

Earthborne water supply systems are not really in danger during floods, except damages due to scour or erosion. During the Brig disaster in 1993, the supply pipelines were damaged and filled with solid matter, which eventually reached the filters upstream of the buildings and caused clogging. The drinking water supply was practically out of operation and the reoperation was significantly retarded. The current guidelines thus recommend to place filters sufficiently high that sedimentation is impossible and cleaning remains simple.

*Sewers* are typically based on the combined sewer system practice, with stormwater and sewage in the same pipeline. Separation into the treatment facilities and the receiving waters occurs at so-called stormwater overflow structures. The most important guidelines are included in the 1991 federal law on water protection, with details dealt with by the Swiss Water Pollution Association VSA.

A sewer with stormwater floods can cause additional floodings, an effect not further elaborated here. The impact of natural floods on sewer systems is of relevance, however. *Stormwater overflows* normally discharging sewage into the receiving waters can become intake structures to a sewer system during high flood levels. Such undesirable events can be countered by check valves with some risk for clogging in both flow directions. They are therefore not generally accepted. The flood level can even reach lower building intakes which must be located at a certain minimum elevation, according to VSA-regulations.

Out-of-the-river floodings may cause damage to sewers via submergence and intake by manholes. Examples such as those of Poschiavo in 1987, and Brig in 1993 have led to highly undesirable conditions with a complete *clogging* by mainly sand and gravel. Only after a fortnight, the sewers of Brig for example were flushed with high-pressure systems. It seems that this potential of damage cannot really be countered by infrastructural protection.

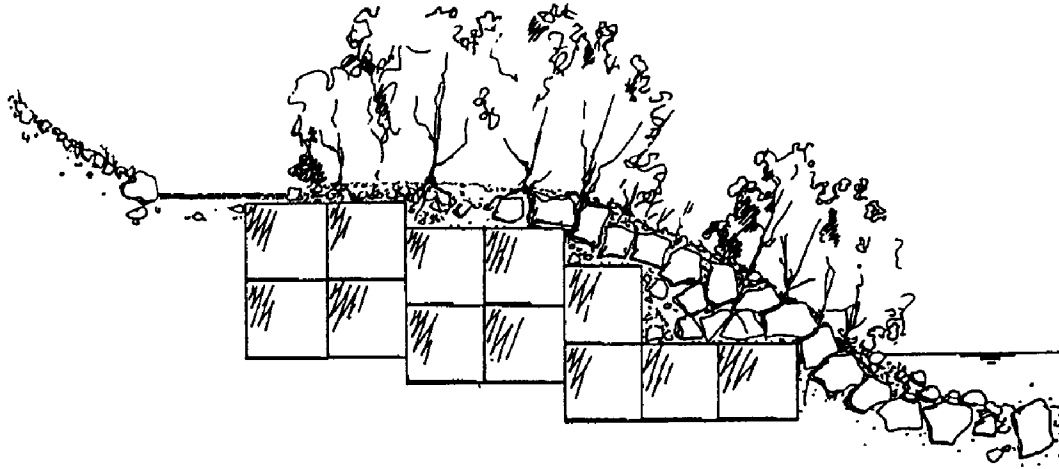
Outlets of sewage treatment facilities into a receiving water can also be influenced by floodings, and the outlet elevation is normally located at the 100 years flood level. Therefore, the sewage is often elevated with screw *pumps* to a sufficiently high level. These pumps are located either at the facility inlet, or between various basins of the plant, or even at the facility outlet. If the treatment facility is still subject to floods, the control installations are at least located at flood-proof elevation.

The Swiss *gas supply* is based on imported gas. Therefore, this country has a distribution network but no gas production plants. The distribution network is not really sensitive to floods, although there might be a damage potential for pipelines located close to rivers and brooks. An example is the pipeline running along Rhone river which might be scoured by out-of-the-river floods. Then, explosions can occur. At the time of design, it was necessary to demonstrate that the Rhone river is actually stable in terms of thalweg geometry, and river migration could be excluded. An additional scour and erosion protection was only exceptionally applied. The control of such pipelines is under the Swiss Federal pipeline inspectorate and details are regulated by SGWA.

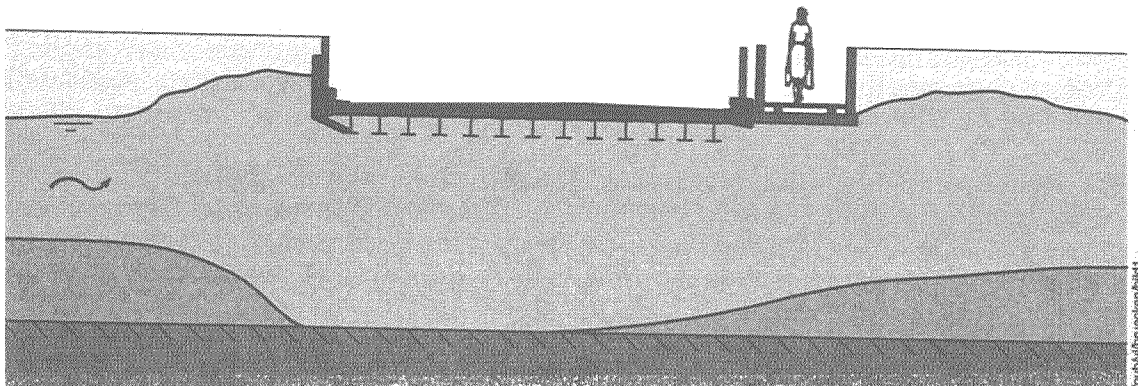
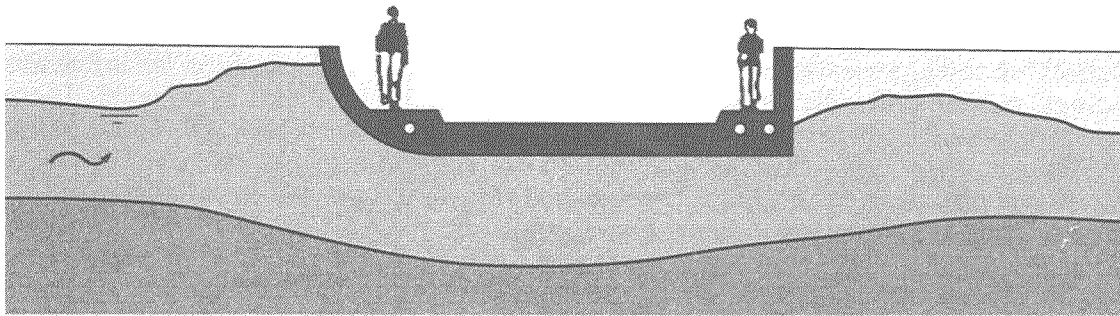
The Swiss *electric supply* involves roughly 60% hydropower and 40% nuclear power. The flood-proofing of its infrastructure was already discussed. One may add that practically all dams are related to hydropower and only few are used for flood storage. Flood security of river powerplants with a large potential of damage follow similar regulations as dams. The overground powerhousees are usually in the flood regions and must be made floodproof, therefore. The access road and the powerhouse entrance must be elevated at least above the 100 years flood level. For underground powerhousees, flooding danger is low and safety may easily be obtained by a sufficiently high entrance elevation. There are actually no guidelines available. The coordinator of such questions is the Swiss Electricity Supply Association.

The gross distribution of electricity involves high tension networks, whose poles are normally flood-proof. Breakdowns are thus seldom and are not really known for the Swiss electric supply network. The large switchyards are normally erected sufficiently above flood elevation, whereas smaller works may be located in flood risk zones. As was demonstrated by

recent incidents the corresponding subworks, transformation stations and distribution cabins are often not sufficiently safe against floods. Cable lines may enhance flooding of electricity stations. Due to an old and unfortunate tradition, the measuring, distribution, regulation and safety installations of the buildings are generally installed at the basement where they may immediately break down.



**Fig.9.2** Shore protection at Reuss river close to Gotthard highway tunnel, with concrete groins of 66 t weight.



**Fig.9.3** Shield backup bridge, schematic streamwise section, design example of Cimavilla bridge at Poschiavo, Switzerland.

The Swiss *telephone* network is laid practically always underground and seems to be less prone to flood damages as compared to the electrical network. Handies increase of course the communication safety during flood flows.

*Traffic infrastructure* related to flood safety has a widely varying degree of protection. Railroads are particularly safe in this country and critical locations are often crossed with embankments. When running along rivers, the railroads have a special protection against bank erosion. Bridges are so high as to inhibit any overtopping or side flows. Along steep slopes, notorious brooks are often bypassed over galleries. The same methods are also used with highways and other strategic roads (Fig.9.2). In contrast, few works have been erected for normal highways, and damages are particularly numerous with road culverts and small bridge openings. These latter may cause significant backwater with corresponding floodings upstream or result in bridge clogging by sediment and float.

Some disastrous river overtoppings were initiated by bridges substructures too close to the water level. Two recent designs were introduced for bridges where their elevation cannot be increased, namely a so-called culvert bridge and the lift bridge. The *culvert bridge* (Fig.9.3) inhibits the bridge flooding by forcing water and sediment through the opening, whereas the *lift bridge* (Fig.9.4) just releases the water flow. Two lift bridges have been built in Brig, one for a public road, the other for the railroad.

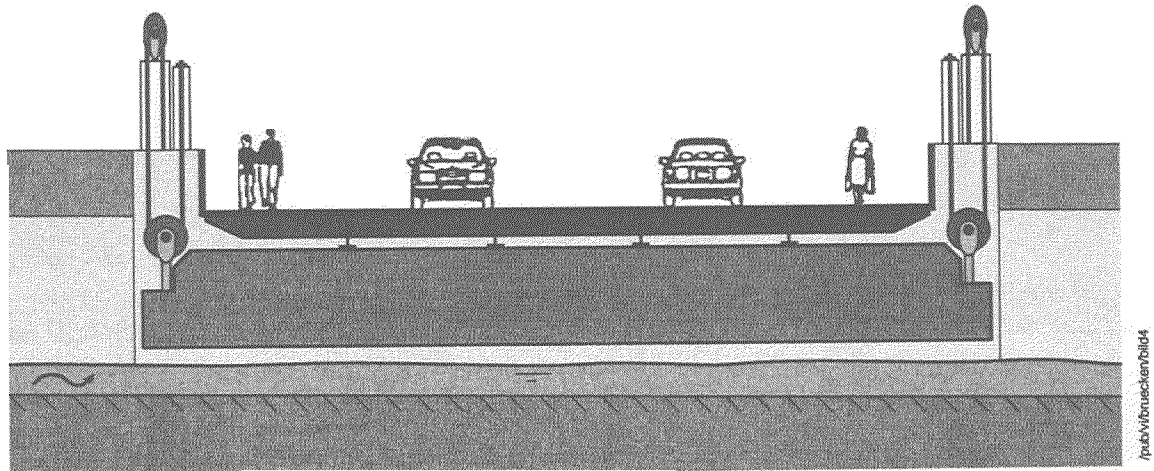


Fig.9.4 Elevation bridge at Brig, Switzerland. The roadway rests on two abutments that may be elevated by 2.8 m.

Few problems arise with the many suspension railways because their poles can easily be designed flood-proof.

### 9.3 BUILDINGS

Buildings in the Alps are normally not flood-proof, as was already mentioned. Given that all the buildings are insured, and insurances do not apply different risk classes, no particular stimulus is created for building protection. Therefore, even new buildings can be found in out-of-the-river floodplains with garages and other installations in the basement. A 1993 federal law is in order that demands a *mapping* of natural hazard zones. Thus, rules and orders are supposed to follow in terms of building protection. The corresponding guidelines are still missing, but may include:

- Flood-proof design of buildings typically on small earth pourings (Fig.9.5), on piers or behind local embankments.
- Omission of basements or addition of seals for entrances, light and air supplies.
- Structural means against erosion and water pressure, including buoyancy.
- Improvement of flood resistance of water and power supply to the buildings considered.