing the entire river system (i.e., the interactions between the **upper, middle, and lower reach** of a stream or river) these questions cannot be answered. Therefore, it is vital that all potential processes that define a potential hazard area be elucidated.

Proven experts carry out hazard assessments, and cantonal natural-hazard services are responsible for a correct technical execution.

Many basic data must be gathered and assessed, because preparing hazard index maps and hazard maps requires the involvement of all available references and information on the proven, assumed, and potential processes in a certain area:

• **Proven process.** An event that is documented.

• **Assumed process.** An event that cannot be verified at the considered location but has occurred in comparable hazard areas.

• **Potential process.** An event that overall assessment shows could occur in a very specific catchment area.

Scenarios

The chronological course of an event may be of decisive importance. Finally, the assessment of potential **weak points** in the system is particularly significant. They can lead to a collapse and hence to completely different behavior.

The potential processes are often interdependent and occur in combination. Therefore, in assessing them, it is recommended that specific hazard situations – so-called scenarios – be developed. Such scenarios can be compared with load assumptions in structural engineering. Yet it is relatively simple there to determine uniformly defined standard load cases. In case of natural hazards the starting point is more complex.

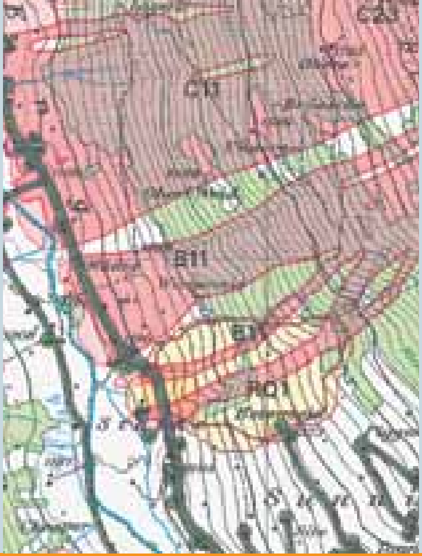
Given the diversity of conditions in nature (among them the topographic and geological conditions) and potential changes during a process under way, **reactions** always occur in the river system in question. At a minimum the assessment of potential hazards should be developed through two **main scenarios** with different recurrence intervals:

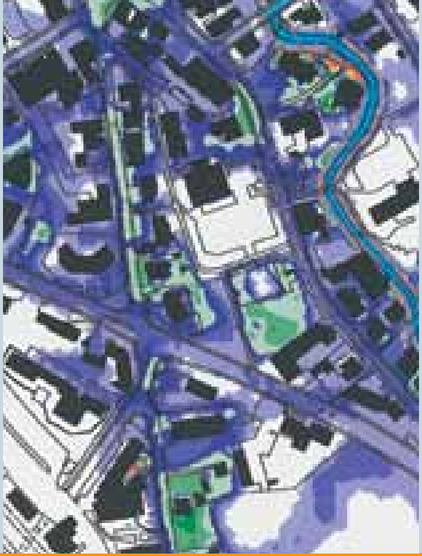
• For **settlement areas,** a flood event with a recurrence interval of Q_{100} to Q_{300} should be used (conservatively selected Q_{100}).

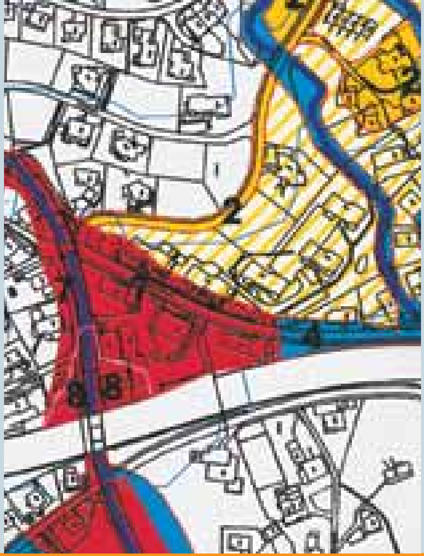
• Another scenario should consider an **extreme flood event** (EFQ). This is a significantly greater event than used for design. Yet no unrealistic scenario should be developed (i.e., in general there should not be cumulative consideration and superposition of independent events).

Ability for dialog

The scenarios chosen must also be explained to the public affected by the hazard assessment and the protective measures related to it. Therefore, the scenarios must be transparent and understandable. Coordinating and exchanging information must also be ensured among specialists and the authorities.







Hazard index map

Hazard index maps provide an overview of the hazard situation. They provide a comprehensive record of where natural hazards must be taken into account and which ones. Potential **points of conflict** can easily be derived from this. In case of flood hazards the extension of the inundated area is presented for the EFQ. Related priorities can be set, and areas free of conflict can be defined at the same time.

Purpose: Basic document for a structure plan.

Content: Rough overview of the hazardous situation; data on types of hazards (usually without indicating degrees of danger); general definition of the areas concerned.

Depth of detail: Little.

Scale: 1:10 000 to 1:50 000

Checking: Periodically within the structure plan framework.

Intensity map

The intensity map provides the extension of the overflow area, the overflow depth, the flow velocity, as well as the direction of flow in a specific scenario. This information can be used in many ways. Security measures for buildings and facilities (conditions for building permits, measures for object protection) can be derived from flow depths and flow velocities.

Purpose: Basic document for emergency planning, for planning measures, and for developing a hazard map.

Depth of detail: Requires hydraulic calculations and detailed topography.

Scale: Analogous to hazard maps.

Hazard map

Hazard maps form the technical basis for considering the natural hazards when developing municipality land-use plans (local planning). They are also of importance for use in planning and ordering of object protection measures (and other measures to reduce damage). Hazard maps contain data on causes, course, intensity, impact areas, and probability of natural hazards occurring in a precisely defined area. The depth of detail is correspondingly high.

Purpose: Serves as synthesis map of all natural hazards, providing basics for adjusted land-use planning (local planning) with a precision corresponding to a **plot size.**

Content: Precise data on types of hazards, spatial range, and degree of danger; detailed documentation.

Scale: 1:2000 to 1:10 000

Checking: Periodically in connection with land-use planning.

		Important for:		
	Application	**Project author**	**Officials**	**Population**
Hazard index maps	**Perimeter**	❑	■	■
	Sensitizing	❑	■	■
	Points of conflict	❑	■	❑
	Structure planning	■	■	❑
Intensity maps	**Design of protective structures**	■	❑	❑
	Conditions for building permit	■	■	■
Hazard maps	**Structure planning**	■	■	❑
	Land-use planning	■	■	■
	Conditions for building permit	❑	■	■

■ **important** ❑ **less important**

	Hazard level	Material importance	Importance for land-use planning
	Red	Substantial danger	Prohibition area
	Blue	Medium danger	Conditional-use area
	Yellow	Low danger	Index zone
	Yellow-white	Remaining danger	Index zone
	White	No danger*	No restrictions*

*According to current knowledge

Graphical Presentation of Hazards

Based on the "Guidelines for considering avalanche hazards in land-use activities" available since 1984, **standardized diagrams showing hazard levels** were also developed for floods and land-mass movements. They were made public with related recommendations.

Standardized classification
Dangers posed by all natural hazards are presented in terms of the intensity and probability (frequency or return period). These parameters are compiled by graduated levels of danger in a so-called intensity/probability diagram color-coded with red, blue, and yellow:

• **Red = substantial danger.** Basically, no structures or facilities may be built or expanded that serve for shelter of human beings or animals. In case of existing buildings, risks should be minimized and security measures should be improved by renovations or when a change in use occurs.

• **Blue = medium danger.** Structures are permitted under certain conditions. These should be indicated in the building and zoning regulations according to the type of hazard.

• **Yellow = low danger.** Landowners are made aware of the existing danger and measures to prevent damage. Planning on special measures is required for sensitive objects.

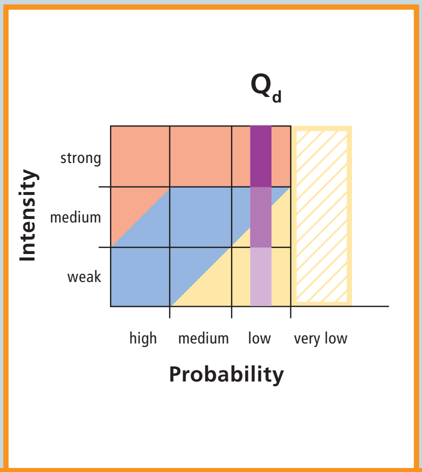
• In case of **flood control,** the hazard situation is also investigated for very rare events (to clarify remaining dangers or risks). The surfaces affected are represented in **cross-hatched yellow-white.**

• **White = no danger** according to current knowledge.

Levels of danger
The levels of danger are chosen so that they can be linked to a special type of behavior or use regulation. They show the degree by which people, animals, and things of considerable material value are endangered. It is taken into account here that safety of human lives is usually much higher inside buildings than in open fields.
The damage impact of the hazard is described for every type of hazard and level of danger. The levels of danger are basically determined separately for each **type of hazard.** In case several types of hazard threatened a surface – e.g., flooding and debris flow – this condition is shown in suitable form on the hazard map. The **highest level of danger** is decisive in each case.
In general, no upgrading to a higher level occurs in case of an overlap by several types of danger, since measures can be taken against each individual danger to avoid damage.

Procedure
Practical implementation of the corresponding assessment diagram in connection with planning corrective measures also shows a few special situations in the flood control sector. Thus, major uncertainties exist in assessing the **probability of occurrence.** Therefore, historic (observed) events and the quality of basic data must also be considered. If a planning of measures is introduced, a need for action has normally been demonstrated (or has been recognized, at minimum).
If the current hazard situation has not been assessed and presented, this must be done promptly (assessing **outset** and **extreme situations** according to illustrations on facing page). In this phase already one must also consider the possible limits of flood protection (choice of design parameters).
Knowledge of **remaining risks** for an extreme event is indispensable, whether during planning of measures to minimize remaining risks (optimizing project effectiveness), preparing a hazard map, or analyzing weak points (collapse of building structures), protection concepts, and emergency planning.

Recommended reading
BWW/BRP/BUWAL (1997 recommendations): Berücksichtigung der Hochwassergefahren bei raumwirksamen Tätigkeiten [Considering Flood Hazards in Regard to Activities with an Impact on Land Use]
BRP/BWW/BUWAL (1997 recommendations): Berücksichtigung der Massenbewegungsgefahren bei raumwirksamen Tätigkeiten [Considering Mass-Movement Hazards in Regard to Activities with an Impact on Land Use]

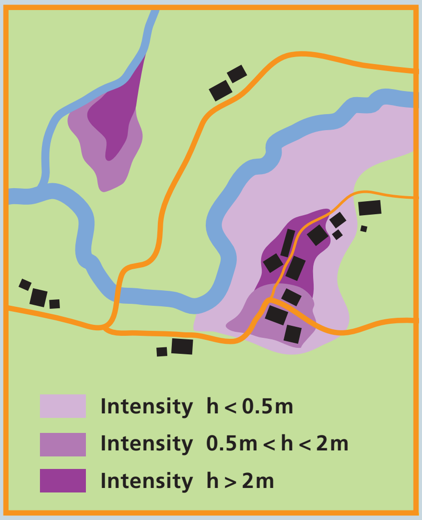


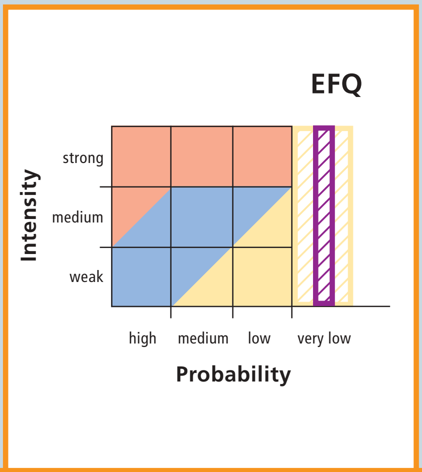
Outset situation

Analysis of hazard situation for a rare event. Floods between Q_{100} and Q_{300} qualify as rare events. This corresponds to the frequently used protection objective for enclosed settlements. In many cases one cannot avoid considering important historic events also, when setting design values (Q_d), and thus taking into account the natural uncertainties.

The river's flow capacity should already be known when setting this **scenario.** Moreover, besides the flood peaks, it is also important to know water outflow volumes and the total volume of debris flow.

The result of this check, based on the corresponding scenarios, provides the extension of endangered surfaces. In addition, in each case we recommend determining the surfaces threatened by high intensity. Other areas affected are represented by one- or two-color gradations.



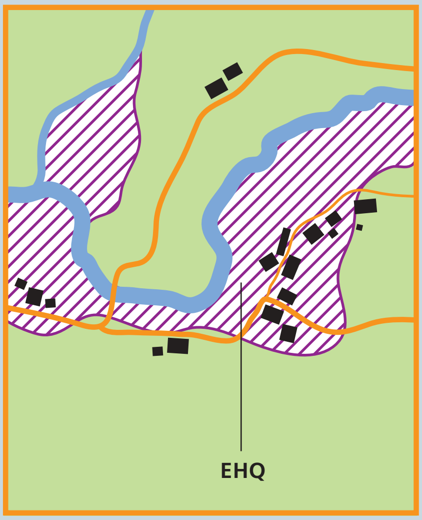


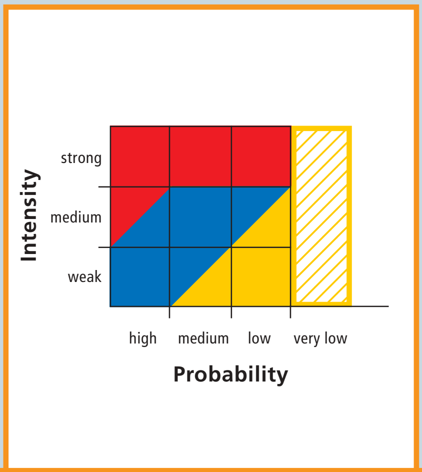
Extreme situation

Determining the remaining risks in an extreme event. To analyze EFQ, events should be used that represent an important additional stress for the system studied. In general, values derived from the 100-year event can be used for these studies.

Multiplication factors of 1.3 to 1.5 times the Q_{100} are used for flood peaks. For example, in the case of the Reuss in Uri canton, a value of 1.5 was derived from plausibility consideration of possible events. Comparable factors were also considered expedient and suitable for the system in the Rhone's case.

In keeping with the uncertainties, higher security factors up to about 2 are appropriate for **smaller catchments** (for comparison: a security factor of 2.25 is required for reservoir dam security). Added surfaces affected by an extreme event are represented by cross-hatching.





Hazard map

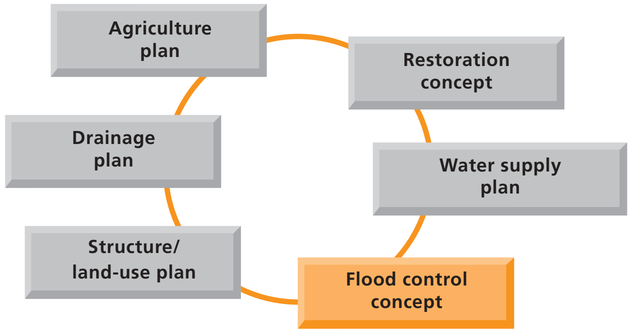
Preparing a complete hazard map. If the problems can be solved with land-use planning measures alone, or if structural measures cannot be realized in the short term, a complete hazard map must be prepared for the current danger situation. This means that the affected surfaces must be studied to find if, in case of more frequent events (e.g., Q_{30}), added **red** (prohibited) and **blue** (conditional use) as well as **yellow** (index) areas should be defined.

In each case a **complete hazard map** should be prepared and implemented for land-use planning covering the conditions after realizing the related structural measures.

Measures

A flood control concept should involve an integrated plan for protective measures. It usually includes a package of measures that cover proper maintenance, cultivation of protective forests, land-use planning measures, object protection, construction measures, emergency planning, and emergency organization.

Integrated planning for protective measures



Desair

Order of Priorities

There are two basically different routes for action in planning flood control measures:

• **Passive measures** in endangered areas that adapt present or planned land use to the danger (and thus to reduce the damage potential).

• **Active measures** at the hazard's source and/or in endangered areas that reduce the existing danger in accord with present or planned use (and thus decrease the hazard potential).

Prevention has priority

The issue of what measures to take in specific cases is often controversial. The related fundamentals are actually set unmistakably, and this applies not only to the flood control law (WBG) but to laws on land-use planning (RPG) and forestry (WaG) as well. They unanimously demand that protection against natural hazards occurs mainly through **preventive measures:**

• **Appropriate maintenance of river and streams.** Maintain flow capacity and the efficiency of existing structural protective measures.

• **Protective forest cultivation.** Now, as before, one of the most reasonably priced measures to defend against natural hazards (above all in cases of avalanches and rockslides).

• **Land-use planning measures.** Avoidance of hazardous areas, object protection, and establishment of no-build zones and inundation surfaces can limit or even prevent an increase in damage potential. Local land-use and landscape planning that takes natural hazards seriously and designates space for extraordinary events is preferred as a precautionary step to building and maintaining costly protective structures to secure settlements or infrastructure facilities.

Material constraints

However, intensive building development during recent decades and related land-use pressure have created protection deficits in many areas that can no longer be corrected by maintenance and planning measures alone. Therefore, **protective structures** and object protections (permanent or temporary) and other technical measures at rivers and streams will also be necessary in the future.

However, planning such measures presumes thorough and demonstrated knowledge of the existing types of hazards and the measures' ability to influence them as well as the buildings' susceptibility to damage. The measures carried out should respect as far as possible the natural character of the river and landscape protection goals. Even emergency interventions following sustained damage may not disregard this principle, at least over the long term.

Residual risks

Each and every item cannot be protected. On the other hand, **cantonal and local authorities** must do their best to make the population secure. There will only be a viable way out of this obvious dilemma if future actions not only defend against natural hazards but also accept **certain risks** and factor them into the equation. This pushes two questions into the forefront: What protection may be offered (and at what price)? And how great can the remaining risk be that it may be acceptable?

Security can be guaranteed **most economically** if natural hazards are avoided and risks are not taken at all. This principle is anything else than new. Our forefathers obeyed it, even if possibly out of fatalism. Generally they had no other option than to bow to the dictates of natural hazards. Now, at the beginning of a new millennium, this familiar adaptation strategy has regained its meaning, since the rising demands for protection can no longer be complied with through technical measures alone. Usage must again adapt more closely to the natural situation (and not the reverse).

Recommended reading

PLANAT (1998): Von der Gefahrenabwehr zur Risikokultur [From Defending against Danger to the Risk Culture]

Appropriate maintenance covers all periodic works required to assure a minimum flow profile for a flood. Maintenance also prevents occurrence of damage to the stream channel protection structures and obviates the need for major renovation work.

Appropriate Maintenance

Standards of how stream and river channels should be maintained can differ quite strikingly. The challenge within this area of conflict between wishes and real possibilities is to find a workable solution. For the days are long past when flood control consisted in preventing overflow out of a river channel at any price. Instead, protection of local sites and landscapes as well as preserving or restoring habitats for animals and plants must also be taken into account. Therefore, appropriate maintenance of rivers and streams places priority on other measures, above all:

- First, it guarantees the long-term functioning of existing protective structures.
- Second, it assures the needed flow section for a flood.
- Third, it contributes to maintaining and improving habitats in and along rivers.

Permanent task

Appropriate maintenance of a river or stream is a permanent task that the **cantons** regulate, finance, and monitor as required by their laws.

The type, scope, and frequency of maintenance depend on the **type of river** and local conditions. The spectrum of possible measures is correspondingly broad. It covers clearing of bushes and trees that reduce the flow section and endanger existing protection structures. It also includes removal of driftwood and dangerous channel fill, repairing minor damage at the channel, regular emptying of sediment detention basins, as well as restoring riparian vegetation. The following points should be given special attention when carrying out these measures:

- All maintenance work should be performed in agreement with property owners, specialized cantonal offices, and services for **nature protection and fisheries.**
- During clearing for soil bioengineering measures and new plantings, cooperation with the **forestry** services and technical offices are necessary and useful.
- Maintenance and restoration of **structural variety** are important goals of appropriate maintenance. This includes channel diversity with varying flow conditions, variable bank slopes, and a rich variety of bank vegetation which, however, must correspond to the specific location. Yet natural development of different plant and animal communities – the so-called **succession** – should also definitely be considered.
- Soil bioengineering techniques that use **living plants** as construction materials should be preferred. If "hard" measures remain necessary, natural stones should be used so that at least small animals and plants can settle in the gaps.
- But even the best intentions are worthless if they are **not implemented.** This only succeeds if all involved are convinced of the plan. It should also be noted here that water pollution and water turbidity should be avoided.

Maintenance concept

Planning appropriate maintenance must be integrated in the flood control concept, because it can immediately influence the choice of corrective measures (e.g., building a sediment detention basin). Yet this planning also allows making a distinction between building and maintenance measures and assures that future maintenance measures be carried out expediently.

Therefore, it is wise to develop a maintenance concept for the river or stream. It lays down general goals and provides information on the following issues:

- Who monitors the river and checks related bank protection works and protective structures?
- At what time interval do these check-ups and investigations occur?
- Who assumes the maintenance duties?
- When should the related maintenance tasks be conducted?
- When are further structural or technical measures necessary?

Recommended reading

BWW (1993): Ingenieurbiologische Bauweisen [Soil Bioengineering Techniques]

Various cantonal offices (e.g., those of Aargau, Berne, and Zurich cantons) have published guidelines on appropriate maintenance of rivers and streams.

Frank; Isenring


Weed out
channel bed


Cultivate
bank vegetation
Plant riparian
vegetation
Maintain
bank slopes
Manage
sediment
Repair
minor damage
Empty sediment
detention basins

Root stumps, wooden debris resulting from avalanches, timber, bushes, shrubs, and trees swept away by floods often lead to blockages with severe consequences at bottlenecks. The subsequent backwater effect leads to uncontrollable overflows. The potential input of wooden debris is difficult to quantify and depends on the condition of the forest, on input by affluents, and on debris already lying in the channel.

Forestry Aspects

When snow melts or after heavy rainfall, mountain torrents swell up rapidly. They undercut banks, entrain earth, sand and stones, leave the streambed, and relocate transported bed load to other points. Especially dangerous debris flow can also be triggered in sediment-loaden torrents.

Maintenance of protective forests

Stable forest stock – structured like a mosaic by age, height of trees, and species – offers good and cost-effective protection against the power of natural processes. But these forests must be cared for constantly, so that they can fulfil their protective function in a sustained manner.

Depending on the natural hazards threatening at a given location, an ideal protective forest has to fulfil very specific requirements. Closed forests with deeply rooted trees in the catchment of the torrent in question protect against the hazards of **torrents** and formation of **debris flow:**

- Treetops hold back precipitation and evaporate part of it in the atmosphere (interception).
- Soil enmeshed with roots soaks up precipitation like a sponge and gives it back only very gradually.
- Tree roots reinforce the earth, stabilize stream banks, and retain potential bed load and other sediment.
- Trees and tree trunks in deceleration and deposition zones of debris flow act as natural brakes.

Clearing in case of restoration projects

Cultivation of forest areas located close to streams and rivers is also a constant task, as for those near torrents. But if these rivers or streams are granted more freedom of motion in connection with restoration projects, it can lead to erosion of the neighboring forested areas.

This raises the issue of diverting forest land from its proper use (clearing permit consistent with forest law). Plans that restore the **natural dynamics** of a river are not diversions from proper use. Therefore, they require no clearing permit – always assuming that the following conditions are fulfilled:

- Interventions are limited to the natural river zone.
- No other uses are allowed within the river zone defined (e.g., camping grounds, motocross tracks, parking lots).
- Within the defined river zone, developing potential forest locations are left to natural succession (in agreement with possibly existing forest development plans).

➜ **http://www.wsl.ch/hazards**

Frank; Weissmann-Zeh

Alluvial Zones

Alluvial zones are dynamic habitats that are periodically or episodically flooded by water (and in which the groundwater level periodically is at the elevation of as far as the roots of plant life). Moreover, erosion and deposition play a major role in these habitats. Vegetation is influenced by the resettlement, aging, and coexistence of various development stages. Floods are no problem for alluvial zones. On the contrary, floods help their regeneration:

- The dynamics of water and the sediment transport invigorates the alluvial forest.
- Floods increase the biodiversity, since newly created gravel bars and deposits become the habitats of pioneer vegetation.
- Floods change the relief and create new flow routes that contribute to the survival of these valuable ecosystems.

Points to note in case of intervention

After an extraordinary flood event, it may nevertheless be necessary to take immediate structural action to protect the surrounding area. In such a case, the following principles should be observed:

- Before carrying out emergency measures, an agreement with the responsible cantonal authorities or the federal alluvial zones advice center is absolutely necessary.
- Dikes, groynes, embankment backfill, or canalization, by which the alluvial zone could be separated from the main channel, are not permitted. They influence alluvial dynamics and water regime in the alluvial zone.
- Lowering the groundwater level and the drying related to it must be avoided.
- When removing material and installing initializing channels (pilot canals), take care that it does not lead to lowering the channel bed and thus to drying of the alluvial zone.
- Excess material should be deposited outside the alluvial zone.
- After an extraordinary event, special attention has to be given to flora and fauna still present.

Exploit opportunities

Opportunities that arise with floods should be exploited in alluvial zones. If possible, the new channel conditions should remain, because improving the alluvial dynamics is usually desirable.

Therefore, after extraordinary events, there is also a possibility of setting up protective structures outside the alluvial area (to allow the waterway greater freedom).

If existing structures or infrastructures are threatened, their removal from the hazard zone should be examined.

Recommended reading

BUWAL (1995): Vollzugshilfe zur Auenverordnung [Implementation Regarding the Ordinance on Alluvial Zones]

Hazard index maps or hazard maps only reveal their full impact if they are also implemented in the related cantonal and local planning tools. There are two relevant levels for action: **structural planning** at the cantonal level and **land-use planning** at the municipality level. Specific details and legally binding phrasing are set at these levels to guarantee proper consideration of natural hazards in general and flood hazards specifically. The goal is to identify **legally binding hazard zones** (or equivalent legal implementation).

Land-Use Planning Measures

Despite all difficulties that a densely settled and intensively used living area like Switzerland presents in this regard, the damage potential should usually be reduced by land-use planning measures. Only when a land use worth preserving exists or when, after **weighing all interests,** a land-use change is absolutely necessary, should structural and technical measures reduce the hazard potential.

The following land-use planning measures contribute to flood prevention:

- Considering **endangered areas** in the cantonal structure plan and in municipality land-use plans (local planning).
- Identifying **river space** in the cantonal structure plan and in the community land-use plans (local planning).
- Defining **off-limits zones** (floodways) or **inundation zones** in the cantonal structure plan and in the community land-use plan (local planning).
- **Excluding or rezoning** endangered land use from recognized hazard areas.
- Introducing **restrictions** for construction permits and demanding object protection for existing and planned objects in endangered areas.

Structure plan

The structure plan paraphrases the activities required to realize the spatial development sought, and it sets the framework for mutual agreement **binding on the authorities.**

Formally, the structure plan consists of **map and text.** One has to be restricted in the map to a rough summary of the hazardous areas at the outset situation. The major weight for natural hazards in the structure plan lies in the text. This text should give an overview of basic studies already available and those being carried out (concept of hazard maps). It should also expound principles to protect against natural hazards and list measures needed, including the affected specialized offices. Hence the structure plan assumes the following tasks in the natural hazards area:

- **Early recognition** of potential conflicts between land uses and natural hazards as well as identifying the specialized offices to call in.
- Giving an **overview** of basic studies already available and those still to be formulated regarding natural hazards (e.g., preparing hazard maps, coordinated plans for various sorts of hazards).
- Formulating cantonal **principles** to protect against natural hazards.
- Setting **guidelines** and tasks for the next planning stage, especially for municipality land-use planning (defining hazard zones).

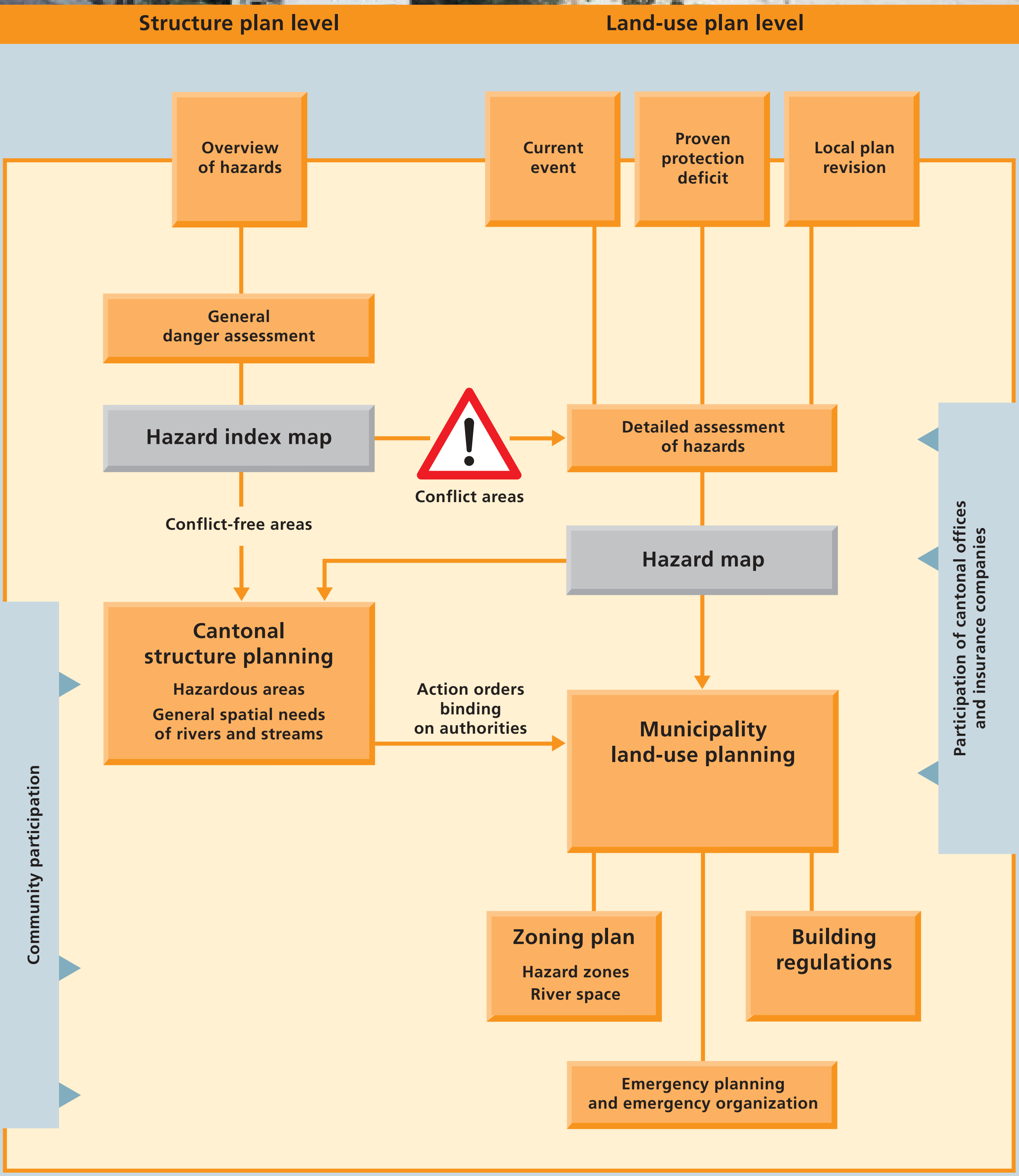
Land-use plan

The land-use plan lays down permissible land use regarding purpose, location, and amount, is detailed down to the plot size and is thus **binding on property owners.**

According to Article 18 of the Federal Law on Land-Use Planning (RPG), cantonal planning law can envision other land-use zones beside construction, farming, and protection zones. Based on this legal foundation, for example, **hazard zones** can be defined that overlap the other uses.

Yet it is also possible that the various uses relate to the hazardous situation defined or are restricted in the definition (positive or negative planning).

The corresponding levels of danger were agreed to primarily after regarding the consequences of **structural use**. Hazards to people and animals should be avoided, and material damage ought to be kept as low as possible. The same requirements concerning levels of danger for structures apply in **farming zones** as in construction zones. **Alarm and evacuation zones** (emergency planning) should be defined for all hazardous areas.


Structure plan level
Land-use plan level
Overview of hazards
Current event
Proven protection deficit
Local plan revision
General danger assessment
Hazard index map
Conflict areas
Detailed assessment of hazards
Conflict-free areas
Hazard map
Cantonal structure planning
Hazardous areas
General spatial needs of rivers and streams
Action orders binding on authorities
Municipality land-use planning
Participation of cantonal offices and insurance companies
Community participation
Zoning plan
Hazard zones
River space
Building regulations
Emergency planning and emergency organization

Experiences from the 1987 flood of the Reuss in Uri canton led to a protection concept defining **off-limits space (see illustrations below):** From a Q_{50} level a flood can overtop the dike at the right bank and flow on the A2 motorway. But another protective dike along the motorway confines the overflow area, and a new culvert inserted in a transverse embankment prevents a backwater effect towards the plain area. Yet during an extreme event even the motorway does not suffice as a spillway channel. Then secondary dikes prevent overflow into the nearby settlement areas.

Off-Limits Zones

If inundation zones were not developed or used intensively, floods could overflow the banks freely without causing damage. Yet such off-limits zones have become extremely rare in Switzerland. But there are still areas where no great damage potential exists – and where no costly structural flood control steps are necessary.
Land-use planning measures should help continue to make such space available to overcome **major floods.**

Limited space
If a floodplain is to be kept off limits, it must be spatially defined in advance. Outlining this area's dimensions occurs through hydraulic calculations and assessment of past events. However, due to intensive use of practically all river valleys, the areas still remaining free are not unlimited considering **extreme events.**
If the remaining risks are to be mastered as well as possible, we recommend that areas left open to uncontrolled flooding be intentionally limited by secondary dams, topographical adjustments along roads and railway lines, or by local terrain remodeling to create **floodways:**
• First, steps must be taken to prevent uncontrolled dike breaks for canalized rivers. Special spillway structures should be foreseen for this. Submersible dikes and fuse plugs are also conceivable.
• When designing the channel the possibility exists to raise one dike to a higher level than the other and thus prevent overtopping there.
• The intensively used area of the valley's plain is protected by secondary dikes along the main river and related adjustments of the road level in case of underpasses.

Flood control at the Reuss river
Inundation zone at a 50-year event.

Overflow area at a 100-year event: Motorway as flood spillway.

Overflow area at an extreme event (greater than 1987).

Luftbild Schweiz

Object Protection

All potentially endangered areas in which a new or changed structure use is envisioned, after weighing all interests, must consider existing hazards by concrete **construction permit restriction.**

This object protection* can be guaranteed by permanent or temporary arrangements – or a combination of these measures (whereby warning times and availability of those responsible must also be considered):

- Design for foundations and other exposed parts of buildings in accordance with potential load (e.g., by scour protection at the foundations).
- Build structures on supports, walls, embankments, or provide dikes or protection walls.
- Seal structural casing and select water-repellent materials to build floors, walls, and roofs.
- Elevate ground floors, entryways (even those in shelters), or garage entrances.
- Secure drinking water and electrical supply against flood influences by well-chosen routing of line wiring and piping.
- Anchor oil tanks and protect sewers against backwater effects by automatic gates or manual valves.
- Bolt openings such as light wells, doors, or windows with protective shields.
- Include emergency escapes in plans and guarantee their permanent access.

Debris flow

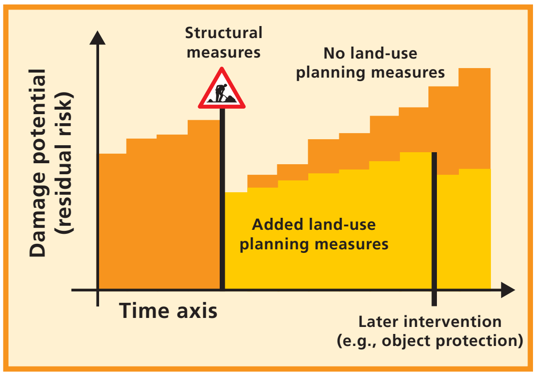
Particularly dangerous processes include debris flow as well as spitting mudflows and superficial landslides often occurring during storms. In cases of major Alpine debris flow, fairly often sediment volumes attaining several hundred thousand cubic meters are transported to the valleys, and the debris flow can attain a velocity of 60 km/h or more.

Even these natural hazards can be reacted to – at least to a certain degree – through related **construction permit restrictions:**

- Adapt structures to the terrain and adapt building shape to possible pressures.
- Lay down use of interior space in keeping with the danger of debris flow at hand.
- Give special attention to the location and elevation of doors, windows, or garage entrances.
- Reinforce outer walls, and protect openings.
- Place structures on embankment terrain (above all in case of new buildings, as such structures are among the most reasonably priced and most effective corrective measures).
- Embank detention dams to protect against minor debris.
- Build diversion walls or diversion dikes.
- Set up split structures upstream of buildings and pylons.

* Building insurance companies also give information concerning object protection measures.

Limits of Efficiency. Structural and technical protective measures reduce the original risk to a certain residual risk. But if the settlement area is expanded, streets or other infrastructures are built within the area secured by protective structural measures, the residual risk can soon be higher than the original risk. Land-use planning measures (and targeted intervention as with object protection) can stabilize the damage potential over the long term.



Protective Structures

The spectrum of proven structural protective measures is great, and a **combination** of corrective measures is usually required. The table on the facing page shows a compilation of conceivable corrective measures.

A few of these protective structures – ones that correspond especially well to the principles set forth in these guidelines – are explained in greater detail on the following pages. Further details can be retrieved on the **FOWG website.**

Demands on protective structures

Structural measures are only justified where proper maintenance of existing protective structures, land-use planning efforts, object protection, as well as protective forest cultivation do not lead to the goal. If structural measures are still needed, they must fulfill the following basic requirements:

• There is no such thing as a standard stream or standard river. Depending on the catchment, geological conditions, local water regime, neighboring land use, and character of the surrounding landscape, different design options also open up in **defining structural measures.**

• Protective structures must always be considered in terms of how they **combine** with the river and its catchment – and thus the possible types of hazard and influence factors.

• The impact of structural measures on the **lower course** must also be clarified very precisely.

• Protective measures may not lead to an increase in potential damage in case design values are exceeded. Thus, the impact of an **overload** should be clarified within project design (and the proper measures possible to limit damage should also be indicated).

• **Impact factors** must be studied in case of protective structure overload (EFQ). Indication should also be given which suitable measures (on construction or object protection) are possible to limit damage and increase system security.

• If protective structures are destroyed, the **reason for failure** should always be analyzed. It should also be determined if it makes sense to **rebuild** them at all.

• Besides improving flood control, **environmental aspects** must also be considered: The natural dynamics should be favored, the landscape be revalued, and networking of the habitats be promoted.

• Wherever natural dynamics must be restricted, ongoing study should occur on how sufficient flood control can be achieved with soil **bioengineering measures.**

• Special attention should be given to the measures' **long-term effect.**

Note on limitations

Structural protection measures have stood in the foreground for a long time in planning corrective measures. Meanwhile things have changed, because this approach in defending against hazards must cope with several limitations at the same time:

• **Technical limitations.** Even costly protective structures will never be able to achieve absolute protection from the natural hazards.

• **Ecological limitations.** Structural intervention often contradicts efforts to impact the least in natural and nearly natural landscapes.

• **Economic limitations.** In view of the frequently overextended financial situation in the public sector, planning, implementation, and even maintenance of costly protective structures can no longer be taken for granted.

• **Efficiency limitations.** The expectation of being armed by protective structures against the power of nature leads in many areas to a disastrous concentration of values. This in turn increases demands for protection.

➜ http://www.bwg.admin.ch/

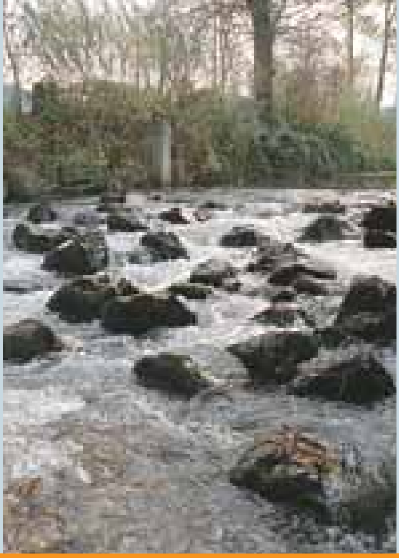
Protective measures / Processes	Flooding	Bed erosion	Bank erosion	Undercutting	Channel migration	Bed load transport	Channel fill	Clogging	Debris flow	Landslide
Measures at upper course										
Detention measures										
Inundation zones; off-limits areas	■	■	■			■				
Flood detention basins	■	■	■			■				
Stabilization measures										
Anchoring									■	■
Drainage									■	■
Structural measures at river channel										
Increasing flow capacity										
Clearing	■									
Flood protection dike; submersible dike	■									
Channel improvement	■	■								
Bridge sheeting; vertical-lift bridge	■					■	■	■	■	
Stabilizing										
Block ramp (ground sill)		■		■						
Placing of blocks		■		■						
Channel widening		■				■				
Sill		■	■	■						
Check dam; torrent check dam		■	■	■		■				
Stabilizing cross section										
Groyne			■	■	■					
Sidewall; riprap			■	■	■					
Soil bioengineering protection			■		■					
Sediment management										
Grid	■							■	■	
Debris flow breaker									■	
Sediment detention basin	■					■	■	■	■	
Sediment management	■					■	■			
Object protection										
Object protection against floods	■		■	■						
Object protection against debris flow									■	■

■ Important connection (influence)

Construction Methods

The spectrum of proved structural protective measures is great. Five examples are explained in closer detail here. It is an intentional selection of **sustainable protective structures.** Their purpose and function is introduced and their advantages and disadvantages are shown (based on experience in recent years).

Groynes are an example of this. They are a well-known structural measure in protective hydraulic engineering. Yet new methods caused them to fall into oblivion. In the meantime, however, they have experienced a renaissance, since they have some advantages over linear bank protection works.



Block ramps

Purpose. Block ramps, also referred to as ground sills, permit the channel bed to be stabilized artificially along the longitudinal profile (checkpoint).

Function. One can overcome a major head by placing coarse blocks (dense packing block by block or by leaving gaps). Various flow conditions develop, depending on the head difference that must be overcome. Uniform flow (an equilibrium situation) will occur if the ramp is long enough.

Advantages / disadvantages. Block ramps allow designing a checkpoint in a more natural way. The longitudinal water network can be assured. Ramps can adapt to practically all channel sizes (step-pool systems). Ramps also improve free migration of aquatic animals (fish, macroinvertebrates).

Submersible dikes

Purpose. Dikes purposely designed to permit overflow or lateral weirs evacuate flood peaks that exceed the flow capacity of the canalized channel. These relief measures serve as "security vents" to protect dike stretches which are not designed for overflow.

Function. A lowered local dike crest – and in this case one protected against erosion – is the main element of these structural measures. Another option is to set up a local fuse plug with an erodable dike part (the dike remains stable up to a certain discharge, overtopping then results in erosion down to a predetermined elevation). Submersible dikes can be fairly long, because the specific discharge spilled amounts to a maximum of 1 m^3/s per meter. However, the overflow length can be reduced by local narrowing of the river's cross section. This can also improve flow conditions and assure smooth functioning. In any case, the performance of submersible dams must be examined for an extreme flood (EFQ).

Advantages / disadvantages. Submersible dikes do not reduce security in flow corridors. Normally the discharge spill is reduced, because the entire dike cannot be destroyed. Yet the lateral overflow function is complex and sometimes quite difficult to master. Long structures are needed for larger overflow discharges. Under certain conditions even several overflow sections should be provided for stability reasons. Lateral spill influences bed load transport. This can induce bed level changes and lead to altered overflow conditions.

AGW (1), Documenta Natura (1), Elber (1), Frank (2)

Channel widening

Purpose. Channel widening stabilizes thebed level and improves its structural diversity as well as that of the transition zone between river and land. This is because channel widening is a measure favoring natural conditions in the river and particularly on channel morphology. Application range for channel widening are midland rivers with a sufficiently large bed load transport rate.

Function. The transport capacity of the waterway is reduced by widening, which leads to local deposits. By a slope increase in the widened reach, the original transport capacity will be reestablished in a natural way. Yet a rising of the upstream channel bed level is the consequence.

Advantages / disadvantages. Widening a channel induces bed structures close to nature. Changed flow conditions alter the flow stress on the banks. Widening leads to locally increased energy slopes and thus to higher flow velocities. This must be considered in designing bank protection measures.

Groynes

Purpose. Groynes are structures that are placed more or less at right angles to the main-flow direction and protect the banks of a stream or river against erosion. They can be used to influence flow and to improve structural diversity.

Function. On the one hand, they serve to protect the bank from erosion (spur dikes keep the main flow of a river from the bank). On the other hand, they improve the structure and increase flow diversity. The depth of discharge in the middle area between the spur dikes is elevated by the narrowed cross section, and this strengthens its ability to transport). In general, discharge depth increases in comparison to a cross section without spur dikes.

Advantages / disadvantages. Groynes are very adaptable if built in a flexible style. Supplements and reinforcements are possible at any time. Besides functioning as bank protection, the groyne offers habitats for aquatic fauna and increases biodiversity significantly. In dynamic rivers with rapidly changing channel morphology, groynes must cope with all possible flow conditions. Therefore, in case meanders shift, groynes must be arranged at shorter distances than at morphologically stable sections of a river. Protective concepts with groynes require more space but favor more diverse bank areas. They have several advantages over linear bank security:

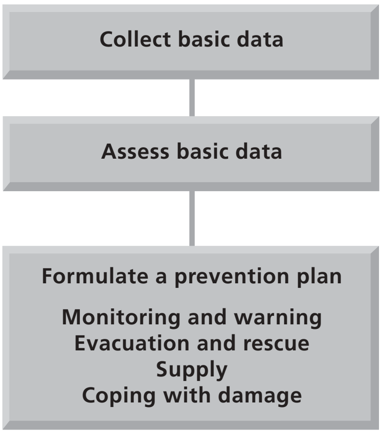
- the impact is locally limited;
- they integrate themselves into the landscape;
- their flexibility is greater in case of overload;
- they can adapt easier to changed conditions;
- they improve structural diversity.

Debris flow breakers

Purpose. These protective structures can force debris flow to be diverted into suitable areas with little damage potential. Hence, settlement areas often lying on the alluvial fan can be protected.

Function. The debris flow is drained by permeable elements of a debris flow breaker. As a result, the debris flow loses an essential driving element and deposits its load. A debris flow breaker allows to stop the first debris flow surge. Depending on the structure's arrangement, the following surges are diverted to lateral deposition areas. A massive diverting structure can intentionally divert debris flow to a preferred deposit area. In this regard, the high dynamics of a debris surge must be considered. A diversion structure should allow minor floods carrying bed load to pass, and diversion should only be activated in case of debris flow. A diversion structure consists of a lateral overflow weir and a diversion facility. The structures are laid out for rare events.

Advantages / disadvantages. Channel improvement designed for debris flow on an alluvial fan can lead to disproportionate structures and impacts. This can be avoided with punctual measures in the headwaters. Impact on landscape is local for debris flow breakers or diversion structures.. There are still few design rules for structures that can influence debris flow behavior. They are often based values gained by experience (from Japanese grids or debris flow breakers in Austria) but also on model testing.



Emergency Planning

There is no absolute protection against floods and the hazards related to them. Violent waters hold a **hazardous potential** that is neither totally comprehensible nor fully controllable. Extreme or long-lasting precipitation can turn streams and rivers in any part of the country into raging floodwaters, trigger debris flow, or activate landslides.

Thus, flood waters rising to extraordinarily high levels repeatedly prove themselves to be serious threats that can indeed be reduced and limited by proper maintenance, planning measures, and protective structures. Yet they can never be turned away entirely. Moreover, it cannot be forgotten that any hydrologic calculation is afflicted with certain uncertainties. Even properly defined design values accepted by all can be exceeded in the **extreme case.**

Hence, emergency planning is necessary in any case that can reduce the **risk that always remains** to an acceptable level. The highest priority is given saving people and livestock as well as limiting collateral damage (e.g., from hazardous goods or chemical plants).

There is always a remaining risk

Frank

Manage prevention

It is crucial that the responsible local or regional authorities are aware of the flood hazards looming. Given the preparedness called for, the effects of flood events can at least be reduced. In connection with planning measures, these principles on conditions in the respective catchment are surveyed and assessed. In a second step, the results will be integrated into a comprehensive **prevention plan.**

The municipalities will be supported in this important work by the cantonal specialist offices and – in case of major plans – also by the federal government's specialist offices. It is useful to create potential synergies with existing organizations and facilities (e.g., in connection with early alarms). There is no standard solution for assessing the remaining risks. Any flood catchment has **its own characteristics** that are determined by local topography, geology, hydrology, topsoil, and land use.

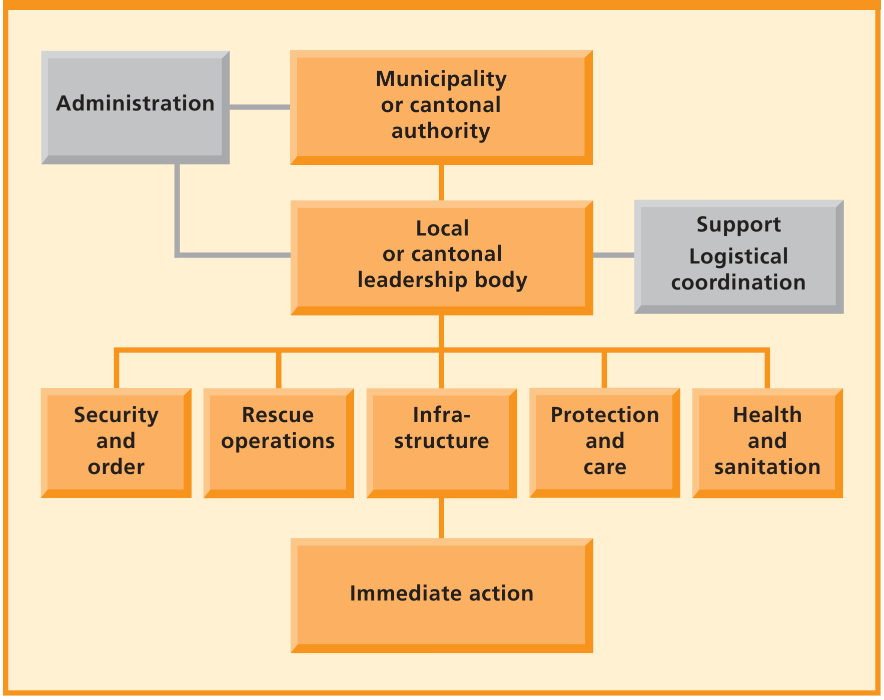
The major responsibility for emergency planning and organization lies within the **municipalities.** There are no standard solutions. A flood is only one of a series of possible emergencies caused by natural hazards.

Emergency Organization

A clearly structured emergency organization with **assigned task areas** and **related action plans** is a central assumption in coping with an emergency caused by flooding or other natural or man-made hazards. But this organization is only useful if it can assume its tasks without delay. The following areas must be covered in this regard:

- **Warning.** Hazardous developments must be recognized promptly in order to orient the local people, to alarm the emergency services, and to take immediate action.
- **Countermeasures.** In certain cases, action can be taken to prevent flooding if potential events are recognized early (e.g., by clearing the river channel of wooden debris transported by avalanches or floating debris in general, by reinforcing dikes, or building mobile dikes).
- **Special risks.** Objects with major damage potential (e.g., hospitals, homes, cultural objects, petrol stations, chemical storage sites, supply facilities, switchboards or communications centers) require a special "flood action plan" so that damage can be prevented effectively.
- **Salvage operations.** Eventual victims should be salvaged, transported to secure areas, and treated medically.
- **Evacuation.** If a flood cannot be prevented or is a serious threat, people must be brought to secure areas and treated. Under certain conditions valuable items should also be removed from the hazardous area. However, it is not easy to determine the right moment for such measures. In principle, one strives for an early moment, but the problem of possible false alarms also arises.

An emergency organization's task areas



- **Infrastructure.** Machines and materials for immediate emergency action must remain prepared to keep transport routes open and to ensure access to the area affected.
- **Monitoring.** Weather and events in the catchment should be monitored constantly to support salvage and clearing work.
- **Communication.** Related devices must not only function in an emergency but be available at the right locations.
- **Object protection.** Individual houses and limited areas can be protected from floods by temporary measures (e.g., sandbag barriers, mobile walls, or – if time permits – even walls).
- **Partners.** Cooperation with the emergency organizations of neighboring communities should be part of the preparation and training plans.

➜ Appendix: Checklists

Appendix

TERMDAT definition	Legal reference	Source
Alarm. Warning the public of danger or a threat by a signal (usually a siren).	Creation and operation of early-warning services	WBV 24, 27 I f.
Bank. Side part of the channel.	Protection of habitats for fish Fishery permit for intrusions (esp. bank clearing) Bank design	BGF 7 BGF 8 I, IIIc WBG 4
Bank vegetation. All plant life at the bank of a river.	General protection; active promotion Special permit restricted to facilities for local use according to WBG and GSchG	NHG 21 NHG 22 II
Biotope	Protection of indigenous animal and plant types Differing degrees of protection Substitution in case of unavoidable intrusion Biotope of national, regional, or local importance; ecological balance Federal subsidies	NHG 18 ff. NHV 14 ff. NHG 18 I bis NHG 18 II ter NHG 18a, b NHG 18c
Discharge. Water volume that flows through a specific channel cross section per unit of time.	Discharge capacity by maintaining rivers or streams, banks, and flood control structures; also in forestry stream training Responsibility: cantons	WBG 4 I WaG 19 WBV 23
Dispossession	Dispossession of rights necessary for WBG/WBV implementation; cantonal authority or that it confers on third parties; applicable law	WBG 17
Downstream riparians. People or objects found downstream from a certain point of a river or stream.	Coordination in case of intercantonal rivers or streams	WBG 5
Environmental impact study	Before planning, construction, change of facilities designated by the Federal Council Environmental compatibility report	USG 9 I, II UVPV Appendix 30.2
Financial aid	Federal subsidies for restoring strained rivers, without legal claim	WBG 7, 9 f. WBV 5 ff.
Flood control. All measures to protect people and things of high value from damage by water, especially from floods, erosion, and sediment deposition.	Protection of people and things of high value from damage by water; defining protection goals and protective measures in isolated cases	WBG 1 I
Gravel mining	Permit according to water quality control law and fishery law Groundwater protection zones	GSchG 44 I BGF 8 III g GSchG 44 II
Groundwater. Underground water network that fills out hollow spaces of the earth's crust.	Groundwater protection zones; groundwater area	GSchG 20 f.
Hazard index map. Overview map that is compiled by scientific criteria and identifies hazards that are recognized and localized but not analyzed and assessed in detail.	Basis for structure plan giving rough recognition of conflicting interest area in case no hazard map is available.	WBV 21
Hazard map. Map at scale of 1:2000 to 1:10 000 compiled according to scientific criteria and within detailed forecasts of a study perimeter made on types of hazards, degrees of hazards, and spatial extent of hazard processes.	Basis for structure and land-use planning as well as for projecting protective measures	WBV 21 WBV 27 I c

Frank

Dictionary on flood control terminology

These guidelines contain an abundance of specialized expressions from various sectors of flood control. In order to simplify understanding and prevent possible misunderstanding, the FOWG has cooperated with the federal chancellery's terminology section for several years to compile a four-language dictionary with emphasis on the flood control, hydraulics, hydrology, geomorphology, and natural-hazards sectors. This work covers more than 800 entries with about 1500 definitions in English, German, French, and Italian.

The dictionary is on **TERMDAT,** the central **terminology databank of the federal administration,** and is already accessible to all public services in Switzerland via Intranet or Internet (KOMB/KTV). The terminology section of the Federal Chancellery will answer further questions on access to TERMDAT.

Interested parties with no access to the federal administration's Intranet can use the European Union's terminology databank dictionary via **EURODICAUTOM.**

INTRANET

➜ http://termdat.bk.admin.ch

INTERNET

➜ http://europa.eu.int/eurodicautom

Glossary

TERMDAT definition	Legal reference	Source
Hazard zone. An area under threats by natural hazards, where land-use restrictions apply binding on property owners according to a hazards analysis.	Area with land-use restrictions Land-use prohibitions	RPG 18 WBV 1II
Inventory	Area of nature and homeland protection/federal inventory with objects of national significance: seek (mandatory) expert opinions by Swiss Federal Commission on Protection of Nature and Homeland (ENHK) in case of possible damage	NHG 5 ff. NHG 18a NHG 23a ff.
Land-use plan. Plan that defines permitted use of land regarding purpose, location, and dimensions **detailed to the plot size** and **binding on property owners.**	Organizes permitted use of land (e.g., building, agriculture, protected zones) Building permit within construction zone Special permit outside it; only if restricted to location and no overriding public interest opposes it; binding on property owners	RPG 14 ff. RPG 22 RPG 24 RPG 21
Maintenance. All measures to maintain discharge capacity and effectiveness of protective structures.	Priority flood control measure Securing existing flood protection Consideration of ecological requirements	WBG 3 I WBG 4 I WBV 23
Moor and moor landscapes	General protection, restricted landscape design and land use, protection goals according to federal law, protection and maintenance measures of the cantons; federal subsidies	NHG 23a ff. NHV 21a ff.
Payment	Legal claim to federal subsidies for structural measures, restoration of structures and facilities, hazard registers and hazard maps, gauging stations, early-warning services	WBG 6, 8 ff. WBV 1–4, 8 ff. SuG
Permit	Building permit within building zone Special permit outside building zone Construction of / changes in structures and facilities in especially endangered water protection zones Water diversion from rivers and streams Special permit for ecological design of hydraulic measures Special permit for laying streams into culverts Mining sand, gravel, or other material Fishery permit for technical impacts on rivers Special permit to remove bank vegetation Special permit for forest clearing Training of rivers and streams	RPG 22 RPG 24 GSchG 19 II GSchG 29 WBG 4 III GSchG 28 III GSchG 38 GSchG 44 BGF 8 NHG 22 II WaG 5 GSchG 37
Procedure	Subsidy procedure Federal opinion on cantonal flood control measures FOWG opinion on measures by other federal offices with impact on flood control	WBV 3–15 WBV 16 f. WBV 18
Protective measures. Measures to reduce or remove a risk, distinguished by active and passive protective measures: **active protective measures** counteract the natural event to reduce the danger or to have an essential influence on the course of an event or its probability of occurring; **passive protective measures** reduce damage without influencing the course of the event.	Priorities: maintenance and spatial planning measures (passive measures) Requirements Intercantonal rivers; coordination	WBG 3 WBG 4 WBG 5

TERMDAT definition	Legal reference	Source
Public procurement	Federal government: federal law on public procurement, free access to the market in keeping with domestic law	BGBM 1 ff., 6
	Cantons: official publication of plans and criteria, financial participation and added charges	BGBM 5 II
	Adjustment of cantonal regulations to domestic market law	BGBM 11
	Intercantonal agreement on procurement procedures	
Public planning restrictions	According to cantonal procedural law	
	When building/changing a structure/facility with coordination needs	RPG 25a II b
	When fulfilling federal task in area of nature or homeland protection	NHV 3
Responsibility for rivers or streams	Cantons or, according to cantonal law, cooperatives or the private sector; the Federal Council's decision-making authority in case of intercantonal waterways if no agreement can be reached between the cantons affected	WBG 5 II
Restoration to nature. All measures with which landscapes or landscape elements changed by human influence (e.g., rivers or streams) are restored to a condition close to nature.	In case of hydraulic-engineering impacts on rivers	WBG 4 II
	Federal subsidies	WBG 7, 9 f.
Right of appeal	Responsible in sectors of nature and landscape protection: federal offices, cantons, municipalities, all-Switzerland environmental organizations (designated by the Federal Council)	USG 55 ff. NHG 12–12b
	Opening of availability in written announcement, in federal register, or in bulletins published by cantons	NHG 12a I
Settlement/Compensation	Advantages/disadvantages of property restrictions due to planning as per RPG	RPG 5
Spatial planning. Anticipated coordination of space-impact activities and their steerage over a longer period.	Structure plan (binding on authorities to coordinate space-impact activities) and land-use plan (property owners bound to provide specifics of structure plan)	RPG 6 ff. RPG 14 ff.
	Planning principles	RPG 3
	Spatial planning measures: in hydraulic-engineering, they take priority over structural measures	WBG 3
Structure plan. Plan that paraphrases activities required to realize the spatial order sought after and defines the framework for mutual agreement which is **binding on authorities.**	Harmonizes space-impact activities; shows the development to strive for, the time sequence, and the resources to be used	RPG 8, RPV 5
	Binding on authorities	RPG 9
Third parties (special advantages)	Cost-sharing in case of federal subsidies	SuG 10 II a WBV 8c

Legal Basis

Federal Law on Public Procurement

Intercantonal Agreement on Public Procurement

BGBM Federal Law on the Domestic Market

BGF Federal Law on Fisheries

GSchG Federal Law on Water Quality Control

NHG Federal Law on Protection of Nature and Landscape

NHV Ordinance on Protection of Nature and Landscape

RPG Federal Law on Land-use Planning

RPV Ordinance on Land-use Planning

LwG Federal Law on Agriculture

ÖQV Ordinance on Ecological Quality

SuG Federal Law on Financial Aid and Payments

USG Federal Law on Environmental Protection

UVPV Ordinance on Environmental Impact Testing

WaG Federal Law on the Forests

WBG Federal Law on Flood Control

WBV Ordinance on Flood Control

Federal laws on the Internet

➜ http://www.admin.ch/

Checklists

Technical report

	Contents	Available: yes	no
	Summary	❑	❑
1	**Occasion and task**	❑	❑
2	**Situation at outset**		
	Historic events (chronicles; event documentation)	❑	❑
	Existing or planned land use	❑	❑
	Characteristics in catchment area	❑	❑
	Hydrologic conditions	❑	❑
	Current channel flow capacity	❑	❑
	Geologic conditions	❑	❑
	Potential types of hazards (processes):		
	• Floods	❑	❑
	• Bank erosion	❑	❑
	• Debris flow deposit	❑	❑
	Scenarios	❑	❑
	Assessment of existing protective structures	❑	❑
	Analysis of weak points along rivers	❑	❑
	Existing hazards situation	❑	❑
	River condition	❑	❑
3	**Project assumptions**		
	Selected protection goals	❑	❑
	Ecological development goals	❑	❑
	Defined design values	❑	❑
4	**Potential damage**		
	Assessment of potential damage	❑	❑
5	**Planning corrective measures**		
	Option studies and decisions	❑	❑
	Maintenance measures	❑	❑
	Spatial planning measures	❑	❑
	Structural measure:		
	• Description of measures including technical justification and evidence (especially **hydraulic assumptions** and evidence)	❑	❑
	• Weighing of interests	❑	❑
6	**Impact of corrective measures**		
	Impact on settlements and land-use surfaces	❑	❑
	Impact on nature and the landscape	❑	❑
	Impact on river ecology and fisheries	❑	❑
	Impact on groundwater	❑	❑
	Impact on agriculture	❑	❑
7	**Remaining hazards and risks**	❑	❑
8	**Implementing action on remaining hazards into structure and land-use plans**	❑	❑
9	**Emergency planning**	❑	❑

Project file on applications for federal (FOWG) subsidies

	Content	Available: yes	no
1	**Technical report** (see opposite page)	❑	❑
2	**Cost estimate**		
	Construction costs (based on budgetary estimate and unit prices for construction work; main items)	❑	❑
	Project and building management costs	❑	❑
	Costs of land procurement	❑	❑
	Contingency costs (list separately)	❑	❑
3	**Plans**		
3.1	**Oversight plans 1:10 000 to 1:50 000**		
	Construction plan	❑	❑
	Subcatchment areas	❑	❑
	Possible precipitation measuring stations	❑	❑
	Possible discharge measuring stations	❑	❑
	Waterway names	❑	❑
	Realized protective structures and secured stretches	❑	❑
	Presentation of existing hazards	❑	❑
3.2	**Situation plan 1:1000 to 1:2000**		
	Measures envisioned	❑	❑
	Top priority points (bridges, buildings)	❑	❑
	Existing and planned vegetation	❑	❑
3.3	**Longitudinal profile**		
	Flood level / energy line for Q_d and EFQ	❑	❑
	Low water level	❑	❑
	Bed level at outset	❑	❑
	Mean project bed level	❑	❑
	Slope	❑	❑
	Possible exploration	❑	❑
	Possible sediment removal points	❑	❑
	Bridges, sills, ramps	❑	❑
	Weirs, rock outcrops	❑	❑
3.4	**Technical cross section** (pre- and post-renovation)		
	Water levels Q_d and EFQ	❑	❑
	Low water level	❑	❑
	Property borders	❑	❑
3.5	**Normal profiles and design profiles**		
	Water levels	❑	❑
	Low water level	❑	❑
	Bank protection	❑	❑
	Streambed protection	❑	❑
	Design and planting	❑	❑
3.6	**Photo documentation**	❑	❑
4	**Accompanying cantonal reports**		
	Water protection and groundwater conditions	❑	❑
	Nature and landscape protection	❑	❑
	River ecology and fisheries	❑	❑
	Forest (in case of clearing)	❑	❑
	Agriculture	❑	❑
	Spatial planning	❑	❑
5	**Environmental impact report**		
	Plans requiring **environmental impact studies** must include a separate report on environmental effects and be opened to a public hearing.	❑	❑
6	**Cantonal decisions**		
	Legally binding decision (for all permits granted)	❑	❑
	Funding key and cost participation	❑	❑
	Perimeter duties of federal government and its agencies	❑	❑

In case of applications for subsidies, the basic data must be compiled in a **project file** to enable comprehensive assessment of the plan with all its decisive impact factors. This project file usually corresponds to the publicly advertised building project.

In connection with flood control measures and plans, environmental impact studies are compulsory for:

- Structures to regulate water level or discharge from natural lakes exceeding 0,5 km² of average lake surface.
- Hydraulic-engineering measures such as river training, canalization, diking, corrections, or sediment and flood detention facilities at a budgetary estimate of more than CHF 15 million.
- Debris dump in lakes covering areas of more than 10 000 m³.
- Mining more than 50 000 m³ of gravel, sand, and other materials from rivers per year (excluding one-time removal for flood security reasons).

Procedure: All four cases to decide by the cantonal right .

Emergency planning: Gathering and assessing basic data

Each catchment indicates specific characteristics for flood formation. Depending on these specifics, a range of hazard criteria results:

• **Winter floods.** Indicated (usually) by slowly flowing flood waves and relatively **long-lasting flood situations.** Bed load transport problems seldom reach major proportions.

• **Summer floods.** They result from intensive rains or hailstorms and are characterized by brief but **high-peak discharges.** In small catchments one must reckon with inundation or even destruction of stream channels as well as flooded landscapes, not to mention structures and infrastructure facilities. **Great volumes of sediments** can accumulate as a result of hill slope and riverbed erosion.

The **hazardous potential** in a flood situation is especially high at the following points:

- in river channels with insufficient capacity;
- in damaged channels;
- at channel bottlenecks;
- along possible channel alternative routes such as roadways or railway tracks;
- in terrain depressions;
- at artificial barriers formed by houses or embankments;
- at knick points in longitudinal profile.

Hazardous situations

❑ Analyze historic sources
❑ Assess event register
❑ Assess hazard maps if available
❑ Note technical studies with local reference
❑ Assess current observations

Meteorological constellations

❑ Snow situations
❑ Thunderstorm situations
❑ Soil saturation by precipitation

Topography and ground cover

❑ Steepness and form of catchment
❑ Proportions of meadows, forest, developed areas, cliffs, glaciers, lakes
❑ Possibilities of infiltrating precipitation
❑ Natural and artificial barriers

Conditions in catchment area

❑ Sediment potential available in catchment (danger of debris flow)
❑ Sediment potential available along river channels (danger of channel debris flows and intensive bed load transport)
❑ Condition of vegetation (ground cover influences runoff of rainwater)
❑ Soil condition (has a significant impact on extent of surface runoffs)

Condition of the river channel

❑ Degree of river training
❑ Flow capacity of the trained river
❑ Stability of training works
❑ Damage to channel bank and bed
❑ Reduction of flow sections because of growing vegetation or sediment deposits
❑ Bottlenecks (bridges, culverts, covered sections such as timber depots)
❑ Mass accumulation in sediment detention basins
❑ Loose wood in streambed area (danger of clogging or damages)

Endangered buildings

❑ Sensitivity to structural damage (openings, materials, supply facilities, institutions)
❑ Earlier cases of damage

Endangered human beings

❑ Jobs in potential flood areas
❑ Jobs in potential landslide areas
❑ Residential population in potential flood areas
❑ Residential population in potential landslide areas

Endangered infrastructures in the catchment area

❑ Road connections
❑ Railway lines
❑ Electricity power plants
❑ Gas and water supply facilities
❑ Telephone exchanges
❑ Transmitting facilities

Emergency planning: Pecautionary plan elements

- ❑ **Early-warning systems.** Set up permanent or situation-related early-warning systems. This permits timely and targeted use of precautionary measures.

- ❑ **Machines and material.** Dredgers, transport vehicles, compressors, pumps, emergency power-generating sets, and tools must be available in case of catastrophes. Under certain conditions, reserve equipment from other communities or regions are also used.

- ❑ **Communication.** Local and regional communication systems are conceived so that they cannot be put out of service by floods or related events. If the facilities on hand do not suffice, preparations should be made for radios, megaphones, mobile transmitters, and communication equipment outside the hazard zone.

- ❑ **Road and railway connections.** Check in advance if settled areas can be cut off from the outside world by floods or related events. If so, **reserve equipment** should be prepared for the first-aid teams, military service, and civil defense as well as building materials (e.g., wood for emergency bridges) and, if necessary, machines and tools as well.

- ❑ **Medical care.** Rescue**,** transport, and care of casualties must be assured. A related concept must be prepared with appropriate specialists and institutions, to the extent that cantonal or local organizations and institutions cannot provide the necessary infrastructure.

- ❑ **Evacuation.** Prepare emergency housing and care options.

- ❑ **Aid.** Various offices at the federal, cantonal, and also local level are in a position to perform direct or indirect aid in emergencies. Therefore, offices responsible for overcoming an extraordinary situation should inform themselves and study documents in advance on the following questions:
  - ❑ What institutions or organizations can provide any form of aid and to what extent?
  - ❑ Who are the responsible contact people, and what are their **current** telephone numbers?
  - ❑ What costs would arise, and how are the procedures?
  - ❑ Who is responsible for distributing donations?

- ❑ **Weather conditions.** Organize weather observation and set up the related alarm concept, because weather changes endanger all people who are engaged in post-event clearing and security work.

- ❑ **Work on the crisis team.** The following strategy has proved itself in crisis situations:
  - ❑ Settle issues with authorities in advance regarding monitoring, alarms, as well as organizational and structural arrangements.
  - ❑ Assure smooth information flow.
  - ❑ Submit reports briefly and to the point.
  - ❑ Inform the public promptly, fully, and regularly on the course and consequences of damage events.
  - ❑ Summon the courage to make decisions (and also to implement them in a timely manner).

Outside assistance

Personal help
Use of outside assistance (e.g., members of the military, of civil defense, of volunteers) can hardly be defined in advance. Each damage event has its own individual demands to cope with.

Financial aid
In case of a flood, the federal, cantonal, and – in case related contacts have been finalized – insurance companies provide contributions to cover damages. Where cantonal insurance on house property exists, comprehensive and unlimited insurance automatically covers elementary damage of buildings. Advance research should determine items left uncovered in such an event. Alternative financial options to cover these remaining costs should be sought in the prevention phase.

Cooperation of the authorities
The federal and cantonal governments are in the position to support communities with appropriate contributions – and in catastrophic cases usually with extraordinary contributions as well. So that these funds can also flow, regulations call for responsible offices being contacted even in the first phase of coping with the catastrophe (and that work be arranged with the cantonal and/or federal offices).

Each damage event has a special character and must therefore be coped with individually. A **precautionary plan** serves in this case as a basis and guiding principle.

Contact

Specialized offices of the Federal Administration

➜ http://www.bwg.admin.ch

Federal Office for Water and Geology (FOWG)
Division of Natural Hazards Mitigation
Ländtestrasse 20
CH-2501 Biel

National Hydrological Survey
Papiermühlestrasse 172
CH-3003 Berne

➜ http://www.planat.ch

PLANAT Secretariat
Ländtestrasse 20
CH-2501 Biel

➜ http://www.umwelt-schweiz.ch

Swiss Agency for the Environment, Forests and Landscape
Papiermühlestrasse 172
CH-3003 Berne

➜ http://www.raumentwicklung.admin.ch

Federal Office for Spatial Development
Einsteinstrasse 2
CH-3003 Berne

➜ http://www.blw.admin.ch

Federal Office of Agriculture
Mattenhofstrasse 5
CH-3003 Berne

➜ http://www.astra.admin.ch

Swiss Federal Roads Authority
Worblentalstrasse 68
CH-3003 Berne

➜ http://www.kultur-schweiz.admin.ch

Federal Office of Culture
Section for Preservation of Culture
Hallwylstrasse 15
CH-3003 Berne