Natural hazards

Recommendations

Consideration of Flood Hazards for Activities with Spatial Impact

Version PDF

Bundesamt für Wasserwirtschaft (BWW)
Federal Office for Water Management

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Foreword

The new federal laws relating to hydraulic engineering and forestry make it obligatory for the cantons to prepare hazard maps, and to take these into account in their activities with spatial impact. The present publication makes recommendations for the fulfilment of these tasks. It is addressed both to **specialists** of the Confederation, cantons and communes responsible for assessing flood hazards and for protection measures, and to the **political bodies** in taking decisions on activities with spatial impact. The publication is also addressed to those **landowners** needing information on the hazards affecting their property.
The present recommendations were prepared by an interdisciplinary panel led by the “Bundesamt für Wasserwirtschaft” (federal office for water management). The panel included representatives of the “Bundesamt für Wasserwirtschaft”, the “Bundesamt für Umwelt, Wald und Landschaft”, and the “Bundesamt für Raumplanung” (the federal offices for water management, for environment, forests and landscape, and for spatial planning), together with representatives of the cantons, and specialists from the hydraulic engineering, earth sciences, technology and insurance sectors.
In spatial planning, all natural hazards must be documented to the same standard. The content of the present recommendations corresponds to that of the “Richtlinien zur Berücksichtigung der Lawinengefahr bei raumwirksamen Tätigkeiten” (recommendations on the consideration of avalanche hazards for activities with spatial impact, Bundesamt für Forstwesen, 1984). Comparable recommendations are in preparation for mass movements. The present recommendations must be adhered to in preparing and implementing hazard maps.

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Contents

Introduction: Hazard maps, the foundation for planning measures

Hydraulic-engineering measures reduce the hazard potential, spatial planning meausures reduce the damage potential.

Measures that have proved their value in the past are not necessarily applicable today. It is certainly true that the centuries-old efforts to combat flood hazards, primarily by more-or-less comprehensive protective structures, have had a decisive influence on the economic development of wide parts of the country. Indeed, without them, some areas could not have been developed at all. However, the extensive damage that occurred in the wake of the heavy storms in 1987 and 1993 has clearly demonstrated that this approach is not a panacea. This is because both the demand for protection and the damage potential are increasing at such a pace that protective structures in themselves are insufficient to counteract the danger. As an old adage has it, land use should be chosen to suit the prevailing circumstances.

Despite the many difficulties that present themselves in this respect in a densely populated and intensively exploited region such as Switzerland, the above principle leads to the realisation that the hazard potential must be reduced in the first instance by **spatial planning measures.** Hydraulic-engineering measures should be applied only after careful consideration of all aspects where uses requiring protection are already in place or where new, more vulnerable, uses are unavoidable. The revised Hydraulic Engineering Act, which came into force in 1991, stipulates this to be the legal order of priorities.

In order to deal responsibly with natural hazards, these must first be **consciously recognised.** Only when the hazards are clearly understood by the players involved, sustainable results can be achieved. Those affected by the reorientation of flood protection procedures are firstly the hydraulic engineers, planners and approval authorities responsible for decisions having spatial impact, and secondly the insurance companies and landowners who can make an active contribution to reducing the damage potential. The recognition that the hazard potential may increase due to neglect of river maintenance, or thoughtless installation of structures that constrict the flow, also falls under the heading of increased awareness.

The preparation of **hazard maps** is essential for the required realisation of flood protection via spatial planning measures. This instrument is stipulated not only by the Hydraulic Engineering Act, but also by

New flood-protection strategy

Aims

The protection of residential areas from flooding is essential for sustainable development. It must be achieved with a minimum of intervention. Forms of land use that provide for, and maintain, the necessary open spaces, and that pay proper attention to natural hazards, are to be encouraged. The basic principle must be applied: retention if possible, pass through only where necessary.

Necessary conditions

In assessing hazard situations, the knowledge of the principal types of hazard occurring is absolutely essential. The hazard situation and the efficacy of present protection measures should periodically be assessed to ensure that changes in the hazard conditions and weak points are identified.

Order of priority

The existing safety level must be maintained by means of proper maintenance; spatial planning measures should ensure that open areas for river flooding are retained, in this way preventing an uncontrolled increase in the hazard potential. Where these measures are insufficient, river protection structures are required. To these must be added suitable emergency planning to limit the residual risks.

Implementation

Flood protection procedures should take account of the different protection objectives. Thus high-value material assets must be better protected than low-value assets; retention areas must whenever possible be maintained or reinstated.
All measures must be subjected to the balancing of interests, and their appropriateness must be assessed.

Basic principles

1. The consideration of natural hazards in comprehensive and land use planning is legally obligatory. The hazard maps form an essential part in this process.

2. Hazard maps are not in themselves legally binding, but only become so on approval of the comprehensive and land use plans.

3. It is the responsibility of the cantons to make provision for the preparation of the hazard maps.

4. Hazard maps are essential to obtain subsidies for natural hazard protection projects under the Forests Act and the Hydraulic Engineering Act.

the Forests Act (cf. Chapter: Legal foundations, which is contained in the Annex). The hazard maps indicate the hazards to which a particular area is subject, and to what degree (extent, magnitude) and at which level of probability these occur. The threat resulting from natural hazards is a fundamental part of the **local characteristics,** analogous to soil fertility or slope inclination, which may hinder certain uses or prevent them altogether.
In land use planning, the authorities assign the areas affected to appropriate uses. In the interests of protecting human life and avoiding damage to material assets and the environment, certain uses in areas with high or average risk are either prohibited or permitted subject to restrictions.
Legal enforcement, whether this pertains to the approval procedure, the cantonal spatial planning or building laws, or land use planning, is the responsibility of the cantons or communes as the case may be. Landowners can apply measures of their own to further reduce the hazard potential.
Whenever possible, hazard maps should be prepared simultaneously for all hazards in a defined planning area. The **assignment of hazard levels** is performed independently of an existing use.

Purpose of the recommendations
To identify existing conflicting uses and to avoid future conflicts, it is essential for the endangered areas and the hazard itself to be objectively and clearly documented. The present recommendations contribute to this objective in that:

- with all activities with spatial impact (preparation and approval of comprehensive and land use plans, procedures and object plans, planning and erection of buildings and installations, issue of permits and concessions, payment of subsidies etc.), flood hazards are taken into account;
- through appropriate land use and suitable exploitation, an undesired increase in the hazard potential is avoided and structural interventions in the river minimised;
- recording and consideration of natural hazards is performed in interdisciplinary collaboration throughout Switzerland on the basis of unique criteria using standard map scales;
- the authorities and landowners are informed of possible hazards and are responsible for taking precautions to avoid unnecessary risks.

Procedures
In dealing with hazards, a stepwise procedure is essential. This must first answer the question as to what can happen and where, and secondly assess the probability and magnitude of possible events, and finally decide on the necessary measures. Although there are no hard-and-fast boundaries between the individual steps, it is important that they should be consciously considered. Following identification of the hazards and their causes, measures should only be taken when justified by the extent of possible damage.

Step 1
The first step is **hazard identification and documentation.** The observations pointing to the existence of a hazard must be recorded and documented with impartiality. A past event is always a useful indictor, especially when in the meantime no changes along the river – for example the erection of protective structures – have taken place. River structures, particularly culverts, can cause extreme flooding, irrespective of whether a damage event has already been recorded at this point or not.
The natural dynamics of rivers and other dynamic effects resulting from human action call for periodic reassessment to take account of the changes.
The purpose of the fundamental data prepared in the first step is to show why an area should be classified as endangered. The data are related to the cause, and serve both to delineate hazard areas and facilitate the planning of measures.

Step 2
The second step concerns **hazard assessment and the preparation of hazard maps.** These contain information extracted from the existing documentation on the probability and extent of damage events. The observations are weighted and assessed and, where necessary, supplemented by simulation studies and/or further investigations.
In designing measures for hazard reduction – i.e. protective structures along the river or measures in the watershed – a knowledge of the hydraulic mechanisms in the river and its surroundings is essential. The main focus of spatial planning measures is their effect on the endangered area. The hazard map is the basis for the determination of the hazard potential by the hydraulic engineer, and provides financial justification for protective measures. It also assists planners in defining appropriate uses. Finally, it enables landowners to take precautionary measures.

Step 3
The third step concerns the actual **planning of measures.** Where a hazard is identified in regard to extent and probability that conflicts with an existing or planned use, the question immediately arises as to what can be done to mitigate it. Here, a distinction must be made between measures to reduce the damage, to reduce the hazard itself and those to limit the residual risk as given below:

- **Measures to reduce the damage** (passive measures). These do not affect the course of an event, but serve to reduce the extent of damage. The spa tial planning measures must ensure that the use is in keeping with the hazard. Local flood protection measures can often be provided for during the building approval procedure by applying building methods geared to the danger (based on the relevant regulations in land use planning).
- **Measures to reduce the hazard** (active measures). These influence the course of the event. Note, however, that while they limit the probability of a damage effect, they do not necessarily influence its magnitude. Over and above the classical hydraulic-engineering protection measures such as river maintenance and protective structures, this category includes measures in the watershed, for example the care of protective forests.
- **Emergency planning** to limit the residual risk. No protective measure is able to provide absolute safety, since the magnitude of natural events can exceed its protective capability. Nevertheless, early-warning services, evacuation plans, rescue services, emergency aid and temporary protective measures can avoid the worst consequences. Once the event has run its course, the task is one of rescuing humans and animals. Usually the damage to material assets cannot be significantly influenced. The insurance against damage by natural forces (“Elementarschadenversicherung”) helps to keep the losses suffered by landowners down to an acceptable level.

Recording of natural hazards and application of measures

Step 1 — **Hazard identification:**
What can happen and where?

Cause-related documentation:
- **event documentation**
- **analysis of the terrain**
- **hydraulic-engineering assessment**

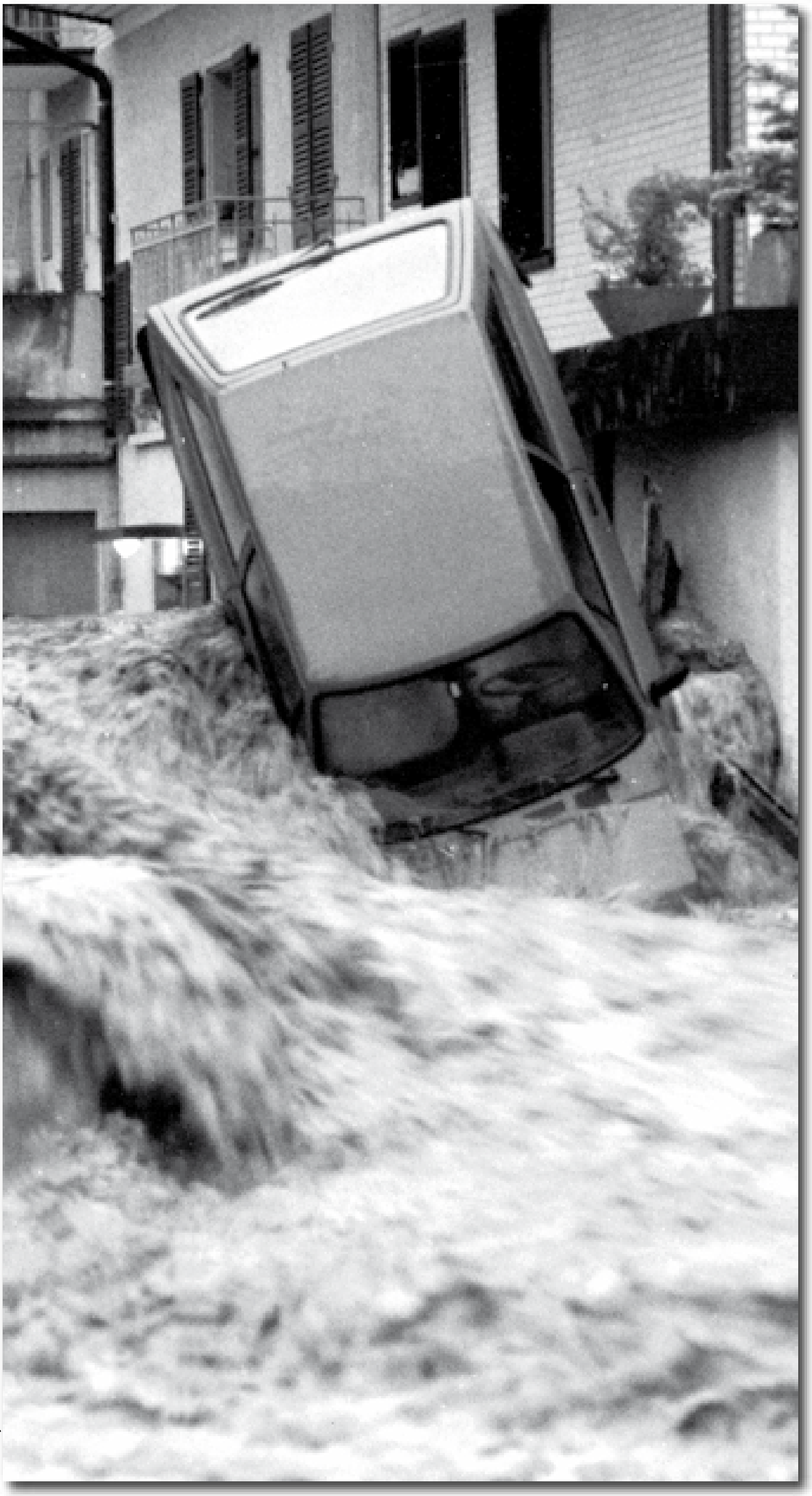
Step 2 — **Hazard assessment:**
How often and how intensively can it happen?

Area and impact-related evaluation:
- **hazard maps**

Step 3 — **Planning of measures:**
How can we protect ourselves?

Implementation:
- **spatial planning**
- **protective measures**
- **emergency planning**

Flooding represents a threat in several respects: (a) it can lead to erosion, thereby undercutting the foundations of buildings; (b) by virtue of its dynamic force, humans and movable property can be washed away and buildings destroyed, and (c) rivers can overrun their banks and, by virtue of the bed load they carry, damage cultivated land and buildings. A body of standing water can also cause heavy damage. A distinction is made between the three types of hazard: flooding, bank erosion and debris deposition, depending on how the flooding affects an exploited area.



Brücklmeyer

Flood hazards

Flooding

Flooding is taken to mean the undesired outflow of water from a natural or man-made channel, or when a body of standing water overflows its banks. Flooding represents a threat when it results in a large depth of water or strong currents in the floodplain. A large range of coarse material may be deposited.

Furthermore, a distinction is made between static and dynamic flooding, whereby intermediate forms may occur. Both may alternate over small areas within the same event.

Static flooding

In static flooding, the water flows, if at all, only very slowly. Outside the channel, the water usually rises quite slowly (except in depressions in the terrain).

This type of flooding occurs in flat terrain and along lakesides. The decisive parameter determining the damage is the maximum depth of flooding. The magnitude of the damage is also influenced by the rate at which the water rises, the depth of solids deposited and the duration of flooding.

Dynamic flooding

Dynamic flooding is characterised by a high flow velocity. It occurs in steep terrain near torrents and mountain rivers. In flatter areas, high dynamic forces arise at constrictions and dike breaches.

The danger arises primarily from the flow pressure. The decisive damage parameter is defined as the product of mean flow velocity × water depth.

Erosion may occur locally within the flooded area, and arises particularly near obstacles such as masts and buildings. In certain cases, the ramming effect of entrained rubble and driftwood can be significant. Normally, the duration of flooding is only a few hours, since in sloping terrain the water drains off rapidly. Large quantities of coarse material, such as stones and boulders, are often left behind in the affected area.

The deposition of debris and rubble is often termed **overbank sedimentation.** Overbank sedimentation is not, however, classified as a separate type of hazard, since it always occurs in conjunction with dynamic flooding. It may in some cases be useful to include an indication of possible deposits in the hazard map, for example by hatching or by using an index. Predictions on the quantity of entrained bed load and the position of the deposits are difficult, since these factors may differ substantially from one event to another.

Practical aspects

Bank overflow results primarily from inadequate runoff capacity in conjunction with high peak runoff and/or bedload deposits in the channel. In these cases, only part of the total runoff overflows to surrounding areas, and the greater part of the water and bed load remain in the channel.

Much more hazardous is **clogging** of structures by driftwood and bedload, for example at culverts and bridges, and at natural constrictions.

Breaches in flood protection dikes represent a particular threat. The entire flow volume, or a very large part of it, together with the entrained solids can suddenly (or within a very short period) overrun surrounding areas, seeking new flow paths and causing a completely unanticipated threat, not only to nearby areas, but also in areas remote from the breach. Dike breaches must be feared particularly in connection with overtopping and with older, poorly maintained, dikes which then do not sustain the floodwater forces.


Comet

Bank erosion

Bank erosion leads to the collapse of river banks due to vertical and lateral erosion. This type of hazard is only relevant to spatial planning if its effects extend beyond the actual channel.
Bank erosion is classified as a separate hazard type, since any measures necessary depend on the scouring depth d (see diagrams) and not on the water depth, as with flooding. Owing to the fact that the affected buildings often lie well above the water level assumed, this type of hazard is sometimes overlooked.
In many cases, bank erosion represents the **hazard type with the greatest damage.** It can interrupt traffic routes lying alongside rivers, and cause houses and bridges to collapse.
Thus the decisive safety criterion for buildings and installations is the depth of their foundations. If this is inadequate, i.e. less than the erosion depth, collapse of the structures is unavoidable. Even in cases in which the foundation depth is sufficient, a check must be made to ensure that if the riverbed is displaced, the structure can withstand the additional dynamic forces caused by the water flow.
Bank erosion mainly occurs in torrents and steep mountain rivers. In more level terrain, it usually affects exposed points such as cut banks, constrictions and obstacles in the stream. In smaller rivers, the action of erosion is less significant, since the flow volume is too small to cause large-scale mass movements.
Decisive here are the forces resulting from the flowing water and the resistance of the banks. In intensively utilised areas, the river banks are mostly protected by vegetation or shoring structures such as riprap, walls or bed paving. If the protective layer is destroyed by heavy flooding, erosion suddenly sets in. The finer the material in the bank, the faster erosion progresses. In principle, an entire valley floor may be affected unless this is prevented by massive obstacles or prominent topographical features that dictate the position of the riverbed.
Where erosion occurs in larger rivers, subsequent events are usually uncontrollable. Bank erosion is manifested either by bank failure or displacement of the riverbed.

Bank failure

Where the foot of the bank is eroded, this results in sliding of the banks. This type of landslide, which often results from vertical erosion of the riverbed, can be very extensive. Whether the erosion is superficial or profound depends on the geological and topographical situation.

Displacement of the riverbed

Meandering and branched rivers often alter their bed under conditions of extreme flooding. The existing banks are carried away approximately down to the level of the previous channel bottom. This type of hazard is accompanied by nearby material deposition, i.e. at the opposite bank or shortly downstream of the eroded section.

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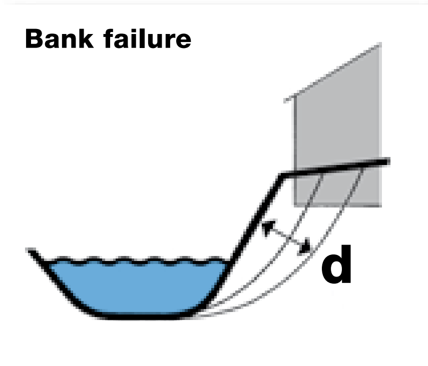

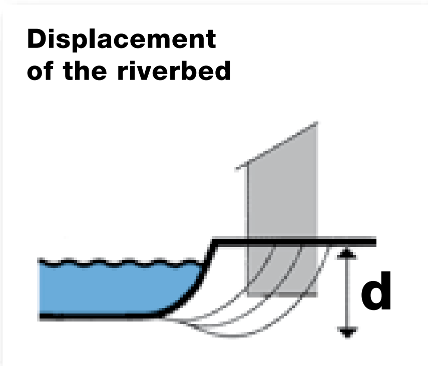

Debris flow


Huber

Debris flow forms a special case in the connotation of flooding. This process, referred to in German as 'Murgang', may also be designated as mudflow. Debris flows arise only in very steep torrent areas with a gradient above 15%, and may be triggered at intervals.
The line between floods involving heavy entrainment of bed load on the one hand, and watery debris flows on the other, is not always easy to draw. Typical for debris flows is their high density (30-70% of solids by volume), and their often high velocity (40-60 km/h). To this must be added their vast transport capacity. Debris flows may not only carry entire trees, but also boulders of several cubic meters in volume.
A further characteristic of debris flows is the large volume of entrained solids. The quantity of solids and water carried can amount to a multiple of the 'normal' floodwater flow, often resulting in a steep front of several meters in height. In addition, debris flows often depart from the usual channel, breaking out sideways.

Damage effects

Debris flows have three main damage effects: (a) destabilization of the embankment due to the force of the erosion; (b) the ramming effect of the debris front, which is further intensified by entrained boulders, and (c) substantial deposits of boulders, rubble and debris.
The deposits formed by debris flows are referred to as **debris deposits.** Should these encroach on a receiving water course, they can block the outflow, causing additional flooding.
If the coarse material carried by the debris flow comes to lie on an alluvial fan, a characteristic **debris flow head** is formed. Upstream of it, massive heaps of debris and rubble are deposited. The water flowing outwardly from this still carries substantial quantities of sand and bed load, and spreads out over the alluvial fan at a much reduced depth and speed. The resulting deposits, which may often be extensive, are referred to as **debris flow lobes.**

The basis for any proper assessment of flood hazards is laid by the impartial documentation of all observations that point to the existence of a hazard. These should be as objective as possible and contain a minimum of interpretation. Data on the precision of the observations, e.g. estimates, calculations or measurements, are absolutely essential.

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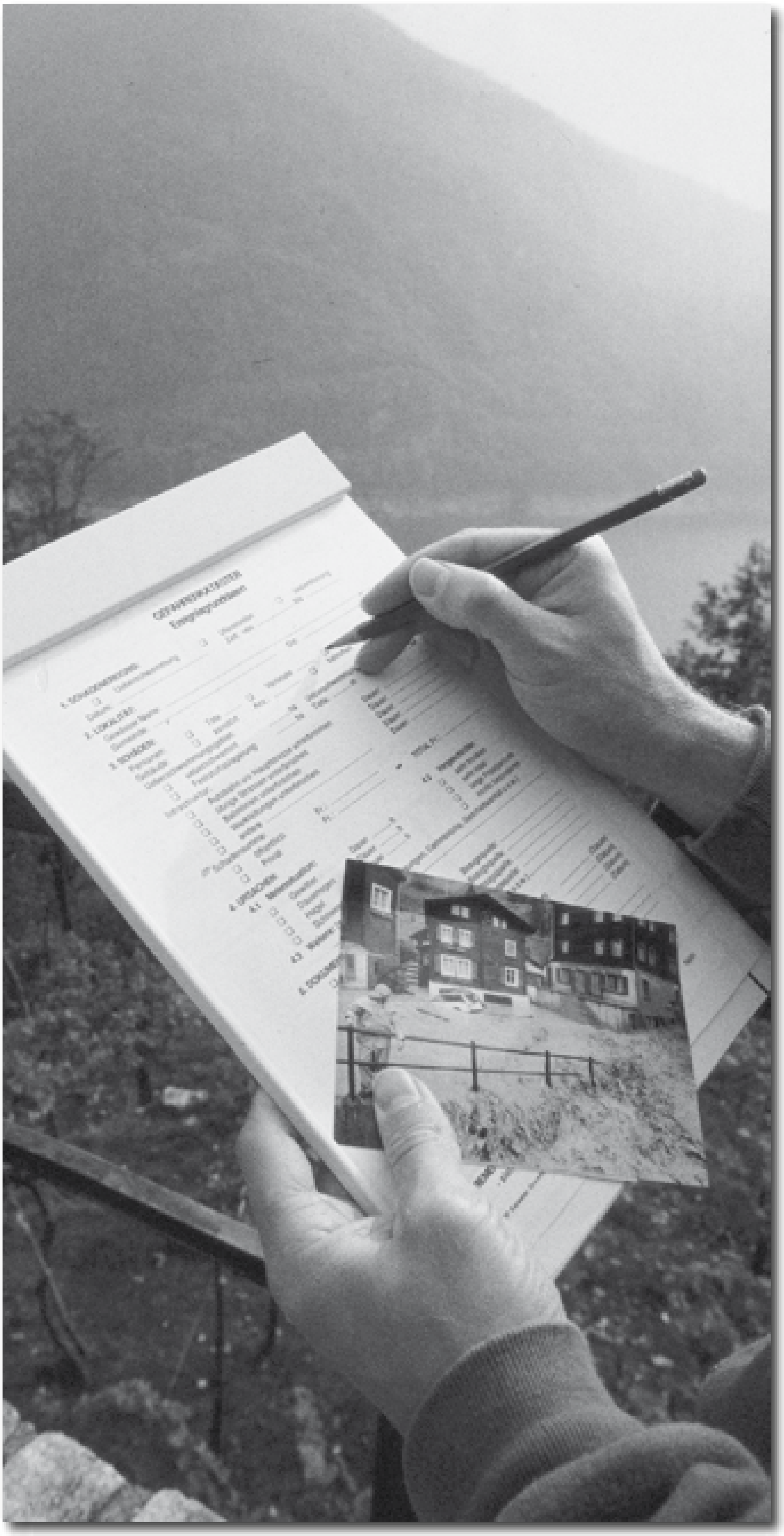
Hazard identification

Event documentation

Event documentation is a record of observed events comprising the principal processes, the damage sustained, the areas affected, the meteorological conditions, and further data on the progress of the events. It consists of a text and a map section.
Recording of the event is performed in different degrees of detail in relation to the extent and damage effect. Event documentation always gives at least one answer to the question as to **what** has occurred, and **when, where** and to **what extent** this happened.
In detailed event documentation, the question is also pursued as to **how** an event occurred and **why** it was possible for damage to occur. Detailed documentation must be prepared in cases where hydraulic-engineering measures are called for.



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Event documentation

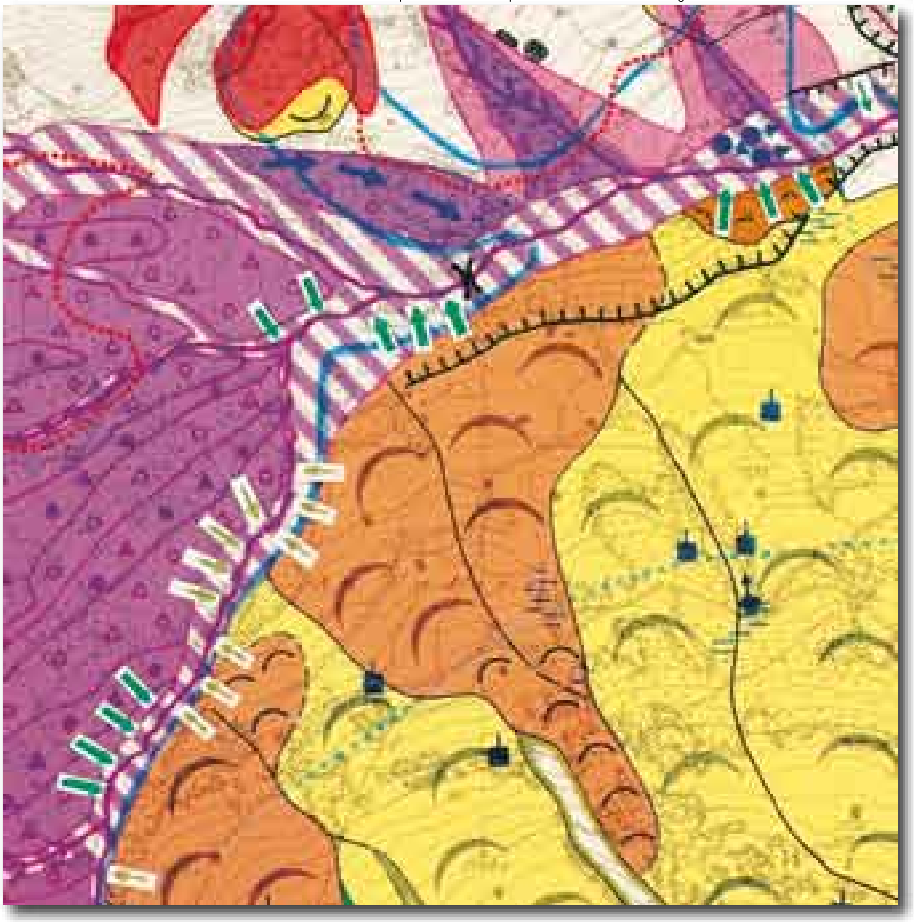
Contents
Data on events, causes and damage effects. The degree of detail is related to the seriousness of the events.

Map scale
Representation of the areas affected on a scale of between 1:2000 and 1:25 000.

Updating
Continuous; with storm events, preferably without delay. The areas affected and studied must be delineated.

Map of phenomena (field analysis)

The map of phenomena shows the **features and indicators** observed in the field, and the impartial interpretation of these in cartographical and text form.
Field analysis is an important adjunct of event documentation. It aids in recognizing and estimating (disposition, trigger mechanisms, mode of action) possible types of hazard.
Field analysis is based on the observation and interpretation of terrain features (e.g. critical points) and 'tell-tale' features of dangerous past or present processes. With its aid, it is possible to identify the causes, the probability of occurrence, and further important attendant circumstances of the events.
In order to map the hazards reliably, a thorough knowledge of the state of the watershed, its past history and of future developments derived from these is a prerequisite.
To unify the presentation and content of the different types of hazard – such as water, avalanches, landslides and rockfall – and the map scales used, the "Bundesamt für Wasserwirtschaft" (BWW, federal office for water management) and the "Bundesamt für Umwelt, Wald und Landschaft" (BUWAL, federal office of the environment, forests and landscape) have published jointly a recommendation* on the preparation of corresponding maps together with suggestions for captions under the title: "Symbolbaukasten zur Kartierung der Phänomene". This work was published in 1995.



Excerpt from a map of phenomena published in the recommendations: "Symbolbaukasten zur Kartierung der Phänomene" (1995).

Map of phenomena

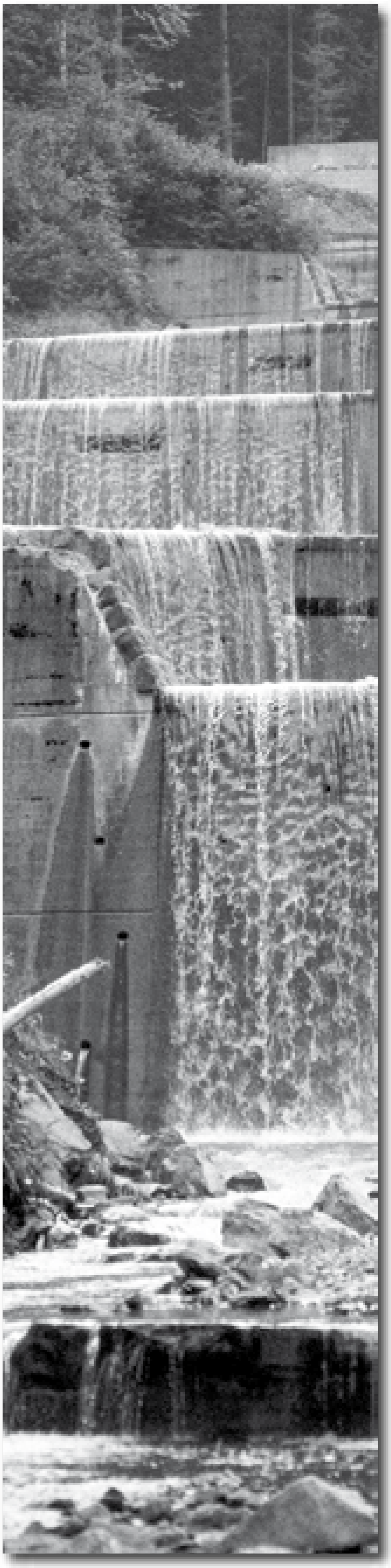
Contents
Information about the disposition to water-related hazards. Recording of "tell-tale features".

Scale
1:1000 to 1:25 000 depending on the designated use.

Updating
Update when the hazard map is revised.

*The recommendation is intended to promote the standardised presentation and clarity of hazard assessments and the simplified preparation of maps. It is obtainable from the EDMZ, 3003 Bern under order number 310.022 (in French and German).

Hydraulic-engineering assessment



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All natural rivers are in a state of continual change. The upper reaches are normally characterised by erosion, the lower reaches by deposition.
The hydraulic-engineering assessment should take account not only of the critical factors such as erosion, accumulation and equilibrium state, but should include all processes pertaining to the flooding process.
Particular attention is directed to **hydrology** (discharge regime, types of flooding), **hydraulics** (discharge capacity in the river channels) and **sediment budget** (debris-flow potential, heavy or moderate bedload transport, formation of meanders or branches).
The assessment enables predictions to be made both of short-term processes during a damage event and long-term developments. Long-term processes result in an alteration of the hazard situation, and thus call for regular assessments of the hazard potential.

Analysis of weak points
Weak points are places (points or sections) at which a hazard may arise. Weak-point analysis highlights the possible causes of a damage event, and explains (for example) why flooding of a nearby area may occur.
Classical weak points are: narrow openings, constrictions, sharp bends, obstacles and knick points in the longitudinal profile. Weak points can be recorded during the field analysis and mapped accordingly. They form an essential foundation for hazard identification and the introduction of measures.
The assessment of a weak point is for the most part subjective. It can be based on numerical simulation (calculation of discharge capacity), on observations (minimum freeboard for a given flood) on a comparison (opening smaller than at points upstream or downstream) or on estimates. Owing to its subjective character, the documentation should always contain data on the precision of the assessment.

Inventories and assessments of protective structures
In the past, protective structures were usually installed at the position of weak points. The protective capacity of a structure depends both on the time at which it was erected, the particular event considered and its probability. Protective structures are subject to continual deterioration, so that their condition must be regularly inspected, particularly following storms.

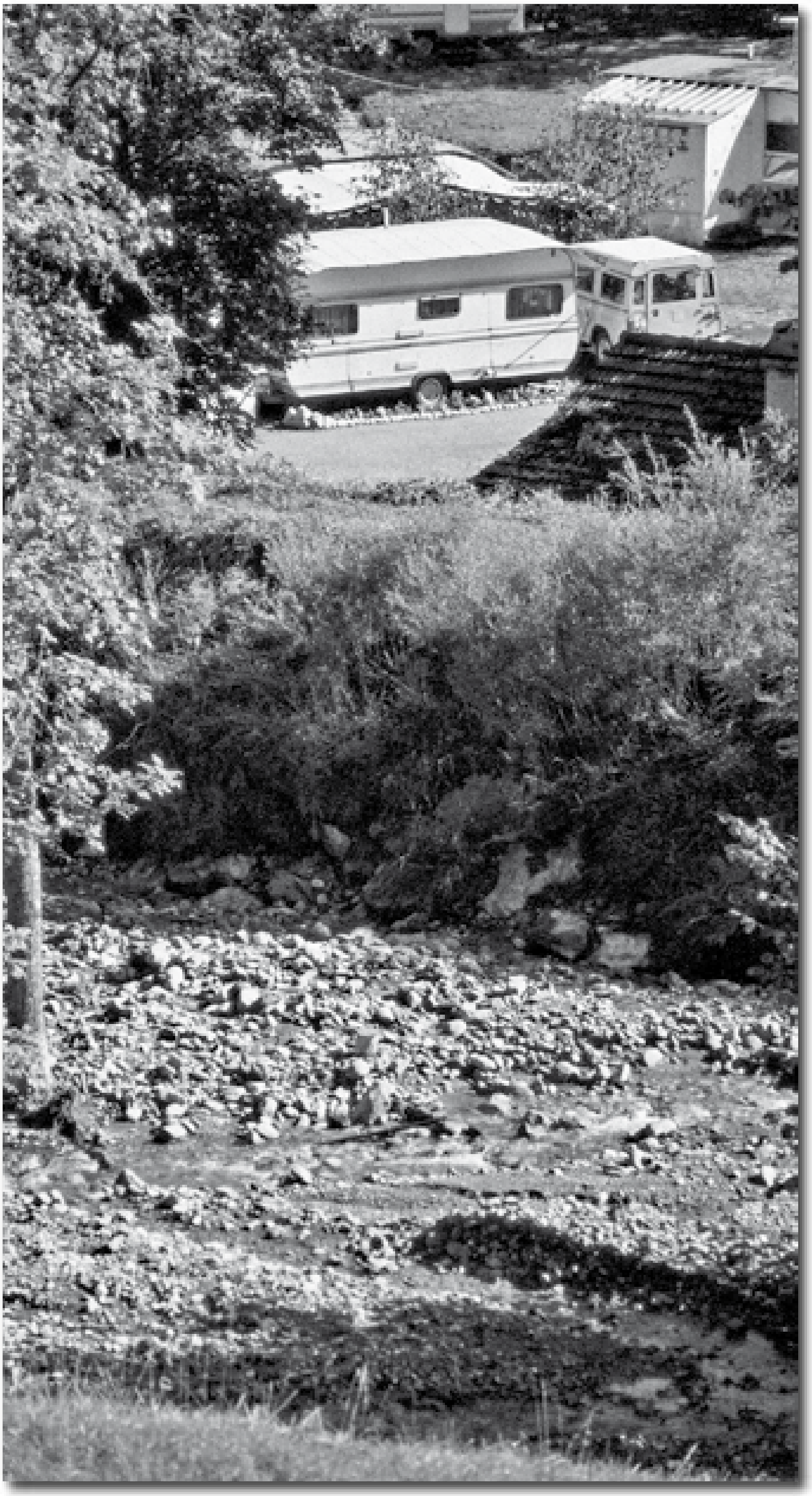
Hydraulic-engineering assessment

Contents
Data on relevant processes and locations at which a hazard may arise, and data on the condition of protective structures.

Map scale
As necessary.

Updating
At the latest when the hazard map is revised, or otherwise in conjunction with maintenance, or when new protective structures are built.

In a second step, the magnitude and probability of flood events are recorded in a hazard map based on the assessment documentation. This is a working tool comprising a two-dimensional representation of the hydraulic hazards and the danger to humans and material assets resulting from these. Note in particular that a hazard map points to an existing hazard as assessed by an expert, and in this sense is not legally binding. It attains legal status indirectly via its incorporation in cantonal and municipal legislation and planning, and/or in conjunction with building approval by the authorities.



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Hazard assessment

Hazard map

Purpose and significance

A hazard map is a map showing the suitability of the terrain for certain uses. It shows which areas according to existing natural hazards are only suitable for certain uses under given conditions, or are unsuitable for use. It forms the functional basis for:

- **Spatial planning** procedures (preparation of cantonal comprehensive plans (master plans; in German: Richtpläne) and land use plans (detailed plans; in German: “Nutzungspläne”) including delineation of hazard zones, preparation of procedures and object plans (in German: “Sachpläne”) by the Confederation and the cantons, issuing of building regulations, and approval of planning applications for buildings and uses).
- The planning of **local protection measures** (in German: “Objektschutzmassnahmen”) and measures by landowners to reduce the hazard.

Through superposition of the hazard areas and existing uses, any contradictions become apparent. Since existing uses cannot normally be changed, or only slightly so, structural measures are usually necessary to attain the required degree of protection.

Hazard maps also lend themselves to the planning of **hydraulic-engineering protection measures,** installation of early-warning systems and organisation of emergency planning. Note here that the map scales and degree of detail required depend on the particular circumstances of the project.

Preparation

A hazard map consists of a **map section** (maps or drawings to a scale of 1:10 000 or larger) and a **text section** (technical report with justification and description of hazard areas). The hazard map should clearly identify the perimeter studied, for example using a bold dashed line. The preparation of hazard maps must be based exclusively on **scientific criteria** (cf. Chapter: Hazard identification). In principle, the assessors may choose their own methods, provided these accord with recognised scientific principles. The degree of detail in the hazard maps depends on the existing or anticipated damage potential and on the hazard potential.

The preparation of hazard maps should wherever possible be based on defined planning areas. The hazard map should be revised whenever substantial changes in the situation occur (e.g. following the erection of protective structures).

Hazard index map

The hazard index map is a special form of hazard map. It provides a rough presentation of the hazard situation and shows what hazards are present over the entire area. In distinction to the hazard map as such, the hazard index map does not usually show hazard levels.

Hazard index maps are particularly suitable at the level of comprehensive planning (scale 1:50 000). They permit areas of conflict to be identified prior to the preparation of detailed hazard maps, and require less time to cover a more extensive area, typically an entire canton.

Hazard index map

Purpose
Basis for comprehensive planning for overall recognition of conflicts of interest in particular areas in cases where hazard maps are not yet available.

Contents
Rough presentation of the hazard situation; specification of the hazard type, usually without hazard levels; large-scale delineation.

Degree of detail
Low degree of detail.

Map scale
1:10 000 to 1:50 000

Areas recorded
Regions or entire cantons.

Hazard map

Purpose
Basis for comprehensive and land use planning, and for designing protective measures.

Contents
Precise data on type of hazard, spatial extent and degree of the hazard at three hazard levels; detailed documentation.

Degree of detail
High degree of detail
(‘plot resolution’ must be possible).

Map scale
1:2000 to 1:10 000

Areas recorded
Main emphasis on inhabited, developed areas, or those to be developed in the future, and on traffic routes.

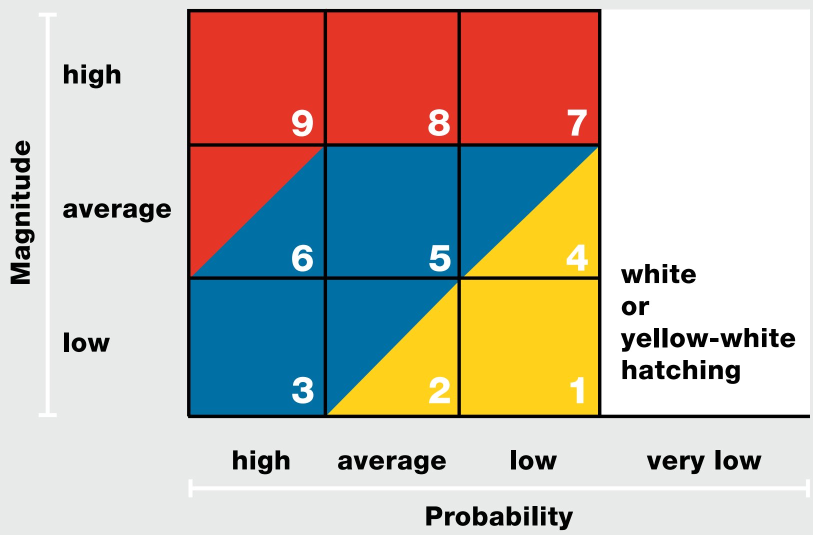
Inspection
Periodically in conjunction with revision of the comprehensive and land use plans.

Updating
On substantial change in the hazard situation (e.g. as a result of protective measures or changes in the natural conditions).

Designation of hazard levels

To guarantee a unified and equivalent evaluation of the various types of natural hazards, and based on the existing "Richtlinen für die Berücksichtigung der Lawinengefahr bei raumwirksamen Tätigkeiten" (in English: "Recommendations for the consideration of avalanche hazards for activities with spatial impact"; Bundesamt für Forstwesen, 1984), harmonised magnitude-probability diagrams were developed.
The degree of the hazard is specified in terms of the **magnitude** and the **probability** (frequency or return period) for the type of hazard considered. These two parameters are combined in the magnitude-probability diagram showing the hazard levels (see below).
The hazard is divided into **three hazard levels,** represented by the colours red, blue and yellow. In distinction to the above-mentioned "Richtlinien für die Berücksichtigung der Lawinengefahr", in flood protection work very rare events are also classified (determination of the residual hazard or residual risk as appropriate). The relevant areas are shown by yellow-white hatching. The hazard levels permit particular types of activity and/or regulations for use to be assigned. They indicate the degree of the hazard to humans, animals and material assets. They also take account of the fact that people are usually much safer in buildings than outside.
The potential damage effect is described for each hazard type and hazard level. The hazard levels are always determined separately for each type of hazard. This is indicated by an index in the hazard map, whereby **Ü** designates flooding, **E** designates bank erosion, and **M** debris deposition. The index may be supplemented by a field number from the assessment matrix.
Further indications, for example warning times, possible bedload deposits and the duration of flooding, can be included as an additional index in the map and explained in the accompanying text.
If an area is endangered simultaneously by **several types of hazard,** for example by flooding and debris flows, this circumstance is indicated in suitable form in the hazard map.
The highest hazard level in any particular case is decisive. In general, where several types of hazard are superimposed, a higher hazard level is not assigned, since measures to avoid damage can be taken separately for each hazard. For spatial planning purposes, it will in many cases prove appropriate to issue prohibitions in areas affected by several hazards.

Magnitude-probability diagram (hazard level diagram)



Red: substantial hazard

- Persons are endangered both within and outside buildings.
- The sudden destruction of buildings may occur.

or:

- Although the events may occur in less intensive form, their probability is higher. In these cases, persons are mainly endangered outside buildings.

In the main, the red area is a **prohibited area.**

Blue: average hazard

- While persons are hardly at risk inside buildings, they are so outside.
- Damage to buildings must be expected, but sudden collapse is unlikely in this area provided that certain requirements on building design are fulfilled.

In the main, the blue area is a **restricted area,** in which heavy damage can be avoided by suitable precautionary measures (restrictions).

Yellow: slight hazard

- Persons hardly at risk.
- Slight damage to buildings and/or obstructions must be anticipated, however substantial damage to buildings are possible.

In the main, the yellow area is a **warning area.**

Yellow-white hatched: residual hazard

Hazards with a very low probability of occurrence and high magnitude may be designated by a yellow-white hatched marking.

The yellow-white hatched area is a **warning area,** indicating a residual hazard, respectively a residual risk.

White: no or negligible hazard according to present status of knowledge

Classification of the parameters

The two parameters used in the hazard level diagram – magnitude and probability – must be determined and assigned to each type of hazard. In this, a distinction is made between high, average and low magnitude and between low, average and high probability.

Magnitude

To describe the extent of a possible damage event, threshold values are assigned to the hazard levels in relation to the possible damage effect on the most important form of use, i.e. residential areas. For other types of use, possible damage is derived in an analogous way. The magnitude is divided into three levels:

- **High magnitude.** Humans and animals at risk inside and outside buildings. Substantial damage and sudden collapse of buildings must be anticipated.
- **Average magnitude.** Humans and animals heavily at risk outside buildings, but hardly so inside. Damage to buildings must be anticipated.
- **Low magnitude.** Humans and animals hardly at risk, neither inside nor outside of buildings. Damage to material assets within buildings (for example in cellars) must be anticipated.

Probability

In place of a continuous scale, for example based on a return period, the probability was also divided into classes. The boundaries chosen of 30 and 300 years were taken from the avalanche guidelines (Bundesamt für Forstwesen, 1984). For hydraulic hazards, the commonly used 100-year boundary was added.

The calculation of the probability of occurrence is subject to uncertainty. Thus the probability assigned to a particular event can never be precisely determined, but is always quoted as a range (which may, by chance, coincide with the class boundaries).

The terms frequency, return period and probability of occurrence are used synonymously, whereby, however, frequency and return period are used only for recurring events.

For a given period of use, n, the probability of occurrence and the return period are related by the equation:

$$\mathbf{p = 1-(1-1/T)^{n}}$$

where **n** is the period of use, **T** the return period, and **p** the probability that at least one event with the return period T occurs within this period of use.

The calculation of the probability of occurrence for a given period of use clearly shows that even with a relatively long return period (300 years), the residual hazard is not negligible. Where an event has a return period of 300 years, there is a probability of 15 % that the event will occur within a period of 50 years. This is no less than the probability of throwing a six with a single throw of the die!

In general, the probability scale, and likewise the magnitude scale, has no fixed upper limit. However, hazards with a very low probability of occurrence (return period >300 years) are assigned to the residual hazard for customary uses.

Residual hazard

In areas with a residual hazard, hazards that have been identified, but which are very rare, are designated by a yellow-white hatched marking. The yellow-white marking is not intended to denote the general residual hazard, but must only be used where a definite hazard is present, and where precautionary measures (emergency planning, observation networks, maintenance) have been taken to significantly reduce it. In such cases, this form of representation is justified provided that heavy intensities are possible, the damage potential is high, or there is a possibility that the probability of occurrence might substantially increase in future. The boundary between yellow-white and plain white is not defined in quantitative terms. Where these markings are used, an explanation is required.

Rare events

With rare and very rare events, magnitude and probability are particularly difficult to determine. They are usually determined from known or possible extreme events. Here, it is important that the magnitude of the event and the probability of its occurrence are determined based on objective scientific criteria.

Probability

Definition	Probability of occurrence in 50 years
high	100 to 82 %
average	82 to 40 %
low	40 to 15 %

Return Periode

Definition	Return period in years
frequent	1 to 30
average	30 to 100
rare	100 to 300

Magnitude criteria for different types of hazard

Frank (2), SBB (1)

Flooding
The **flow velocity (v)** and the **flooding depth (h)** are used as a measure of the possible impact. The flow velocities are normally directly dependent on the inclination of the terrain. At large flow velocities, coarse deposits may occur. Locally, erosion may also appear.

Bank erosion
With bank erosion, the **average depth (d)** of the anticipated scouring measured perpendicular to the surface of the bank is taken as a measure of the possible impact.

Debris deposition
While tentative methods exist for the calculation of debris flows, these are hardly proven, and are not in general use. They involve computational methods to estimate the **pressure effect** of the debris. Instead, observations of debris heads can be used to estimate the pressure effect.

Since the transitions are gradual (see diagrams below), the boundaries should be regarded as guide values.

Criteria for flooding

High magnitude:
$h > 2\,m$
or:
$v \times h > 2\,m^2/s$

Average magnitude:
$2\,m > h > 0.5\,m$
or:
$2\,m^2/s > v \times h > 0.5\,m^2/s$

Low magnitude:
$h < 0.5\,m$
or:
$v \times h < 0.5\,m^2/s$

h = water depth
v = flow velocity of the water

Criteria for bank erosion

high magnitude:
$d > 2\,m$

average magnitude:
$2\,m > d > 0.5\,m$

low magnitude:
$d < 0.5\,m$

d = average depth of scouring (measured normal to the surface of the bank)

Where there is a possibility of displacement of the riverbed, the flow pressure must also be checked to determine whether the criterion: $v \times h < 2\,m^2/s$ or $0.5\,m^2/s$ is fulfilled

Criteria for debris deposition

high magnitude:
$h > 1\,m$
and:
$v > 1\,m/s$

average magnitude:
$h < 1\,m$
or:
$v < 1\,m/s$

low magnitude:
none

h = depth of debris deposition
v = flow velocity of the debris flow

Hazards and possible damage effects

Keystone

The threat to human life is particularly great with sudden events. The greater the threat, the more important are the **warning times.**

With **flooding,** the warning time depends mainly on the topography of the catchment area: the steeper the terrain and the smaller the catchment area, the shorter the warning time, the quicker the rise of water and the more limited the opportunities for taking avoiding action. With flooding events, the heavy precipitation causing them is readily apparent in the area, so that there is mostly no real surprise effect. The duration of flooding can be roughly estimated at several hours to a few days.

With **bank erosion,** scouring of the bank normally takes place at intervals and in sections, so that the danger may be anticipated a short time (less than an hour) in advance.

Thus outdoors, persons who act reasonably are hardly in danger. Note, however, that sections of the bank may break away without warning.

As opposed to that, with **debris deposition** events, reliable warnings are hardly possible since a particular torrent does not always carry debris flows as a result of heavy rainfall. Furthermore, the time elapsed between triggering and arrival of the debris flow at the debris fan is only a few minutes.

Damage effects for flooding	Damage effects for bank erosion	Damage effects for debris deposition
High magnitude With high **water depths,** the first floor of a building will be completely flooded, and escape routes to the upper floors or the roof may be obstructed. While buildings are not usually destroyed, the first floors and the cellars may be heavily damaged. With high **flow velocities,** dynamic loads arise that can destroy a building. Very extensive bed load transport, local erosion and the deposition of boulders and rubble must be expected. Obstacles and the corners of houses are particularly at risk owing to the high flow concentrations at these points. Humans and animals within buildings are at risk.	**High magnitude** Through scouring of the ground below the foundations, a building may suddenly collapse, so that humans and animals in buildings are at risk. Where the riverbed is displaced, the parts of the building concerned become in effect a part of the river. In the absence of extensive rehabilitation measures, buildings may become unusable.	**High magnitude** The pressure effect of the debris head, mostly in combination with the ramming force of individual boulders, can lead to the sudden collapse of buildings. Humans and animals in buildings are at risk. The damage effect is increased by massive deposits of debris and rubble.
Average magnitude Water penetrates buildings, windows may break. Extensive bedload transport, local erosion and deposition must be expected. Persons and animals outdoors and in vehicles are at risk. In buildings, escape to the upper storeys is mostly possible.	**Average magnitude** Buildings that are normally anchored and those with cellars are not destroyed as a result of erosion. However, where displacement of the riverbed may occur, the flow pressure must be checked to determine whether the criterion: $v \times h < 2\,m^2/s$ is fulfilled. In channels with a flood rate of greater than $20\,m^3/s$, this criterion is usually not fulfilled, and the respective areas are marked in red.	**Average magnitude** Despite the low water level, debris lobes pose a threat by virtue of the entrained rubble. Buildings may be damaged. Persons and animals outdoors are at risk.
Low magnitude Water that threatens to enter buildings can be diverted by relatively simple means. However, cellars are at risk. Normally, there is no risk to persons and animals. At the upper limit value, vehicles may be swept away.	**Low magnitude** Scouring and the removal of humus can occur at obstacles. Low magnitudes are only to be expected with small rivers. Where the riverbed may be displaced, the flow pressure must additionally be checked (i.e. whether the criterion: $v \times h < 0.5\,m^2/s$ is fulfilled).	**Low magnitude** Hardly occurs for this type of hazard.

In hazard evaluation, the question arises as to what can happen. In planning measures, the further question arises as to what is permitted to happen and/or how to protect ourselves. By defining protection objectives, the degree of safety necessary for the various categories of object may be quantified. If the degree of protection is sufficient, suitable maintenance and restrictions of use must be applied to ensure that the danger and damage potential do not rise in an unforeseen fashion, and that hydraulic-engineering protection measures do not become necessary. In the wake of recent intensive building activity, protection deficits have arisen at many places that can no longer be remedied through maintenance and planning measures alone. Decisions on the measures to be taken must be based on a balancing out of interests.

Frank

Planning of measures

Spatial planning measures

The hazard map forms the professional basis for the consideration of natural hazards in all tasks and activities having spatial impact, namely:

- the preparation and approval of comprehensive and land use plans, procedures and object plans of the Confederation, including the basic documentation required for this;
- planning, erection, modification and use of buildings and installations;
- the issue of concessions and permits for buildings and installations, as well as other rights of use;
- the payment of contributions for buildings and installations (particularly transport and supply installations, and residential buildings), river training, soil improvement or protection measures.

The existing legislation and the instruments of spatial planning form the basis for adequate consideration of natural hazards in activities having spatial impact. Concerning enforcement, the main focus is on making full use of the opportunities provided and exploiting the available leeway. Where necessary, amendments and additions to the cantonal laws must be made.

Consideration of natural hazards in comprehensive planning (arts. 6 to 12 RPG)	**Consideration of natural hazards in land use planning (arts. 14 to 24 RPG)**
Responsibility for comprehensive planning Canton	**Responsibility for land use planning** Commune
Form Map and text; fundamentals.	**Form** Zonal plan and building regulations.
Map scale/degree of detail Usually 1: 50 000	**Map scale/degree of detail** 1: 2000 to 1: 5000
Task Coordination to achieve the desired spatial development in all specialised activities of the Confederation, cantons and communes with spatial impact.	**Task** Determination of types of use. Distinction between residential and non-residential areas.
Content related to Hazards Guidance on procedures to reconcile the various activities having spatial impact; where necessary rough delineation of the hazard areas in the map.	**Content related to Hazards** Consideration of the hazard areas defined in the hazard map, designated by type of hazard, hazard levels and the corresponding consequences for use.
Hazard levels Usually single stage: i.e. hazard existent, hazard not existent; additional specification of the leading type of hazard: H = flooding L = avalanche M = mass movement	**Hazard levels** 3-stage: substantial hazard, average hazard and slight hazard; specification of type of hazard and the consequences for use derived from this.
Precision None (text only) or rough outline consideration of hazard areas.	**Precision** Consideration of the hazard areas down to single plots.
Updating Supplementing or updating when changed conditions or new tasks arise; general inspection of comprehensive planning and, where necessary, revision every 10 years.	**Updating** When the hazard demonstrably increases through natural events or by the erection of protective structures; with comprehensive revision of the zonal plan (approx. every 10 to 15 years).
Binding nature of comprehensive planning Legally binding for all authorities.	**Binding nature of land use planning** Legally binding for landowners.


Della Valle

Article 6 of the Spatial Planning Act requires the cantons, among other things, to specify “the areas substantially threatened by natural hazards or damage effects” in the guiding principles section of the comprehensive plan.

The **cantonal comprehensive plan** serves to ensure orderly regional development, coordination and precautionary action. Formally, the comprehensive plan comprises a map and text, and is based on a set of guiding principles.

The comprehensive plan provides exemplary provisions and guidance on reconciling the various activities having spatial impact. It also shows the initial planning and geographical situation. The comprehensive plan, which is legally binding for all authorities, has a whole series of tasks to fulfil:

- it shows how the activities having spatial impact must be reconciled with one-another within the context of the desired spatial development.
- it determines the direction in which future planning and cooperation should proceed, and specifies the necessary steps.
- it provides the planning authorities at all levels with binding specifications for exercising their planning latitude.

Specialized field “Natural hazards”

In the specialized field of natural hazards, the comprehensive plan can perform the following functions:

- the timely recognition of possible conflicts between uses and natural hazards, and specification of the specialist agencies to be consulted in particular cases.
- outline of the current status of the set of guiding principles, or of those that need to be prepared, concerning natural hazards (for example preparation of hazard maps, coordinated procedures for the different types of hazard).
- the formulation of guiding principles for the cantons in protecting against natural hazards.
- the preparation of specifications and tasks (for example delineation of hazard zones) to be performed by the subordinate planning authorities, in particular the municipal land use planning authorities.

Comprehensive plan map

The comprehensive plan map must be limited to a rough presentation of the initial situation in the hazard areas. Specific conflicts of use resulting from natural hazards or planned protective structures may be included in comprehensive plans.

Comprehensive plan text

Where natural hazards are concerned, the emphasis in comprehensive planning lies on the text. The text should outline the current set of guiding principles and those still to be prepared (basic scheme of hazard map), designate the principles underlying protection from natural hazards, and list the necessary measures together with the specialist agencies concerned. Finally, in conjunction with land use planning for hazard areas, it can where necessary assign the communities the task of issuing building prohibitions and restrictions of use.

Land use planning

At the land use planning level, the degree of detail and legal obligation must be determined to make possible and ensure adequate consideration of natural hazards. The final objective is the delineation of legally binding hazard zones, or implementation of an equivalent legislative mode.
As specified in art. 18 of the Spatial Planning Act: “Further zones and areas”, cantonal planning legislation can specify further use zones in addition to existing building, agricultural and protection zones. On this legislative basis, **hazard zones,** for example, can be delineated that are superimposed on the remaining uses. It is also possible to explicitely delineate the various uses or to downgrade the possible uses in relation to the hazard situation (positive or negative planning).
In land use planning, the hazard map serves as a foundation for the delineation of hazard zones (or analogous measures). Although in land use planning a balancing of interests must theoretically be performed, it is practically inconceivable that other interests could make necessary the rescinding of professionally delineated hazard zones.

Significance of hazard levels
The hazard levels were designed primarily with the consequences for **building uses** in mind, in order to avoid a threat to humans and animals, and to reduce material damage to a minimum. At the planning application stage, further detailed investigations may be required to permit the specific formulation of restrictions.
In **agricultural zones,** with respect to hazard levels for buildings, the same requirements apply as in the building zone. Land use planning does not normally make reference to the actual type of agricultural use. Written agreements with individual farmers may here prove useful.
Alarm and evacuation plans (emergency planning) must be prepared for all hazard areas. In particular, escape routes to safe areas must be provided. >

The significance of hazard levels

Red zone: substantial hazard

In these, **no buildings or installations** intended for occupation by persons or animals may normally be erected or extended. Undeveloped building zones must be back-zoned. Only in exceptional cases – i.e. if essential at the site – may buildings that have been destroyed be rebuilt (and here, only when the necessary safety measures are taken). Conversions and changes necessary to continue operation may only be made if this leads to a reduction of the risk (i.e. if the group of persons endangered is not enlarged and the safety measures are enhanced). In existing residential areas, where there is a serious protection deficit, hydraulic-engineering measures should, if possible, be taken.

Blue zone: average hazard

Here, building is permitted subject to **restrictions.** These must be specified in the building and zonal regulations in a way commensurate with the particular hazard. Further detailed investigations may be necessary in individual cases. No highly sensitive objects should be erected, and no new building zones should, if possible, be designated.

Yellow zone: slight hazard

Landowners must be advised of the **existing hazard,** and be made aware of possible measures to avoid damage. Special (i.e. individual) planning is necessary for measures for sensitive objects.

Yellow-white hatched zone

The yellow-white hatched zone shows the residual risk. Emergency planning and special (i.e. individual) measures for **sensitive objects** are required. Installations with particularly high loss potential must be avoided.

Sensitive objects
Sensitive objects are firstly buildings and installations in which a considerable number of **people** are present (and are difficult to evacuate). This is particularly the case with hospitals, old people's homes and schools. Sensitive objects are secondly buildings and installations in which substantial **consequential damage** can occur.
This is particularly the case for storage facilities and factories with large quantities of hazardous substances, and for landfills. Thirdly, sensitive objects are buildings and installations in which even with hazards of low magnitude, substantial direct or indirect **financial losses** must be feared. These include for example switching stations, telephone exchanges, EDP installations, waterworks and sewer treatment plants.

The following advice is not exhaustive, but is intended as a basis for planning procedures appropriate to local conditions.

Settlement areas
In the **blue hazard zone,** new buildings, extensions and conversions must only be approved subject to restrictions, and these vary depending on the type of hazard.
To avoid damage by **bank erosion,** the following apply:
- adequate anchoring of buildings below the anticipated erosion depth;
- foundations in reinforced concrete to ensure that the loads can be withstood with non-uniform erosion;
- structural proof of stability against flow pressure where a displacement of the riverbed is anticipated.

To avoid damage by **debris deposition,** the following apply:
- raised entrances and avoidance of windows below the level of deposits;
- structural provisions (e.g. reinforced concrete) to combat the ramming effect on given components.

To avoid damage by **flooding,** the following apply:
- raised entrances, where necessary with hermetically sealing doors;
- unbreakable windows and light wells with unbreakable glass covers;
- oil tanks and supply lines protected against lifting and breakage;
- essential electrical supply installations installed in the upper storeys;
- avoid concentration of high-cost equipment in the lower storeys, particularly in cellars;
- no enclosed rooms;
- provision of escape routes to higher parts of the building;
- with particularly hazardous uses such as underground garages, further investigations must be made.

In the **yellow hazard zone,** excessive damage to objects may be avoided by raised entrances, sealed cellar windows and provisions for sealing the entrances to lower-lying garages.

Infrastructure installations
Infrastructure installations such as railways, roads and transmission lines of public, and often national, interest, are mostly located at fixed points and require protection by **technical measures** in the river or at the installations themselves.
The threat to persons, which may at times be high, and the economic and ecological consequences of interruptions or damage, for example to electricity supply installations or waste water treatment plants, make a generally high level of safety necessary.

Agriculture
Areas frequently affected by damage events (i.e. red and blue hazard zones) are only marginally suitable for agriculture. Essential installations such as shelters and drinking troughs should, if possible, be situated outside the red zones, especially when these were designated owing to the high frequency of events (corresponding to fields 6 and 9 in the magnitude-probability diagram).
Horticulture must only be approved in areas of frequent flooding if it is assured that the necessary infrastructure (e.g. storage facilities for fertilisers and pesticides) can be located outside the affected areas, or is protected by technical safety measures. For agriculture in general, dynamic flooding mostly leads to the destruction of the crops. Also, the fertility of the affected areas can be reduced by the deposition of rubble and by the erosion of humus.
Long-lasting deep flooding is only possible in the basins of large rivers. The sensitivity of crops to this form of flooding is very variable. While meadows and pastures can largely survive inundation for a period up to three days without damage, arable crops can do so only in the very short term. The fine-grain solids deposited do not normally lead to a loss of soil fertility.

Recreation facilities

Uses with a recreation function generally occur in conjunction with a low concentration of material assets, but with a higher endangerment to persons.

For recreation installations, the risk acceptance is mostly higher. The risk to persons can often be reduced to an acceptable level by a suitable warning procedure, provided that the old und the sick are not involved and there is no likelihood of persons being surprised in their sleep. Furthermore, attention should be given to the coincidence of the hazard with the presence of persons. Thus winter sports and flooding are hardly likely to occur simultaneously, and outdoor swimming pools are only very marginally frequented in bad weather.

Special consideration must be given to the question as to what extent approval appears justified where damage to infrastructure installations may occur, and also in the case of extended use of auxiliary facilities (e.g. clubhouses).


Tiefbauamt Kanton Bern

The following **particularities** must be considered depending on the type of recreation facility:

- Parks and green areas serving for recreation: no restrictions in hazard zones.
- Sports facilities such as tennis courts, football grounds or light athletics stadiums: avoidance of zones with frequent and high intensities, particularly where there is a threat of bank erosion. With red zones with infrequent events (i.e. with a return period greater than 100 years), approval can be considered.
- Open-air swimming pools: auxiliary uses such as restaurants must not be located in red zones.
- Camping grounds: increased risk to persons, since summer flooding and dense occupation may coincide. Thus alarm procedures and safe escape routes must be prepared. Camping grounds with a fully developed infrastructure and consisting predominantly of permanent plots for caravans for long-period occupation are to be rejected where frequent events occur, since the threat to persons in vehicles is greater than in the open.
- Large public events: they must be prohibited in areas with suddenly occurring intensive types of hazard (debris flow, bank erosion, dynamic flooding) and short advance warning times, unless timely evacuation can be assured.

Further measures

The measures for the reduction of damage (passive measures) are accompanied by measures for the reduction of the hazard (active measures), or by emergency measures for the limitation of the residual risk.

Hydraulic-engineering measures
Where active measures against flooding must be taken, the Hydraulic Engineering Act (Bundesgesetz über den Wasserbau, WBG) specifies that measures* must first be taken to ensure proper **maintenance of rivers.**
The term "proper maintenance of rivers" denotes the maintenance of the flow capacity and the effectiveness of structural protection measures. However, despite painstaking maintenance, the service life of protection structures inevitably has its limits. By periodical inspection of the protection measures taken, possible weak points (e.g. instability of older dikes) may be recognised in good time.
Structural protection measures comprise bank protection, diking, channel improvement and flood retention measures. The WBG specifies that these should not be taken unless protection against flooding can no longer be assured with maintenance and planning measures alone.
Planning measures of this kind make necessary a knowledge of the natural processes involved and their amenability to human influence. Measures must be designed in relation to local conditions and be as near-natural as possible and in harmony with the landscape. The damage potential determined with the aid of hazard maps is an important basis for financial justification of protection measures.
The mosaic of hydraulic-engineering measures is supplemented by **further protection measures,** such as care of the protective forests in the catchment area and alongside rivers, maintaining potential flooding areas open, combating hermetic sealing of the soil surface and the reactivation of alluvial areas. Though these measures do not involve technical intervention in the river, they all fall under retention measures.

Emergency and rescue measures
In the same way as even the best fire protection structures are no substitute for a fire brigade, the best precautionary measures cannot exclude each and every risk. To limit the residual risk and/or avoid the worst consequences in cases when flooding exceeds all expectations, sufficient personnel and material resources must be available for rescue measures. Today's modern technology with radio communication, helicopters, heavy construction machinery and warning systems permit much more effective help to be given than in previous eras.

Insurance companies
An insurance against damage by natural forces (in German: Elementarschadenversicherung) is not of course a measure suitable for avoiding damage, but represents an action of solidarity with the community at large. Insurances – analogous to rescue measures – are basically a means of dealing with the residual risk.
The **principle of solidarity,** that is to say spreading the loss amongst the greatest possible number of persons, is certainly applicable to large flood catastrophes. Here, the necessary precautionary payments (premiums) would exceed the financial means of individuals. Moreover, the events are so rare as to be beyond people's personal experience.
By contrast, financial precautions against frequent, smaller, events are the **responsibility of each individual.** The insurance companies can make an ac-

* Guidelines about flood control at rivers and streams were published 2003 (Federal Office for Water and Geology: Flood Control at Rivers and Streams, Biel 2003, 72 p.)

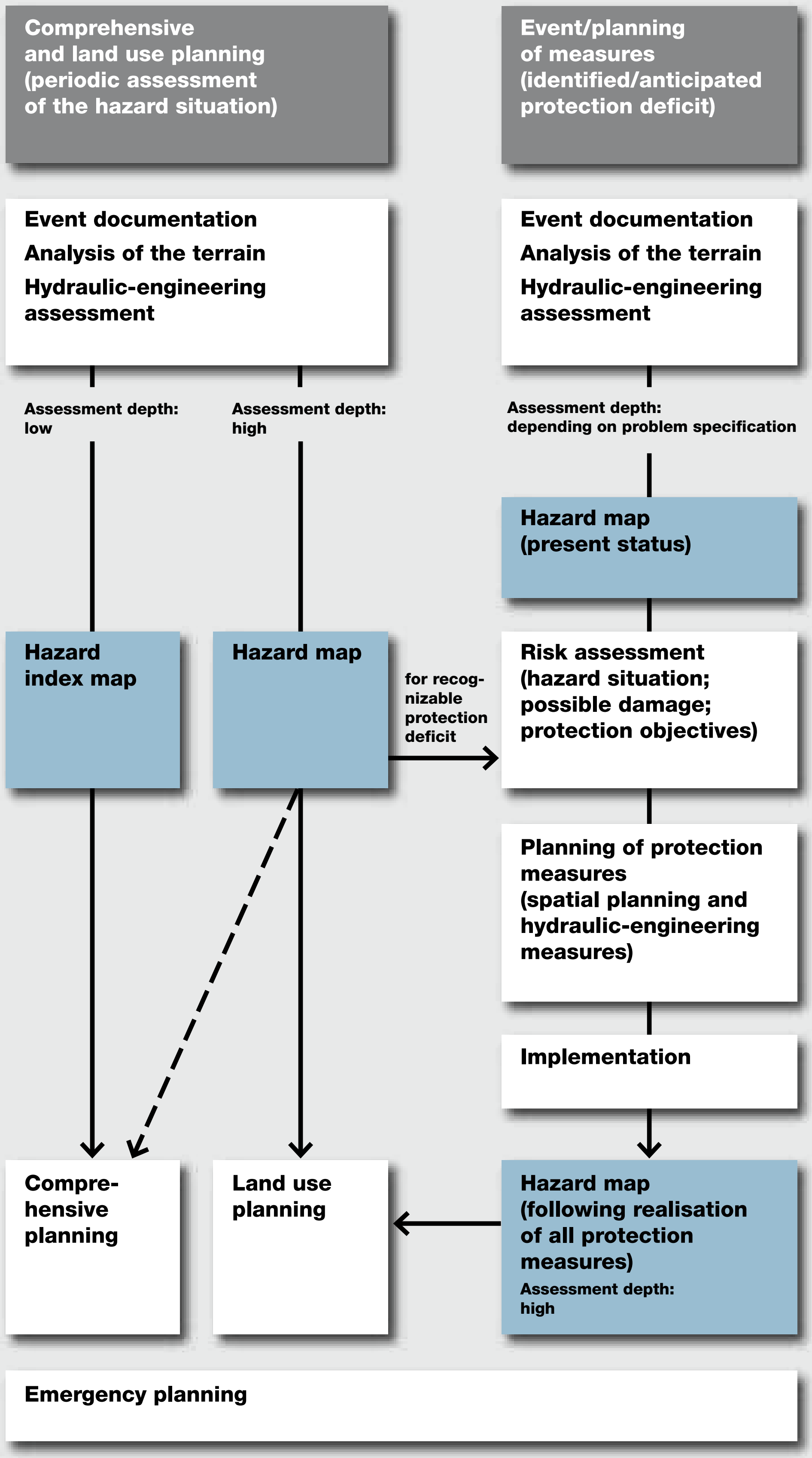
tive contribution to reducing the damage potential in cases where higher risks are taken by individuals (e.g. concentration of high-cost installations in the cellars of buildings in flood areas), by excluding or limiting coverage (maximum insured sum for cellars; exclusion following repeated claims for damage), or making coverage subject to provisions (e.g. installation of hermetically sealed cellar windows).
However, where the losses are invariably covered by the insurance company, appealing to the responsibility of individuals only to adopt uses appropriate to the risk is ineffective.

Institutional measures
In several cantons (Freiburg, Grisons, Obwalden), the appointment of a hazard commission has proved extremely effective. Hazard commissions are constituted as **interdisciplinary specialist committees.** They are responsible, amongst other things, for the preparation and updating of hazard maps, and – in their function as consulting organ – for fostering the implementation of these. Hazard commissions normally confine themselves to consultation and tabling of proposals. Thus they do not issue decisions and orders.
The agencies concerned with the determination of natural hazards and the implementation of measures should be represented in the commissions, i.e. those for hydraulic engineering, building insurance, forestry service, spatial planning and building authorities, together with responsible representatives of the communes.
Possible **principal tasks** of such hazard commissions are:
- monitoring, assessment and coordination of the preparation and updating of hazard maps (and, where relevant, hazard registers);
- consultation on implementing hazard protection principles in the comprehensive and land use plans;
- consultation of the authorities and official agencies and, where present, the cantonal building insurance agencies;
- assessment of hazard zone plans.

Furthermore, hazard commissions can assume the following tasks:
- the assessment of building projects in hazard zones;
- preparation and provision of fundamental documentation on the use of public funds for protection against natural hazards;
- supporting the responsible authorities in natural disasters;
- ensuring the internal exchange of information within the administration;
- public relations.


Frank

Procedures for meeting flood hazards in activities having spatial impact



Case study (Engelberger Aa/Canton of Nidwalden) on implementing hazard levels

Present status

Status following realisation of flood protection measures

Prepared for: Canton of Nidwalden (Abteilung Wasserbau and Oberforstamt); Prepared by: Öko-B, Stans; Niederer & Pozzi, Zürich; CES Bauingenieur AG, Hergiswil

Legal foundations

The recommendations on the consideration of flood hazards for activities with spatial impact are based on a series of federal laws and their associated ordinances as follows:

Federal Act of 22 June 1979 on Spatial Planning (Bundesgesetz vom 22. Juni 1979 über die Raumplanung, RPG)

Art. 1 Aims
[1] They [the Confederation, cantons and communes] shall take account of the natural environment and of the needs of the population and the economy [in their spatial planning activities].

Art. 6 Basic principles
[2] They [the cantons] shall determine which areas
c. are seriously threatened by natural hazards or harmful emissions.

Art. 18 Other zones and areas
[1] Cantonal legislation may include other land use zones.

Federal Act of 21 June 1991 on Hydraulic Engineering (Bundesgesetz vom 21. Juni 1991 über den Wasserbau, WBG)

Art. 3 Measures
[1] The cantons shall make provision for flood protection mainly through maintenance of the rivers and lakes and by measures having spatial impact.
[2] Where this is not sufficient, measures shall be taken such as protective structures, barriers and river training, and those to restrain bedload and flooding, together with all further provisions to prevent mass movements.

Art. 6 Financial compensation for hydraulic-engineering measures
[1] The Confederation shall pay [...] compensation for flood protection measures, namely for:
b. the preparation of hazard registers and hazard maps, [...]

Ordinance of 2 November 1994 on Hydraulic Engineering (Verordnung vom 2. November 1994 über den Wasserbau, WBV)

Art. 1 Basic principles
[2] Normally, no compensation is paid for measures for the protection of buildings and installations built in delineated hazard zones or known hazard areas.

Art. 20 Guidelines
The Federal Office shall issue guidelines concerning namely:
b. The preparation of hazard registers and hazard maps.

Art. 21 Hazard areas
The cantons shall delineate the hazard areas and take these into account in their comprehensive and land use planning and in their other activities having spatial impact.

Art. 22 Monitoring
The cantons shall periodically monitor the hazard situation of lakes and rivers and the effectiveness of the flood protection measures taken.

Art. 27 Procurement of basic data by the cantons
[1] The cantons shall:
b. maintain hazard registers;
c. maintain hazard maps and update these periodically;
e. document larger damage events.

Federal Act of 4 October 1991 on Forests (Bundesgesetz vom 4. Oktober 1991 über den Wald, WaG)

Art. 19 Protection against natural events
Where necessary to protect humans or substantial material assets, the cantons shall secure the source zones of avalanches together with landslide, erosion and rockfall areas, and make provision for river control using forestry methods.

Art. 36 Protection from natural events
The Confederation shall pay compensation [...] namely for the costs of:
c. the preparation of hazard registers and hazard maps, [...]

Ordinance of 30 November on Forests (Verordnung vom 30. November 1992 über den Wald, WaV)

Art. 15 Basic principles
[1] The cantons shall prepare the basic data for the protection against natural events, in particular hazard registers and hazard maps.
[2] In preparing the basic data, they shall take into account the work performed and technical guidelines prepared by the federal agencies.
[3] The cantons shall take into account the basic data in all activities having spatial impact, in particular in their comprehensive and land use planning.

Art. 43 Hazard map, measurement stations, early warning services
[1] The preparation of hazard registers and hazard maps [...] shall be [...] financially compensated.

Glossary and literature

(German technical terms in brackets)

Active measure (aktive Massnahmen)
This resists the natural event, thereby reducing the hazard or substantially altering the progress of the event or its probability of occurrence (e.g. barriers in torrents, flood protection dams, drainage, afforestation).

Bank erosion (Ufererosion)
Sliding of river banks caused by vertical or horizontal erosion.

Damage potential (Schadenpotenzial)
Magnitude of possible damage.

Debris deposition (Übermurung)
Deposition of debris outside the channel (frequently in the fan area of a torrent).

Degree of protection (Schutzgrad)
A measure of the existing safety.

Flood (Hochwasser)
State of a body of water in which the water level or the flow has reached or exceeded a given threshold value.

Flooding (Überschwemmung)
Covering of a land area with water and solids originating from the riverbed.

Hazard (Gefahr)
State, condition or process from which damage to the environment, humans and/or material assets can arise.

Hazard index map (Gefahrenhinweiskarte)
Outline map prepared according to scientific criteria with references to hazards that have been identified and localised, but that have neither been analysed in detail nor evaluated.

Hazard map (Gefahrenkarte)
Map prepared strictly according to scientific criteria with the following content: threat or non-threat at a point in the terrain, type of hazard at this point, and magnitude and probability of occurrence of the types of hazard concerned.

Hazard potential (Gefahrenpotenzial)
Sum of the hazardous or damaging factors in the area concerned.

Hazard zone plan (Gefahrenzonenplan)
Planning instrument based on the hazard map that is legally binding for landowners, and that has been approved by the responsible political bodies.

Land use plan (Nutzungsplan)
Spatial planning instrument on the scale of a commune.

Local protection (Objektschutz)
Protection of an object (building or installation) by a structure erected at, or around, the object.

Natural hazards (Naturgefahren)
The sum total of natural processes and influences that can represent a hazard to humans and/or material assets.

Passive measure (passive Massnahmen)
This leads to a reduction of the damage, but does not actively affect the progress of the natural event (e.g. spatial planning measure, local protection measure, emergency planning).

Protection deficit (Schutzdefizit)
Inadequate safety, i.e. if the degree of protection lies below the protection objective.

Protection objective (Schutzziel)
A measure of the safety to be achieved with flood protection measures.

Residual risk (Restrisiko)
Risk remaining following realisation of all planned safety measures.

Risk (Risiko)
Magnitude and probability of possible damage.

Structure plan (Richtplan)
Spatial planning instrument on the scale of an entire canton.

Threat (Gefährdung)
Danger related directly to a given situation or object.

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Richtlinien für den Hochwasserschutz (1992)

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Richtlinien zur Berücksichtigung der Lawinengefahr bei raumwirksamen Tätigkeiten (1984)

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