zukunft SEIT 1909 denken

Wildbach- und Lawinenverbauung Forsttechnischer Dienst

Regular Inspection of Torrent Control Structures

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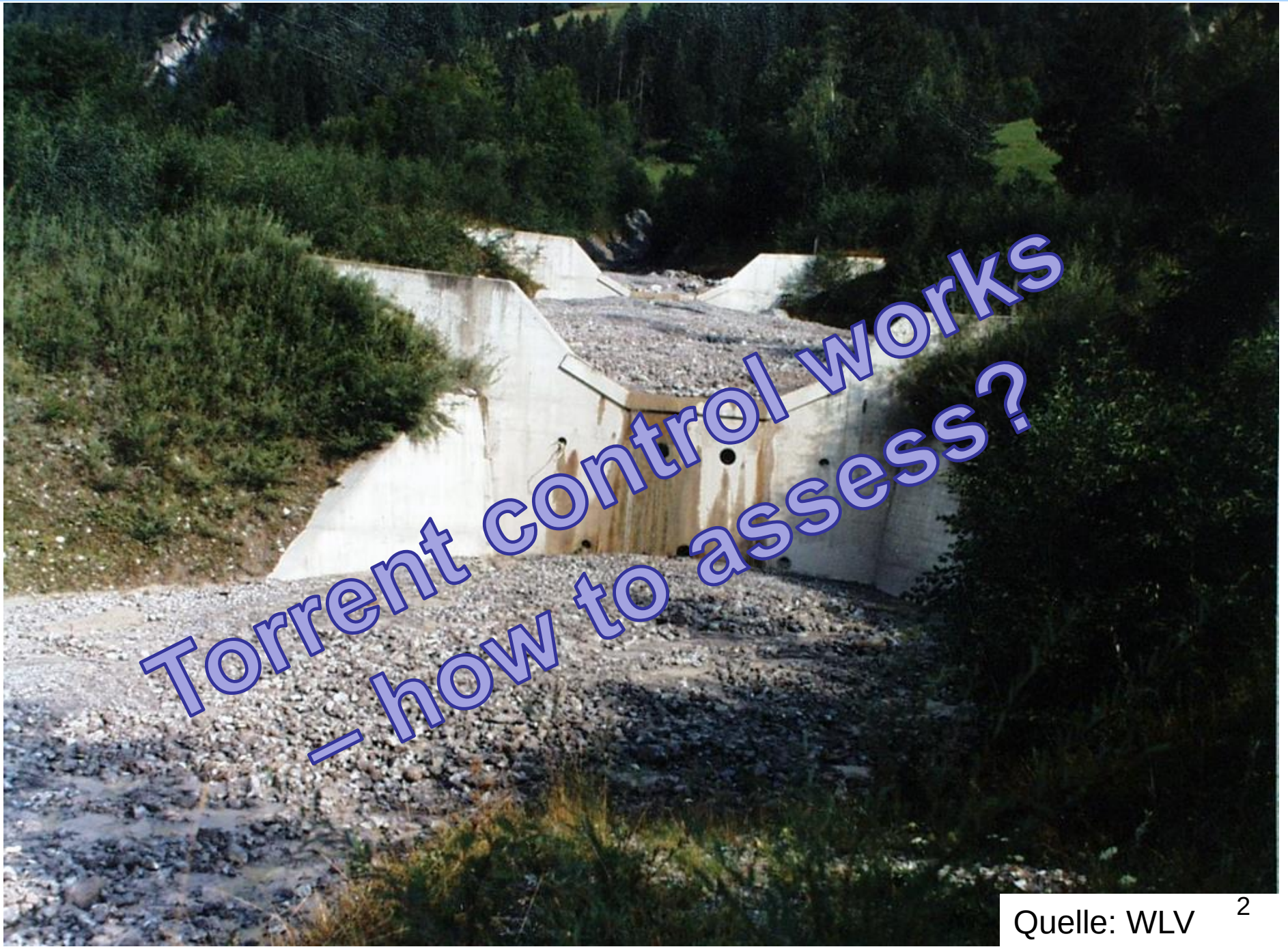
(Based on the work of Jürgen Suda)

Online Seminar
Torrent Supervision
Slovenian Forest Service



Quelle: WLV

Introduction

- The monitoring activities include both the natural hazard processes and the monitoring of the effectiveness of existing protective measures.
- The basic principle is continuous monitoring with regularly recurring monitoring steps by the local authority responsible for safety (usually the municipality) and is carried out by its bodies without special expertise.
- The standards of regular monitoring are therefore defined in accordance with the applicable ÖN 4800 standard in such a way that they can be carried out and documented by non-experts with a simple training course (ÖWAV torrent monitoring course).

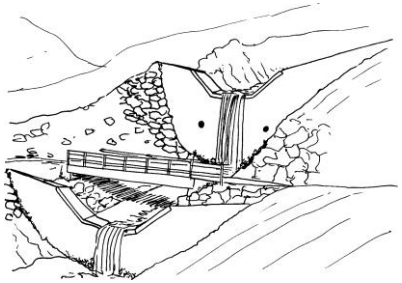
Introduction

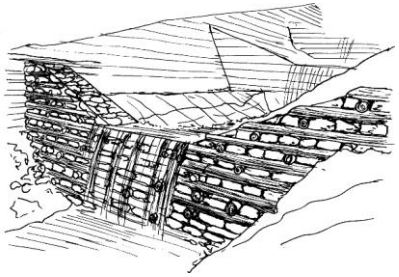
- The monitoring activity is therefore based on visual observation, without assessment of the defects or damage identified (this is subsequently the responsibility of torrent control experts). An essential basis is therefore a central torrent database for the ongoing documentation of survey results and standardized, simple survey criteria.
- This basic principle also applies to the assessment of the condition and function of protective structures. It is therefore the aim of the course participants to have a basic understanding of torrent protection structures, their function and effect on hazard processes in order to carry out accurate documentation.

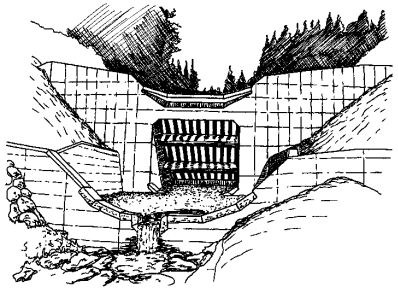
Introduction

- A non-objective of the course is the ability to expertly assess the documentation results with regard to the need for action and to determine appropriate measures, including prioritisation. This task is the responsibility of in-depth checks and inspections, which are triggered by the person responsible for safety or the legal owner (keeper) on the basis of information from ongoing monitoring and are to be carried out by experts.

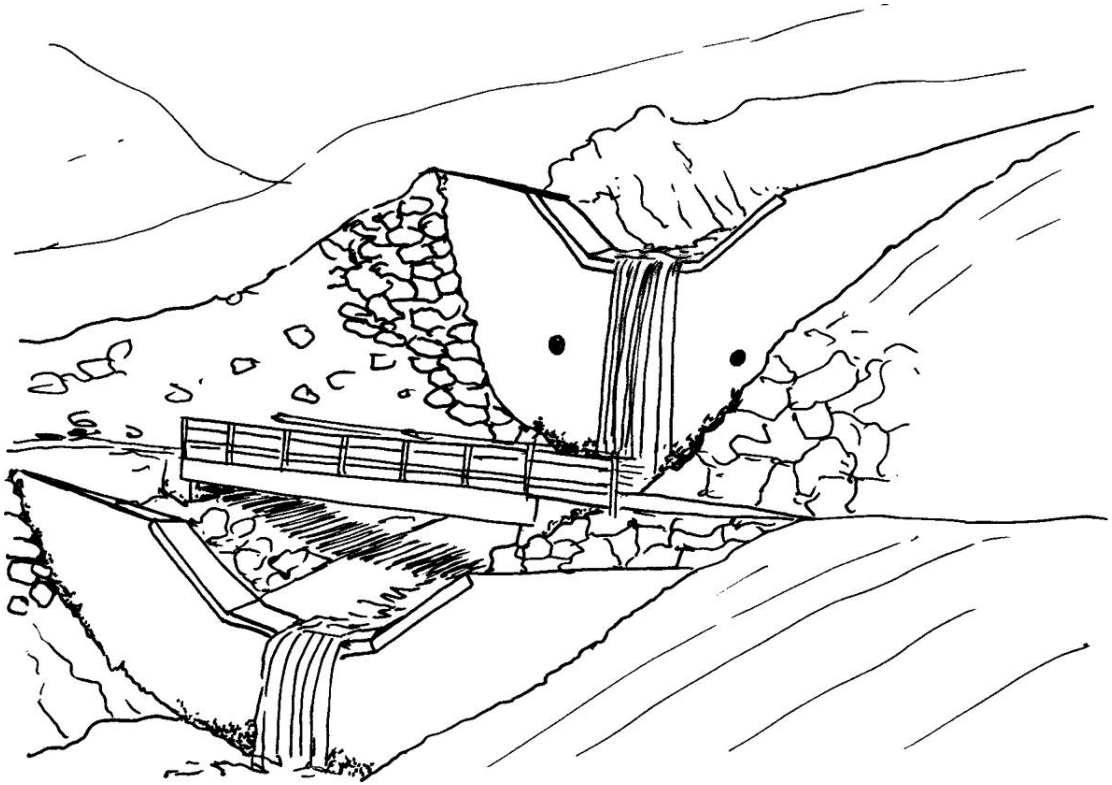
Inhalt





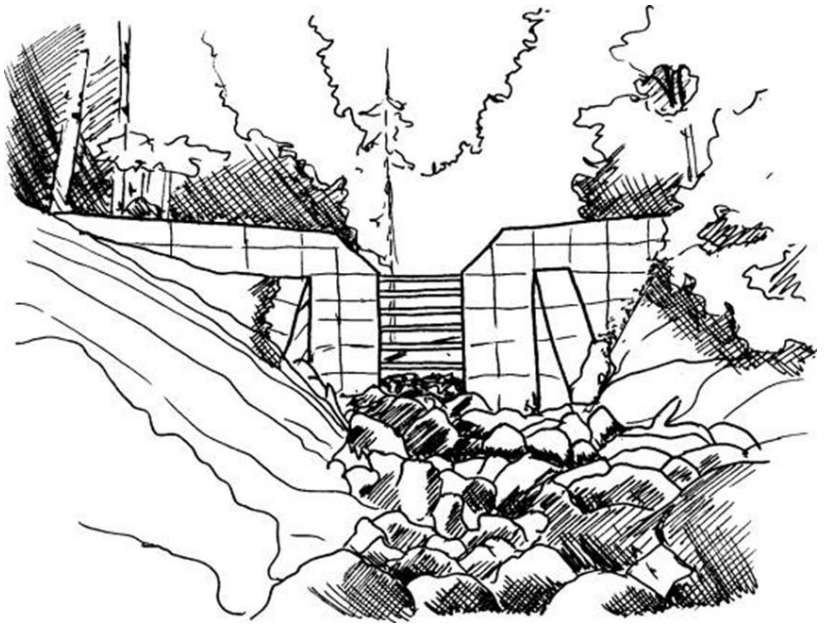


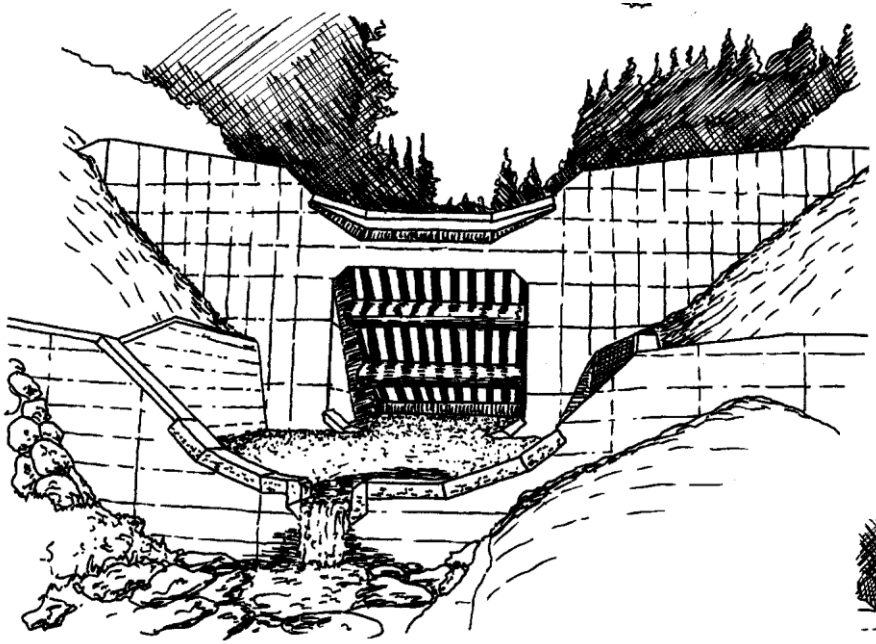
1. **Building types of protective structures for torrent control**
2. **System of regular monitoring of protective structures according to ÖNORM B 4800 (Austrian standard)**
3. **Relevant types of structural damage for regular monitoring**

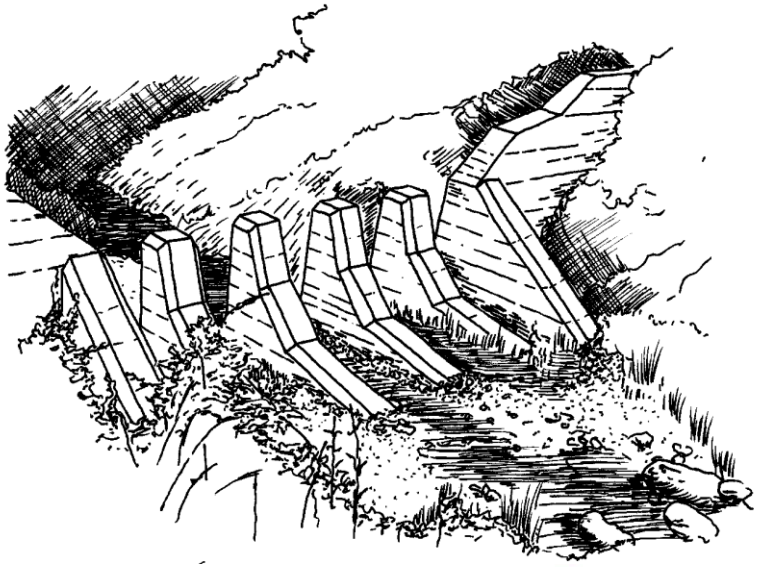


1. Building types of protective structures for torrent control

Torrent control structures







Classification

According to ÖNORM B 4800 protective structures for torrent control are structures that counteract the hazards caused by torrents and are built in torrent catchment areas. The most important **criterion for classification** is the location in relation to the main direction of movement (flow direction) of the process. In this sense, a distinction is made between transverse and longitudinal structures.

Differentiation in the way the structures are addressed:

- functional types
- structural types

Functional Types

The effects of the processes, which depend on the respective conditions in the catchment area, usually require adapted, specific protection systems.

A protection system consists of a combination of individual protective measures that work together.

A large number of different types of protective structures are used.

Each type is optimised for a specific function in the protection system.

Diversion

includes all measures that serve to guide flow processes (e.g. floods, mudflows or avalanches) past the protected area by the shortest route.

Stabilisation

includes all measures that serve to maintain a desired state.
For protection against fluvial processes, these are all measures that serve to secure the bed and banks in the prevailing situation and to protect against lateral and depth erosion.

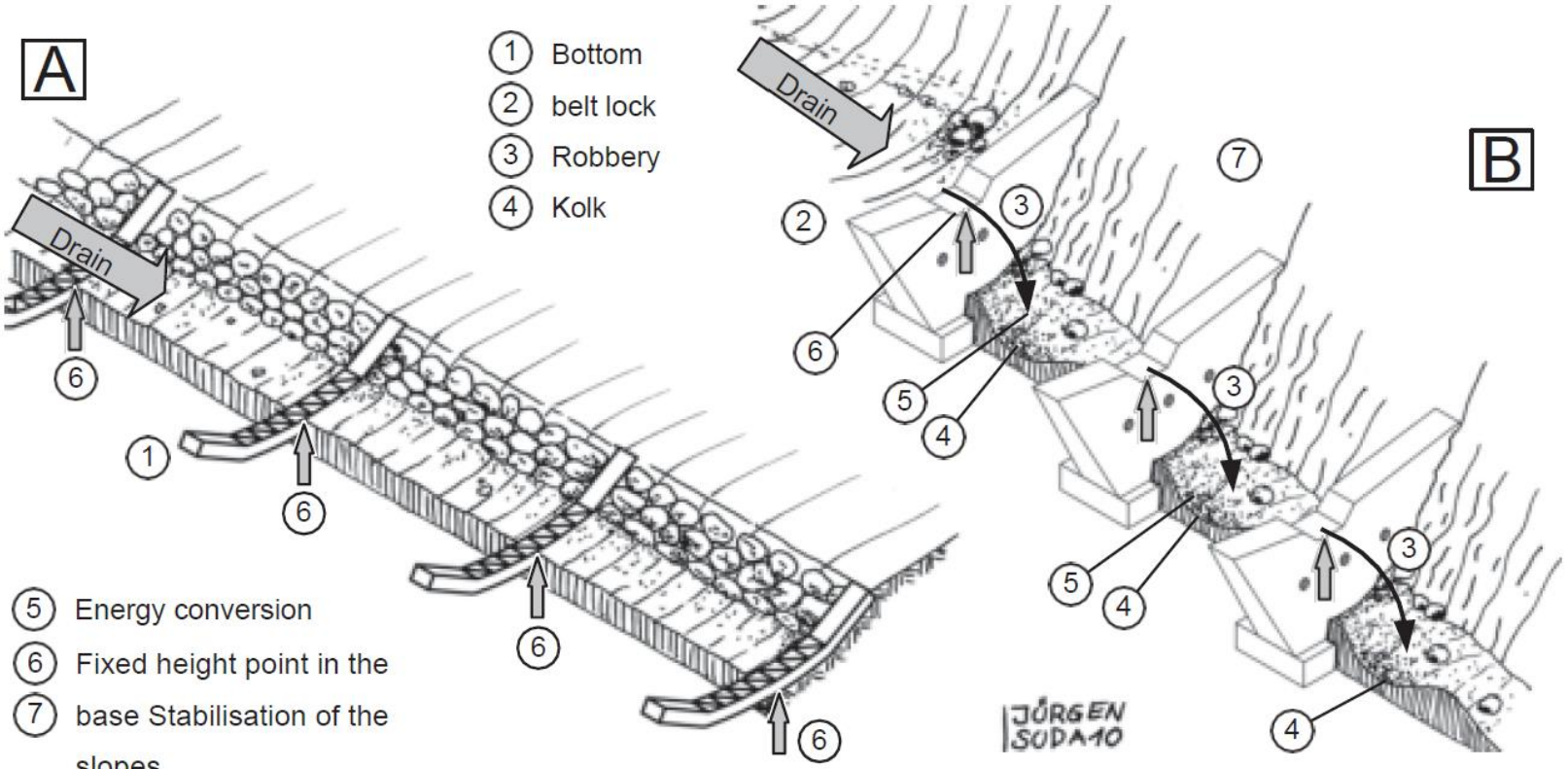
Consolidation

includes all measures that serve to improve a condition. All other properties correspond to those of stabilisation.

Bypass

includes all measures that serve to contain a discharge and to divert it past the protected area in a specially constructed channel or pipe.

Function: Stabilization, Consolidation



Retention

includes all measures that serve to retain water, snow or solids.

Retention of water consists of the reduction of peak runoff as a result of natural storage effects or artificial measures.

Retention of bedload includes retention through artificial measures. In addition to bedload, the retention of mudflows also belongs in this area.

Dosage

comprises the temporary retention of water or bed load in a basin and the reduction of the amount released into the lower reaches to an innocuous extent.

Filtering

involves the selective retention of coarse solid components (e.g. driftwood or boulders) from a flow process using an artificial measure. Those solid components that could lead to a blockage or a blockage of the discharge profile in the lower course are retained. Fine components can pass through unhindered.


A


B


C


E


D


F


G

Energy dissipation

includes all measures that serve to reduce the energy of a flow process by means of a braking structure or a fall.

This measure reduces the flow velocity, changes the properties of the transported medium and transforms the flow process.

Energy conversion is used primarily to break and slow mudflows.

Deflection

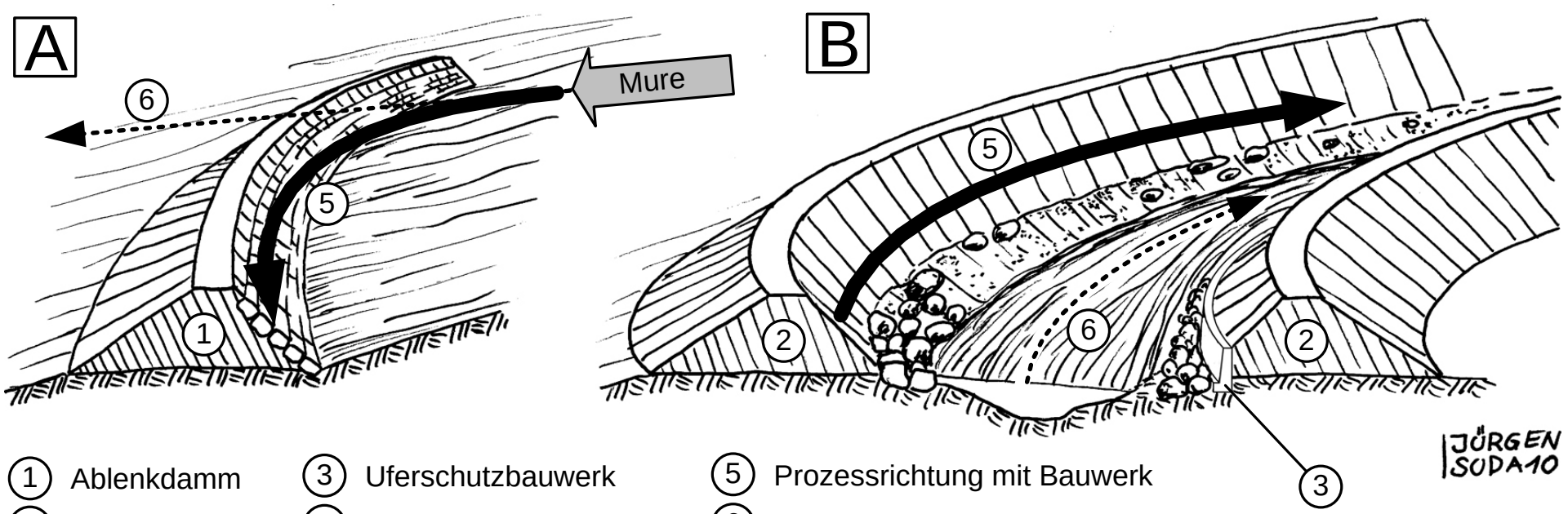
includes all measures that serve to change the direction of flow and fall processes in a targeted manner and to divert the hazard away from the protected area.


A


B


C


D



1 Ablenkdamm
2 Leitdamm
3 Uferschutzbauwerk
4 Erosionsschutz
5 Prozessrichtung mit Bauwerk
6 Prozessrichtung ohne Bauwerk

Structural Types

A **transverse structure** is a structure that is arranged perpendicular to the direction of flow (process direction).

A **longitudinal structure** is a structure aligned in the direction of flow (process direction). Longitudinal structures serve to divert flow processes and to protect the banks against erosion (stabilisation).

Structural Classification of tranversal structures

Dams (torrent dams)

represent an artificial step in the channel. A dam is defined as a step with a height (H) greater than 2 m. The height (H) is the perpendicular distance from the lower edge of the foundation to the height of the discharge section.

Ground sills

are also an artificial step with a height (H) of up to 2 m.

Ground ramps

create a sloping drop and usually have a high surface roughness.

Buhnes

are transverse structures that extend from the bank into a flowing waterway, but do not span the entire width of the riverbed. Short groynes are referred to as spurs.


A


B


C


D

Structural Classification of longitudinal structures

Regulation

combination of bank protection structures and bed protection structures

or

combination of bank protection structures and transverse structures in the bed

Diversion structures (guide structures) and deflection structures are similar. They limit lateral spreading or change the direction of the process. They are divided into **massive structures** (e.g. guide walls) and **earth structures** (dams). On the side facing the current, the embankment slope is protected against erosion by means of bank protection structures.

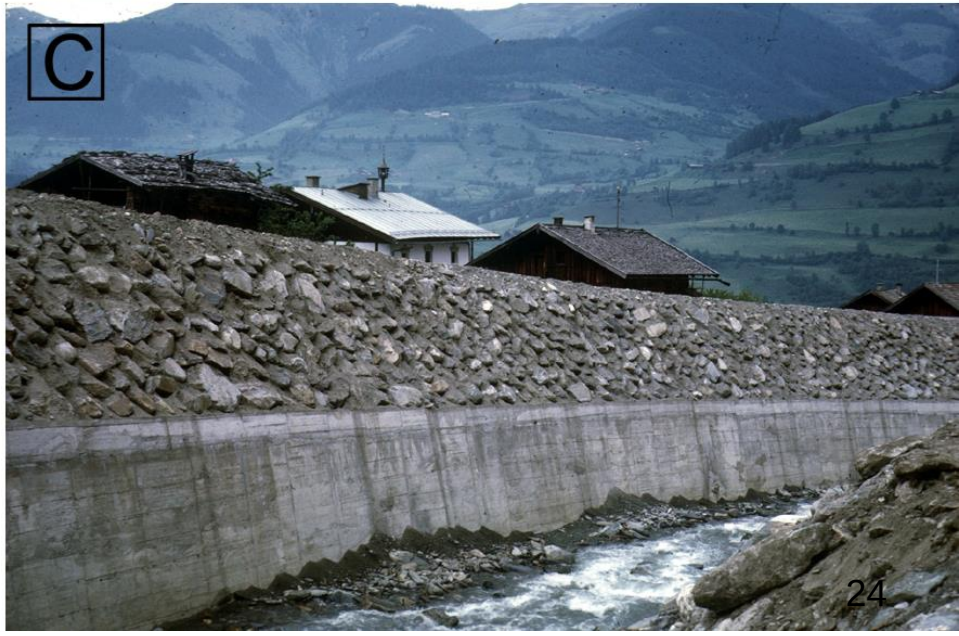

A


B


C


A


B


C

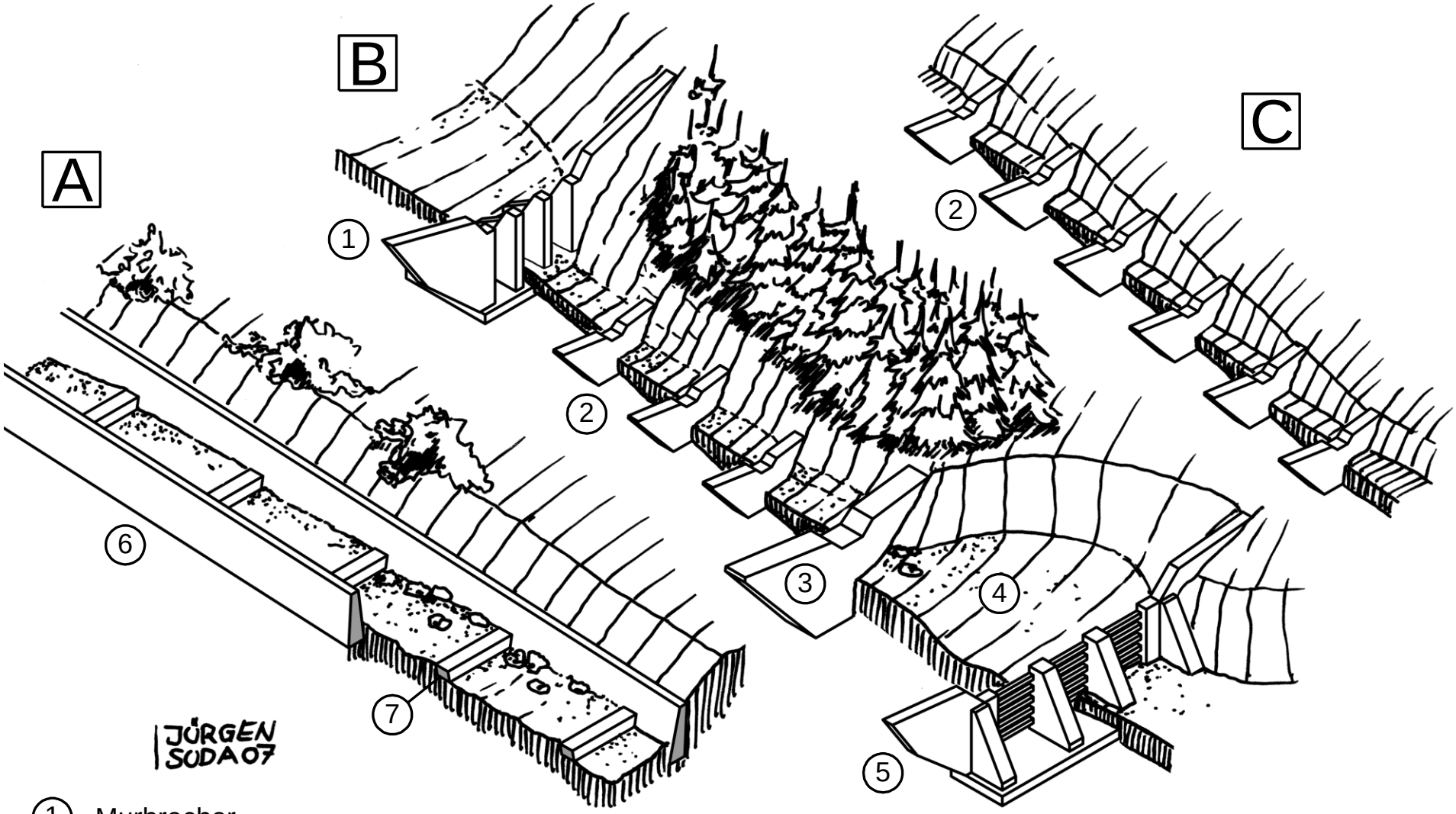
Protection Systems in Torrents (functional group of structures)

Individual structures of the torrent control system are interrelated through the channels. This means that they form an association of structures.

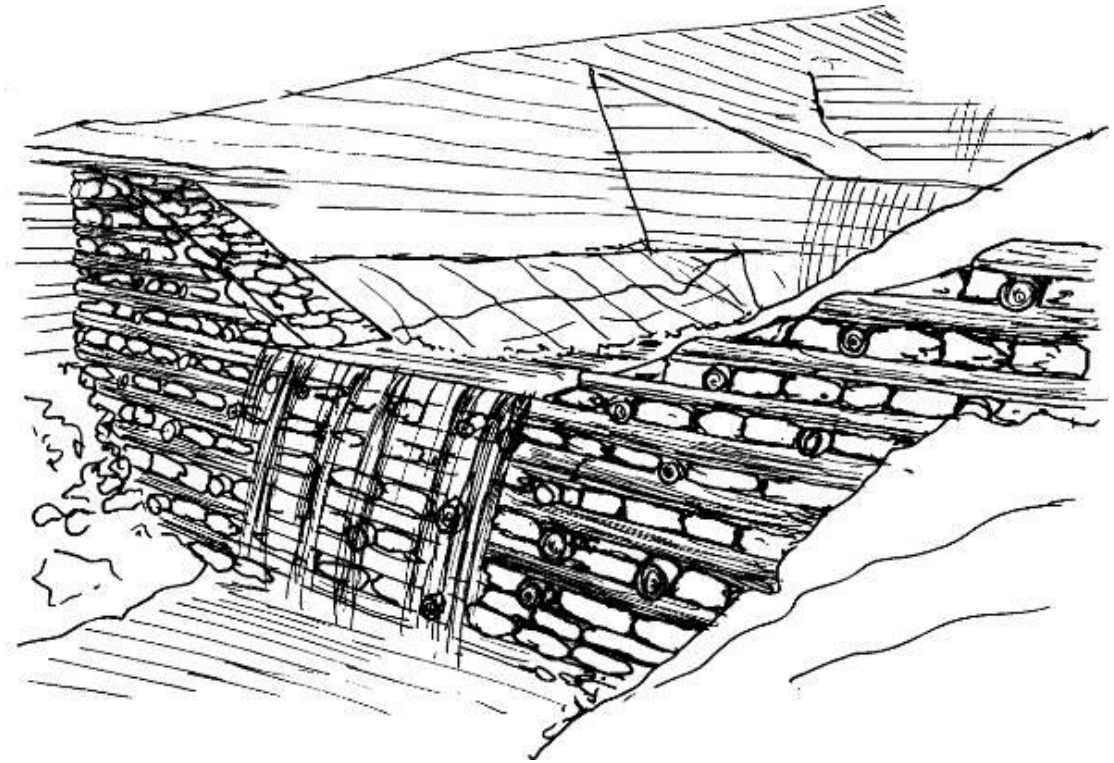
Regulation
Closed control of a stream, which consists of a combination of uninterrupted, bilateral longitudinal structures (bank protection structures) and transverse structures with a bed stabilising effect.

Functional chain
A series of several consecutive protective structures of different types and functions. Functional chains in torrents often perform the following sub-functions: bedload dosing, filtering, energy dissipation and retention of solids and water.

Staging
Series of several successive barriers or ground sills of the same design and function. In most cases, gradations of barriers (barrier gradation) or ground sills are used to stabilise or consolidate the streambed.



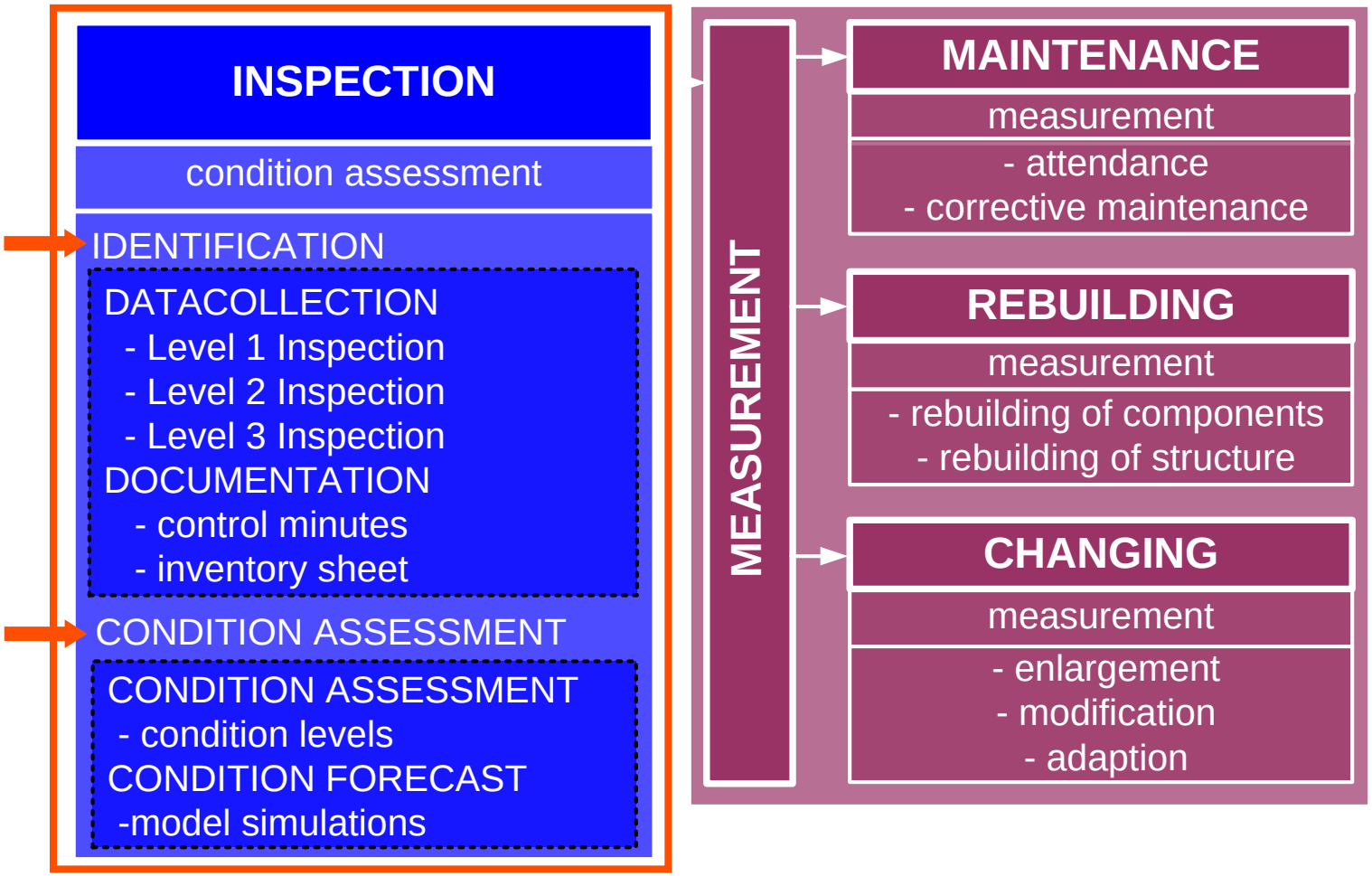
1 Murbrecher
2 Staffel aus Konsolidierungssperren
3 Absturzbauwerk
4 Retentionsbecken
5 Dosiersperre
6 Ufermauer
7 Grundschwellen



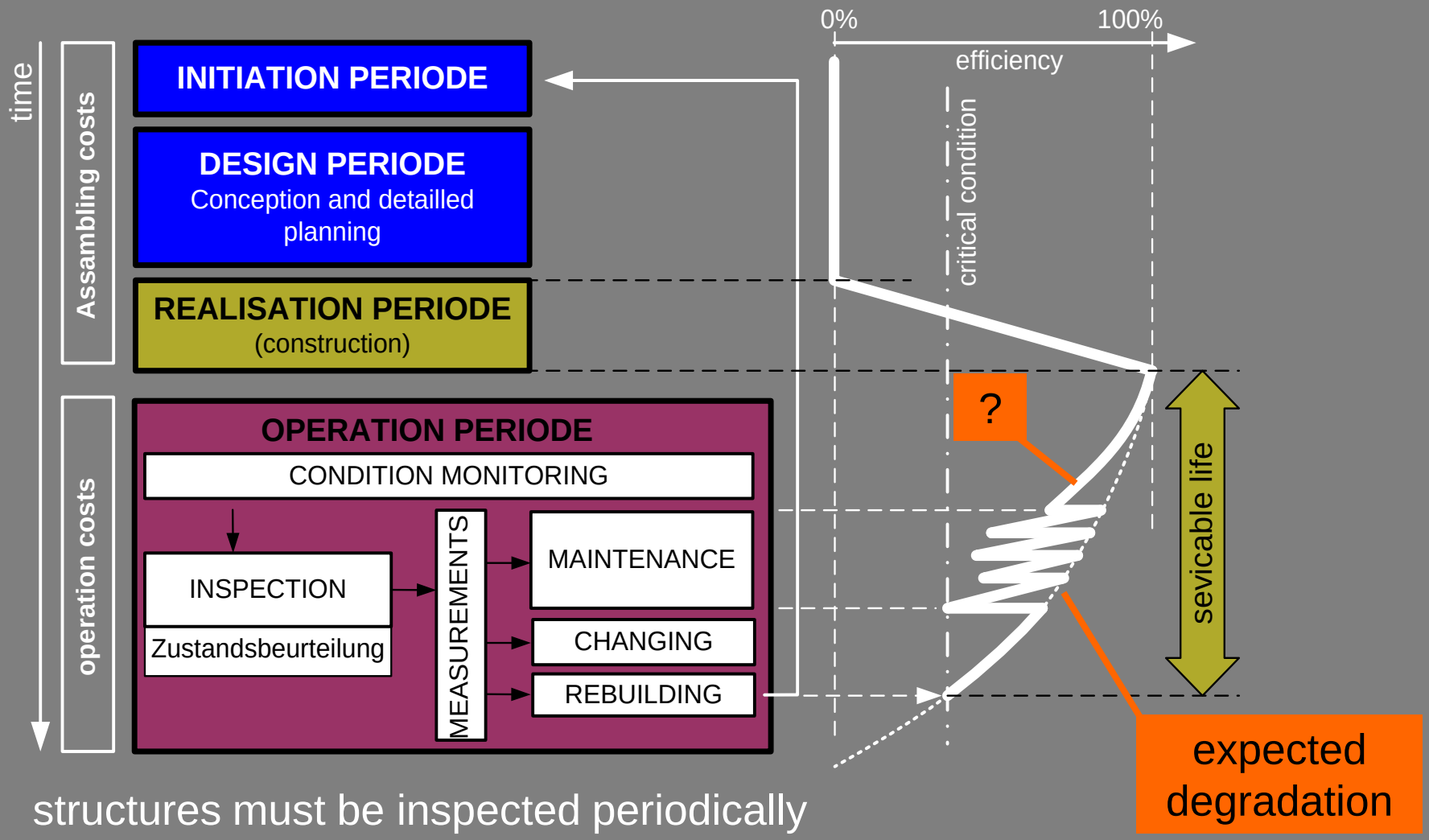
2. System of regular monitoring of protective structures

according to ÖNORM B 4800 (Austrian standard)

MONITORING of Torrential Barriers

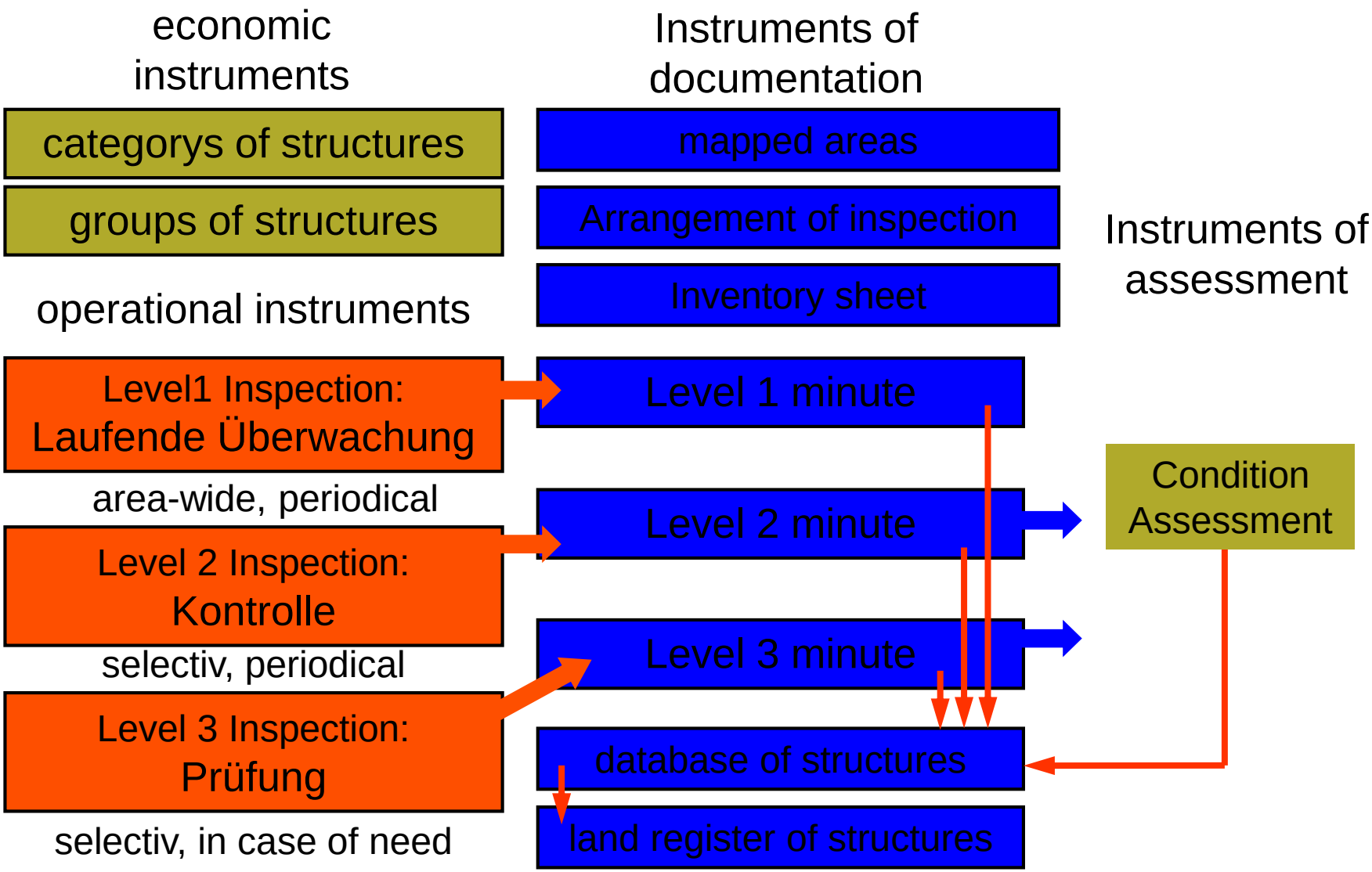


Lebenszyklus



structures must be inspected periodically

for comparable data and same quality level a guideline is necessary


economic instruments
categorys of structures
groups of structures
operational instruments
Level1 Inspection: Laufende Überwachung
area-wide, periodical
Level 2 Inspection: Kontrolle
selectiv, periodical
Level 3 Inspection: Prüfung
selectiv, in case of need
Instruments of documentation
mapped areas
Arrangement of inspection
Inventory sheet
Level 1 minute
Level 2 minute
Level 3 minute
database of structures
land register of structures
Instruments of assessment
Condition Assessment

Structure categories

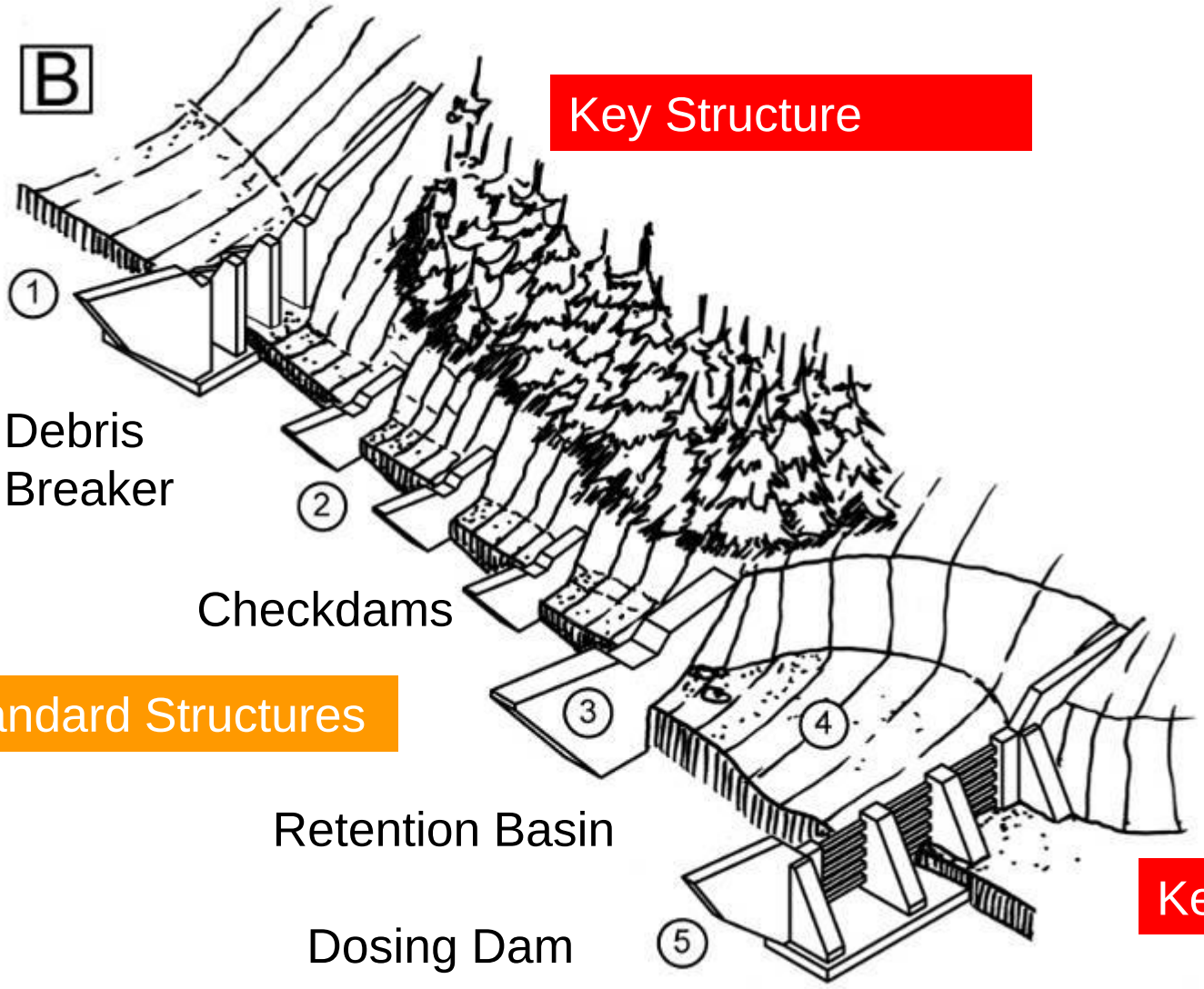
Standard structures

- Standard structures are structures whose failure has only a moderate or minor (local) impact on the defence system or on the protected areas.

Key structures (S)

- Key structures are structures whose failure has a major impact on the defence system or on the protected areas.
- In any case, the following are to be classified as key structures: barrier structures with a retentive, metering, filtering, energy-absorbing and deflecting function, flood retention systems and barriers with a central function for the stability of barrier graduations. Supporting structures for valley push and slope drainage also count as key structures.

Function Chain of protection works



Key Structure

Debris Breaker

Checkdams

Standard Structures

Retention Basin

Dosing Dam

Key Structure

Examples Key Structures in Torrents

The category of structure has an effect on the Inspection periode and the type of Inspection

PRINCIPE: Inspection periode of key structures is shorter

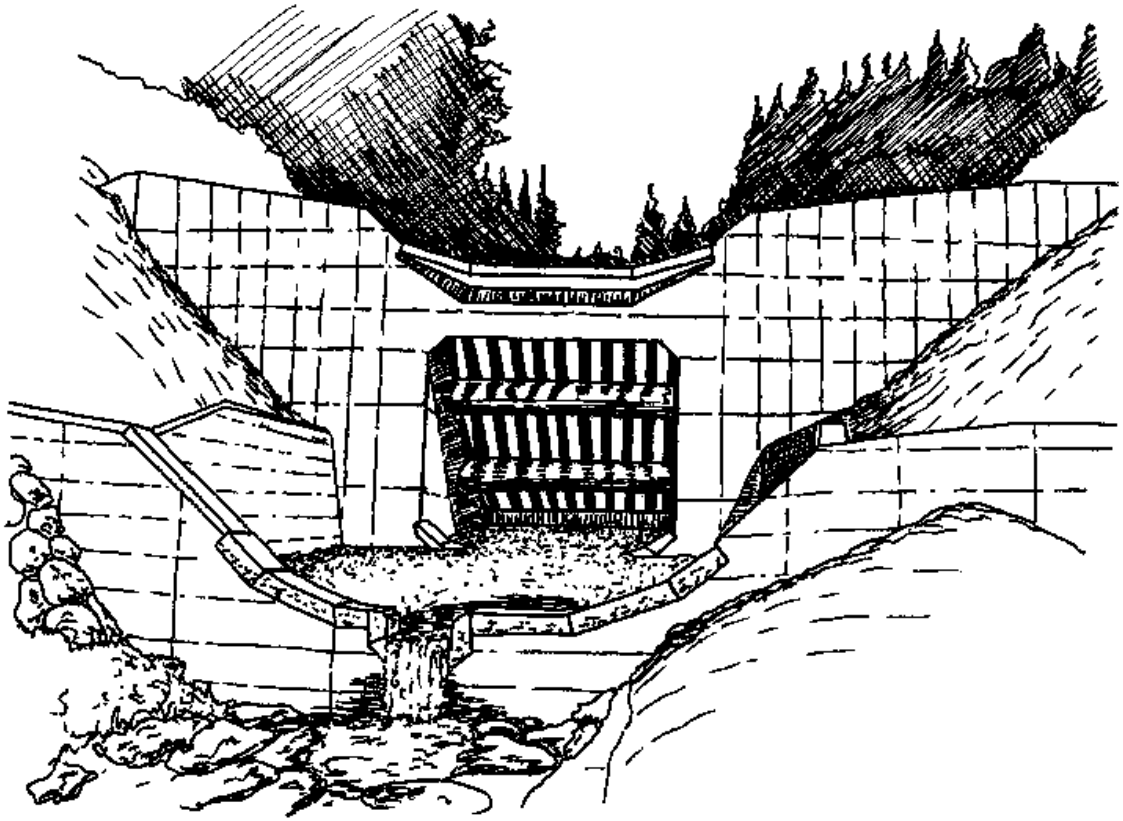
Type of Inspection	Inspection periode	Executed by	Result
Level 1 Inspection Laufende Überwachung	Key structures: annually Standard structures: in periods of 5 years	Lumbermen	Level 1 minutes
Level 2 Inspection Kontrolle	Key structures: in periods of 5 years or „spezial inspection“ after events	Experts	Level 2 minutes
Level 3 Inspection Prüfung	in case of need	Experts (interdisciplinary)	Level 3 minutes

Visual Inspection

Advanced methods

Regular Monitoring (Level 1)

- Serves to determine the usability (functional efficiency) of the structures
- Determination of damage that can be detected externally during inspection
- Responsible: rights holder in agreement with the Torrent Control Service (inspection agreement)
- Implementation: trained personnel
- Intervals: key structures annually (LÜ1)
  standard structures: every 5 years (LÜ2) if necessary after events
- Documentation: standardized protocol, torrent database



3. Relevant types of structural damage for regular monitoring

Factors influencing the state of preservation of protective structures

Protective structures have certain properties due to their shape, their supporting structure, the materials used and any defects that may have been built into them. In addition, they are in close contact with natural processes. Besides these processes, the development of the condition of these structures during their service life also depends on human influences (anthropogenic processes). The sum of these processes allows us to derive boundary conditions for the development of the structure's condition.

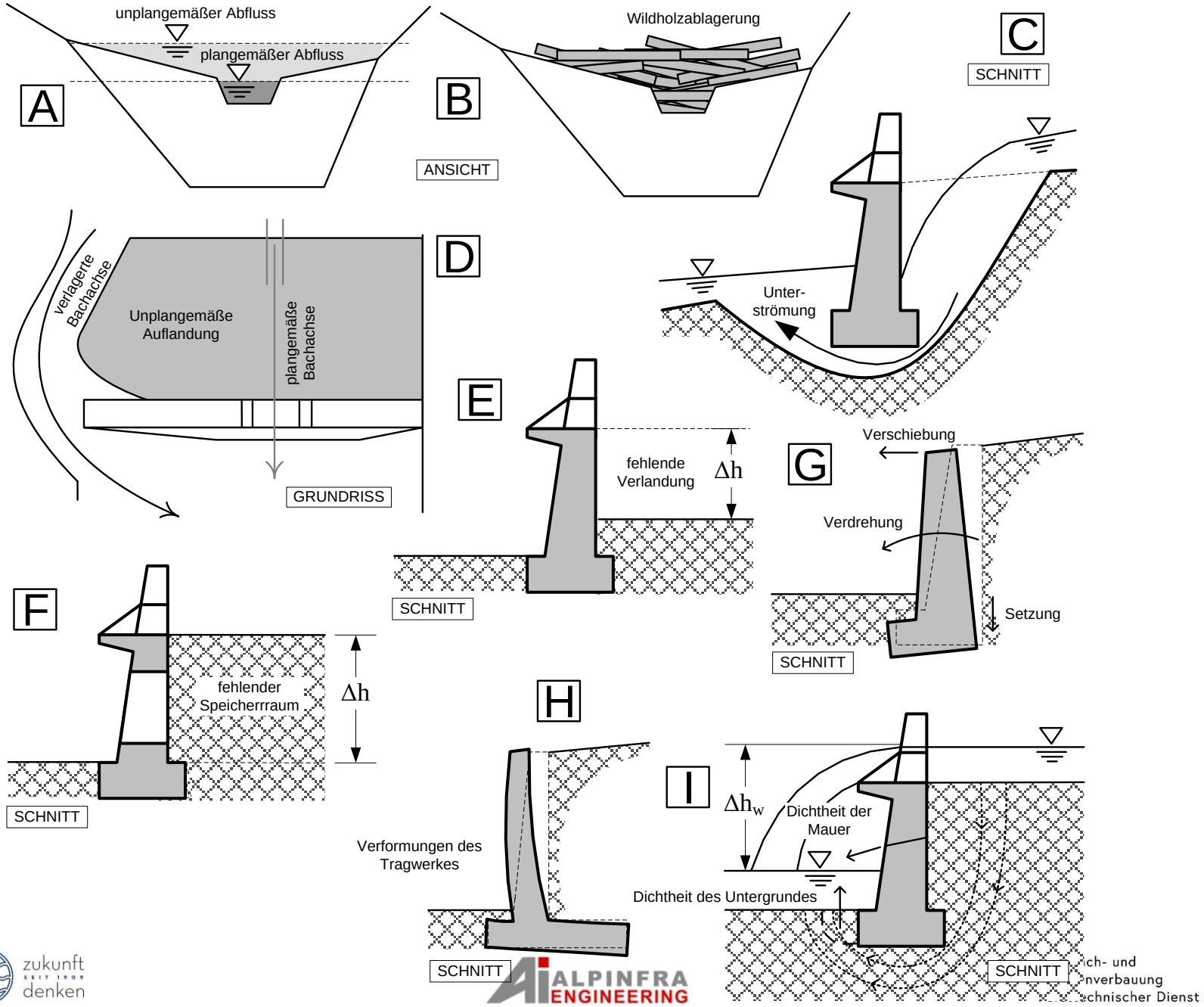
A failure of the **process-related usability** occurs when the individual structure or the overall system was not able to sufficiently retain bed load, floods, mudslides, and avalanches to the extent of the design events, so as not to exceed the maximum design quantities in the protected area. The following types of failure can be distinguished:

- unplanned overflow of the flood discharge
- debris jams (stabilisation, consolidation, dosing)
- undercurrent, piping
- lateral bypassing of the structure
- unplanned lack of backfilling of the siltation area (stabilisation, consolidation)
- lack of storage volume in the retention basin (dosing, filtering, retention)

This is to be distinguished from the **building-related usability**.

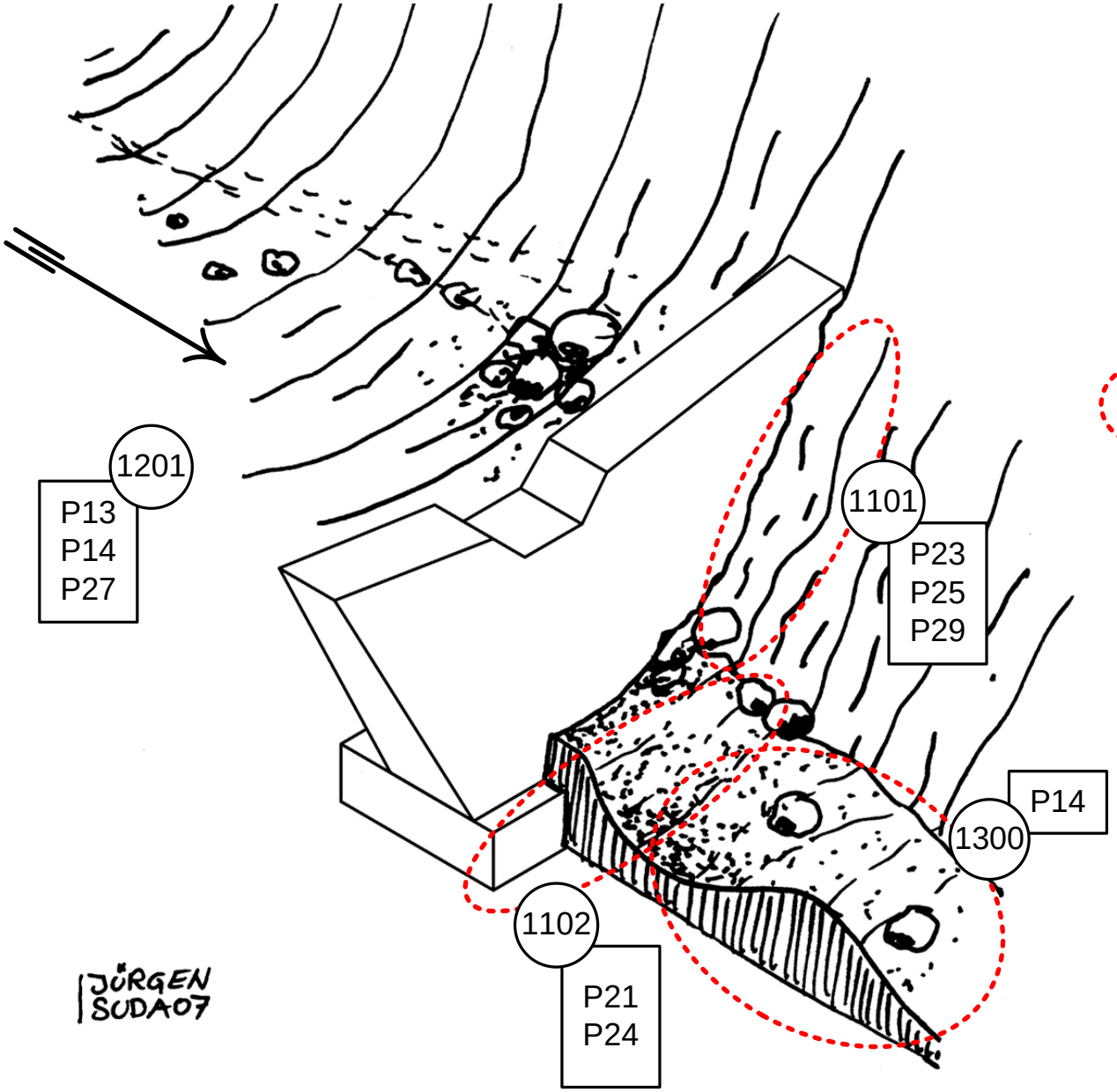
The following are particularly important here:

- excessive deformations in the substrate
- excessive deformations in the supporting structure
- insufficient water impermeability of the supporting structure and/or the substrate (especially water retention)


A
unplangemäßer Abfluss
plangemäßer Abfluss
B
Wildholzablagerung
ANSICHT
C
SCHNITT
Unter-
strömung
D
verlagerte
Bachachse
Unplangemäße
Auflandung
plangemäße
Bachachse
GRUNDRISS
E
fehlende
Verlandung
Δh
SCHNITT
F
fehlender
Speicherrraum
Δh
SCHNITT
G
Verschiebung
Verdrehung
Setzung
SCHNITT
H
Verformungen des
Tragwerkes
SCHNITT
I
Δhw
Dichtheit der
Mauer
Dichtheit des Untergrundes
SCHNITT

The following relevant criteria are to be observed during ongoing monitoring as part of the torrent inspection:

- In the approach and side areas
  - Apparently unusual deposits, tendencies towards erosion, tendencies towards bypassing
- In the discharge section
  - Annoying log jams, deposits?
  - Severe damage to the crest and armour plating
- On the dam body
  - Apparently unusual deformations or cracks
  - In the drainage cross-section of the stream (torrent inspection)
  - Debris in the drainage cross-section that inhibits drainage



P13 Schadenstyp

1300 Anlagenteil

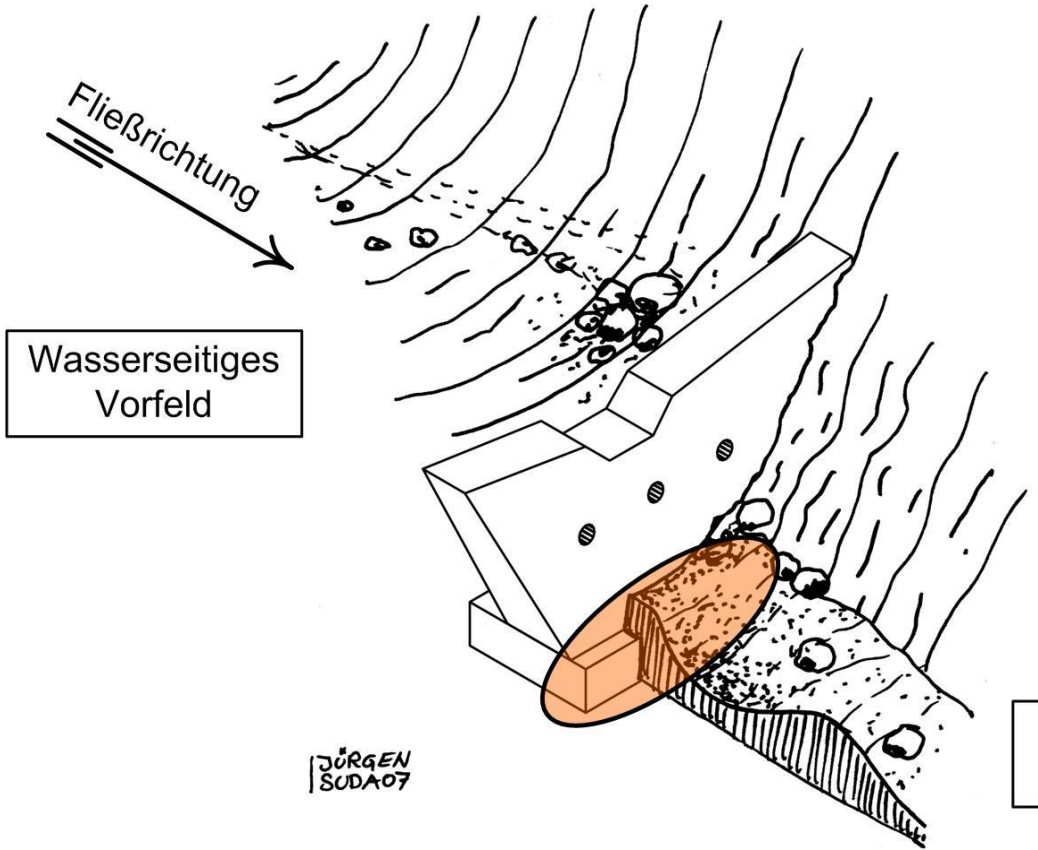
Besonders beanspruchter Bereich für angegebene Schadenstypen

B1

Reduced bottom resistance with barriers/ground sills

Damage description

This type of damage is relevant for all functions. Erosion of the ground material in the airside apron leads to the loss of the lower integration of the structure. As a result, the structure loses the geotechnical resistance in the floor. This damage mechanism occurs mainly in foundations in loose rock.



The loss of lower resistance occurs in the air-side foundation area. The scour or a bed lowering forms on the downstream side, where the overflow jet hits the bed.

Potential consequential damages

- Structure movements, undercutting (requires intact flanks)
- In extreme cases: destruction of the structure (tipping, sliding, ground failure)
- Removal of the slope foot can also result in the loss of lateral integration on the leeward side of the structure

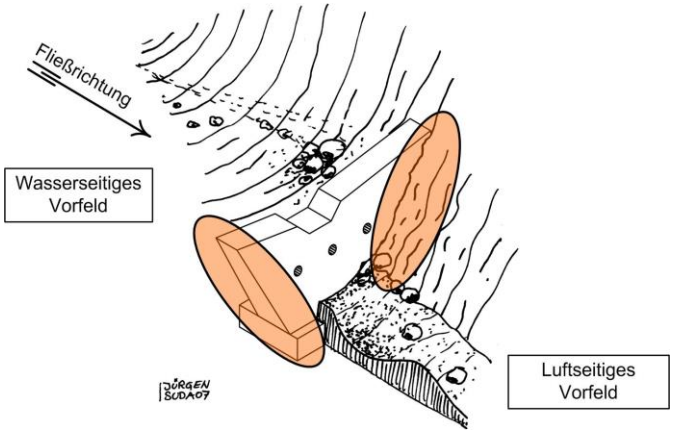
B2

Reduced resistance in the area of the lateral integration

Damage Description

This type of damage is relevant for the stabilisation and consolidation functions.

Erosion of the slope can result in the loss of lateral integration on the air side of the structure. This causes the structure to lose resistance in the flanks. This damage mechanism occurs primarily in foundations in loose rock.



B3

Undercurrent of transverse structures

Damage description

- Undercurrent can occur at transverse structures.In the process, a flow channel usually forms in the bed area due to scouring and/or hydraulic failure in unconsolidated rock.
- Wet spots or seepage in the structure/substrate joint can precede this damage.
- In extreme cases, all the water flows through the bedrock under the dam. This results in the erosion of the backfill and a deepening of the stream due to channel erosion.
- The prerequisite for this damage mechanism is a stable anchoring of the dam in the flanks, as otherwise the structure will fail on slopes due to hydraulic ground failure.

Mögliche Folgeschäden

- Bauwerksbewegungen, Verlust der äußeren Standsicherheit (Kippen, Gleiten, Grundbruch; P11), Tiefenerosion im Gerinne

Quelle: Institut für alpine Naturgefahren, BOKU

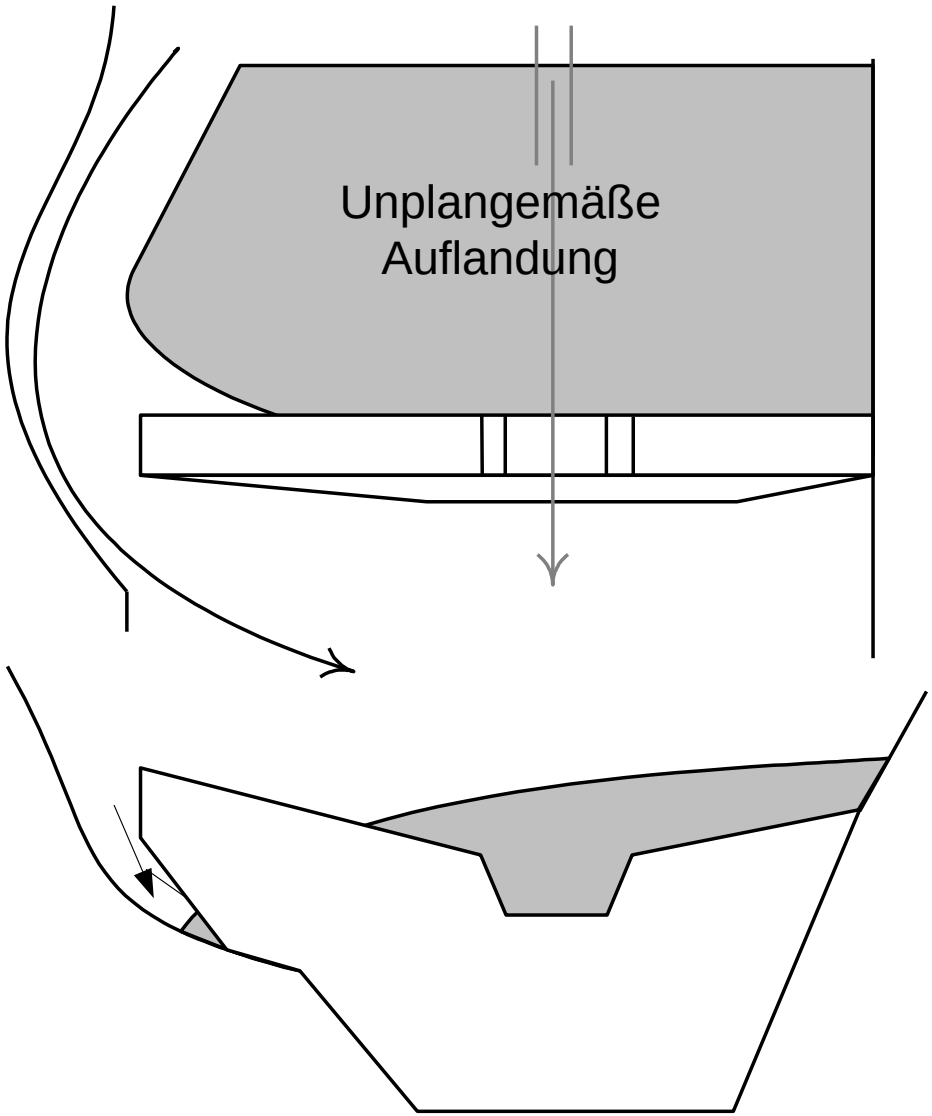
Quelle: WLV

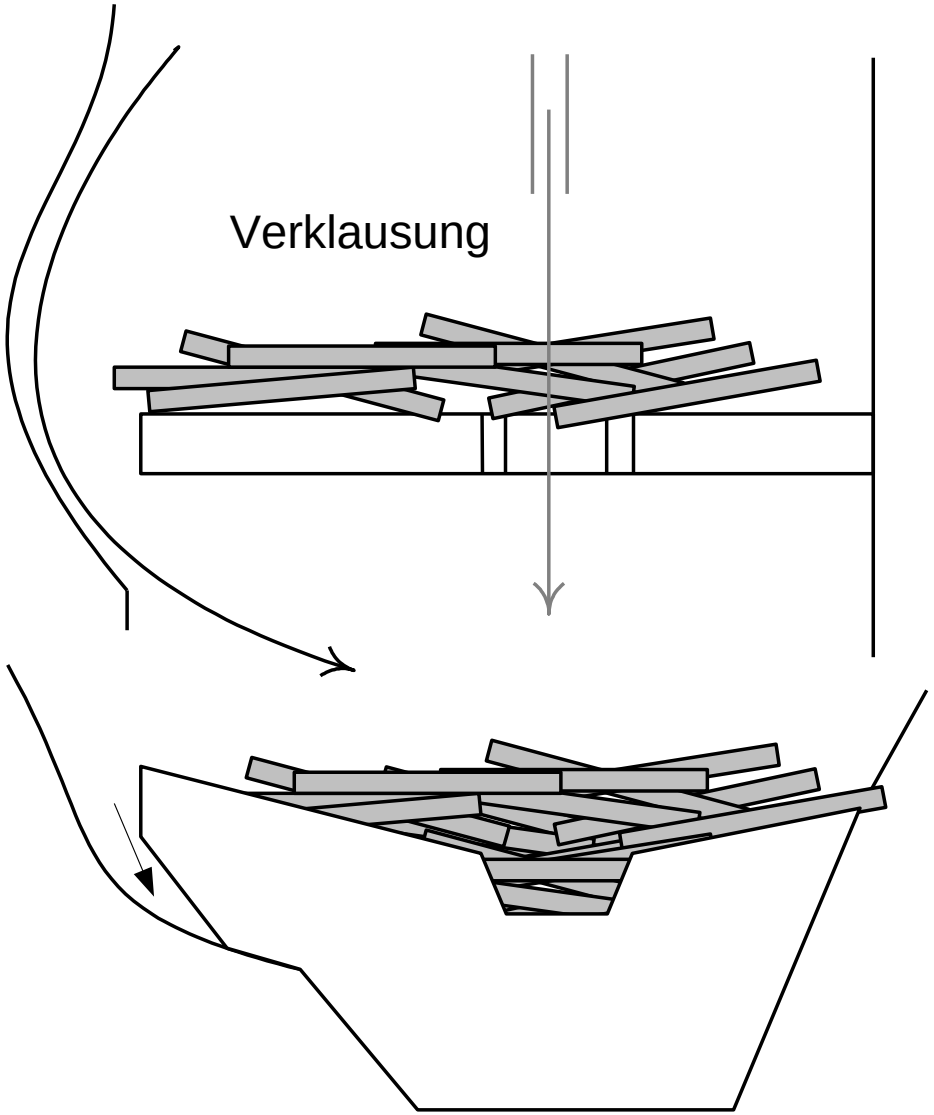
B4

Bypass of transverse structures

Damage description

- When a transverse structure is bypassed, the water flows around it to the side.
- In normal circumstances, torrents pass transverse structures in torrent control works over the designated discharge section.
- However, various influences in the torrent or at the protective structure can cause the stream to bypass the transverse structure.


Unplangemäße
Auflandung


Verklausung

Quelle: Institut für alpine Naturgefahren, BOKU

Quelle: Institut für alpine Naturgefahren, BOKU

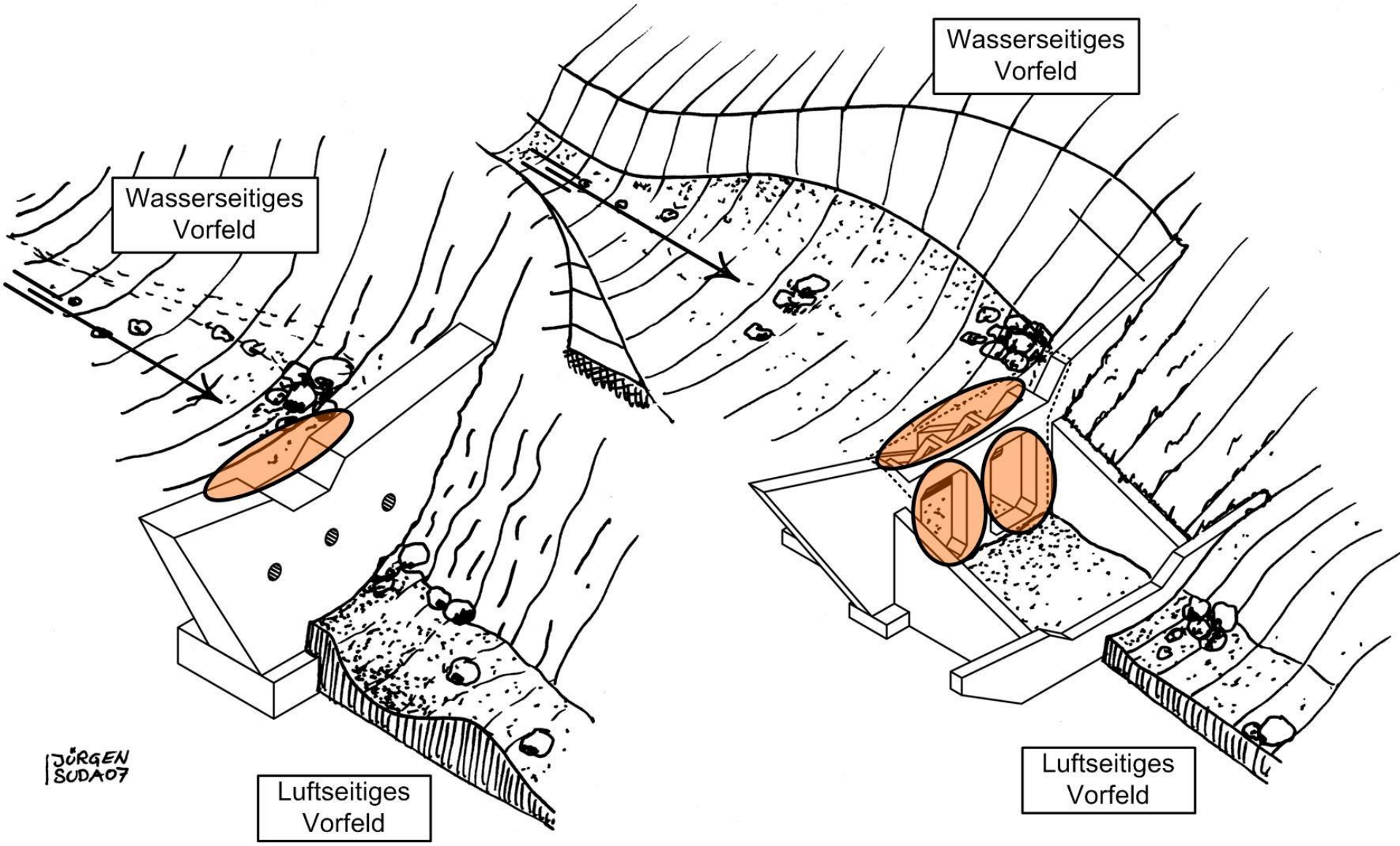
Quelle: Institut für alpine Naturgefahren, BOKU

B5

Clogging of transvers structures

Damage description

- This type of damage is relevant for the functions of discharge, filtering and retention. The clogging of a structure is the blocking of the discharge section and/or openings (large drains, slots) by debris, driftwood, avalanche snow, etc.
- A blockage in the structure in the area of the discharge section or the openings leads to a reduction in the usability of the structure, as its hydraulic properties change significantly and an unplanned backwater occurs.


Wasserseitiges Vorfeld
Wasserseitiges Vorfeld
Luftseitiges Vorfeld
Luftseitiges Vorfeld
JÜRGEN SUDA07

Quelle: WLV

B6

unplanned silting up of the channel bed

Damage description

- In the event of unplanned siltation, the optimal silt level of consolidation barriers is exceeded, i.e. more bedload is deposited in the water-side barrier foreland than planned.
- In extreme cases, the entire barrier or ground sill is over-graveled.
- Unplanned sedimentation or ballasting can also occur at retention, dosing or filter structures if the reservoir is already full or the available reservoir volume is too small for an event.
- In longitudinal structures, the planned bed level of the channel is exceeded by unplanned sedimentation. In extreme cases, the entire channel is ballasted.

Quelle: Institut für alpine Naturgefahren, BOKU

B7

Insufficient storage capacity in the retention basin

Damage description

- **This type of damage is relevant for the functions of dosing, filtering and retention.**
- This type of damage includes the lack of retention space (storage volume) for the design event in retention basins.
- **Open barriers with retention basins are not silted up as planned.** Their function is to retain water and/or solids, to store them and/or to release them in a controlled manner into the lower reaches. If the available storage volume is too low, the planned retention effect cannot be achieved. This leads to a loss of process-related usability.
- Silting up after an event is usually planned, but if there is insufficient storage volume, the basin must be cleared artificially.

Quelle: WLV

Quelle: Institut für alpine Naturgefahren, BOKU

B8

Destruction of parts of structures – transverse structures

Damage description

- This type of damage is relevant for the stabilisation, consolidation and retention functions. This type of damage can be the result of slight erosion or overuse of the structure during an event.
- This type of damage is caused by the discharge process, resulting in severe erosion of parts of the structure or the actual dam body. It is relevant to the load-bearing capacity.
- The appearance of the erosion depends on the material.

Quelle: Institut für alpine Naturgefahren, BOKU

Quelle: WLV

B9

Vandalism

Damage description

- This damage takes a wide variety of forms, depending on the severity of the stress or impact.
- Vandalism can take a wide variety of forms. In this case, structures near inhabited areas are primarily at risk. This damage can be seen, for example, in the removal of safety signs or the bending or destruction of barriers in the crown area.
- Damage caused by vandalism will be limited to the more easily damaged parts of the structure, such as safety equipment (railing, signs, barriers) or young plants. The structure itself can hardly be damaged by vandalism.

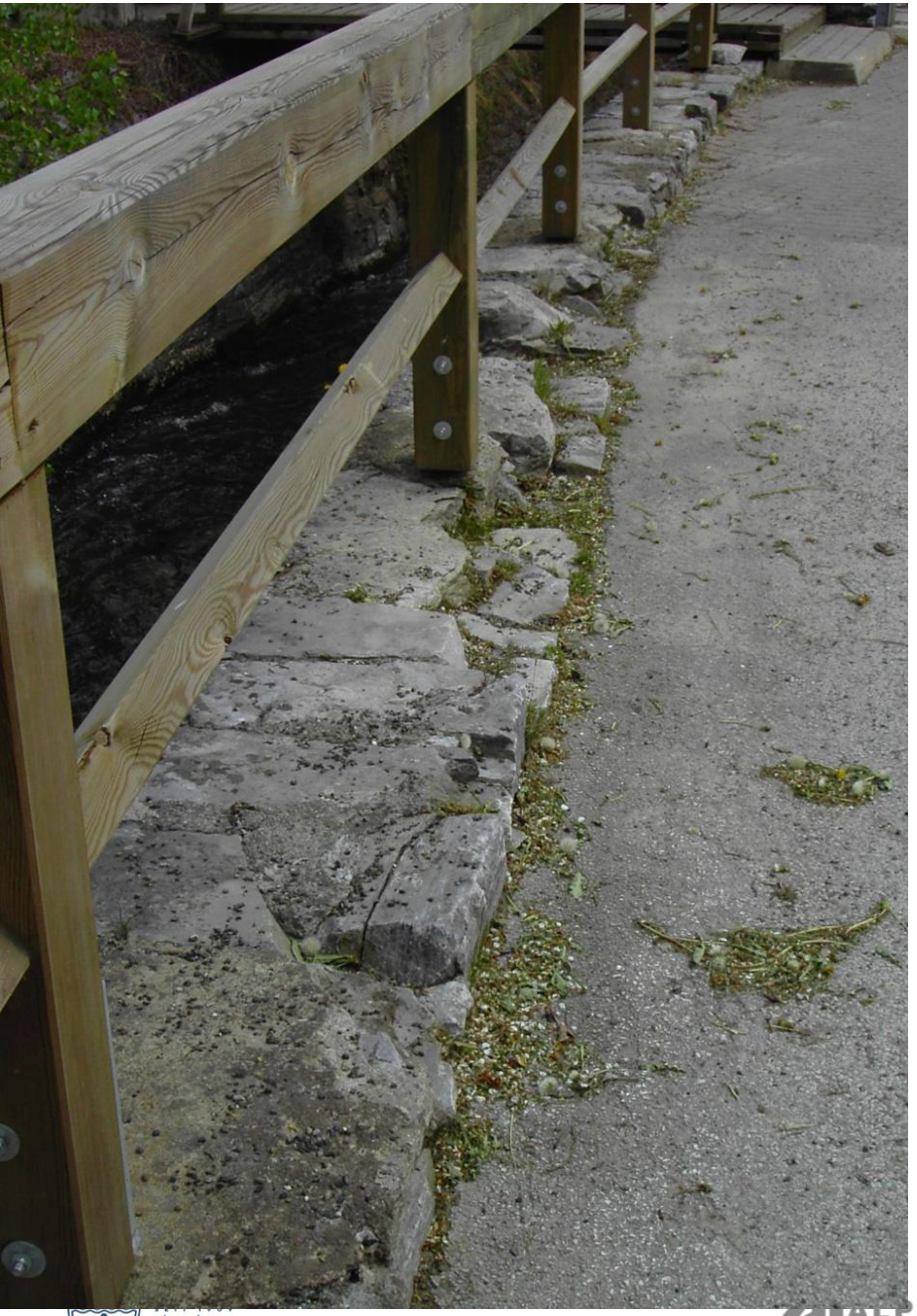
B10

Damages on safety devices

Damage description

- Safety equipment is installed to protect against unauthorised access to protective structures or on roads. This can be barriers (barrier fences or fences), fall protection (railing) or warning signs (traffic signs, information signs, navigation signs, etc.). If safety equipment is missing, personal injury or accidents on the road may occur.


Betreten der Sperren
verboten!
Eltern haften für Kinder



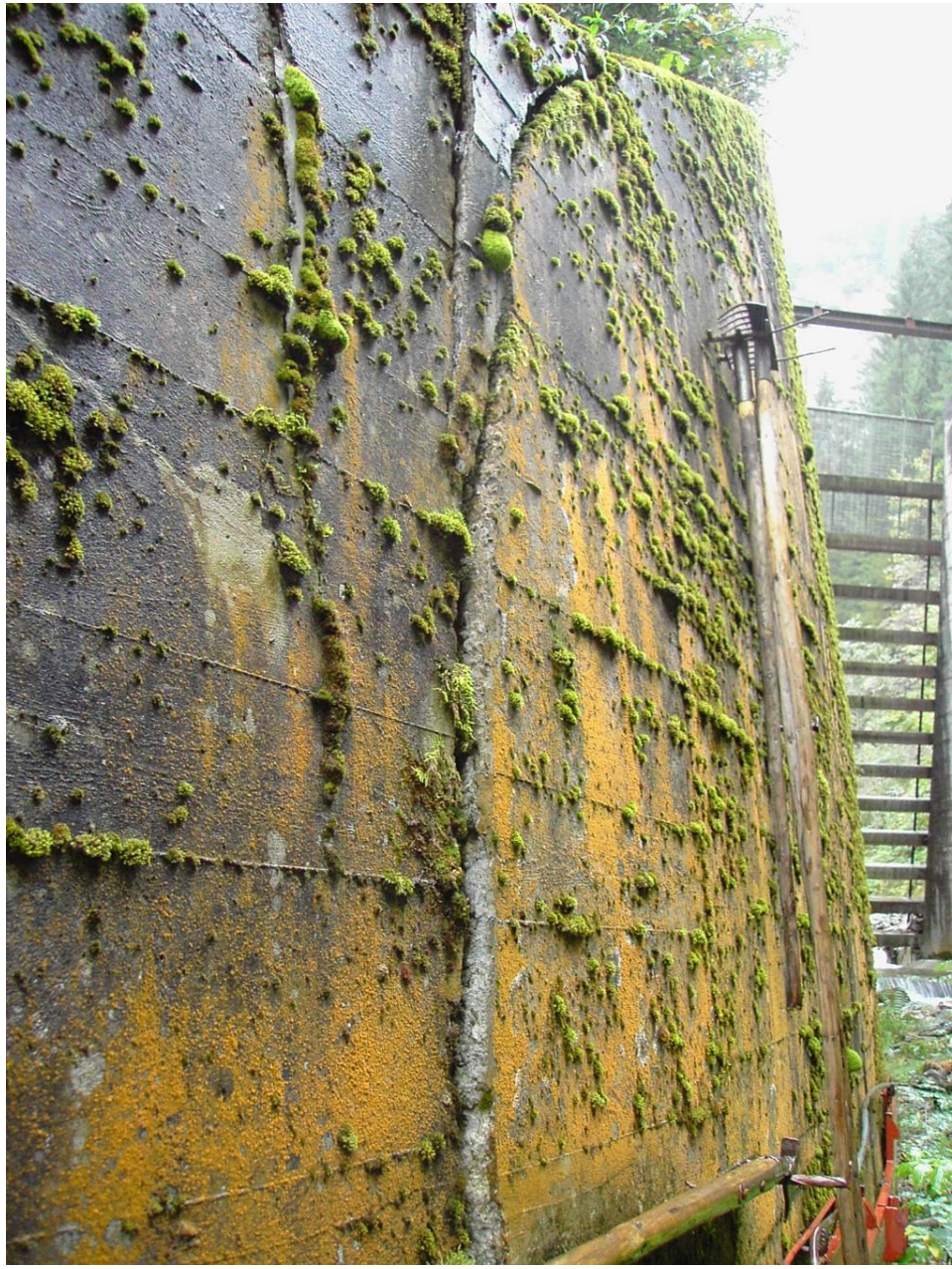
B11

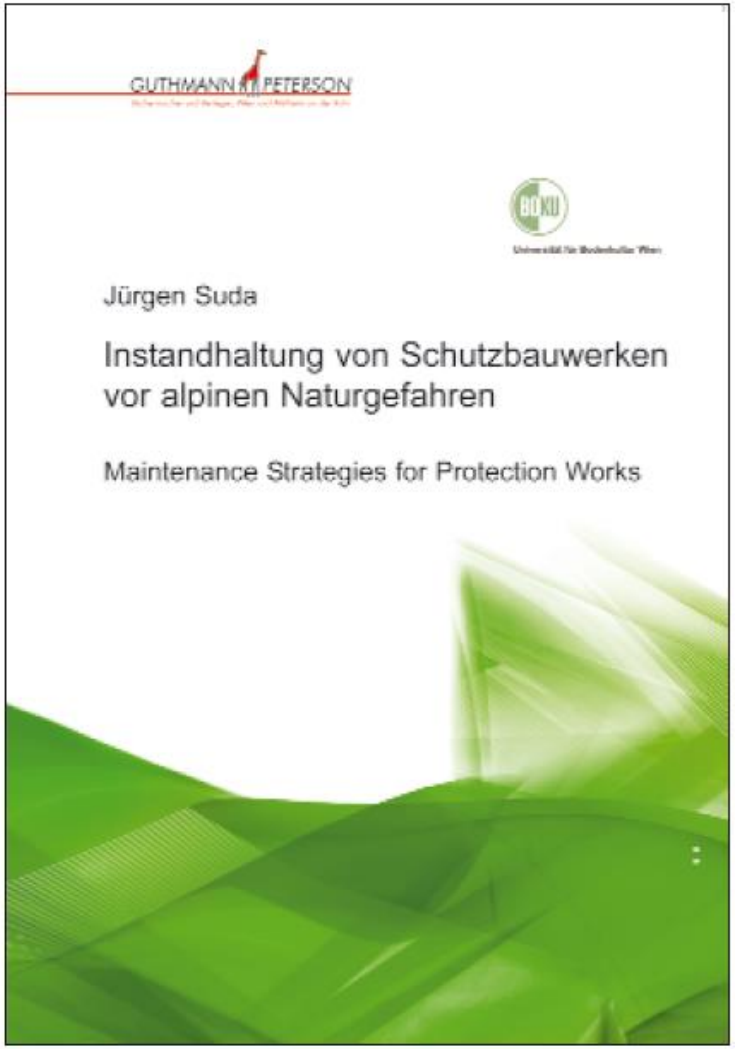
Cracks

- Cracks are caused by local tensile failure of the material.The causes of cracks are very diverse.
- Without training in construction and knowledge of the possible causes of crack formation, it is not possible to assess the relevance of cracks.
- In general, Cracks in the structure rarely affect the process-related usability of the structure.
  - Fine cracks are usually not a problem and do not need to be recorded.
  - Wide cracks can be problematic! If they are new, they should be documented.

Quelle: WLV

Quelle: Institut für alpine Naturgefahren, BOKU





Jürgen Suda

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