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**Federal Office for the Environment FOEN**

# ENVIRONMENT

# Natural Hazards: Prevention Pays

NATURAL HAZARDS IN THE ALPINE REGION

# Switzerland at a glance

**The hazard situation in the Alpine country of Switzerland is influenced by the significant differences in altitude over a small area and relatively high precipitation volumes as compared with the rest of western Europe. Floods, in particular, can arise almost everywhere as water run-off per square meter is almost four times the global mean.**

Switzerland lies in the temperate climate zone of the centre of western Europe and borders on France, Germany, Austria, Liechtenstein and Italy. It's territory totals 41,285 square kilometres ($km^2$), of which almost two thirds are located in the Alpine region. The intensively developed residential and economic zone is concentrated on the relatively flat Central Plateau which only accounts for 23 percent of the country's territory. Nestled between the Jura mountains in the north west and the foothills of the Alps in the south, this plain, which ranges from 50 to 100 kilometres in width, extends in a north-east direction from Lake Geneva to Lake Constance.

### Densely populated Central Plateau

The vast majority of Switzerland's population of around 7.5 million people live in the lowland. In addition to the centres of industrial production, the majority of the important service operations and the main road, rail and aviation infrastructure, all of the major cities, i.e. Geneva, Lausanne, Bern, Lucerne, Zurich and Basle, are located here. Thus, with a population density of almost 600 people per $km^2$, the Swiss Central Plateau is one of the most densely populated areas in Europe.

### High levels of runoff

Due to the prevailing westerly winds and the country's proximity to the Atlantic Ocean, the Mediterranean Sea and the North Sea, a lot of humid air is blown towards the Alps. Rain fronts often accumulate for days in front of this meteorological barrier, giving Switzerland above-average annual precipitation volumes of 1,457 litres per square metre ($m^2$). A good two thirds of this, i.e. almost 1,000 litres per $m^2$, is discharged to other countries through an intricate network of streams and rivers. The mean water runoff in Switzerland is almost four times higher than that in the rest of Europe and the world. Thus, a total of 40 billion cubic metres of water flow into the Mediterranean, North Sea and the Black Sea via the main rivers, i.e. the Rhine, Rhone, Ticino (via the Po) and Inn (via the Danube). This explains Switzerland's crucial role as a water reservoir for western Europe.

### Almost countrywide flood risk

Due to the extensive network of water courses, whose combined length totals around 65,000 kilometres, and due to the extreme differences in altitude of up to 4,000 metres over a relatively small area between the Alps and the Central Plateau, floods can occur almost everywhere in Switzerland. Moreover, the steepness of the terrain exacerbates erosion and hence, also, the risks posed by landslides and debris flows. Warmer periods, when the seasonal snow and glacier melt in the Alpine region coincide with intensive storms or orographic precipitation, are particularly critical. In this situation, rivers and lakes often break their banks and flood the valley plains.

### Wide range of hazards in the mountains

However, the mountain regions are significantly more vulnerable to natural hazards than the Central Plateau. Heavy snowfall and unfavourably structured snow cover create a risk of avalanches at high altitudes, while heavy rainfall during the warmer seasons can trigger landslides and debris flows. Rock fall and rock slides can also put both settlements and important transport routes at risk, as demonstrated, for example, by the blocking of the

## Land Use in Switzerland


Federal Statistical Office FSO, GEOSTAT / FOEN

Gotthard motorway, a key cross-Alpine road axis between northern and southern Europe, in 2006. The above-average climate warming in the Alpine region and the resulting thawing of the permafrost and retreat of the glaciers will cause greater volumes of loose material to be mobilized in the future, a development which represents an additional threat to settlements, transport routes and other infrastructure. Longer periods of drought also increase the risk of forest fires, particularly in the south of Switzerland. Overall, climate change is expected to increase the intensity of precipitation and storms, prompting the need for more measures to limit the extent of the damage caused by floods, hail and severe storms. Earthquakes tend to be a rare occurrence in Switzerland, however when they arise they represent the natural hazard with the greatest potential for damage. Individual areas such as Valais and the Basle region are at greater risk from earthquakes than other parts of the country.

### Safety as a public service

The protection of the population and important material assets against natural hazards is provided as a public service by the state. In the federal state of Switzerland, this task is perceived as the joint task of the Confederation, cantons and municipalities. The authorities on all three levels work closely with each other in this area, which requires close cooperation. Thus, for example, the 26 cantons are responsible for the maintenance of the protection forests and water bodies, hazard mapping and the planning, construction and maintenance of protective structures – however they receive financial and expert support from the federal authorities. The Federal Office for the Environment is responsible for the strategic management of these tasks and guarantees safety at national level on the basis of uniform standards. It is up to the 26 cantons to decide whether to organize these tasks centrally or to delegate some of them to the political municipalities, of which there are over 2,700 in Switzerland. Thus, the system accommodates the cultures of political cohabitation which vary from region to region.

■ Beat Jordi

HAZARD PREVENTION

# There is no such thing as absolute safety

**As a mountainous country with considerable variations in altitude over a relatively small area, Switzerland is particularly vulnerable to the various types of natural hazards. Swiss society is in a position to reduce existing risks to human life and material assets to an acceptable level, however there is no such thing as absolute safety.**

On the night of 23 August 2005, the swollen Glyssibach torrent burst its narrow banks and discharged thousands of tonnes of debris and mud into a neighbourhood of Brienz in the canton of Bern. Following heavy rain throughout the Alpine foothills, numerous landslides were triggered on the steep slopes of the Brienzer Rothorn mountain, the contents of which were conveyed down to the valley at top speed by the mountain torrents. Ten buildings failed to withstand this force of nature and were completely destroyed by the deluge of debris and water from the Glyssibach, and a further 18 houses suffered extensive damage. Two people lost their lives on the night of the disaster, however the majority of people who were taken by complete surprise by the event – and, in some cases, roused from their sleep – managed to make it to safety in good time.

### More space for mountain torrents

Just a short time after the devastating debris flows, the Bernese cantonal authorities responsible for flood protection in the region decided – in consultation with the federal authorities and the affected municipality – that some of the houses destroyed by the flood should not be rebuilt in the same location. To create sufficient space for the torrent's bed load in the case of future extreme events, its discharge corridor in the village is being widened considerably to 18 to 21 metres and secured by means of massive dikes. An even wider channel is needed in the flatter estuary area where the Glyssibach torrent deposited its debris on a number of occasions in the past. For reasons of space, it will be necessary to sacrifice some of the existing development land in this case as some of the destroyed houses on the alluvial fan bordered directly on the old torrent bed. The families affected by this measure found alternative solutions and were compensated for the loss of land by the municipalitiy.

### The renunciation of land use in high risk areas

As in Brienz, a row of 14 houses in Chippis near Siders on the river Rhone

*continued on page 8*

**Flood damage in Switzerland between 1972 and 2002**

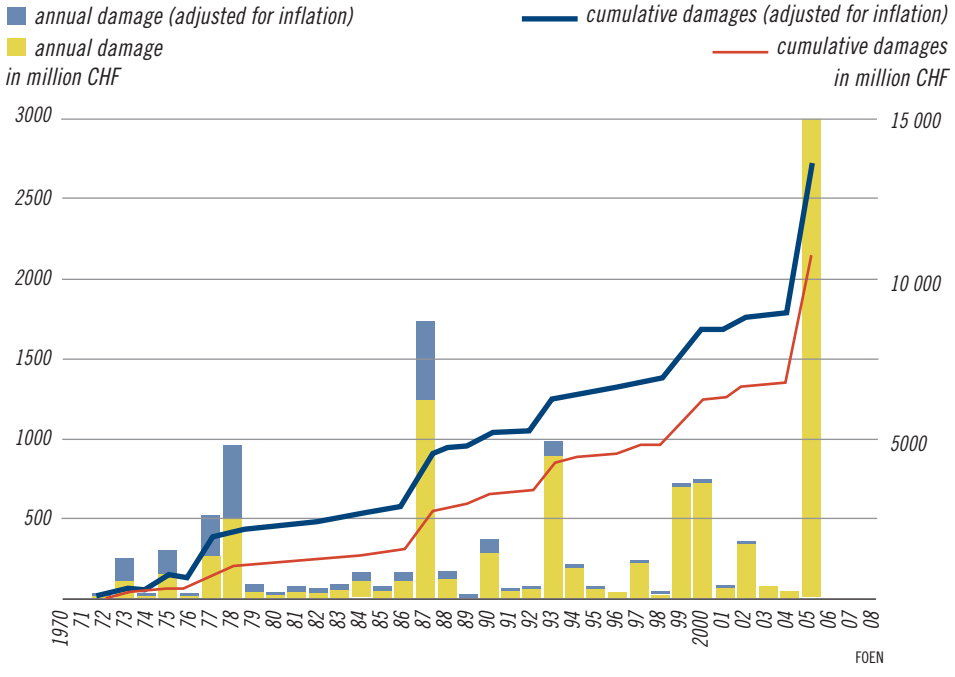
WSL

**As demonstrated by an analysis of flood damage between 1972 and 2002, large areas of Switzerland are flood-prone. Each blue dot on the map marks a loss event.**

Swiss Air Force

**The destruction of part of Brienz village in the canton of Bern by debris flow from the Glyssibach torrent during the storm of August 2005.**

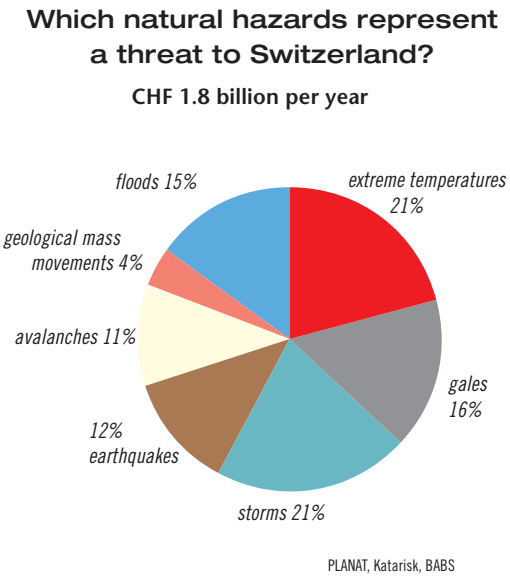
## Flood damage in Switzerland between 1972 and 2005




**The scale of the damage caused by floods is increasing. The storms of August 2005 – with heavy flooding in Central Switzerland and Bernese Oberland – were the most expensive extreme event ever suffered by Switzerland.**

AURA

**Avalanche damage in Goms near Selkingen, canton of Valais, February 1999.**




**The total cost of the risk posed to Switzerland by all natural hazards is CHF 1,800 million per year.**

Keystone

**Damage caused by Storm Lothar in December 1999.**

in the canton of Valais had to give way to provide sufficient discharge capacity for the confined river in the event of flooding. This measure is included in the plans for the Third Rhone Correction. These two examples herald a turning point in the approach to natural hazards in Switzerland. "We can no longer cling to existing land-use practices in high risk areas at any price," says Hans Peter Willi, Head of FOEN's Hazard Prevention Division. "Swiss society should consistently avoid using areas where human life and material assets cannot be protected at a reasonable cost for development and give them back to nature or agriculture." This renunciation of land use in high risk areas may well be advisable if this measure ensures greater safety for buildings in adjacent areas.

### Increasing damage

The concept of safeguarding hazard zones by keeping them free of development is also supported by the insurance companies which have had to pay out large compensation sums in recent decades, in particular as a result of the repeated floods – in some cases in the same location, as was the case, for example, in the Matte neighbourhood of Bern on the bank of the river Aare. Since 1972 alone, the total cost of flood damage in Switzerland exceeds CHF 11 billion (adjusted for inflation). At around CHF 3 billion, the large-scale havoc wreaked by the storms of August 2005 generated the highest costs. However, the scale of damage arising from natural disasters is constantly increasing, not only in Switzerland, but also in other countries. The main reasons for this are the general expansion of settlement areas, the associated appreciation of development land values in areas potentially at risk, the greater vulnerability of infrastructure and increasing mobility and communications requirements. "The situation is aggravated by the increasing intensity of extreme weather events arising from climate factors caused by the greenhouse effect, which is exacerbated by human activity," explains Markus Nauser from FOEN's Climate Section. "As an Alpine country, Switzerland is affected particularly severely by the effects of climate change." The rising freezing level is causing glaciers and permafrost in the high mountains to melt which, in turn, aggravates the risks posed by debris flows, rock fall and rockslides. In general, the increased water and energy content of the atmosphere at higher temperatures promotes more intensive precipitation and heavier storms.

### Identifying the hazards and taking action

"In order to be able to provide better protection to people and important

Swiss Air Force

**Thanks to a discharge corridor, which channels the water from the rising Engelberger Aa river across the airfield into Lake Lucerne in the event of flooding, Buochs, canton of Nidwalden, (right) was protected from flooding in August 2005. Ennetbürgen, canton of Nidwalden, (left) was partly flooded because the protective dike, which has now been completed, was not finished due to project delays arising from planning objections.**

material assets against risks we must first record and assess the different natural hazards on the basis of uniform criteria adopted nation-wide" says Hans Peter Willi. The hazard maps which are co-financed by the federal authorities and are due to be completed by 2011 will serve this purpose. "These should highlight areas that should not be developed for safety reasons, on the one hand, and possible protection deficits in existing settlement and infrastructure areas, on the other."

The state guarantees the provision of basic safety services – as a public service – over a wide area, in particular through the maintenance of the protection forests and through appropriate hydraulic engineering measures and the maintenance of watercourses. If, despite these measures, people, residential buildings, transport links and other important facilities are exposed to unacceptable risks to the point where the target-protection objectives are not fulfilled, additional measures must be undertaken to improve the situation. These measures may be structural in nature – as in the case of avalanche sheds, rock fall nets, debris flow barriers and flood dikes. For financial, technical and ecological reasons, however, the state cannot afford to protect all buildings and infrastructure against natural hazards by constructing expensive protective structures. Spending of up to 20 percent of the value of the goods at risk on protective structures is seen as a worthwhile investment.

### Increasing individual responsibility

Depending on the situation, the implementation of local protection measures (proofing) appears to offer an obvious solution to reducing the vulnerability of individual buildings and facilities in the case of a hazard event. The destructive effects of large earthquakes, which are admittedly very rare in Switzerland but constitute the natural hazard with the greatest potential in terms of the extent of the damage they cause, can only be prevented through the implementation of such structural protection measures in the relevant building or facility, i.e. earthquake proofing. Generally, the owner is liable for the cost of all types of proofing. However, some buildings insurers have recently begun to invest in prevention as this enables them to avoid large compensation payments for a relatively small outlay. The significant increase in the excess paid for household contents insurance from CHF 200 to CHF 500 also provides a financial incentive for the promotion of private damage protection.

### Prevention pays

According to a survey commissioned

by the Federal Council, i.e. Swiss government, and published by the PLANAT expert commission in 2006, Switzerland already spends CHF 2.9 billion or 0.6 percent of gross domestic product annually on measures to provide protection against natural hazards. This corresponds to barely 1.2 tenths of a percent of the total value of all of the country's buildings and their contents. Of this expenditure, 60 percent falls to private entities and the rest is made by the state. Flood protection and storm protection account for most of the money spent. Almost half is used for prevention. How effective these investments in the safety of our environment can be, is clearly demonstrated by the flood events in the Buochs area (canton of Nidwalden) during the storms of August 2005. Hydraulic engineering measures carried out to modernize and improve flood protection on the Engelberger Aa river and completed shortly before this event at a cost CHF 26 million helped to prevent flood damage in excess of CHF 100 million.

**Organizational safety measures**

Because it is impossible to provide absolute protection against extreme events, the organizational measures imposed by crisis management committees – such as evacuation and blocking of roads and rail links – play a key role in situations of imminent danger. They are particularly important at local level in areas that are inadequately shielded against floods, debris flows, landslides and avalanches by protective structures. To be able to save as many human lives as possible and limit the scale of the damage in the event of a natural hazard, the local emergency services and the affected population must be fully aware of existing weaknesses and know how to behave in such serious situations. For this purpose they are dependent on reliable warning and alarm systems which can also function in emergency situations accompanied by breakdowns in power supplies and communications links. The event analysis of the storms of August 2005, which has not yet been completed, has highlighted some deficits in this regard which the federal authorities now aim to resolve through targeted measures to improve hazard warning and alarm systems. Switzerland already spends around CHF 400 million annually on provisions for such intervention.

**The community of solidarity of the insured**

Considerably more money, i.e. almost CHF 1.1 billion per year, is spent on provision for recovery. Insurance premiums account for three quarters of this sum. The well developed community of solidarity among insured parties with buildings insurance enables regions, companies and individuals severely affected by natural disasters to survive economically and finance their new start – as, for example, in Brienz where, 20 months after the disaster, few traces remain of the disastrous night of August 2005.

■ Beat Jordi

FOEN

## One-stop office for all natural hazards

As the leading authority at federal level with responsibility for this area, FOEN has been dealing with all natural hazards and the associated safety issues since 2006. Its strategy in this area, which was developed jointly with expert organizations and cantons, is aimed at safeguarding the lives and livelihoods of individuals and communities .

Through integrated risk management based on the principle of sustainability, FOEN aims to guarantee a high level of protection for the population and important material assets throughout Switzerland on the basis of uniform safety standards. Important areas of activity in this regard include the development of basic principles, consultancy and quality control services for hazard protection projects, education and training for actors at all levels, the exchange of experience with other countries and engagement in a societal risk dialogue.

## LINKS

www.bafu.admin.ch/naturgefahren (only available in German, French and Italian)

www.planat.ch

www.swissworld.org

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INTEGRATED RISK MANAGEMENT

# A sustainable approach to risk

**Providing protection against natural hazards is the shared task of many stakeholders. In addition to the state, private institutions and all potential victims are also involved in this endeavour. The planning of protective measures should be tailored to individual situations and be as sustainable as possible. The example of the Sarner Aa river demonstrates the criteria, on the basis of which FOEN evaluates such projects.**

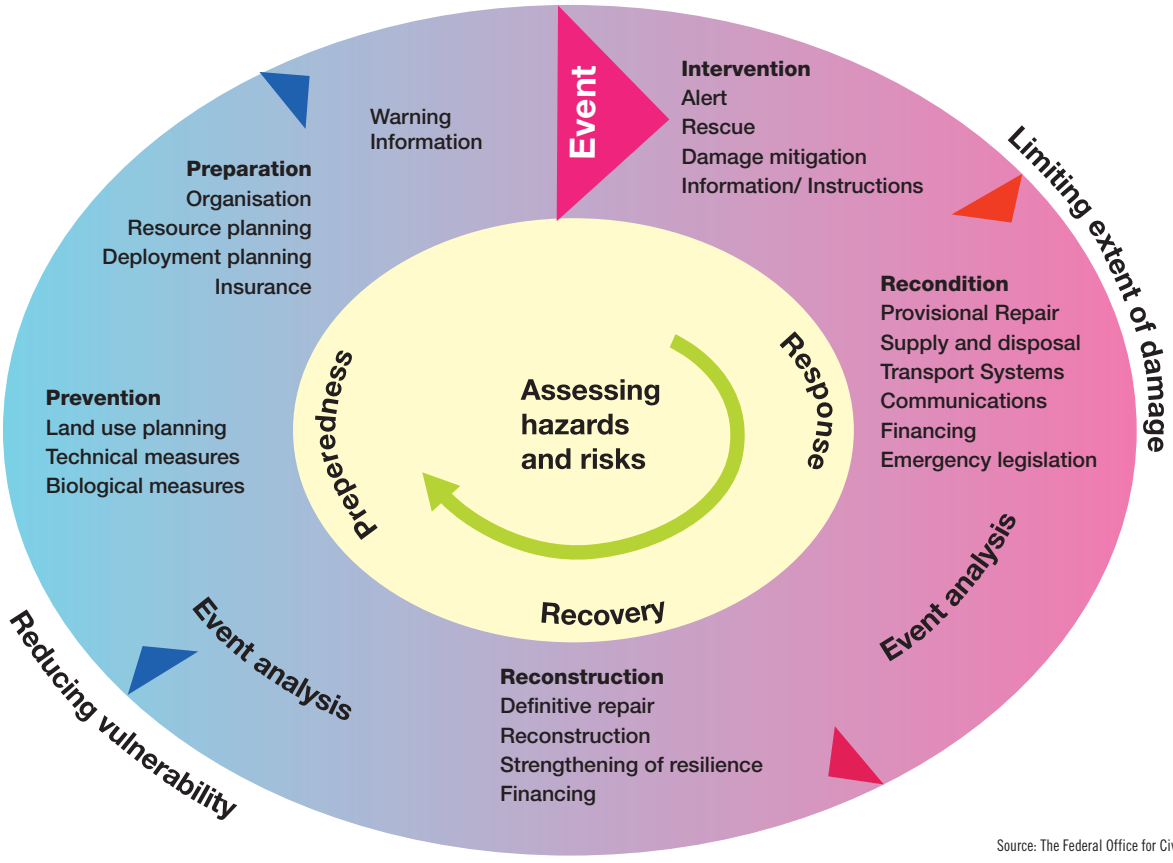
Swiss Air Force

**To protect Sarnen, the capital of the canton of Obwalden, against floods of this kind (August 2005), it is intended to increase the flow capacity of the river Sarner Aa.**

Sarnen, the capital of the canton of Obwalden, was flooded for the third time since 1999 on 23 August 2005. Within 36 hours, the water in Lake Sarnen rose a good two metres to a level of 472.42 metres, thus exceeding the previous record from 1999 – another year of extensive flooding – by 1.14 metres. The crisis management authorities appealed to the population to leave the ground floors of their houses, seek refuge in the upper floors and prepare for evacuation. Throughout the Sarner Aa valley, the main river, which was in full flood, and its overflowing tributaries caused extensive damage to houses, industrial buildings and infrastructure to a tune of over CHF 200 million. Over 1,000 debris flows and accumulations of debris on 450 hectares of land were recorded throughout the canton. The main transport axes were blocked by floods, debris deposits and landslides with the result that a number of municipalities were cut off from their surroundings.

### Effectively minimizing risk

Given the deficits that exist in the protection of the living and economic environments of several thousand people, the urgent need for measures to improve safety in the valley of the Sarner Aa is uncontested. "We want to protect human life, livelihoods and important material assets at an acceptable cost," says Gian Reto Bezzola, Head of the Risk Management Section at FOEN. "The degree of protection provided should be consistent with standards in the rest of Switzerland." The process involved in providing protection against natural hazards is based on clearly defined steps. First, experts assess the relevant risks on site – starting inter alia




Source: The Federal Office for Civil Protection

**The cycle of integrated risk management: an integrated and holistic risk management assumes that all types of measures for natural disaster reduction are considered. Generally, measures of preparedness, response and recovery (reconstruction) should be equally implemented.**

from experience with previous hazard events. Based on the existing natural hazards, current and planned land uses and the ecological status of the location, the second step involves the joint definition by all stakeholders of the action that needs to be taken. The question as to what can be allowed to happen as a result of a hazard event is answered with the help of a risk evaluation which takes the relevant social, economic and ecological factors into account. Depending on the defined protection objectives, experts identify the optimum combination of protection measures from the catalogue of available measures. Priority is given here to the appropriate maintenance of protective structures, the preservation of the flow capacity of watercourses and the maintenance of protection forests. "Particular priority is given to spatial planning measures," notes Gian Reto Bezzola. "This means that riverine zones, retention areas and discharge corridors can be kept free for extreme events, thus enabling them to make an important contribution to the prevention of an unchecked increase in damage potential." Structural measures are only considered when these measures prove insufficient. However, it is not possible to provide complete protection against hazard events. Moreover, rare large-scale events can exceed the capacity of the measures implemented with a specific protection objective in mind. The associated residual risks must be minimized with the help of suitable precautions. Alarm-raising and evacuation, local proofing of assets and insurance cover for eventual damage constitute important elements in tackling residual risks.

### A touchstone for the concept of sustainable hydraulic engineering

The protection objectives defined for the Sarner Aa valley can only be fulfilled with the help of structural measures. One possible solution would be the construction of a bypass tunnel from Lake Sarnen to Lake Wichel, which is located around four kilome-

AURA (2), FOEN (4)

**Integrated risk management incorporates all measures that contribute to the reduction of damage caused by natural hazards: for example, emergency management during disasters, the maintenance of protective structures, repair work, the maintenance of protection forests and structural measures.**

tres further down in the valley. This would mean that once the water in the lake reaches a certain level, the water would be channelled underground through the mountain ridge to the east of Sarnen without affecting the valley river. Based on current information, this solution would cost around CHF 67 million.

Another solution, which would cost CHF 47 million, involves the deepening and widening of the Sarner Aa. The river would be deepened by up to two metres and widened by a maximum of 20 metres downstream of Lake Sarnen. Additional embankments are planned to provide flood protection to residential areas as well as targeted flooding outside of developed areas. "Thus, the capacity of the existing watercourse could be increased and the section of the river outside the settlement area would be ecologically upgraded at a significantly lower cost," explains Gian Reto Bezzola. "In view of the limited financial resources available which oblige us to adopt the most sustainable solutions possible, in the case of the Sarner Aa, a number of factors support an over-ground solution."

This variant affects many more stakeholders, and would, therefore, take longer to implement. Due to potential damage arising from another flood event, a delay of around two years would generate an additional risk of the order of CHF 5 million. This is still significantly less than the difference in price between the two variants. Thus, FOEN favours the cheaper option and proposes that the additional risk be covered by insurance. "Economically acceptable and environment-friendly hazard prevention ultimately involves the acceptance of damage in the case of rare large-scale events," says Gian Reto Bezzola. ■ Beat Jordi

INFO

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HAZARD MAPS

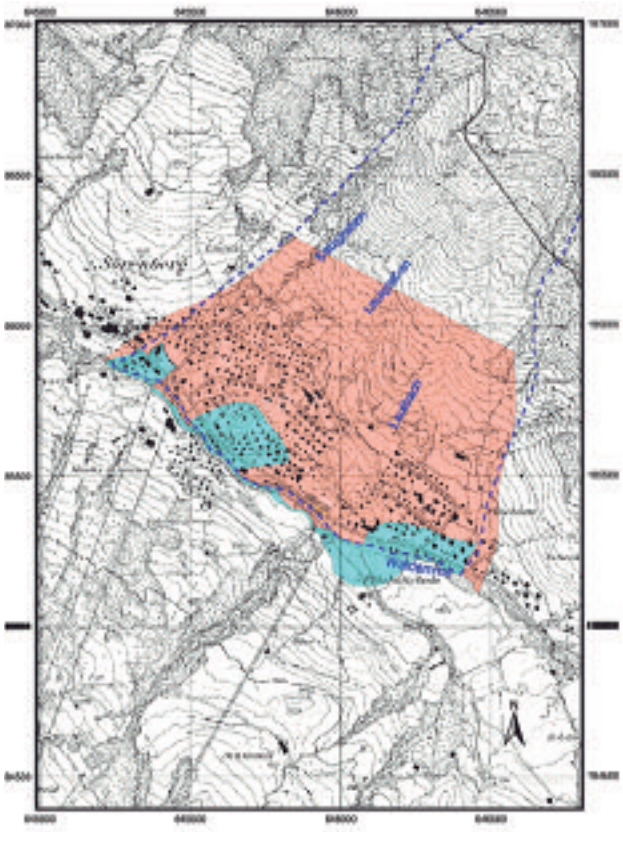
# Experts survey all risk areas

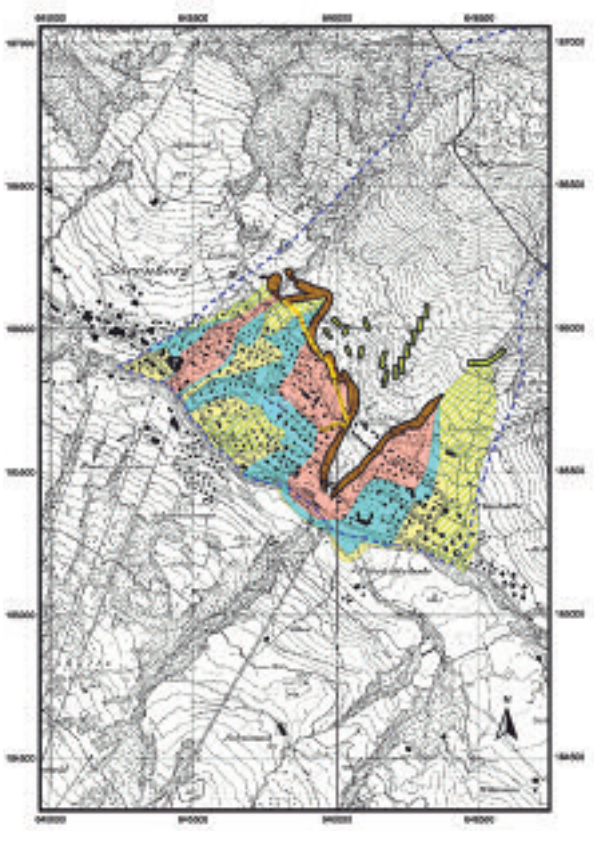
**Thanks to the hazard maps, we should know by 2011 where and to what extent human beings and important material assets in Switzerland are at risk from natural hazards. The maps, which are being compiled by experts, help to ensure that areas at risk are kept free from development. They also constitute an important basis for the planning of protective structures and for emergency planning for crisis situations.**

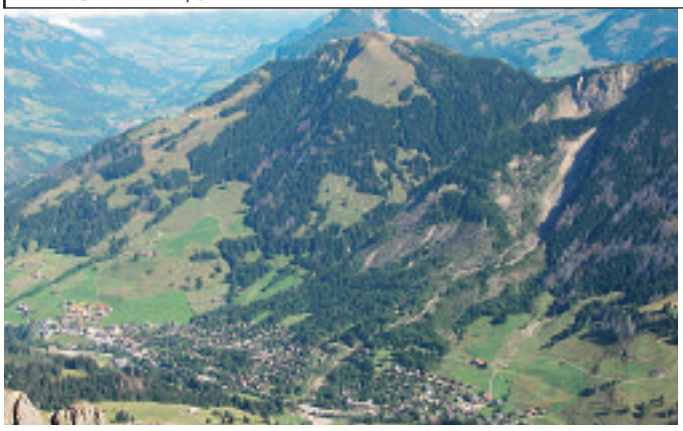
As the saying goes "a rolling stone gathers no moss," and, given that it is the inspiration behind the name of the eponymous rock band, it must be true. Sure enough, the block of limestone lying on the foot of a beech tree on the south-eastern flank of the Urmiberg above Brunnen in the canton of Schwyz is smooth and moss-free. "It has not been lying there long," says geologist Markus Liniger. The boulder fell loose from a ledge 50 metres higher up. Using his geologists' compass, Markus Liniger establishes the dip direction and slope inclination. The slope is 42 degrees steep yet the tree was able to block the rock's descent. The forest stands on loose limy soil. Other evidence of rock fall activity is provided by the many marks in the bark of the trees. They generally lie at a height of around one and a half metres. It may be concluded from this that the stones descend towards the valley in smallish hops. The limestone

**Hundreds of houses in Sörenberg in the canton of Lucerne are located in the red hazard zone and, therefore, in the high risk category (left). Nünalpstock, the unstable peak above the village poses a risk of a major rock falls and slides. The threat to a large part of the settlement is now to be averted by means of structural protection measures. As part of the project (right) it is planned to construct barriers and channeling elements on the slope (dark green) and a training dike (brown). The future hazard map reflects the risk reduction following the implementation of the hazard protection project.**

Fachbereich Naturgefahren, canton of Lucerne







Beat Jordi, Biel (2006), Fachbereich Naturgefahren, canton of Lucerne (1911)

**Sörenberg im Entlebuch was built after 1970 on the piles of rubble deposited by major rock slide events. Other major rock slides have occurred since the slide of 1910 (right) – the last one in 1999.**

## Hazard maps as a source of dispute

The red area on hazard maps largely indicates areas where development is banned. Planning permission is not granted here: buildings that are destroyed are not rebuilt and very few conversions or extensions are allowed. The owners must therefore accept a loss in the value of their property and have no right to compensation. As a result, hazard maps can easily become a cause of dispute and this makes their meticulous compilation all the more important. The hazard category is derived from the intensity and probability of the individual hazard types. Uniform quantifiable indicators exist for the definition of the intensity categories. "The procedure has proven optimal in numerous projects," reports Roberto Loat from FOEN. "This is further substantiated by the low number of objections. An important reason for this is that a risk dialogue between the authorities and local residents is initiated at an early stage in the project."

lies in layers parallel to the slope and is strongly fissured. The geologist measures the existing joint faces in the rock and identifies the potential falling bodies. He will enter these values – along with other data such as the slope inclination, fall height, absorbability and coarseness of the surface, tree stem density and mean stem thickness – into the computer and generate a simulation of the rock fall process.

### Assessing the hazards

The protection forest at the Urmiberg currently does a very satisfactory job. Beeches, pines and spruces grow on the sunny scarp and numerous holly trees attest to the mild local climate. An access road was built in the 1990s to facilitate the maintenance of the protection forest or enable its establishment in the first place. However, it is still possible for stones to crash down across the forest edge. Markus Liniger records the evidence of this in his notebook. How often does this happen, how large are the falling bodies, how far do they travel and at what kind of force? It is important to know the answers to these questions because the land at the foot of mount Urmiberg is used for settlement and other purposes.

This hazard assessment was commissioned by the canton of Schwyz. Together with information from the natural hazards database, the site findings, calculations and rock fall simulations will be used in the compilation of the "Rock fall" hazard map to be created on a scale of 1:5000.

### Avalanches, floods, landslides, rock fall

The cantons are currently working on the systematic surveying of their hazard areas. They are doing this, first, to fulfil an obligation defined in the forest and water engineering legislation and, second, because there is a significant need for populations to be aware of the hazard situation in their localities. By 2011, hazard maps indicating the areas in which avalanches, floods, slides and rock fall could represent a risk to human life and important material assets should be available for all residential areas in Switzerland.

According to a survey carried out by FOEN on the status of the hazard mapping process, with two thirds of the area to be mapped already covered, avalanche risk emerges as the best documented risk. In addition to this, 30 percent of flood hazard areas, 29 percent of rock fall areas and 23 percent of areas affected by landslide activity, have been mapped.

### Four hazard categories

The Swiss hazard maps specify four hazard categories:

- Areas at "serious risk" from hazards are marked in red. Buildings in these

locations could be completely destroyed by natural hazard events, thus people are also at risk here even inside the buildings.

- The areas marked in blue are at "medium risk." People are usually protected if they remain inside solidly built houses, but not if they go outside. Damage to buildings may be expected, but they would not be expected to collapse if they have been constructed in accordance with the relevant standards.
- Areas marked in yellow are characterized by a "low risk" to human life but considerable material damage is still a possibility.
- A residual risk exists in yellow-white hatched areas.

"Used in conjunction with intensity maps and other documents, hazard maps constitute a basic prerequisite for making hazards and risks understandable to the authorities and stakeholders," says Roberto Loat from FOEN's Risk Management Section.

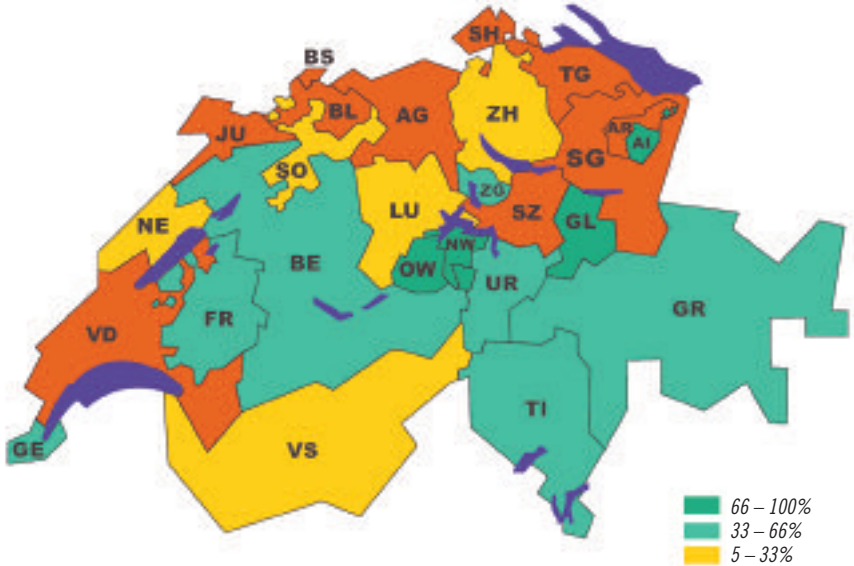
**Spatial planning instrument**

The area in which the hazard maps are most effective as an instrument is spatial planning at municipal level, which is binding on land and property owners. Thus, no more development zones should be designated in the areas marked in red on hazard maps. If not already in force, zoning bans should be considered in areas in which the state can only provide an adequate level of safety at an unacceptable cost. In areas classified in the blue hazard category, new buildings are generally only authorized in conjunction with stringent safety requirements. However, these spatial planning measures come too late in many areas. What happens if buildings or important infrastructure has already been built in hazard areas and risks exist? In such cases, the level of safety required and the level of damage that should be accepted must first be clarified. "If people or significant material assets could be affected, the protection objective is set at a higher level than for less important material assets with limited damage potential," says Roberto Loat.

**Rock-slide risk in Sörenberg**

Seven hundred residential units stand underneath a slope in Sörenberg in the canton of Lucerne which is sliding at a rate of two centimetres per year. The residential settlement in question originates for the most part from the early 1970s. "The housing was built at the time in full knowledge of the risk situation," says René Graf, Director of the Natural Hazards Department at the Lucerne Cantonal Authority for Agriculture and Forest. The area is called "Laui" which is derived from the German term Steinlawine, i.e. rock slide or rock avalanche. However, the collective memory of the rock slide of 1910 – with debris flows that extended right down to the now developed area – had been suppressed. Sudden slope failures, which can arise as secondary events in mobile slopes (see page 19), represent a real risk at present. Two larger debris flows were

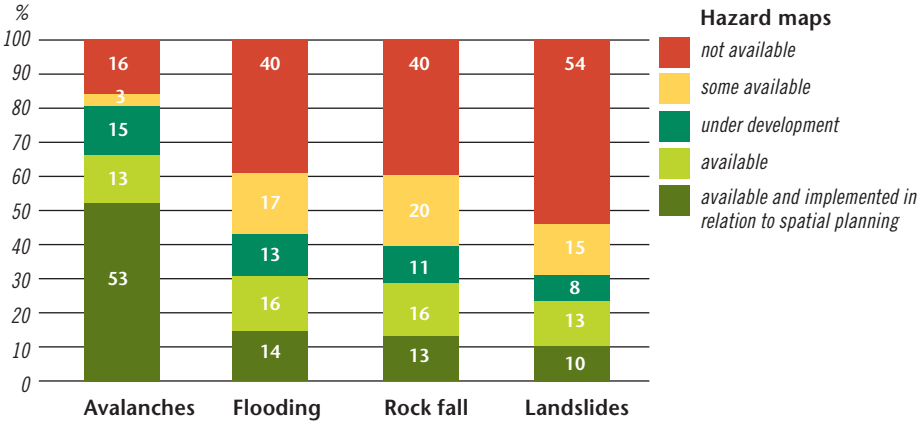
**Hazard map for flooding, status 2006**




Percentage of mapped area per canton

FOEN

## Percentage of Swiss territory covered by hazard maps based on hazard types




BAFU

triggered in 1999. Human life is at risk when debris flows penetrate to residential areas. For this reason, the Lucerne cantonal parliament authorized an overall structural measures concept costing CHF 14.2 million. The buildings will be protected in future by two large sediment retention basins and a 1.8 kilometre-long, five-metre-high training dike. All going smoothly, work will start on the project in 2007. The cost will be met jointly by the Confederation, canton, municipalities and owners of the affected houses. René Graf estimates that the house owners' contribution will range between a few hundred and a few thousand francs per residential unit.

### Avoiding harm to human life

It is also intended to monitor and control the conditions in the rock-slide area with the help of a permanent recording system. "The aim of these measures is to avoid harm to human life," says René Graf. This means that it will be possible to know when there is risk of a disaster in areas where the protective structures are not sufficient to safeguard the houses. "Today, the advance warning time for debris flows is two hours – barely enough time for evacuation. One day, it will be 24 hours or longer." Despite these measures, some houses will still be located in the red zone and should the worst case arise or should they be destroyed as a result of a different event – for example a fire – planning permission will not be granted for their reconstruction in the same location.

### Practical test passed

Overall, the hazard maps already available passed their practical test during the storms of August 2005. The experts were around 80 percent correct in their hazard assessment. The knowledge provided by the maps proved life-saving in some instances. Roberto Loat is aware of several such cases. "Thanks to the hazard map, for example, it was known that several houses on Lake Lucerne in Weggis (canton of Lucerne) were at risk from a landslide. Thus, the affected people were evacuated. The slope slid shortly afterwards. Three buildings were destroyed but nobody was hurt." The Engelberger Aa river provides another such example. Based on the hazard maps, part of the flood discharge was forced to spill over and deliberately inundate undeveloped areas. This overflowing water could then be channelled and conveyed to Lake Lucerne without causing damage. Uncontrolled flooding would have resulted in the inundation of Buochs and Ennetbürgen in the canton of Nidwalden. "On average, we calculate that it costs CHF 5,000 per square kilometre to compile a hazard map. This figure can, of course, vary significantly, notes Roberto Loat. "Compared with the potential damage caused by an extreme hazard event, this is a very small sum. The storms of 2005 caused damage totalling over CHF 100,000 per square kilometre in the affected areas."

■ Hansjakob Baumgartner

## LINKS

www.bafu.admin.ch/naturgefahren > Umgang mit Naturgefahren > Gefahrenkartierung und planerische Massnahmen (only available in German, French and Italian)

www.planat.ch > Risk Management > Preparedness > Prevention

## INFO

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LANDSLIDES

# Entire mountain slopes on the move

**The sliding of slopes is an essential fact of the earth's unending geological history. Permanent landslides have been under way in several areas of Switzerland for thousands of years now. The thawing permafrost soils at higher altitudes are now increasingly on the move too. A satellite monitoring system is assisting in the timely identification of this hazard and its avoidance.**

The tower is slightly crooked, but nothing else about the church in Peiden in Val Lumnezia (Lugnez) in the canton of Graubünden betrays the fact that this house of God is on the move. Over the past century, its position has shifted to the south-east by over 16 metres and it has subsided by four metres. Peiden is located in a 30-square-kilometre slide area with a slate sagging. The left side of the valley from Lumbrein to Cumbel, which stands on a nappe with a 15 degree gradient, is creeping valleywards at a rate of between 1 and 20 centimetres per year. On a geological timescale, this is a brisk speed. Anyone who hikes from Peiden to Vignon will experience a geological drama. The terrain is shaped by the accumulated slide material and fresh cracks, landslides and rock falls bear witness to the fact that an ongoing chapter of geological history is being written here.*

### On the move for millennia

The landslide process in the valley, which has been populated since the Bronze Age, started several thousand years ago. Due to its location in a zone subject to what are known as differential movements, of the eight villages located on the landslide body, Peiden is by far the most severely affected. When the movement of the ground is deep, steady and slow, buildings are barely affected. This is not the case, however, if the speed of the movement is higher at the front of the building than that at the back. The houses in Peiden are neat and fully intact, but some of them show traces of repeated repair work. Repairs have not been carried out for years on one particular building. Wide cracks gape open in the masonry of the derelict Walser house.

The proximity of the village to the river Glogn (Glenner), which is eroding the foot of the slope one hundred metres further down, is also unfavourable. Following floods in the late 1920s, the

** The hike from the «Valgronda» post-office car stop outside Cumbel via Peiden – Bual Sut – Degen takes a good two hours. Map 1:25 000, sheet 1214 Ilanz (Glion).*

## Near-surface slope failures

If the slip surface of a landslide is near the surface, vegetation can also influence the process. The root system of some tree species can extend to as many as two or more metres underground. Deep rooting trees and bushes draw water from the soil and hence the crucial lubricant.

Meadows also stabilize the soil. Because the presence of numerous types of plants on a small surface creates a greater variety of soil anchors, plant cover with a high level of biodiversity provides better protection against erosion than a homogenous species community. The fertilizing of steep slopes – whether intentional or the result of nitrogen emissions from the air – diminishes their stability as it reduces biodiversity and promotes flat-rooting species.

www.waldwissen.net > Natural Hazards > Erosion

FOEN

**Destructive landslide in Lutzenberg, canton of Appenzell, 2002.**

Hans Rudolf Keusen, Geotest AG, Zollikofen

**The Stieregghütte (mountain chalet) at the foot of Mettenberg mountain near Grindelwald in the canton of Bern fell victim to this moraine slide in 2005.**

ground began to slide so strongly that Peiden almost had to be evacuated. Resettlement was considered but the inhabitants did not want it. The population at the time was 87, it is now 11. The adverse geological location, hastened migration from the village. According to the website of the municipality of Suraua, to which Peiden belongs, "fear of the forces of nature fuelled by over-pessimistic forecasts prompted many families to leave Peiden."

**Crack in a building as an indicator of the large-scale landslide in Peiden, canton of Graubünden.**

FOEN

### Well known landslide area

Lugnez is a textbook example of a large landslide area. Measurement data from the area go as far back as 1887. Like major rock falls, deep-seated landslides can rarely be halted by human intervention or only at a disproportionate cost. However, deceleration has been achieved with the help of underground drainage, even in the case of very large landslides *(see «Drainage as a recipe for success» page 21).*

Drainage, corrections of the river Glenner and the construction of the Zervreila dam in its watershed area have also alleviated the situation in Lugnez somewhat. No further significant acceleration has been observed for decades. However, the slope continues to slide. Peiden would not be built again today. The village is located in the red zone on the hazard map and is, therefore, at "serious risk" (see page 14). The situation is less critical in other parts of the valley where the slide activity is deep-seated and steady. It is possible to build there, although safety requirements must be fulfilled. "A strong reinforced concrete substructure may be necessary, for example," says Hugo Raetzo from the Landslides, Avalanches and Protection Forest Section at FOEN.

### Monitoring of areas at risk

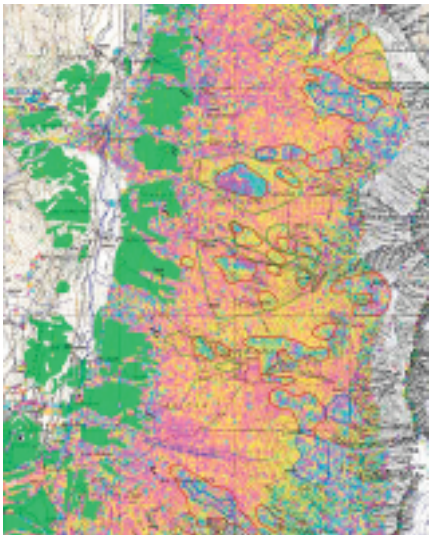
The safety of the population in a landslide area is at risk if the process accelerates, if differential movements damage houses or if secondary landslides develop spontaneously. The latter can move rapidly in the direction of the valley and just a few thousand cubic metres of rock is enough to destroy buildings. Slope-type debris-flows have also caused fatalities in Switzerland in the past. Dozens of people die in rapid landslides in Italy every year. In addition, debris flows can develop from the landslide areas, and, due to the high volumes of bed load they carry, these

represent a risk to settlements located as far as several kilometres away from the landslide area. Because landslide movements can accelerate abruptly, their development should be monitored. Today, FOEN uses the most modern resources available, such as radar interferometry, for this purpose. Using radar waves, it is possible to obtain maximum-precision distance measurements at every point on the earth's surface from satellites located 800 kilometres away. Boulders, roads and buildings are suitable reflective measuring points as vegetation covers the ground conditions in the radar images. A dozen such points in Lugnez are caught by the eye of the satellite. The resulting data produce an accurate image of the landslide and enable the identification of the zone of differential movements. This technology also provides geologists and engineers with valuable insights into other well known landslide areas such as Grächen in the canton of Valais, Grindelwald in Bern, Lauterbrunnen in Bern, Schwarzsee in Fribourg and Villars-Leysin in Vaud. The results of these observations are now incorporated, inter alia into the hazard maps which, in turn, act as a basis for the definition of hazard zones and areas in which development is banned in local zoning plans.

**European partnership**

The European Space Agency (ESA) has been collecting radar data by satellite since 1991. As part of its cooperation with the ESA, Switzerland is authorized to use this archive. Envisat, the European earth observation satellite, has been flying over every location on earth at intervals of 35 days since 2002. Thanks to the support provided by the Space Affairs Service at the State Secretariat for Education and Research, FOEN also has access to the latest radar data from the Alps.

**Ground movements (encircled in red) can be recognized using satellite images as, for example, in the Arolla area in the canton of Valais.**



FOEN

"Radar interferometry offers enormous potential for hazard identification and risk management. Despite costing less, the information obtained using this large-scale analysis instrument is more detailed" says Hugo Raetzo. This method opens up new possibilities, particularly in unpopulated areas, i.e. high mountain areas where measurement networks do not exist or where measurement costs would be excessive.

**New risks from melting permafrost**

This new technology is badly needed, not least in relation to the new risks arising from climate change. In the permafrost area – at altitudes greater than 2,300 metres above sea level – the ice which binds the unconsolidated sediments is melting. As a result there is an increasing risk that previously stable slopes and rock sections will slide or strong rainfall will trigger debris flows. As recent studies show, the increase in temperature in the 20th century has already given rise to mass movements, in particular since the late 1980s. Slopes have started to slide and rock glaciers consisting of frozen debris and ice are creeping faster towards the valleys.

Although this mainly occurs in locations far removed from inhabited areas, landslides and rock falls in these locations can represent a – direct or indirect – risk to traffic routes and settlements in the valleys. For example the rock glacier in the forefield of Glacier de Tasarmine in Lower Valais, which had been inert for a long time, has become active in recent years. Satellite data show that it is creeping towards the valley at a rate of 0.8 to 1.5 metres per year, and as much as two metres per year at the front of the rock glacier. The findings coincide fully with the values obtained – with far greater difficulty – from the ground measurements. Moreover, the satellite brought previously unknown ground movements to light: a laterally connected debris slope at mount Dent de Perroc has also started sliding.

The road to Arolla in the canton of Valais crosses the valley eight hundred metres further down. "We clearly need to know what is going on in the Alpine permafrost zone," says Hugo Raetzo. "Radar interferometry provides excellent opportunities in this regard which are also acceptable from a cost perspective."

■ Hansjakob Baumgartner

## LINKS

www.bafu.admin.ch/naturgefahren > Rutschungen
(only available in German, French and Italian)

www.planat.ch > Natural Hazards > Mass Movement > Landslide

www.vallumnezia.ch > Informationen A-Z > Geologie
(only available in German and Romantsch)

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## Disregarded warnings in Falli Hölli

FOEN/Docuphot

**The name says it all: the demolished Falli Hölli, i.e. Hell Fall, holiday development in 1994.**

The first sign was a fault with the drinking-water supply. In March 1994, a water pipe in the Falli Hölli holiday house development near Plasselb in Fribourg had become displaced and needed be repaired twice. The western flank of mount Schwyberg had started to creep. Thirty-three million cubic metres of debris and mud were slowly sliding down the valley. Boreholes revealed that the slip surface lay at a depth of 37 metres. This quickly eliminated any hope that the slope could be stabilized with the help of engineering measures. Thirty-seven houses were completely destroyed – moved 200 metres, torn apart, overturned and buried by the falling masses of earth. The landslide reached its maximum speed of six metres per day by the end of July, from October no further obvious displacements could be observed.

Boreholes also brought pieces of wood to light, the relics of previous mass movements. The determination of their age using carbon dating revealed that the western slope of mount Schwyberg had been active in the past 5,000 years. The Falli Hölli development was not planned until the 1960s. Everything was done by the book and planning permission had been obtained, however geological reports compiled at the time did contain warnings. In a report produced for the Fribourg Cantonal Planning Authority, geologist Gottfried Schmid stated: "It is safe to say that the ground conditions pose a serious disadvantage to the stability of the structure."

Today, the canton does not grant planning permission in the area although, at a rate of 1 centimetre per year, current movements are small. The ban on building is justified by the possibility of the renewed acceleration of the landslide. From a geological perspective, this argument could have been used decades ago – even without the help of the hazard map. "However, even today, too little attention is paid to the acceleration scenarios associated with unstable slopes in Switzerland," notes FOEN geologist Hugo Raetzo.

## Drainage: a recipe for success

At the back of the Valle di Campo – a side valley of the Maggia Valley in the canton of Ticino – a huge slide mass of 800 million cubic metres with an area of around six square kilometres was moving on a slip surface of up to 170 metres depth. It not only imperilled the villages Campo and Cimalmotto located on it, but also risked causing an afflux in the Rovana River which could have triggered catastrophic flood waves and floods right down to Locarno and Ascona.

These risks have largely been eliminated thanks to engineering measures. High water pressure in the body of the landslide emerged as the main cause of the movements. Thus, a 1,800-metre long drainage tunnel was constructed below it, from which drainage boreholes lead directly into the slide. The water is also drained on the surface through channels. If the Rovana runs high, the water now flows through a newly constructed diversion tunnel. Thanks to this tunnel, it was possible to prevent – for a large part – the continuous erosion of the foot of the slope. Following the implementation of this measure, the landslide along the slip surface practically came to a standstill.

**Stabilized slide mass in the Campo valley, canton of Ticino.**

FOEN

EARTHQUAKE PROTECTION

# If the earth were to shake tomorrow…

**Despite what people may think Switzerland is not immune to strong earthquakes with enormous potential for damage. As things stand, the country would be ill-prepared for such an event. Preventive measures could go a long way towards mitigating the disastrous effects of a major earthquake. These would involve providing better protection for buildings and infrastructure and suitable insurance cover for the residual risks.**

Keystone

**Historical depiction of the strong earthquake of 1356 in Basle and photo of the collapsed roof of a church as a result of seismic shaking in the Siders area of the canton of Valais (1946).**

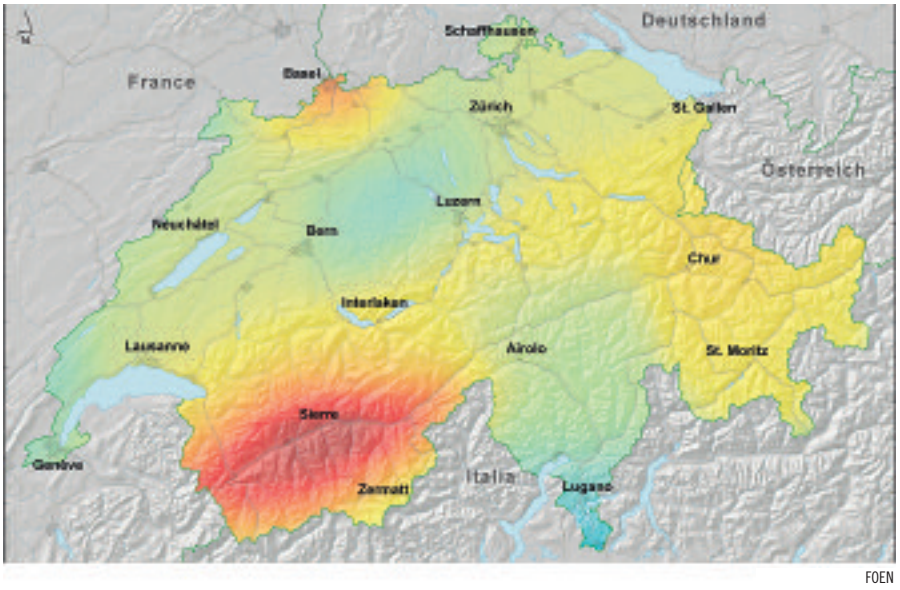
"I got the fright of my life," reports geologist Marcel Burri when asked about his recollection of events on the evening of 19 January 1946 in Siders in the canton of Valais. "I was on my way home from school. We were violently jolted around. Everyone was screaming. The electricity supply failed and fires started all over the place. We ran home through the rubble to our parents. We were very afraid and did not know when it would finally end or how strong the next tremor would be. That was my first sleepless night."

Fortunately, earthquakes of this level of intensity have not re-occurred in Switzerland in recent decades. For this reason, such recollections are fading from the collective memory. However, in view of the very real risk posed by earthquakes, such a carefree attitude is misguided. "Given the growth in population and increasing value of material assets, the risk has actually increased significantly," stresses Blaise Duvernay, Manager of the Federal Coordination Office for Earthquake Mitigation at FOEN. "For this reason it is important to make people aware of this natural hazard and to prepare as well as possible for its occurrence. New buildings and infrastructure must be designed and built in compliance with the rules of earthquake-resistant design."

**A largely underestimated hazard**

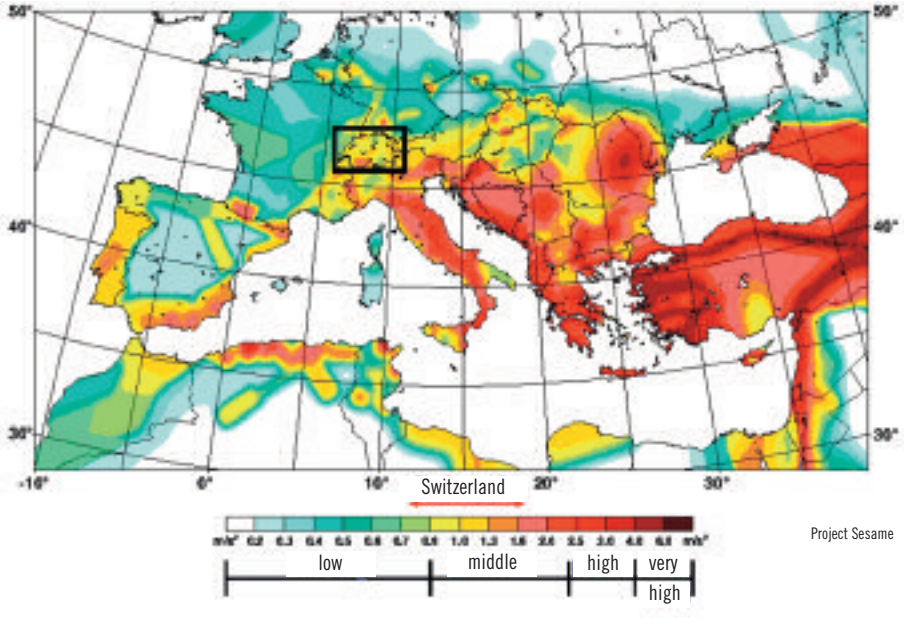
Unlike storms and floods, earthquakes cannot be forecast. Based on historical data, experts at the Swiss Seismologial Service at the Swiss Federal Institute of Technology Zurich (ETHZ) can, however, predict the probability of their occurrence. The areas of Switzerland most at risk from earthquakes are the canton of Valais, the Basle region, central Switzerland, the Engadin mountain valley and the Rhine valley upstream of Lake Constance. Approximately 500 seismic shocks are recorded in Switzerland each year. Most of them occur in these regions, however, the population is only aware of around two percent. These events are triggered by an abrupt release of energy stored in the earth's crust caused by the collision of the African and Eurasian tectonic plates. Statistically, an earthquake measuring 5 on the Richter scale can be expected in Switzer-

## Earthquake risk in Switzerland




FOEN

**In the European context, Switzerland is at medium risk from earthquakes. Strong earthquakes are possible here, but are far less common than in typical risk areas such as Turkey. As indicated by the scale of possible ground acceleration (m/s²), the earthquake risk in Switzerland is greatest in Valais and in the Basle region. The lower the value the lower the hazard.**




Project Sesame

land every ten years and an event of a magnitude of 6 may be expected every 100 years. The intensity of the tremors in Siders in 1946 is estimated at 6.1 and that of the disastrous earthquake in Basle in 1356 at 6.9. A comparable earthquake in the Basle region today would probably claim around 1,500 lives and cause direct damage to property ranging between CHF 60 and 100 billion. Damage on a scale of between CHF 2 and 5 billion could be expected in Siders. "By way of comparison, the direct damage to buildings and infrastructure arising from the floods of August 2005 totalled around CHF 3 billion," says Blaise Duvernay. "Thus, in terms of damage potential, earthquakes are among the most significant natural risks facing Switzerland."

### Patchy precautions

Contrary to the widely held view that earthquake resistant construction is expensive, the additional costs associated with such measures in new buildings represent at most 1 percent of the value of the building. In 1989, the Swiss Engineers' and Architects' Association adopted its SIA Standard 160 containing provisions on earthquake resistant construction which take modern advances in this area into account. This was followed by the adoption of SIA Standards 260–267 in 2003 which contain more stringent requirements for load-bearing structures in line with the specifications in force within the EU. Compared with the older standard, the new ones take better account of the crucial influence of local geological factors and introduce structural design concepts which enable the provision of a high level of protection at an acceptable cost. Ninety percent of buildings

Thomas Wenk, Zurich (2)

**The Swiss Confederation is having all of its important buildings and infrastructure inspected for earthquake resistance and retrofitting them where necessary – for example the Ganterbrücke bridge on the A9 national highway in the Simplon area of Valais and the lecture hall at the ETH Zurich which has been retrofitted with steel columns.**

in Switzerland were constructed before 1989, however, and are not, therefore, specifically designed to resist strong seismic shocks. The deficits in masonry buildings with more than four to five floors are particularly obvious. Serious weaknesses also exist in the old masonry buildings with wood floors and in typical town houses, in which almost all of the load-bearing walls have been removed to create space for retail businesses.

In most cantons, the application of the seismic requirements of the structural design codes are neither explicitely demanded nor controlled and this makes the task of ensuring comprehensive prevention more difficult. Furthermore, architects, engineers and clients often lack the necessary information and training. Because many clients do not specifically request earthquake resistant buildings, the number of buildings that are vulnerable to strong tremors is constantly on the increase, even today. Thus, the risk posed by earthquakes in Switzerland increases daily, in particularly in private new buildings.

### Switzerland's parliament building: a shining example

There is no constitutional basis for earthquake hazard mitigation in Switzerland. However, a programme of measures for federal buildings and structures which are financed or require the authorization of the federal authorities has been in existence since 2000. The objective of the Federal Coordination Office for Earthquake Mitigation, which was established in 2001 and is affiliated to FOEN, is to monitor and improve earthquake safety in buildings which are the responsibility of the Confederation. It also coordinates working groups which harmonize the measures necessary for critical infrastructure, cultural assets and seismic monitoring and for intervention in the event of an earthquake. Between 2001 and 2004, experts inspected over 300 federal buildings and 690 major bridges belonging to the national road network. A further 500 buildings and around 3,300 bridges are to be inspected by 2008. If the experts encounter problems in the course of these inspections, the structures must be surveyed in detail and earthquake-proofed if necessary. In addition, the SIA earthquake regulations must be implemented in all new federal buildings. Inspections – and proofing, if necessary – are also mandatory for all major conversion or restoration projects. The prime example of the work carried out by this programme is the Swiss Bundeshaus, the Federal Parliament building, where the earthquake resistance was improved as part of its renovation in 2006 and 2007. "The most important structural measure involves the connection of the facade to the floor/ceiling slabs," explains Blaise Duvernay. "In addition, where possible, low-resistance floor/ceiling slabs are being replaced by reinforced concrete ones."

Blaise Duvernay puts this progress into context, however, by explaining that the 3,000 public federal and cantonal buildings inspected by the end of 2006 represent less than two tenths of a percent of Switzerland's total building stock of over 1.8 million structures. "Thus the cantons are required to improve this situation in the years to come through the introduction of inspection procedures for private construction projects and, in particular, the inspection of buildings involving a serious risk to human life."

### Valais is moving

Earthquake mitigation in Switzerland is

## Simulated earthquakes

The canton of Valais is also working on raising its population's awareness of earthquakes. For example, a 300 square metre stand at the 2006 Valais Fair in Martigny was devoted to this natural hazard. For the first time in Switzerland, 15,000 people were able to test FOEN's earthquake simulator and experience at first hand the effect of earth tremors measuring 6 to 7 on the Richter Scale at their epicentre. Since then, the simulator has been used at exhibitions and fairs throughout the country.

FOEN/E. Ammon, AURA

**A school classroom shaken by the earthquake simulator.**

the responsibility of the cantons. Up to now, however, only Valais and Basle-City have included the corresponding preventive measures in their legislation and introduced them into their planning authorization procedures. Valais has assumed a pioneering role in the Swiss context. In 2004, the cantonal government made compliance with the SIA earthquake standards 260–267 mandatory and defined inspection procedures for public and private buildings. The canton has been equally active in the compilation of maps of subsoil classes which facilitate the earthquake resistant design of new buildings. The same applies to the studies carried out on microzoning which are used to establish the behaviour of the substratum in the event of seismic shocks. As a result they provide engineers with better design bases which are specific to the local situation and are more comprehensive than the general standards.

The effects of an earthquake on a building depend not only on its magnitude and the distance of the location from the epicentre, but to a large extent also on the local properties of the substratum. Thus, soft soil heightens the intensity of seismic shocks. This is true, for example, of the loose sediment deposits from rivers and lakes in the Rhone plain. Whereas in the past the valley floor was mainly used for agricultural purposes, today it is densely populated and heavily industrialized. Because the damage potential in the case of an earthquake in the Rhone valley has increased significantly since 1946, several microzoning studies have been carried out in recent years in Brig, Visp and Monthey. Sitten and Martigny are due to follow suit in 2007 and 2008. Further studies of this nature have also been carried out in other parts of Switzerland, i.e. in the canton of Basle-City and on the Ecublens campus of the Swiss Federal Institute of Technology Lausanne (EPFL) and the campus of the Swiss Federal Institute of Technology Zurich (ETHZ). By the end of 2006, ten cantons had compiled maps of soil foundation classes for their most densely populated areas with the help of the federal authorities. The results can be downloaded free of charge from: www.bafu. admin.ch > Naturgefahren > Erdbeben > Erdbebengefährdung der Schweiz > Geologische Standorteffekte > Karte der Baugrundklassen nach SIA 261.

### LINKS

www.bafu.admin.ch > Naturgefahren > Erdbeben

www.seismo.ethz.ch

www.sgeb.ch (German)

www.planat.ch >natural hazards >earthquake

www.crealp.ch > Dangers naturels > Séismes (French)

www.seisme.ch (French)

www.bebende.ch (German and French)

www.rheintal06.ch (German)

**Next step: mandatory earthquake insurance?**

Nowhere in the world is the population better insured than in Switzerland. This observation does not apply, however, to damage caused by seismic shocks. With the exception of the canton of Zurich, there is no guaranteed cover in Switzerland for damage to buildings caused by earthquakes. Since early 2005, the Swiss Insurance Association (SVV) and the Association of Cantonal Fire Insurance Companies (VKF) have been working on a project to establish nationwide mandatory insurance of earthquake damage under the supervision of the Federal Office of Private Insurance (FOPI). What is involved here in practice is the extension of current mandatory buildings insurance.

"The product is not clearly defined at the moment. When this stage has been reached it will have to be approved by the cantons and authorized by the Federal Council," says Blaise Duvernay. "Earthquake insurance will be introduced in 2008 at the earliest."

■ Cornélia Mühlberger de Preux

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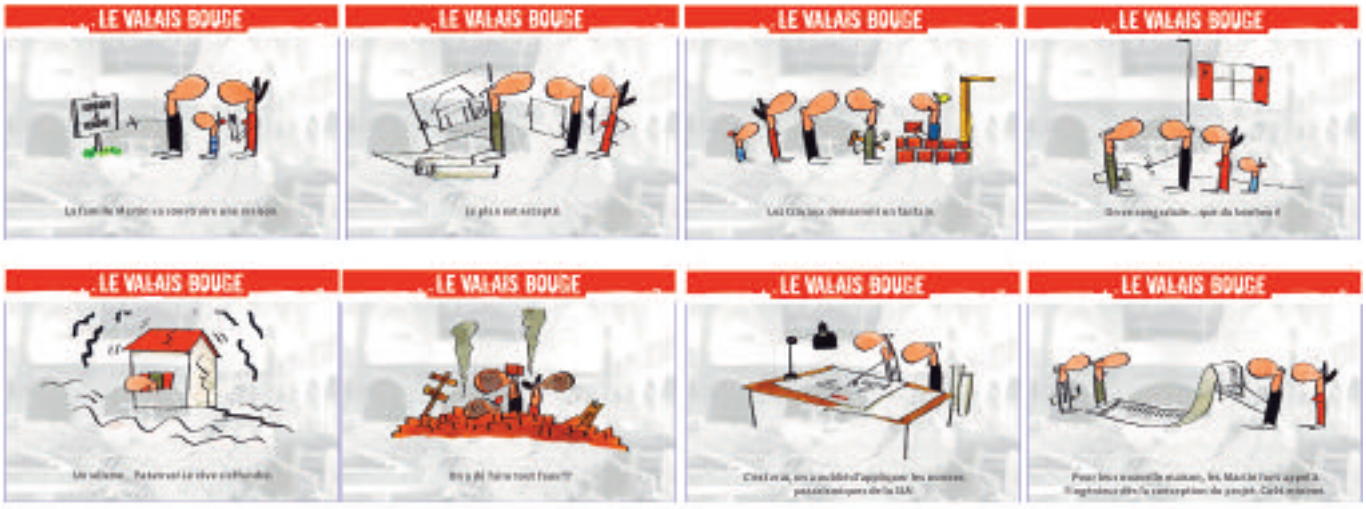



**Presentation from the exhibition "Le Valais bouge" (i.e. "Valais is moving"): earthquake risk should be established before building starts and taken into account.**

# How Valais proofs its buildings

**The canton of Valais is a pioneer in the area of earthquake resistant construction. ENVIRONMENT spoke to engineer Xavier Mittaz to find out exactly what earthquake proofing involves. As an expert in the area, he inspects the earthquake resistance of building projects on behalf of the canton.**

*ENVIRONMENT: What measures must be taken in the design and construction of a building to ensure maximum earthquake resistance?*

**Xavier Mittaz:** The load-bearing elements which absorb the seismic forces must be continuous and as regularly spaced as possible, both in the plan and elevation. This means that the architect and construction engineer must work together in the design phase. In Valais, seismic calculations must be submitted as part of the planning authorization procedure for new buildings with more than two floors above ground-floor level. The same applies to projects involving the comprehensive renovation of existing buildings.

*Which older buildings pose the most problems?*

The buldings that cause most problems are those built between 1950 and 1970. Savings were often made in the area of building materials at the time, and the increasing use of reinforced concrete made it possible to construct ceiling slabs with greater spans and hence reduce the number of load-bearing walls. Older houses with a lot of thick walls often prove less vulnerable if they have not been altered too extensively.

*To what extent are critical buildings and structures like hospitals, schools and dikes protected in Valais?*

The canton launched its "Lifelines" inspection campaign in the late 1990s. Measures to improve earthquake resistance have already been implemented in acute hospitals. The same applies to the control centre of the Valais cantonal police force. Several administrative buildings and schools are currently being inspected with a view to future conversion. The safety of dams is monitored by the Confederation.

*Do architects and engineers have access to specific training?*

Courses in earthquake resistant construction have been on offer in Valais since 2003. In 2005, the Swiss Society for Earthquake Engineering and Structural Dynamics (SGEB) organized a further training course on earthquakes and existing structures and the corresponding SIA 2018 standard. In French-speaking Switzerland, training opportunities are also available at the College of Technology and Architecture in Fribourg.

Interview: Cornélia Mühlberger de Preux

## Recommended reading

- *Erdbebensicheres Bauen in der Schweiz, BAFU, 2006. Orders: www.umwelt-schweiz.ch/div-7523-d.*
- *Ist unser Haus erdbebensicher? Faltprospekt, BAFU, 2007. Orders: www.umwelt-schweiz.ch/div-7527-d.*

FLOOD PROTECTION

# The deceptive safety of channelized waterways

Pioneering achievements in the field of hydraulic engineering have made a crucial contribution to Switzerland's economic development. However, the old flood control structures often fail to satisfy the requirements of sustainable flood protection. Thus, expensive rehabilitation work needs to be carried out on many water courses to improve safety levels.

FOEN/E.Ammon, AURA

**Interrupted railway track and inundated alluvial plain following dike failure in the upper reaches of the river Aare near Meiringen in the canton of Bern in August 2005.**

Some 60 billion cubic metres of water fall from the sky in Switzerland every year. In terms of the country's total area this represents a precipitation volume of almost 146 centimetres. This abundance of water has always represented a mixed blessing for the people of Switzerland. Dreaded diseases like malaria were still prevalent in marshy areas – such as the Bernese Seeland – into the 19th century. In the alluvial plains, untamed rivers repeatedly laid waste to harvests, destroyed settlements and swept bridges away. To facilitate agriculture and settlement in the valleys without continuous setbacks, the unpredictable meandering water courses had to be tamed using the resources available at the time.

*continued overleaf*

Christian Meuli, ARGE Hochwasserschutz, canton of Grisons

**Rivers need space: the diverted and rehabilitated bed of the river Flaz in Oberengadin provides better flood protection to Samedan in Graubunden.**

### A pioneering era in hydraulic engineering

Thus, the first major river correction involving the diversion of the river Kander into Lake Thun was carried out almost 300 years ago. The real boom in hydraulic engineering in Switzerland did not begin, however, until the 19th century when almost all of the important Alpine rivers – such as the Rhine, Linth, Reuss, Aare and Rhone – were channelized and diked.

The guiding principle behind the hydraulic engineering measures implemented at the time was the realization on the part of engineers that straightened channels had greater flow and bed-load-transport capacity. This means that the rivers deposit less bed load on gentler stretches and cannot burst their banks so easily. The main engineering feats of this period included the diversion of the river Linth into Lake Walen and the first training of the Jura waters which diverted the river Aare into Lake Biel through the construction of the Hagneck Canal.

### A nation united against floods

Like the re-occurring floods, the river corrections also made a central contribution to the cohesion of the then young Swiss Confederation. Individual regions and cantons would not have been able to cope with the floods or bear the financial burden of these major infrastructure projects alone. The action against the forces of nature required not only solidarity between upstream and downstream populations, but also financial commitment on all levels of the state.

Thanks to straightening, deepening and diking, the water courses could safely accommodate greater volumes of water and there were fewer floods in the valleys. Combined with gradual reafforestation in the headwaters, torrent control also made a crucial contribution to the improvement of the situation towards the end of the 19th century. This gain in safety led to a rapid expansion of industry in the alluvial plains: new settlements arose in the areas protected by the dikes and agriculture gained fertile alluvial land.

### New insights gained over time

The inadequacies of these protection measures became evident, however, over the course of the decades – for example in the Rhone valley in Valais. As part of the first Rhone correction, which was carried out between 1863 and 1890, dikes had been constructed on both banks of the river. Even at low water, the river filled the 70-metre space between these dikes and this resulted in the deposition of considerable volumes of debris. With time, the river bed aggraded and the dikes risked overflowing in the event of a flood.

This problem was remedied by the second Rhone correction which took place between 1930 and 1960. The river channel was adapted to the lower flow and narrowed, a measure which increased the flow velocity and improved bed-load transport significantly. As the most recent studies show, however, even these measures could not increase the transport capacity of the Rhone sufficiently. Thus, a targeted long-term approach to bed-load management was required.

### The neglect of excess load

Almost all of Switzerland's large water courses were tamed using the same principle as that used for the Rhone: i.e. based on the calculation of rare flow peaks – for example, with a return period of 100 years – the dimensions of the necessary river channel were determined and reinforcement dikes constructed.

"The weaknesses of this system came to light in recent decades with the increased occurrence of extreme flood events," says Simone Hunziker of FOEN's Hazard Prevention Division. "A society that depends on flood protection structures to protect its settlements and infrastructure against a one-hundred-year flood will suffer even greater losses if a water course exceeds this calculated value." In such cases of excess load dams can collapse or be overtopped, settlements flooded and transport links destroyed.

**A new protection philosophy**

The bank protection structures and dikes in often extensively narrowed rivers are showing their age in many locations today. In some cases, for example on the river Thur, the water shooting down into the straightened bed has eroded and deepened the riverbed which has resulted in the partial undercutting of the bank structures. As a result, urgent rehabilitation projects are due to be carried out on numerous major water courses over the coming decades. This process offers the hydraulic engineering experts an opportunity to remedy the existing deficits and implement the principles of sustainable flood protection.

Where possible, the water courses are widened again and liberated from their narrow constraints, because the higher the dikes the greater the risk of flooding during an extreme flood event which exceeds the designed capacity of the protection structures. River widening increases flow capacity, decreases the maximum water level and reduces the flow rate. On the other hand, however, it also creates valuable habitats for plant and animal species which depend on periodic flooding.

**The combination of different measures**

In addition, modern flood protection combines different measures which improve the protection of human life and important material assets. These include, for example, the targeted management of bed load, the use of spatial planning instruments to keep hazard zones free of development and the raising of bridges, where the accumulation of floating debris could hinder water flow. Moreover, computer simulations of possible flood events help in the identification of unpopulated corridors for use in cases of excess load: volumes of water that exceed the capacity of a river bed can be discharged there under controlled conditions. Examples for solutions of this kind that have already been implemented include sections of the recently rehabilitated Engelberger Aa river, the diversion of the river Flaz to protect Samedan in the canton of Grisons and the river Reuss in Urnerland before it enters Lake Lucerne. The motorway, which is closed during flooding, acts as an ad-ditional drainage corridor when the riverbed is no longer able to discharge the volumes of water present.

**Widened rivers or rivers with fewer flood protection structures – like this stretch of the Rhone in Pfynwald forest between Leuk and Siders in the canton of Valais – provide diverse habitats and popular recreational areas.**

**Low bridges often become critical bottlenecks in the case of flooding. Driftwood can block the flow, as in this example of the Rhone near Naters in Valais in October 2000.**

(2) Keystone

## FOEN flood statistics

Experts can use statistical methods to estimate the frequency of extreme flood events on the basis of previous maximum values. Combined with hydrological analyses and model calculations, flood statistics represent an important hydraulic engineering tool. They can be used to design the river-bed dimensions necessary to achieve protection objectives in the rehabilitation of water courses. However, uncertain factors such as climate change must be taken into account as it is questionable whether the data available from the past will also apply in the future.

Since the late 1950s, the large reservoirs in the canton of Valais, have exercised an attenuating effect on the flow in the Rhone, particularly in the case of small and medium-sized flood events. Without this retention capacity, the flooding of the main valley that occurred in the major flood years of 1987, 1993 and 2000 would have been more disastrous.

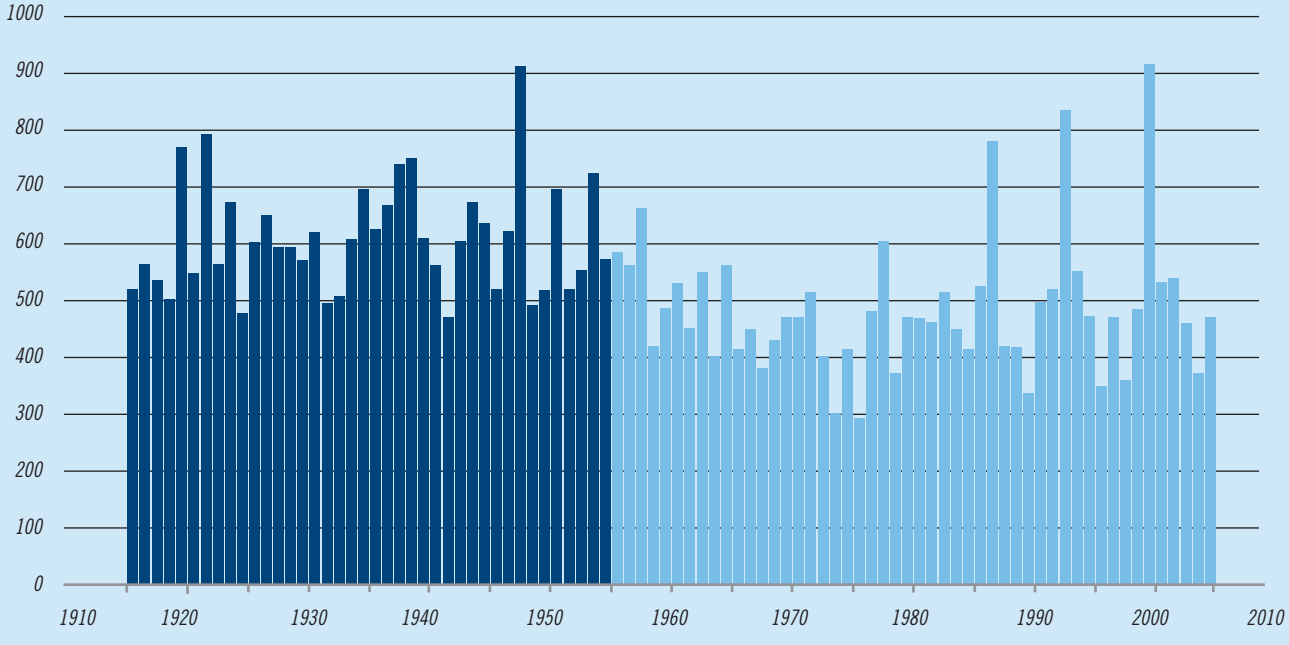
www.bafu.admin.ch > water > hydrological foundations and data

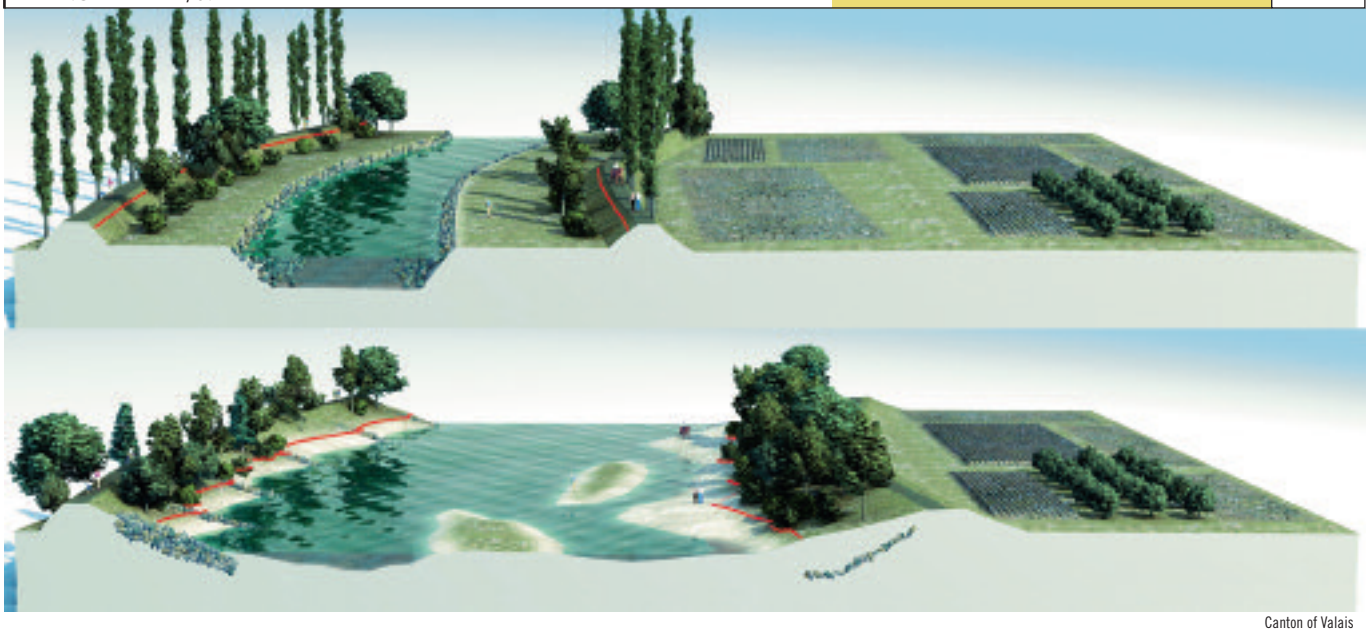
**Somewhat conflicting concerns**

Settlements, industrial zones, roads, railway lines and other valuable infrastructure take priority in the implementation of flood protection structures. In addition to hydraulic engineering measures, targeted local flood proofing and the adapted use of buildings at risk contribute to the reduction of vulnerability. Given that the occasional flooding of pasture or forest areas that can recover from floods relatively quickly, is hardly likely to cause significant damage, this is more likely to be allowed to happen. To optimize the protection objectives and proposed measures, the interests of all stakeholders must be carefully considered – taking their sometimes conflicting concerns into account – in the context of river rehabilitation projects.

"Possible conflict arises today mainly due to the conflicting interests of flood

**Annual peak flows of the river Rhone at the FOEN measuring station in Sion in cubic metres per second**





Canton of Valais

**The planned Third Rhone Correction (description below) is intended to give the river more space again.**

protection, nature conservation and agriculture," says Jean-Pierre Jordan, consultant for the Third Rhone Correction at FOEN. "Agricultural land has to be sacrificed for the widening of the Rhone. This measure was initially controversial even within the federal administration – the Federal Office for Spatial Development (ARE) and the Federal Office for Agriculture (FOAG) expressly demanded that good agricultural land be protected. "All of the authorities now support the solution that has been found: thanks to integrated land reclamation which suits the farmers and improves their production conditions, the loss of this land is largely compensated."

### Potential damage totalling ten billion francs

The Third Rhone Correction is the largest and most expensive river rehabilitation project currently under way in Switzerland. Over CHF 1 billion will have to be invested in this measure over the coming 30 years. Simulations of the effects of a flood which would be statistically expected to occur every 100 years show that this represents a good investment. In an extreme event, at worst, 14,000 hectares of land in the main valley would be flooded. The current cost of the damage arising from such an event would be around CHF 10 billion, and the destruction of major industrial plants – for example Alcan and Lonza – would account for half of this sum.

### Priority measures in critical areas

The implementation plan for the Third Rhone Correction, which was authorized in summer 2006, specifies the framework for the entire rehabilitation of the river and ensures that the necessary spatial coordination is carried out. The technical details of the work to be carried out as part of the General Rhone Project, which is due to be presented for consultation in 2008, are defined. It is planned to implement priority measures costing a total of CHF 360 million in the five sectors of Visp, Siders, Sion, Fully and Aigle to improve the level of safety in critical areas. In the case of Visp, an eight-kilometre-long subsection of the river is involved. The flow capacity on the town perimeter, where widening is not an option, will be increased through the deepening of the river bed. "Considerable widening is planned upstream and downstream of this stretch of the river," explains Jean-Pierre Jordan. The rehabilitation measures are ultimately being carried out with long-term developments in mind. "Even if there is an acceleration in climate change and a general increase in flows, the system would be able to cope with the new requirements with the help of minor adaptations."

■ Lucienne Rey, Beat Jordi

## LINKS

www.rhone-thur.eawag.ch (German)

www.vs.ch/rhone (French and German)

www.alpenrhein.net (German)

www.wwf.ch > Unsere Themen > Wasser (German, French and Italian)

www.svv.ch > Publikationen > Wenn das Wasser kommt

## INFO

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FLOOD PROTECTION AND NEW FINANCIAL EQUALIZATION

# Reduction of unacceptable risks takes priority

**Under the New Financial Equalization framework, from 2008, federal spending on protection against natural hazards in Switzerland will be specifically effect-oriented. As part of this approach, the federal authorities will take the risk situation in the relevant regions, the associated damage potential, the corresponding rehabilitation requirements and the sustainability of the proposed measures into account.**

In order to protect settlement areas against disastrous floods, the Confederation, cantons and municipalities will have to spend several billion Swiss francs on flood protection in the coming decades. The Third Rhone Correction alone will cost CHF 1 billion, and rehabilitation measures totalling CHF 600 million are planned in the Alpine foothills as a result of the floods of August 2005. To these are added equally urgent projects on the large Alpine rivers Aare, Reuss, Linth and Alpenrhein. In order to be able to finance the currently planned flood protection measures within the desired time frame, the federal and cantonal authorities will need increased funding. FOEN's regular annual budget in this area is CHF 67 million. In accordance with the New Financial Equalization, the allocation of resources will be based on new criteria from 2008. This also applies to the funding of other hazard prevention measures by the Confederation, i.e. protection forest maintenance, construction and maintenance of avalanche barriers and rock fall nets and the production of the hazard maps.

**Risk-based criteria**

"In future, money will be allocated to the cantons on the basis of priority," explains Christian Schuler from the FOEN Hazard Prevention Division. "The reduction of unacceptable risks is particularly important in this context." In order to ensure that urgent projects which can prevent large-scale damage are implemented as quickly as possible, from 2008, funding will focus more specifically on the existing risks. The corresponding potential damage can be determined, inter alia with the help of the hazard maps.

**Financial incentives for worthwhile projects**

In addition to the general funding for the development of general hazard information, such as hazard maps, smaller projects and periodic maintenance tasks, important projects are processed, evaluated and financed on an individual basis. All projects must fulfil certain minimum requirements. The Confederation also wishes to promote optimized solutions by granting higher subsidies. It is hoped that better quality and the targeted improvement of structural flood protection measures can be achieved in this way. In addition to risk-oriented criteria, the Confederation will also take the issue of sustainability into consideration.

**Optimized flood protection through the widening of the river Thur.**

Amt für Umwelt TG

EXTREME WEATHER

# Climate change aggravates natural hazards

FOEN/AURA

**Flood damage in Oey-Diemtigen, canton of Bern, following the storms of August 2005. More extreme weather events may be expected as a result of climate change.**

As an Alpine country Switzerland is affected more than most by climate change. It must adjust to the fact that the risks posed by floods, debris flows, rock fall, winter storms and heat waves are increasing. Thus, new approaches are needed to improve hazard prevention.

Since November 2006, the heating systems in 40 houses in Oey-Diemtigen in the canton of Bern no longer run on oil but on wood. The construction of a district heating system in this municipality in the Bernese Oberland is related to climate change. Oey was one of the areas particularly badly affected by the storms of August 2005 – half of the village was buried under metre-high piles of debris. Hans Küng, the President of the municipality, recalls that the decision not to replace the heating systems destroyed in the flood individually, but to substitute them with a shared wood chip burner, arose at an early stage in the aftermath of the disaster. Wood is available in abundance in the Diemtigtal valley. As a result of the flood, renewable energy sources and $CO^2$ suddenly became a focus of interest among the population. After some to-ing and fro-ing, the heating system was eventually installed in record time. "The construction of this heating system is an excellent example of how something good and sustainable can come out of a difficult situation," says Hans Küng, one of the project initiators.

### More energy in the atmosphere

It is not possible to prove scientifically whether the flood of 2005 was actually a result of climate change because – including other factors – the measurement series are not long enough. However, there are clear indications of a link between global warming and the frequency of extreme climate events. There have been 16 major flood events in the past 200 years; of these, seven occurred during the period of warming from the mid-1970s. The energy and water content of the atmosphere is increasing due to the greenhouse effect. As a result, the probability of extreme weather phenomena also rises. "We go by the rule of thumb that the doubling of $CO^2$ concentration means that the frequency of floods and winter storms increases by a factor of three to five and the frequency of heat waves may even increase by multiples of these," says Martin Grosjean, Executive Director of the Swiss National Centre of Competence in Research on Climate (NCCR Climate).

### Future climate forecast

Despite uncertainties regarding the speed at which climate change is taking place, researchers on the Schweiz 2050 project have created a forecast of Switzerland's future climate. Their model calculations are based on an average emissions scenario. According to them, the temperatures in the entire country are rising – and, moreover, faster than hitherto. As compared with the late 20th century, the increase in winter temperatures is around two degrees and three degrees in summer

temperatures. Winter precipitation volumes are increasing by around 10 percent, however they are declining by around 20 percent in the hot season. Stronger deviations may be expected from year to year, both in relation to temperatures and precipitation. Thus, Switzerland must adapt to events such as the heat wave summer of 2003. The consequences at the time were almost 1,000 fatalities, large-scale harvest failure, problems with overheated or parched water courses and an increase in forest fires, as demonstrated by the large-scale destruction of the protection forest above Leuk in August 2003, which involved arson.

**Increased rock fall hazard**

More and more mountaineers are experiencing the effects of the increasing temperatures in the mountains at first hand. Climbers on the Schreckhorn mountain and the Eigernordwand (north face of the Eiger) were injured by rock fall in the very hot July of 2006 and there were three fatalities on the west flank of the Jungfrau peak. The emergency services also had to rescue 25 mountaineers on the Matterhorn due to a rock fall event. These "dramatic developments in many places" come as no surprise to geologist Hans Rudolf Keusen. For example, since 1980, average temperatures on the Jungfraujoch (the lowest point on the ridge linking the Mönch and Jungfrau peaks) have risen by up to two degrees. Periods with a zero-degree limit above 4,000 metres are increasing and the nights are also getting warmer at high altitudes. "The thawing of the permafrost makes the rocks unstable. This leads to more rock falls and more frequent rock slides," explains Hans Rudolf Keusen. Mountain climbers must adjust to the fact that, as a result of this, some routes will become "objectively more dangerous." To this is added the fact that the rapid retreat of the Alpine glaciers, in particular on steep mountain slopes, is mobilizing large volumes of scree and this aggravates the risk of debris flows, in particular.

**There is no such thing as absolute safety**

In the future, the situation facing mountain climbers in the Alps today, will be increasingly applicable to natural hazards in general. The state cannot guarantee absolute safety to the population and does not make any claim to do so (it is not an automatic right in any case). "Natural hazards cannot be brought under control with the help of technical measures alone," says Hans Peter Willi, Head of FOEN's Hazard Prevention Division. "On the contrary, climate change highlights the need for comprehensive risk management which requires a broad range of risk-reduction measures in addition to robust protective structures that can cope with cases of excess load."

**Increasing damage potential**

The level of the financial burden already posed by natural hazards was demonstrated clearly in August 2005. With damage totalling CHF 3 billion, the floods of August 2005 in Switzerland were the most expensive natural disaster of the past 100 years. The greater vulnerability as compared with previous flood events is directly linked to the increasingly intensive use of land in the areas at risk.

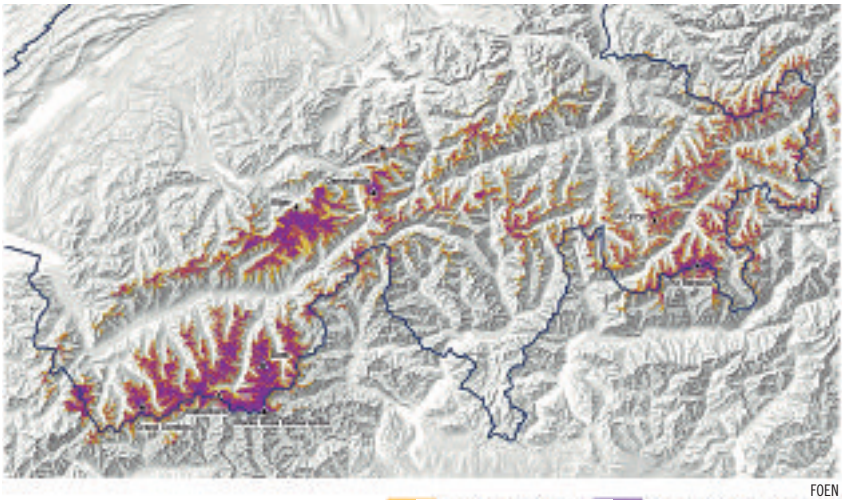
In terms of the extent of the damage they cause, of all the climate-relat-

**Fighting a large-scale forest fire near Leuk in the canton of Valais in August 2003 and rock fall on the Gotthard motorway near Gurtnellen in the canton of Uri in May 2006. Climate change aggravates the risk of forest fires, in particular in Valais and Ticino. The risk of rock fall and rock slides is also increasing.**

E. Ammon, AURA (2)

**Modelling of potential permafrost distribution in the Swiss Alpine region (below) and view from the Schafberg to the Berninatal valley with Pontresina, canton of Grisons. The Giandains avalanche and debris flow barrier, which was completed in 2003, is intended to protect the village from, inter alia, the consequences of the thawing permafrost on the disintegrating Schafberg. The municipality of Pontresina tackled the possible consequences of climate change at an early stage and was the first mountain municipality in Switzerland to implement comprehensive hazard protection measures.**

Beat Jordi, Biel




FOEN

ed natural hazards, floods already represent the greatest risk in Switzerland today. This risk will tend to increase further as a result of climate change.

"First, as a result of the rising zero-degree limit, precipitation is increasingly falling in the form of rain instead of snow, even at higher altitudes," explains FOEN climate expert Markus Nauser. "During extreme weather events, this increases the runoff in water courses with Alpine watershed areas and, therefore, the flood risk in the Swiss Central Plateau." Second, the increase in precipitation intensity and extremes forecast by the experts from the Schweiz 2050 project supports the expected rise in floods, landslides and debris flows.

### Water courses need more space

These predictions also have an impact on flood protection. In order to be able to channel the expected runoff peaks and water volumes without causing damage, water courses, which are confined in many locations, will require far more space in the future. "There is significant need for action because the existing protection measures no longer meet the increased requirements," explains Gian Reto Bezzola, an expert on floods at FOEN. "The protection

structures are often ineffectual in cases exceeding the design load and can only be adapted to changing requirements at a considerable cost."

**Expecting the unexpected**

An overview of the protection deficits will be available when the hazard maps have been completed. As part of the hazard assessment process, which is supported by the federal authorities, the experts must examine the potential outcome of an extreme event for each hazard. This enables the recognition of weaknesses and risks which should be fully remedied in accordance with the principles of integrated risk management or reduced to an acceptable level.

A balanced and aware approach to risk differs from previous hazard defence concepts whereby hydraulic engineering based the dimensioning of protective dikes on rarely attained peak flows. It was merely hoped that future floods would not inundate the dikes. "As opposed to this, today, possible weak points and bottlenecks such as bridges where driftwood can block a river bed are inspected," explains Hans Peter Willi. Experts also inspect locations where dike failure could occur and the water could overflow in the first place. Based on the different possible scenarios, preventive measures are then taken and emergency concepts developed. "Our aim is to ensure that in the case exceeding the design load a river will overflow at a location where the water will cause least damage," says Hans Peter Willi.

**Containing new hazards**

As a result of climate change, our society will have to abandon certain sensitive land-use practices in hazard zones. Thus, for example, the authorities in the Aosta valley in Italy are already implementing a targeted policy of depopulation when individual residential buildings and manufacturing plants can no longer be adequately protected at an acceptable cost. In such cases, the state assumes a significant proportion of the costs arising from the abandonment of affected properties.

FOEN is currently examining the establishment of a national prevention fund which could be used to finance similar measures. "We must expect the unexpected," says Hans Peter Willi. "With the help of a smart adaptation strategy we aim to minimize the possible economic consequences of climate change and to limit new risks to an acceptable level."

■ Kaspar Meuli

## LINKS

www.bafu.admin.ch/klima > Publikationen (only available in German, French and Italian)

www.occc.ch > Projects + Publications

www.meteoschweiz.ch

www.hitzewelle.ch (only available in German and French)

www.swissre.com > Research & Publications > Top Topics view > Focus report > The effects of climate change

## INFO

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Hans-Peter Willi, see page 10

**Global warming represents an additional stress factor for the forest: scientific measurement of the sap flow of a pubescent oak (left). Experts from the University of Bern drill ice cores from the depths of the Piz Zupo glacier to reconstruct the climate of the past 500 years (right).**

Medienstelle NFS Klima, Bern

Keystone

**Descent of a powder avalanche over Evolène in the canton of Valais on 22 February 1999. Twelve lives had already been lost on the previous evening due to another major avalanche in the region.**

PROTECTIVE FOREST

# Well maintained forests provide greater safety

**Switzerland's mountain forests protect hundreds of settlements and transport routes against natural hazards such as avalanche and rock fall. The long-term maintenance of the tree stands that make up this biological protection system is expensive. The Swiss Confederation supports these protection measures to a tune of CHF 50 million annually – for example, in the "Bawald" forest over Ritzingen in the Goms region of the canton of Valais.**

High above Ritzingen in Valais, in the steep "Bawald" forest which protects the village against avalanche and rock fall, a group of young conifers stands in a small clearing at 1,700 metres above sea-level. Just a few metres further down, there are massive spruce trees, which are over 250 years old. "In the very snowy winter of 1999, a snow slab crashed down over the young fir trees," reports forester Fredy Zuberbühler, manager of the Mittelgoms forestry operation. "They were bent over like the runners on a Davos sledge. It was a pitiful sight." At the time, he gave up on the trees and was already thinking about what should be done to close the resulting gap. However, the trees recovered and stand high and straight today as though nothing had ever happened to them.

One day, when the two-hundred-year old members of the same species are no longer standing, these young trees will stabilize the snow mantle and actually prevent avalanches from starting in the first place. The foresters had to give nature a helping hand in the upper part of the slope. Avalanches, some of which penetrated down to the valley floor, repeatedly formed here

where the snow can pile up metres high. Thus, the forestry service installed wooden snow rakes ten years ago. The young trees can now develop undisturbed and in a few decades they will replace these temporary structures in their protective function.

**Growth under extreme conditions**

However, such interventions should remain exceptional. Fredy Zuberbühler, who knows the 100-hectare protective forest better than anyone else, says that, in over 20 years of working in the Bawald, the one thing he has learned is patience: "Living things – be they plants or animals – develop formidable strength that enables them to survive in these extreme conditions." Drought in summer and snow pressure in winter make life very difficult for them.

The spruces, which represent 90 percent of the forest stand here, grow so slowly in the early years that, 20 years ago, the foresters thought they should close the gaps in the stand by planting seedlings. However, while almost all of the planted seedlings died, the robust naturally-occurring seedlings survived because they were better adapted to the harsh conditions. Fredy Zuberbühler shows a photo of a young group of small slightly bushy fir trees which grew around a fallen tree 20 years. Today, they are "out of the woods" and, at almost 50 years of age, have reached the size of majestic Christmas trees.

**The aim is to achieve a good mix**

"Nature cannot manage things in the mountain forest on its own, however," explains Marzio Giamboni from FOEN's Landslides, Avalanches and Protective Forest Section. "If the stands were left to their own devices, we could expect the large-scale collapse that occurs in virgin forests." This must not be allowed to happen in locations where settlements or transport routes require protection.

From 1950, the protective forests in many locations were no longer managed as it was feared at the time that human intervention would weaken them. This approach resulted in a trend for the development of over-aged tree stands with an unbalanced species composition. "Mountain forest requires a good horizontal and vertical mix of varieties and age classes to be able to fulfil its protective function on a continuous basis," says Forest Inspector Norbert Carlen from the Cantonal Office for Forest and Landscape in Sitten. For this reason, the forestry services in the mountain regions have professionalized forest maintenance over the past two decades.

**Goms protective forest as experimental ground**

The Swiss Mountain Forest Maintenance Group (Schweizerische Gebirgswaldpflegegruppe) – an expert body – used the Bawald forest as experimental ground for the development of generally applicable guidelines for protective forest maintenance. According to an initial stand survey, around two thirds of the forest area was over-aged. Over the following years, the forestry service created small gaps to provide light and space for the next generation of trees by means of targeted logging. The response to this measure was positive in terms of regrowth. However, even today, 20 years later, it is necessary to look very carefully to be able to identify the tiny trees in the sometimes tall grass. The annual increment of the young trees at this altitude is just a few centimetres. To protect them, logged or fallen trees are left in the forest. Stabilized by their own snags, they compact the snow and thus prevent the dreaded creep of the snow masses which can move valleyward by up to five metres in the course of a winter and thus put considerable pressure on the young trees.

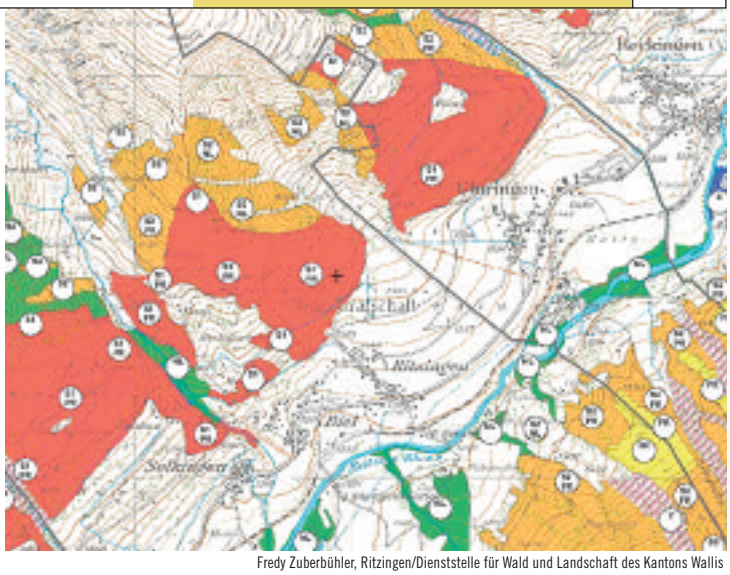
**Sustainable protective forest maintenance**

The insights gained in the Bawald were applied in the FOEN project "Sustainability and Success Monitoring in the Protective Forest" which provides the relevant foresters with basic information and practice-based working papers in the form of a manual. "The knowledge we have today is far more detailed," says Philipp Gerold from the Forest Maintenance Section in the can-

## The threat of air pollution

In addition to maintenance, air pollution has a considerable impact on the vitality of protective forests. Over 90 percent of forest locations in Switzerland are currently affected by excessive nitrogen inputs. This results in the gradual acidification and over-fertilization of the soil, which, in the long term, causes the eluviation of important minerals and, hence, the imbalanced supply of nutrients to the trees.

This gives rise, inter alia, to negative effects on the root system and vulnerability of the trees to windthrow, drought, diseases and harmful organisms. Moreover, the direct input of pollutants – for example through ozone – represents an additional stress factor for the trees. The reduction in air pollution targeted by the federal authorities alleviates these threats to the protective forest.



Fredy Zuberbühler, Ritzingen/Dienststelle für Wald und Landschaft des Kantons Wallis

**The "Bawald" forest over Ritzingen in the Goms region of the canton of Valais protects the village against avalanches and rock fall. On the cantonal map of the forest functions, the top priority protective forests are indicated in red and the second priority ones are indicated in orange.**

ton of Valais. "In the past, we were limited to the recording of removals. Today, we observe the protective forest and know exactly where action is required." After two decades of working in the Bawald forest, Fredy Zuberbühler is satisfied. "We intervened where it was absolutely necessary. Now we can leave the forest to its own devices for the next quarter of a century."

### Immensely beneficial protective effect

In terms of the area covered, at altitudes up to the natural tree line, i.e. around 2,000 metres above sea level, evergreen coniferous forest is the main source of avalanche protection – as is the case with the Bawald forest above Ritzingen. Unlike most technical protection structures, mountain forests in steep terrain also provide protection against other natural hazards such as rock fall and near-surface slope failure. Based on Switzerland's closed forest area, which totals around 10,850 square kilometres, FOEN estimates that the proportion of forest area with a protection function is between 40 and 60 percent. A previous National Research Foundation study calculated the economic value of this effect at around CHF 4 billion per year, which explains the significant role of the forest as a central component of integrated risk management.

### The SilvaProtect-CH project

FOEN funds the maintenance of protective forests to the tune of around CHF 50 million annually to ensure the long-term protection of settlements and transport routes against natural hazards. An important condition for the allocation of federal funding is the delineation of the corresponding forests by the cantons. However, due to the lack of a standard method, the data recorded since 1991 are inconsistent. On the request of the cantons and in consultation with them, in 2004, FOEN launched its own system for the modelled delineation of forest areas with a protective function. The system, which is known as SilvaProtect-CH, is based on a geographical information system (GIS), which records all of the natural hazards that can be warded off by these forests.

According to the modelling which has now been completed, 21.2 percent of Switzerland's protective forest is located in the canton of Grisons, 18.3 percent in Valais, 17.5 percent in Ticino and 12.3 percent in the canton of Bern. The findings are currently being discussed with the cantonal forestry services. Harmonized criteria for protective forest delineation are due to be adopted by late 2007. Implementation at cantonal level is due to take place by late 2010.

■ Urs Fitze

## LINKS

www.bafu.admin.ch > Naturgefahren > Schutzwald (only available in German, French and Italian)

www.forestknowledge.net

www.wsl.ch > search > protective forest

## INFO

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PROTECTIVE FOREST LEARNING PATHS

# Recognizing the importance of the protection forest

**The purpose of the learning paths in nine Swiss mountain regions is to raise public awareness of natural hazards on high ground and the effect of the protective forest. The Schutzwald Schweiz ("Protection Forest Switzerland") group, which is funded by the federal authorities, has chosen to do this by means of sensory experience.**

The Swiss population's conception of the forest has changed radically, even in the mountain regions. Whereas it was once seen as an important source of raw material and income and as a shield against natural hazards, today it is frequently viewed as an amenity area, even by local residents. However, the importance of the protection function of mountain forests has actually increased due to the spread of settlement areas and proliferation of transport routes. The "schutz.wald. mensch" (protective.forest.man) project was launched in 2002 to update this imbalanced image of the forest. Its aim is to link the recreational and useful aspects of the forest, thus it combines pleasant walks in the forest with the raising of awareness of natural hazards.

**First-hand experience**

Learning paths represent a proven but now rather jaded awareness-raising instrument. Thus, in this case, a concept was consciously chosen that differs from the usual approach to learning paths, says biologist and environmental trainer Klemens Niederberger, who developed the project on behalf of the Schutzwald Schweiz group. The emphasis here is not on signposted information panels, but on sensory experience which provides far more direct access to the topic. The aim is to ensure that the importance of the protection forest becomes rooted in the participants' thoughts and actions in the long term.

Participants have to overcome challenges at different installations along the paths. For example, they must negotiate a point with loose rocks and, having overcome this hurdle, they can then learn about the topic of rock fall on an information panel. Thus, participants do not encounter the topic as passive readers but as observers who access information first and foremost through their own experience and reasoning.

**Signs of natural forces**

The nine learning paths in Moléson (Fribourg), Adelboden (Bern), Bettmeralp (Valais), Grafenort/Engelberg (Obwalden), Altdorf (Uri), Wägital (Schwyz), Werdenberg (St Gallen), Poschiavo (Graubunden) and Arosa, (Graubunden, from August 2007) have different installations on topics such as avalanches, landslides and forest maintenance. Vivid examples are provided on site alongside the traces of natural forces left by rock falls, rock slides, torrents, debris flows, floods, landslides and avalanches. www.schutz-wald-mensch.ch

**The learning paths in the nine mountain forests enable participants to experience at first hand natural hazards in the mountain regions, the functions of the protection forests and the enormous significance of forest maintenance.**

SILVIVA

FOEN

**More space for the previously channelized river Magliasina in Ticino: the new river bed is protected against erosion using bioengineering methods.**

PROTECTION IN HARMONY WITH NATURE

# Greater safety through reserved open spaces

Structural measures for protection against natural hazards often impact heavily on landscapes and habitats. However, modern hydraulic engineering is moving away from the drive to tame rivers with the help of structural flood controls. It is giving water courses more space and combining flood protection concerns with those of nature-oriented landscape management.

Turquoise water meanders along its course to Lake Lugano in the half-shade of the alluvial forest. This idyllic landscape near Caslano in the canton of Ticino is, however, a recent development: as recently as the 1990s a narrow canal kept the small mountain river Magliasina in bounds to protect a golf course on the flood plain from flooding. However, when an unusually heavy storm broke in Ticino in September 1998, the channelized water course became an unexpectedly destructive force. The torrential river damaged the transport routes, buildings and facilities that had increasingly encroached on its banks in recent decades.

## More space for nature

The flood damage of around CHF 7 million prompted a review of the previous protection concept. Just a few months later, the municipalities involved agreed to give the river Magliasina more space. The structural flood controls on a good two kilometres of the river were removed, the riverbank was flattened out somewhat and parts of the river bed extended to twice its previous width. Native shrubs and trees protect the embankment from erosion. Willow seedlings, lying willow branches and coconut nets provide stability for steeper sections of the river bank. These bioengineering safety measures have not only made the river banks more attrac-

tive for leisure-seekers, they have also created a diverse habitat for plants and animals. As model calculations show, thanks to the extra space, the owners of properties bordering the area are largely protected against flooding, even in the event of a peak flow exceeding that of a one hundred year flood.

**Expensive infrastructure – costly damage**

Floods become a social problem when they put human life and important material assets at risk. "The significant increase in built infrastructure is a one of the main reasons for the enormous damage caused by floods," notes Markus Thommen from FOEN's Landscape and Land Use Section.

This applies in particular in the mountain region where the steep territory increases the momentum of the water courses – and hence also their destructive power in the event of a flood. The damage potential is rising here due to the continuing improvements in the quality of the infrastructure. The federal authorities alone, spend almost CHF 100 million annually on structural improvements such as access roads, barns and farm buildings. "In the storm of 2005, in addition to public transport routes and inhabited buildings, numerous farmland improvements as well as forest roads were damaged," notes Markus Thommen. To minimize the damage arising from such events, nature must be given more space again. "In some cases, it would make more sense to leave areas which are particularly vulnerable and can only be protected at a very high cost entirely to the devices of nature."

**Significant need for action**

As part of ecomorphology investigations on the structure of water courses, which are co-funded by the federal authorities, the cantons have collected data on rivers and streams with a total length of almost 27,300 kilometres. Of this, around 10,000 are significantly restricted, unnatural or culverted. Renaturation with widening is required to remedy these deficits. "However, this is only possible if the land along the water courses is available," says Markus Thommen. The need for action is greatest in highly developed settlement and economic zones because, in the past, water courses in these locations were often severely restricted so as to provide additional land for development.

The question arises, however, as to whether society is actually prepared to curb its development activities to improve flood protection and upgrade the habitat quality of the water courses. Jean-Michel Gobat from the Institute of Botany at the University of Neuchâtel has explored this issue as part of Swiss National Research Programme 48, Landscapes and Habitats of the Alps. According to the project findings, ecological flood protection projects have the best chance of being implemented if the memory of a flood event is still current as this makes people more receptive to radical measures.

**Working with nature**

It is not only important to work with nature in the context of hazard prevention, it also pays to do so in the aftermath of a loss event. After Storm Lothar, serious soil degradation arose in numerous forests because heavy machinery was used on wet ground during the clean-up operation. "Driving at excessive speed on flooded fields immediately after the drain off of flood water frequently causes further damage through soil compaction which is often more serious than the damage caused by the natural hazard in the first place," explains Jürg Zihler from FOEN's Soil Section. It is also a matter of economic self-interest, not to lapse into blind activism but allow the soil to settle and dry for a few days. "Even in cases involving contamination with organic substances – for example oil – in our experience, the soil recovers relatively well," notes Alexander Imhof, Director of the Department for Pollution Control at the Uri Cantonal Office for Environmental Protection. "It is amazing how quickly the plants shoot up through the layers of mud." However, if the alluvium cover is more than 15 centimetres thick, it must be removed – preferably using a caterpillar tracked vehicle.

■ Lucienne Rey

## LINKS

www.umwelt-schweiz.ch/naturgefahren > Publikationen > Hochwasser > Fallbeispiele Wasserbau > Malcantone (German, French and Italian)

www.rhone-thur.eawag.ch (German)

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ALERTING

# Timely warning when danger threatens

The extent of the damage caused by natural disasters can be significantly reduced if crisis management units, emergency services and other stakeholders are warned in good time. Emergency planning provides more time to move people, animals and mobile assets to safety and to organize the preparedness measures for damage reduction. For this reason, Switzerland aims to improve its warning and alert systems.


Beat Baumann, Wasserwirtschaftsamt, canton of Bern

**Evacuation of a resident from the flooded Matte neighbourhood of Bern in August 2005.**

Several thousand cars sank in the wave of storms of August 2005. The flood damage to motor vehicles in Switzerland alone totalled almost CHF 100 million. "If the population had been warned on time, people could have moved numerous parked cars to safety without running any risk," says Hans Peter Willi, Head of the Hazard Prevention Division at FOEN.

With the exception of strong earthquakes which can occur without any warning, most of the natural hazards that represent a threat to Switzerland – for example heavy storms, avalanches and floods – announce their imminent arrival a few days or hours in advance. Experts at MeteoSwiss (Swiss Weather Service), the Swiss Federal Institute for Snow and Avalanche Research (SLF) in Davos and FOEN monitor weather developments with the help of the very latest technologies. Based on model calculations and their experience, they can often predict critical weather situations and their possible effects in good time. In exceptional situations, they collaborate with the National Emergency Operations Centre (NEOC) in Zurich which informs the crisis task forces at cantonal level and, if necessary, instructs the population via electronic media.

### Improving warning and alerting systems

"The weaknesses that emerged in August 2005 showed that there is room for improvement in our natural hazard warning and alert systems," says Hans Peter Willi. Thus, the federal authorities aim to optimize the cooperation between the different expert bodies, create a shared natural hazards internet platform (gemeinsame Informationsplattform Naturgefahren/GIN) and improve the operational reliability of the measuring devices. "In the case of extreme events, the action undertaken in the early hours is often crucial for the further course and extent of the damage," explains Hans Peter Willi. "The decision is taken at this point as to whether the damage can be limited through suitable organizational measures."

### Good preparedness reduces the damage

To ensure that things do not get out of control when a hazard event exceeds the capacity of existing protective structures, emergency planning which is tailored to the situation is required in the hazard zones. This includes, in particular, the advance raising of public awareness, the thorough training of crisis management units who are familiar with the weaknesses of the local structural safety concepts and well prepared emergency services with the necessary operating resources. If the fire brigade, police and other emergency services are mobilized in good time, depending on the risk involved, they can close threatened transport routes, evacuate people and animals, install temporary protection measures and – in the case of flooding – keep bottlenecks on water courses free from debris and driftwood. If those affected by the hazard are given prior warning, they will have time to move vehicles and other material assets to safety without putting their lives at risk.

### FOEN's automatic alarm annunciators

Early warning based on detailed precipitation and run-off forecasts and alerting based on water level measurements often play a crucial role. To this end, the FOEN Hydrology Division has already equipped 26 of its water measurement stations on larger water courses and lakes with alarm annunciators. If the Rhine, Aare, Lütschine, Emme, Reuss, Linth, Limmat, Töss, Sitter, Thur, Ticino or Maggia reach a critical water level, these devices send an automatic alert to the appointed security company Certas. From there, FOEN's clients are notified around the clock by telephone and kept informed about the critical water level. The main subscribers to this service are the cantonal and municipal crisis management units, the emergency services and the fire services in large industrial concerns. Depending on the watershed area of a river and the respective threshold value, which is defined in advance in consultation with the client, those responsible have one to two hours time to implement the necessary emergency measures. Thus, for example, FOEN has installed seven additional alarm annunciators in its measuring stations on the Aare from Lake Brienz to its outlet from Lake Biel since the flood of 2005. The measures undertaken in cooperation with the Bernese Water Management Office and the cantonal police are intended to facilitate the timely alerting of the crisis management units and emergency services in neighbouring municipalities.

■ Beat Jordi

**LINKS**

www.bafu.admin.ch > Hydrology > Hydrological foundations and data > Forecasts and alerts

www.meteoschweiz.ch > Danger

www.slf.ch

www.naz.ch

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Hans Peter Willi, see page 10

**Road blocks (left: For Pedestrians/Caution!/Danger of Avalanches/Road closed) and temporary protection measures are important ways of reducing the extent of the damage caused by natural hazards in critical situations.**

Keystone/Vereinigung Kantonaler Feuerversicherungen VKF, Bern


Swiss Air Force

**In August 2005, the industrial zone on the Reuss plain near Schattdorf in the canton of Uri was flooded for days. The emergency services had to pump out large volumes of contaminated mud.**

MAJOR ACCIDENTS CAUSED BY NATURAL HAZARDS

# When chemical stores are flooded

Some industrial concerns and businesses which work with environmentally hazardous substances are located in hazard zones. In the absence of adequate protection measures, harmful chemicals could be released there in the event of flooding, rock fall or an earthquake. Such locations will now be surveyed and assessed systematically with the help of FOEN's new databases.

On 22 August 2005, the torrents from the Uri tributary valleys deposited tonnes of debris on the Reuss plain. The material deposed by the Schächen torrent near Schattdorf blocked the overflowing stream and the resulting water mass formed a lake in the industrial zone, flooding 201 industrial operations employing over 2,000 people, including large industrial premises, such as those belonging to the RUAG corporation and Dätwyler rubber factory. The chemical emergency response teams were deployed for days; once the water had retreated they had to pump large volumes of mud contaminated with leaked oil and various chemical substances. It could have been worse if some of the particularly toxic substances also stored there, such as chromates, perchloroethylene and other chlorinated solvents, had also leaked. However, fortunately, the containers with the environmentally hazardous substances remained intact and were successfully recovered by the emergency services. Where time allowed, some containers had been moved to safety before the flood.

### Pressure from land use exacerbates risks

Due to their handling of hazardous substances, around 2,300 plants in Switzerland are subject to the provisions of the Federal Ordinance on Major Accidents (Störfallverordnung, StFV). "Some of these locations are at risk from natural hazards, thus in the event of flooding, rock fall or an earthquake the release of hazardous substances poses an additional risk," reports Daniel Bonomi from FOEN's Prevention of Major Accidents and Earthquake Mitigation Section. In addition to the increasing pressure from land use – in particular in the highly industrialized Central Plateau, the Basle region and in the plains of the large Alpine valleys – operational factors also play a role in the problematic choice of these locations. For example, chemical works are often located near large water courses because they need cooling water and because, in the past, the water courses provided a very convenient means for the disposal of

Canton of Ticino

**Vulnerable industrial zone at the foot of the eroded scarp near Preonzo in the Leventina district of Ticino.**

their polluted waste water. "As a result, these companies unintentionally exposed themselves to the risk of flooding," concludes Daniel Bonomi.

**Registration of operations at risk**

The application of the provisions of the ordinance on major accidents (StFV) in relation to stationary plants is basically the responsibility of the cantons. During their inspections of the relevant plants, they must also check whether industrial accidents could be triggered by natural hazards and identify the preventive measures that must be taken by the owners. A national overview of the extent of this problem is still lacking. However, with the ERKAS risk register and the newly established SilvaProtect (see page 39) and Aquaprotect databases, which contain a spatial breakdown of the risks posed by avalanches, landslides and floods, FOEN already has a nationwide basis for a systematic assessment. This is due to be carried out for the first time in 2007 and is expected to provide indications of potential problem cases. Whether a particular industrial zone is actually at risk from natural events, should also be indicated by the hazard maps to be developed by the cantons. "If these facts had been known, some factories probably would not have been built in their current locations," says Daniel Bonomi. "The best way to provide protection against major accidents caused by natural hazards is to avoid building potentially dangerous plants in areas at risk from natural hazards."

**Industrial zone under a crumbling crag**

The industrial zone of the municipality of Preonzo, which lies between Bellinzona and Biasca in the canton of Ticino, is a rather unsafe location which would probably not be zoned for development today. The unstable rock formations on the crumbling scarp right at the foot of Alpe di Roscioro represent a permanent threat to safety. In May 2002, following heavy rainfall, around 150,000 cubic metres of rock plummeted down to the valley. Some of the boulders actually reached the 30-metre-high and 120-metre-wide protective barrier which was being constructed at the time. The slope is now permanently monitored by measuring probes.

**Lessons learned from damage**

The managers from the company BERNINA International, which produces sewing machines in Steckborn in the canton of Thurgau, also learned some valuable lessons from damage caused by a natural hazard. After a heavy storm on 13 June 2000, the Feldbach torrent pushed large volumes of water and debris through the village. The first and second basements of the factory were flooded by around 35,000 cubic metres of mud and water, giving rise to CHF 20 million worth of damage. The wastewater treatment plant and the chemical store containing toxic cyanides and heavy metal salts were also flooded. "Thanks to a major operation lasting several days, the emergency services succeeded in ensuring that the contaminated water did not reach Lake Constance nearby," says Bruno Hertzog, who is responsible for major accident prevention at the Thurgau Cantonal Office for the Environment. After this event, the municipality of Steckborn optimized its struc-

tural flood protection. The company affected by the flood also upgraded the protection of its chemical store, radically reduced the volumes of hazardous substances stored there and consistently separated substances which react strongly with each other.
"The implementation of such operational safety measures is primarily in industry's own economic self-interest because through these measures it can protect itself against expensive damage and long breaks in production due to natural hazards," notes Daniel Bonomi. "At the same time, they also provide a service to the population and environment as they prevent additional damage through the release of hazardous substances." However, at present empirical values are still lacking which would enable the assessment of their extent as compared with the overall damage caused by natural hazards.

**A narrow escape**

In the case of the Lonza AG works in Visp in the canton of Valais – one of Switzerland's biggest chemical plants – the safe operation of the plant is also a matter of concern for the owners of adjacent properties. The company land, which was built on one hundred years ago, is dissected by the Rhone to the north and is bordered on the west by the Vispa, a tributary from the Saas and Matter valley, which enters the valley river at this location. Several alarming flood events have occurred here over the past two decades, i.e. in 1987, 1993 and, most recently, 2000. Kurt Gimmel, Director of Emergency Services at Lonza Visp, recalls 20 October 2000 with horror. "Just another 20 centimetres and the rising Rhone would have breached the dike crest and flooded the plant." Fortunately, this did not happen because the canton had raised the dike crest along the 1.5 kilometres of the company premises by 60 centimetres back in 1993. Despite this, the situation was so serious that – for the first time in the long history of the works – almost all of the over 2,000 employees were evacuated. Hours beforehand, production processes had been shut down and operation ceased as the cooling water supply was no longer guaranteed. If the dike had been flooded or breached, the works could have been inundated by up to 2.5 metres of water and the town of Visp would also have been flooded.

**Improved flood protection**

The implementation of structural flood protection on water courses is basically the task of the state. Thus, the Rhone dikes upstream and downstream of the company land were raised and reinforced again in 2001. It is even planned to equip the nearby town of Visp and, hence also, the industrial zone to withstand a one-thousand-year event in the future. Thus, the canton of Valais is planning comprehensive protection measures in the vicinity of the Lonza plant. As part of the Third Rhone Correction, from

**Flood safety in the vicinity of the Lonza Plant in Visp (left) is being significantly improved by the Third Rhone Correction. The company has already implemented various measures to improve earthquake safety. Thus the blue steel frame protects the spherical tank used to store liquefied gas against heavy seismic shocks.**

FOEN/Stefan Hartmann, Zurich

2008, the dikes will be reinforced again and the flow capacity of the river increased through the deepening of its bed. The channel will be widened to the east and west of the company premises and the confluence of the Vispa with the Rhone will also be significantly widened. As opposed to this, it will not be possible to widen the Rhone river bed in the direct vicinity of the company premises as the plants on both sides of the river practically border on the existing dikes.

**Company flood protection concept**

Because all structural protection measures have their limits, companies also need to implement technical and organizational measures to mitigate damage if affected by a natural hazard. Lonza AG has a permanently manned alarm centre for this purpose which constantly monitors the Rhone water level, the weather situation in the watershed area of its tributaries and the run-off from hydroelectric power stations in the tributary valleys. If the water in the Rhone reaches a level of 2.6 metres, the alarm is raised in accordance with the new protection concept. If the water level rises by a further 20 centimetres, production is completely shut down and the plant secured, an operation which takes around eleven hours to complete. This task includes, for example, the securing of storage tanks and vats to prevent them from floating and breaking free. Mobile objects such as tank wagons containing chemicals are removed in good time and containers of substances that are hazardous to water are moved to higher storage locations. Evacuation of the plant personnel would begin two hours before a threatened flood.

**Structural protection measures**

As part of the risk analysis carried out in 1993, Lonza AG also assessed the company's earthquake risk. It emerged from this analysis, that some chemical plants from the 1970 and 1980s did not fulfil the applicable earthquake safety requirements. Thus, vulnerable areas of the plant were earthquake-proofed. For example, the columns supporting a spherical tank containing liquid gas were reinforced with a steel frame and the 26 concrete columns of the spherical ammonia tank have now been fitted with special hard rubber buffers and a concrete slab so that they are better able to withstand seismic waves.

■ Stefan Hartmann, Beat Jordi

## LINKS

www.bafu.admin.ch > Themen > Stoerfallvorsorge ( German and French)

www.vs.ch/rhone.vs ( German and French)

www.kgvonline.ch ( German and French)

## INFO

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**The cooling water from the Rhone is crucial for the Lonza plant in Visp. During flooding, the supply of the plants is no longer guaranteed due to the debris. In extreme cases, Kurt Gimmel, Director of the company's emergency services, must order the suspension of production.**

Stefan Hartmann, Zurich

**www.bafu.admin.ch/naturgefahren** (mainly D, F, I)

**Protection against natural hazards**
As a federal authority, FOEN's mission is to protect the Swiss population and important material assets on the basis of uniform nation-wide safety standards. FOEN is responsible for protection against the entire range of climatic, geological and technical hazards. The careful maintenance of water courses and protection forests constitutes a key element of FOEN's safety strategy.

**www.planat.ch** (E, D, F, I)

**National Platform for Natural Hazards (PLANAT)**
The extra-parliamentary commission PLANAT was commissioned by the Swiss government to develop a strategy to improve protection against natural hazards throughout Switzerland through optimized risk management. Its website presents the results of its work and also acts as an information platform and central point of contact. It provides documentation, images, contact and internet information on the entire topic of natural hazards.

**www.wsl.ch** > en > Research > Projects > Natural Hazards

**Centre of excellence in research**
The Swiss Federal Institute for Forest, Snow and Landscape Research carries out basic research and supervises a large number of applied projects in the area of natural hazards. Its key focus areas include mountain hydrology and torrents, snow and permafrost, avalanches, landslides and rock fall, and hazard alerting and prevention. Current avalanche warnings can be found at www.slf.ch.

**www.seismo.ethz.ch** (E, D, F)

**Seismological Service**
The website of the Swiss Seismological Service provides information on the risk of earthquakes in Switzerland. The earthquake hazard map shows that the canton of Valais and the Basle region are particularly vulnerable to earthquakes. The seismological events recorded in the Earthquake Lists go back to the 13th century.

**www.katarisk.ch** (E, D, F, I)

**Risk assessment**
In terms of civil protection, the military threat to Switzerland has been eclipsed by the risks posed by natural disasters and societal emergencies. The Katarisk project analyses and evaluates these risks using a standardized method. The website also provides information (in German, French and Italian) on practical risk management.

**www.meteoswiss.ch** > danger

**Weather warnings**
MeteoSwiss, the Swiss meteorological service, has developed a modern multi-level storm warning system in collaboration with the cantonal civil protection authorities and the National Emergency Operations Centre (NEOC). The website provides direct information in the form of maps on the risks posed by storms, heavy rainfall, heavy snowfall and forest fire.

**www.naz.ch** > English > Themes > Natural hazards

**Alerting the population**
The National Emergency Operations Centre (NEOC) is the Swiss federal centre of expertise for exceptional emergency events. Its core tasks include the issuing of early warnings and alerts in the event of suspected or increased radioactivity, chemical accidents and dam ruptures. It also redoubles its efforts in these areas to protect the population and livelihoods in the event of a natural disaster.

**www.praeventionsstiftung.ch** > En

**Providing better protection for buildings**
In recent years, storms, hail and floods were responsible for 95 percent of the damage caused to buildings in Switzerland and covered by insurance. The Cantonal Public Building Insurance Companies' KGV Prevention Foundation would like to reverse this trend for increasing damages in the long term and, thus, promotes buildings-related risk management.

**www.swissre.com** > Research & Publications > Top topics view > Natural catastrophes

**Natural hazards throughout the world**
As a globally active reinsurer, Swiss Re is particularly affected by the increasing damages being paid as a result of natural disasters. The company's detailed analyses provide a sound introduction to the global problem of natural disasters.

**www.unisdr.org**

**International Strategy for Disaster Reduction**
The International Strategy for Disaster Reduction ISDR aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development.

Natural Hazards
online

INTERNATIONAL COOPERATION

# Worldwide exchange of experience

**The natural hazard protection concepts developed in Switzerland attract interest beyond the country's borders. Thus, the expertise developed in Switzerland is used in the context of bilateral cooperation with various other countries. Switzerland also benefits from this international exchange of experience.**

The United Nations International Strategy for Disaster Reduction (ISDR) aims to contribute to the building of disaster-resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development. To this end, 168 states adopted the Hyogo Framework for Action at the international conference in Kobe, Japan in January 2005. The Swiss Agency for Development and Cooperation (SDC) promotes the implementation of the Hyogo Framework in various countries. It also supports the ISDR secretariat in Geneva. Switzerland is also involved in various other international and regional organizations, for example it acts as an Advisor Country to the Asian Disaster Reduction Centre (ADRC) whose headquarters are in Kobe. The latter aims to facilitate the exchange of information and experience between experts and institutions in all member countries, to provide information on disaster prevention and to promote international cooperation. The World Bank and regional development banks are also becoming increasingly active in the area of disaster reduction and Switzerland supports the corresponding endeavours.

### Cooperation with the WMO

The World Meteorological Organization (WMO), which is a specialized agency of the UN and based in Geneva, also deals with the development and implementation of strategies for the prevention of natural disasters. The WMO focuses on early warning systems in this context. Thus, for example, its Hydrology and Water Resources Programme (HWRP) promotes the assessment of flood risk and forecasting through expert consultation and cooperation projects. The aim of the Associated Programme on Flood Management (APFM), which is also a WMO initiative, is the implementation of flood management based on the Integrated Water Resources Management approach. The WMO works closely with Switzerland in this area and the planned initiatives include a pilot project in Mexico.

### Promotion of hazard maps

As part of its bilateral international development work, SDC supports projects for protection against natural hazards in several countries. The concepts developed in Switzerland provide a valuable complement to the information and experience available locally. For example, hazard maps, which show natural hazards such as floods and landslides in selected areas have been produced in various countries, for example the Latin American states of Nicaragua and Ecuador. "Our strategy of identifying areas at serious risk from natural hazards in good time and of avoiding their use as settlement areas where possible can also be implemented in developing and emerging nations at a relatively low cost," explains Hans Peter Willi, Head of FOEN's Hazard Prevention Division. The selected approaches are also suited, however, to industrial countries, as demonstrated by their application in the German federal state of Saxony and in the Czech Republic.

The European Union's new Floods Directive will oblige all Member States to produce flood hazard maps for high risk areas. Together with France, Switzerland is joint director of the European Exchange Circle on Flood Mapping (EXCIMAP), the aim of which is to formulate a recommendation incorporating good-practice methods for high-quality hazard maps.

### Bilateral contact with Asia

Switzerland has been involved in a technical exchange of experience in the area of flood protection with Japan for 20 years. Another bilateral cooperation relationship was recently established with the Chinese Ministry for Water Resources which is interested in adapting the Swiss Federal Law on Hydraulic Engineering for the People's Republic of China. The dynamic contact between the two countries also gave rise, inter alia, to a project for improving flood forecasting and alerting on the Yangtze, for which Switzerland provided crucial support.

Keystone/EPA

**As seen here on the Rio Bilampi in Nicaragua, settlements and human life are at risk from flooding in many developing countries. Hazard maps, which register the risk posed by such natural hazards, are being compiled in various regions with the help of Switzerland.**

### Exchange of experience in the Alpine region

The Platform for Natural Hazards of the Alpine Convention (PLANALP) involves representatives from all of the Alpine countries, the European Union and various NGOs. The aim of PLANALP, which was established in 2004 and is chaired by Andreas Götz, Vice Director of FOEN, is the development and implementation of hazard prevention and adaptation strategies throughout the Alpine region, for example through the creation of expert networks on the level of research and administrative bodies. The platform is intended to promote the cross-border exchange of experience, improve early warning systems and firmly establish integrated risk management throughout the Alpine region. The Swiss mountain forest maintenance group, Schweizerische Gebirgswaldpflegegruppe (GWG), which was established in 1981 with international involvement, pursues similar objectives in the area of protection forest management.

The promotion of international networking is also the aim of the Interpraevent research society, which was founded in 1968. The society unites natural hazard experts from organizations and authorities in the Alpine region as well as Japan and Taiwan. It aims, in particular, to promote interdisciplinary research on the protection of living space against floods, avalanches, landslides and other mass movements. To this end, Interpraevent analyses the causes of natural disasters and derives preventive, damage-limiting protective measures from the information obtained and develops the research findings with a view to their practical implementation.

■ Beat Jordi

## LINKS

www.unisdr.org

www.adrc.or.jp

www.worldbank.org > Topics > Urban Development > Hazard Risk Management

www.deza.ch > English > Search: natural hazard

www.apfm.info

www.cepri.fr > English version

www.planat.ch > E > Services > Publications > Flood Risk Reduction in China

www.planat.ch > E > PLANAT > PLANALP

www.iksr.org > Floods

www.interpraevent.at

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