

Institute of Hydraulic Engineering and Technical Hydromechanics

Dr.-Ing. Torsten Heyer

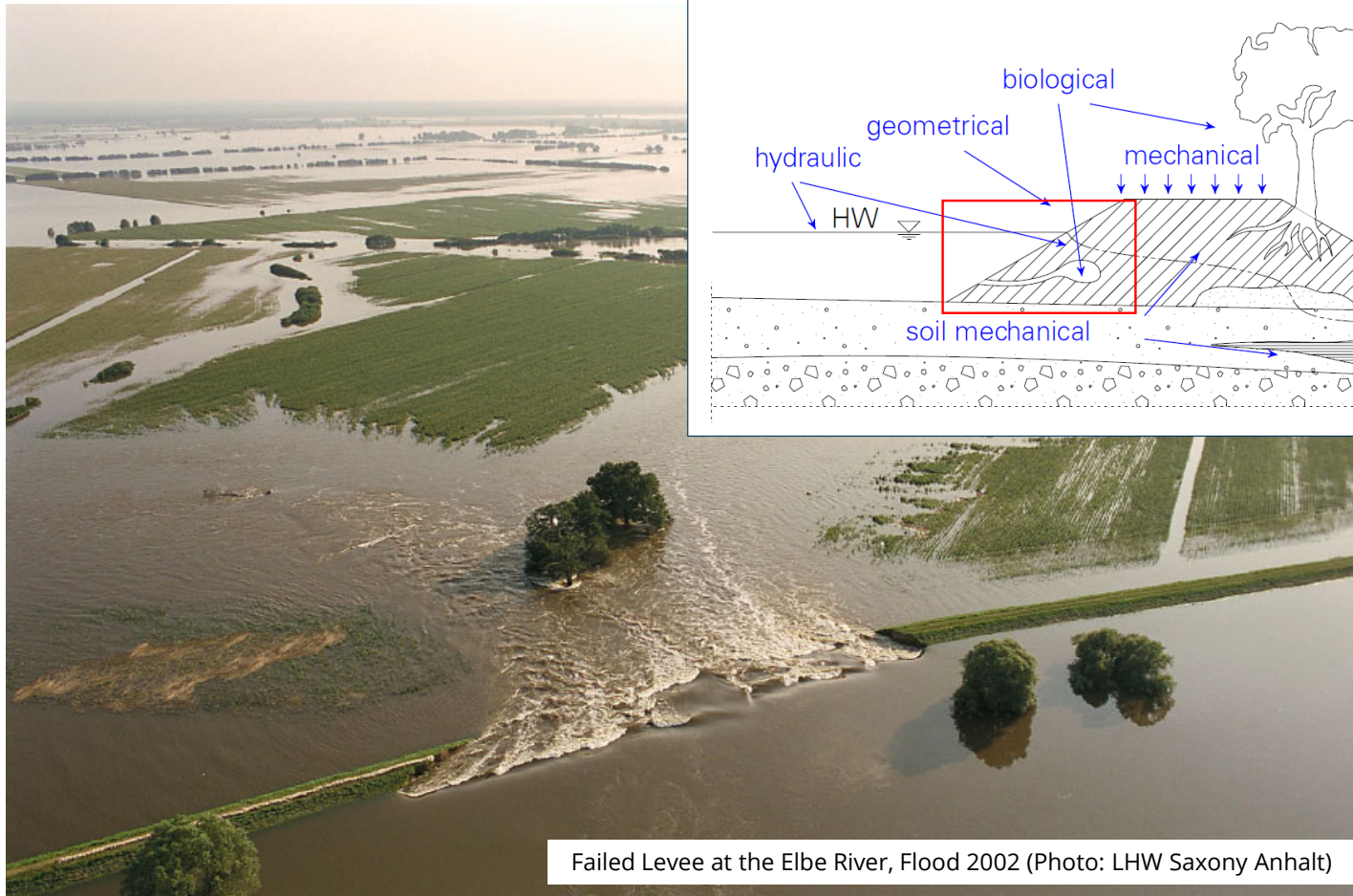
Beaver Burrowing Activity in Levees

Characteristics, Countermeasures, Cavity Detection

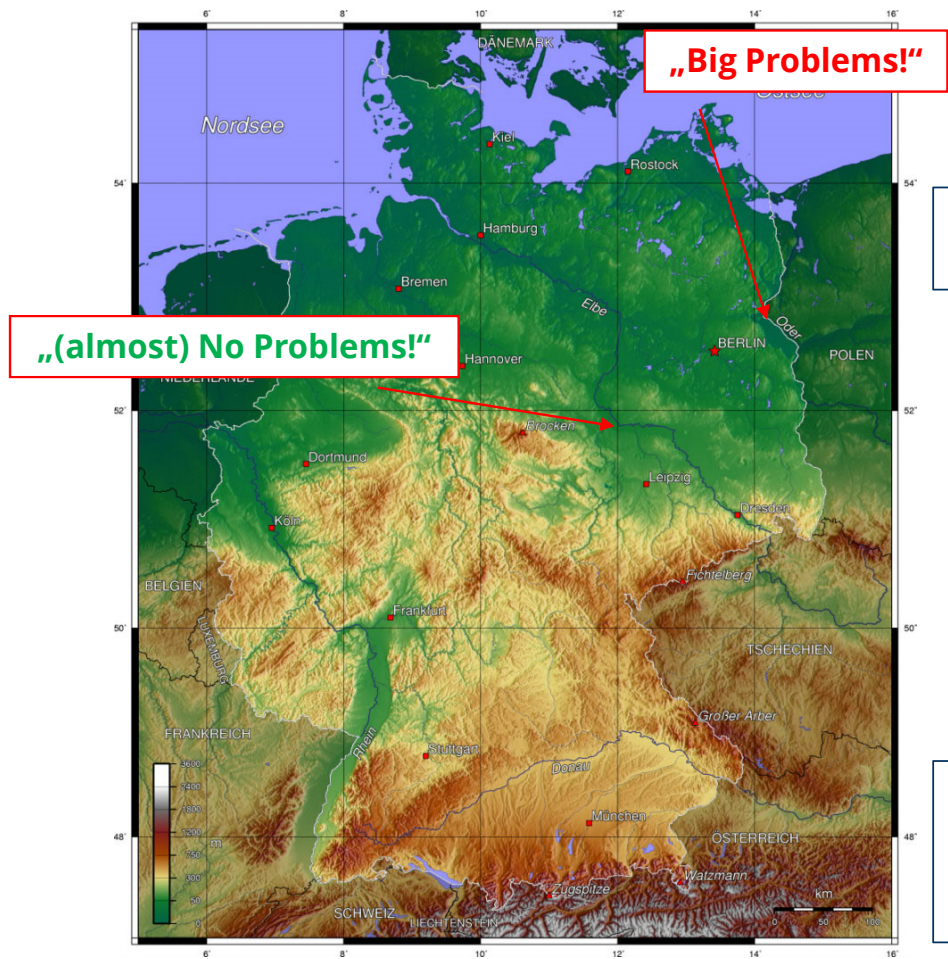
International Beaver Burrowing in Infrastructure Symposium (IBBI)

Wageningen (NL), February 3rd, 2025

What's the problem?



Levees at (Beaver) Risk?



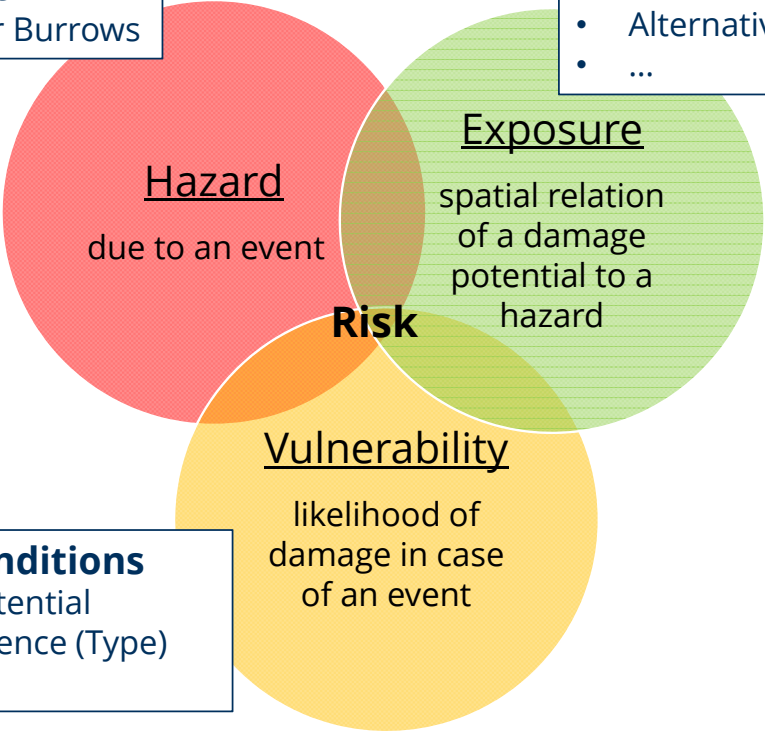
$$\text{Risk}_{\text{Event}} = \text{Probability}_{\text{Event}} * \text{Damage}_{\text{Event}}$$

[EUR] = 0,0...1,0 * [EUR]

Event
Flood & Beaver Burrows

Levee Location

- Foreland width
- Alternative refuges
- ...



Local Conditions

- Damage potential
- Levee Resilience (Type)
- ...

What's the problem?

- Cavities (tunnels, tunnel systems, dens) and surface damages at
 - ▣ River banks → erosion and sediment input (small water courses)
 - ▣ Foreland → danger to river maintenance works
 - ▣ Levees (on water- and landside) → reduced reliability → risk increase
- Flood at Oder River in 2010: 550 Damages incl. 150 larger tunnel systems in levees (10-20 m into levee)
- most damages in levees, if distance to main river bed is < 20 m



Source: F. Krüger



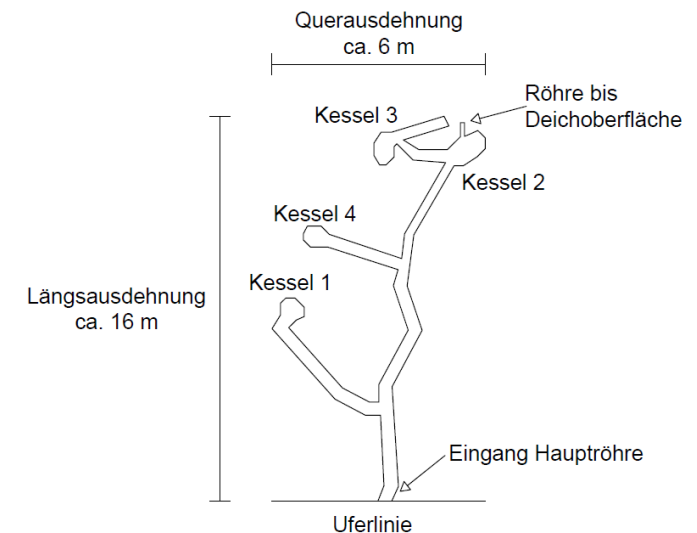
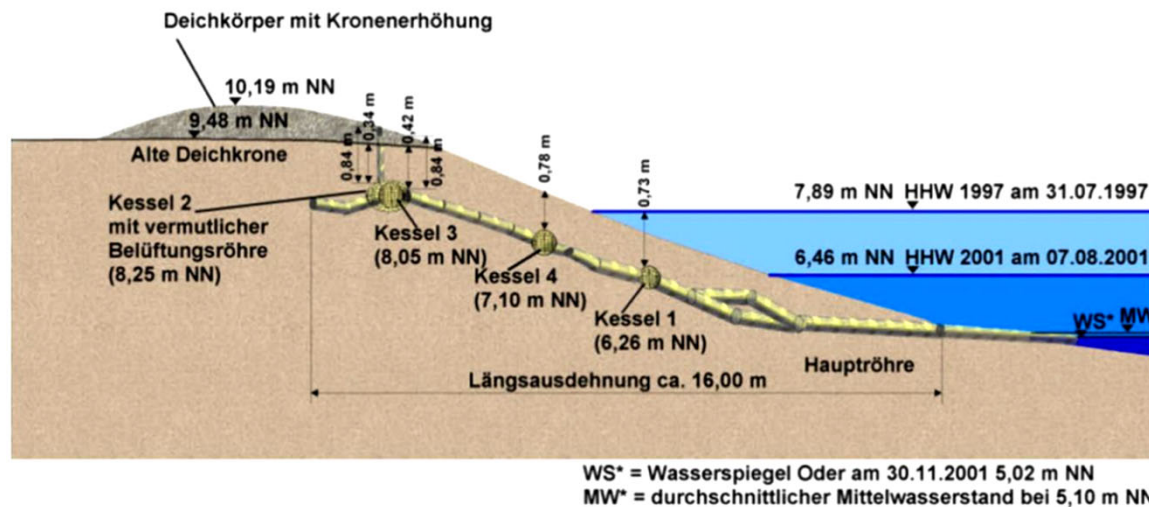
Source: F. Krüger



Source: rbb 24

What's the problem?

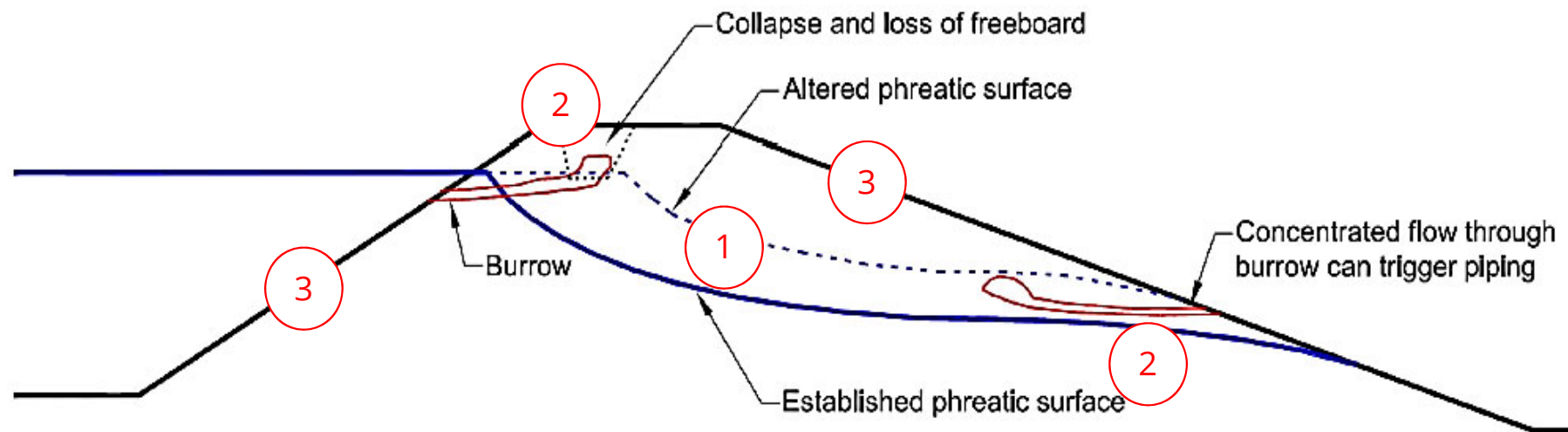
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Source: Hahmann (2004)

Impact on Levee Stability

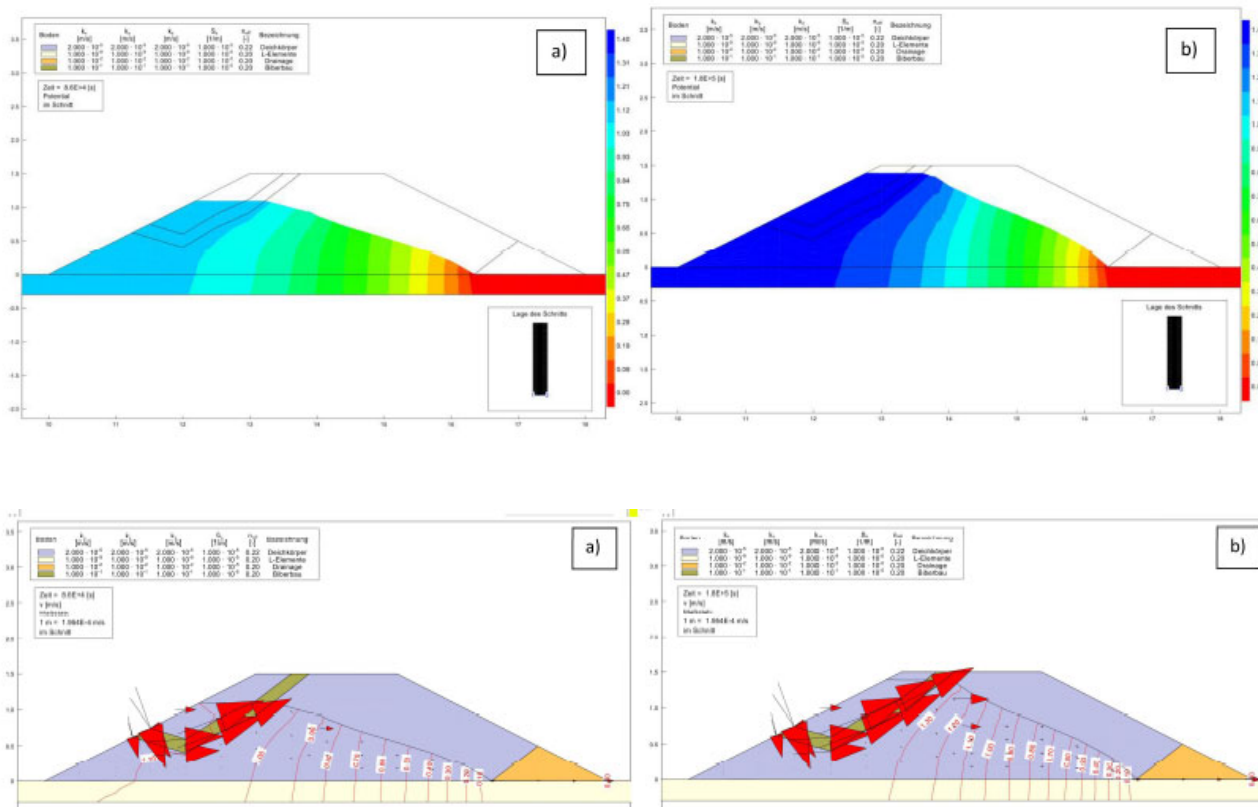
- 1) Altered seepage behavior
- 2) Structural instability
- 3) Decreased erosion resistance → less important with regard to beaver activity
 - ▣ Indirect hazards (tree felling, blocking of culverts, etc.)



Source: Cobos Roa (2015), modified

Impact on Levee Stability

■ Altered seepage behaviour



Length of seepage path decreases:

- Hydraulic gradient increases
- Seepage velocity increases, which favours piping
- Phreatic surface on higher level, leading to decreased stability of landside slope

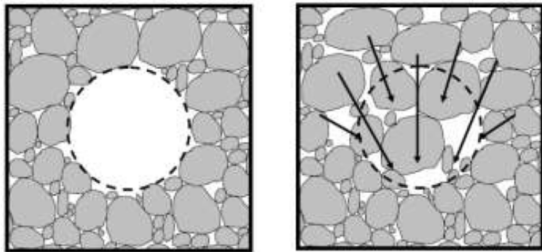
Investigations van Bonn (2022):

- if tunnel length exceeds about 60% of levee width, failure is likely

Source: van Bonn (2022)

Impact on Levee Stability

▣ Structural instability

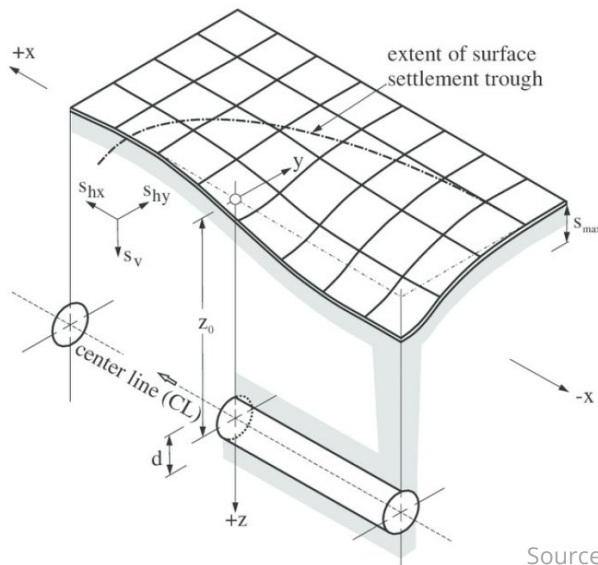


Collapse of Tunnel System

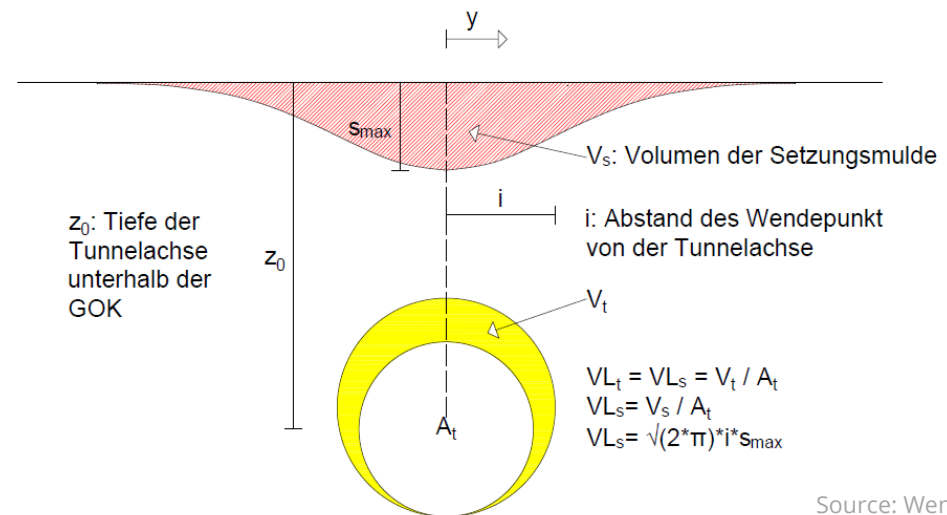
- Loss of Freeboard
- Overtopping
- Breaching

Investigations Wendler (2021):

- Deformation of cavities and earth surface can be predicted by analytical and numerical models (Analogy: Tunnel engineering)
- Goal: “satellite based detection” (e.g. InSAR) could not be achieved



Source: Attewell (1986)



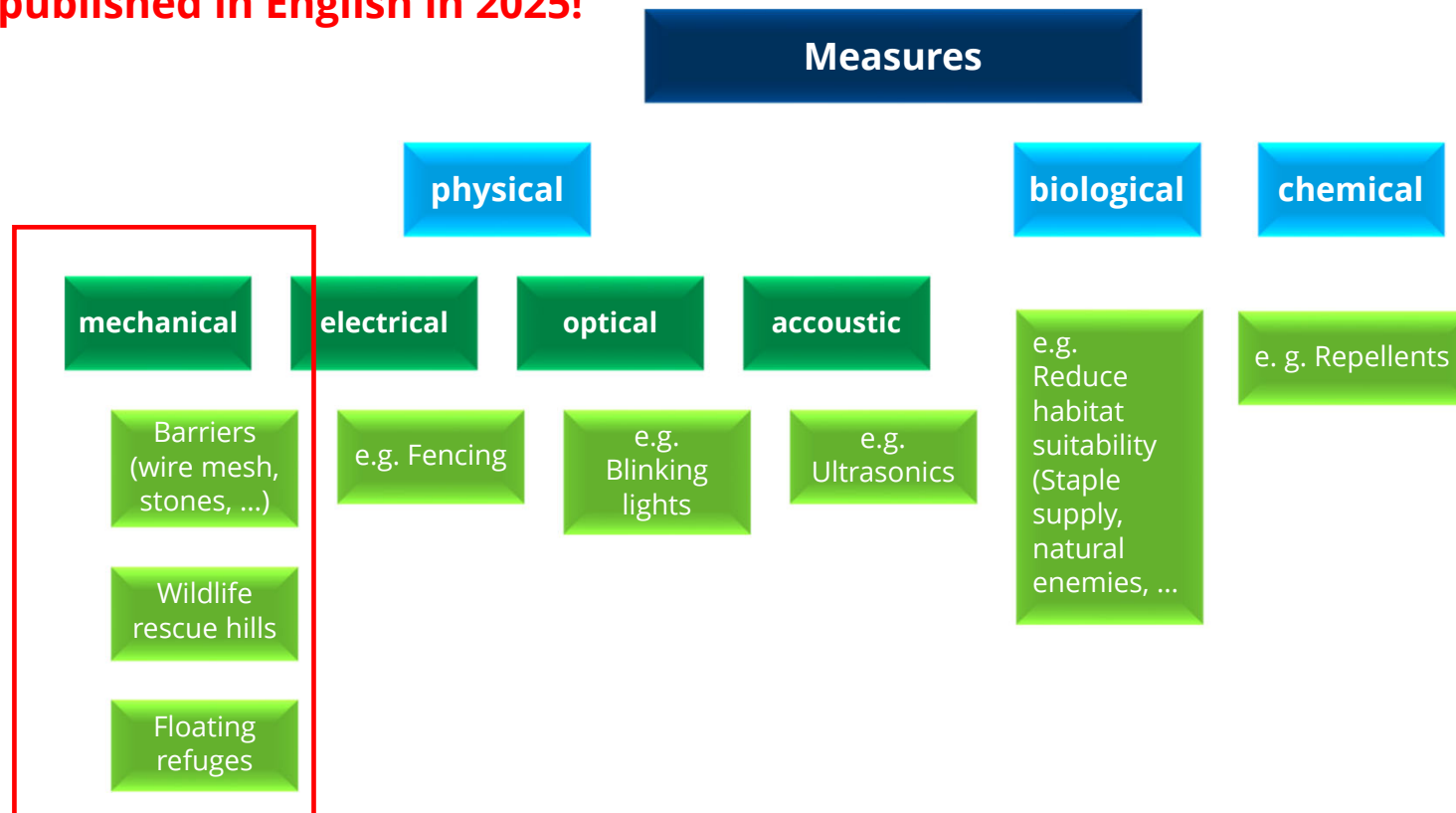
Source: Wendler (2021)

Countermeasures

→ DWA-Guidelines M 608-2:

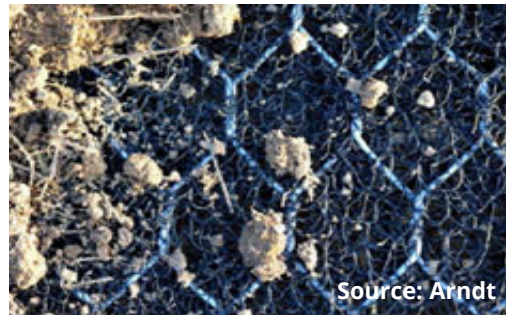
„Muskrat, Beaver, Nutria – Technical design and protection of river banks, dikes and dams“

■ to be published in English in 2025!



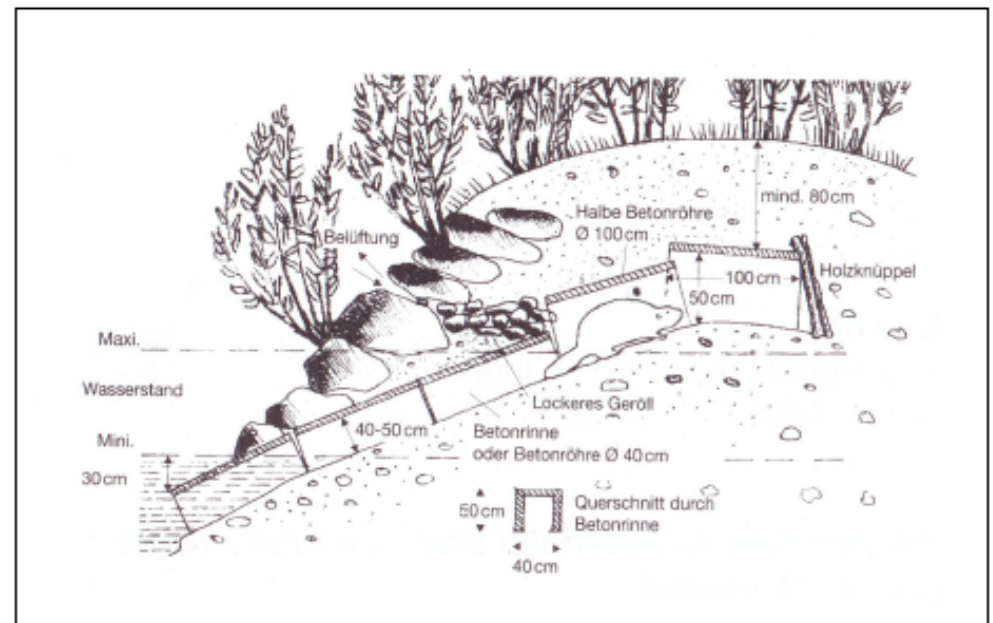
Mechanical Barriers

- **Technical solutions:** Coated wire mesh (corrosion!?), natural & artificial stones, sheet pile walls, ...
- **Appropriate placement** (location, extent) **and construction crucial** for effectiveness
- **Durability und sustainability** must be considered (**maintenance and environmental issues!**)



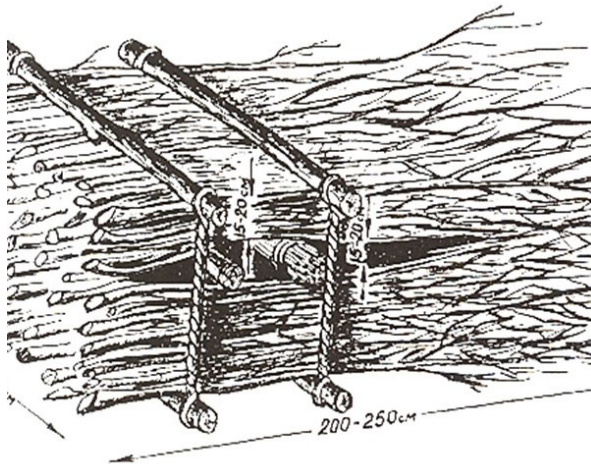
Wildlife Rescue Hills

- Only in locations, where hills are **not critical from a hydraulic point** of view, e.g. wide flood plains
- **Not applicable in narrow river sections** due to backwater effect

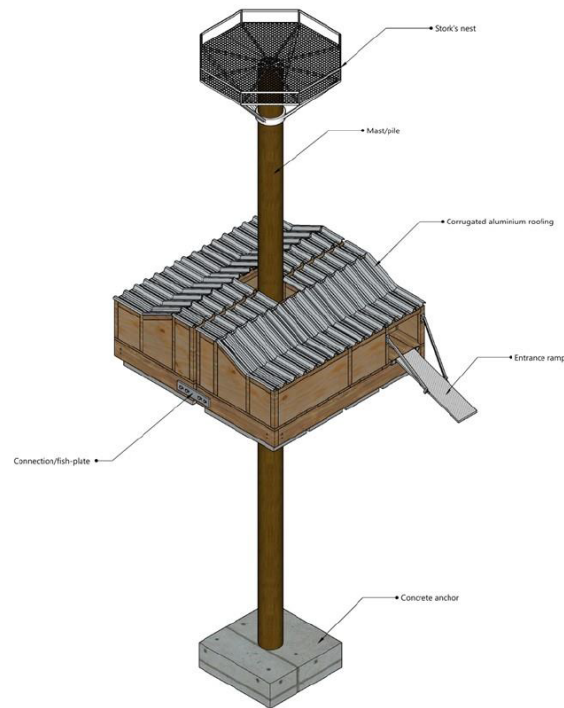


Floating Beaver Refuges

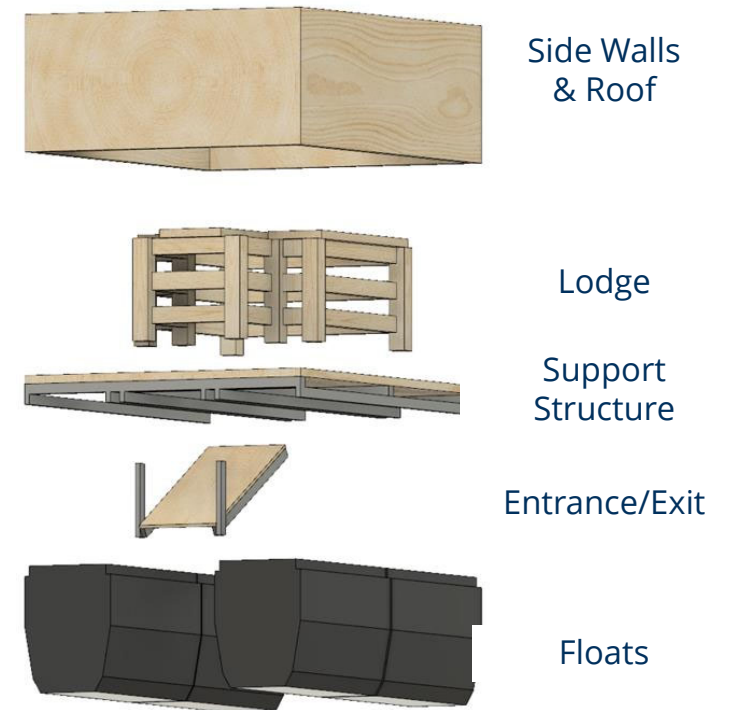
- Idea: provision of **alternative (better?) shelters**
- **Feasible** from technical point of view → **reasonable** from biological point of view?



Source: Safonow (1972)



Source: Gerrits (2022)



Source: Gautier (2024)

Cavity Detection

- **Unsolved problem → Call for joint research!**

Ground penetrating radar (GPR)

Frequency domain electromagnetics (FDEM)

Microwave sensing

Electrical resistivity tomography (ERT)

Geomagnetics

Tracking dog

Multispectral imaging

Thermal imaging

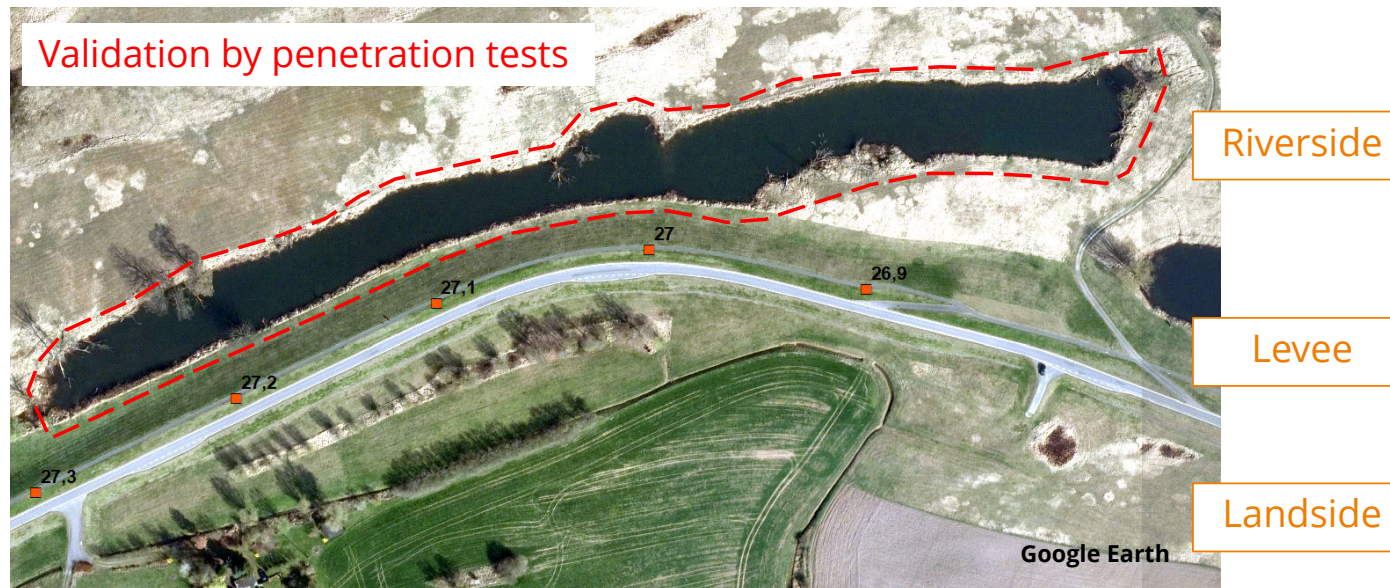
drone
based

Satellite radar interferometry (InSAR)

UW-photogrammetry (UUV, GoPro)

Other:

- Horizontal sonar
- Bees
- Avalanche transmitter
- ...



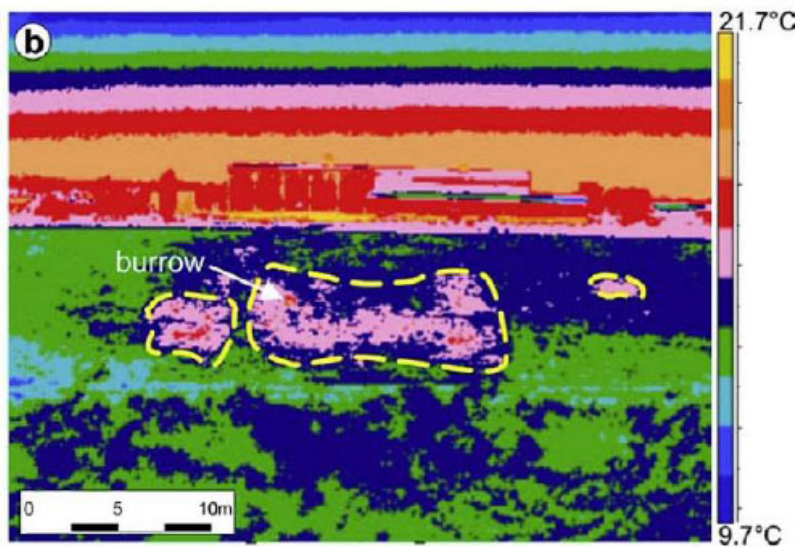
Potential
Methods



Field
Survey

Cavity Detection

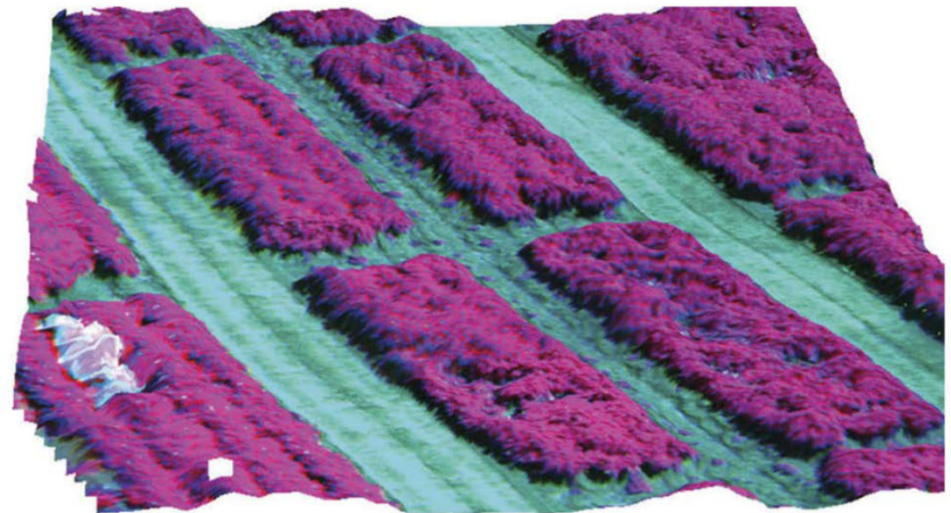
Thermal Imaging



Borgatti (2017)

→ **Surface Temperature**
cooler or warmer?

Multispectral Imaging



Hunt (2018)

→ **Plant Stress**
low soil moisture content?

Final Remarks

www.dwa.de

DWA
Klare Konzepte. Sichere Umwelt.

DWA-Regelwerk

Merkblatt DWA-M 608-2

Bisam, Biber, Nutria – Teil 2: Technische Gestaltung und Sicherung von Ufern, Deichen und Dämmen

Mai 2023

TECHNISCHE UNIVERSITÄT DRESDEN

Methods for Detecting Cavities Caused by Beavers in Forelands and Levees

Field survey at the Oder River in Brandenburg/Germany

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Jörg Seidel, Leibniz-Centre for Agricultural Landscape Research (ZALF) e. V., Mönchengladbach (Germany)

Motivation

With its successful re-naturalisation in Europe, the beaver as a protected species receives a high, mostly positive attention by the public. In many states, however, in regions where beaver habitat overlaps with that of humans, conflicts also arise. This is especially true for those areas where adjacent levees are intended to protect agricultural land and settlements from flooding. In the case of flooding, beavers could use these levees as a place of refuge. In doing so, beavers dig tunnels and dams in dimensions that can significantly increase the failure probability of the levees or may even lead to sudden failure. Furthermore, these cavities can be dangerous with regard to river maintenance works. Provided these cavities can be detected in a relatively short time over long levee sections, appropriate counter measures can be taken. Motivated by this problem, the aim of a project on the Oder River in the border state of Brandenburg (Germany) was to find methods for the detection of beaver-caused cavities in levees and their foreland and to test them with regard to their suitability and practicability.

Field Survey & Methods

As a result of an initial research, the following 10 methods were tested in a field survey (partly also in laboratory pre-tests):

- Ground penetrating radar (GPR)
- Frequency domain electromagnetic (FDEM)
- Micro-wave sensing
- Electrical resistivity tomography (ERT)
- Geonics
- Tracking dog
- Multippectral imaging
- Thermal imaging
- Satellite radar interferometry (InSAR)
- VW photogrammetry (VUX, GoPro)

The validation of the measured data was carried out by means of penetration tests.

Results

As a result of the field investigations, which took place over the period June-September 2020, the following can be stated:

- none of the methods investigated could demonstrate a clear suitability for cavity detection
- In the foreland area some cavities caused by beavers could be detected by the methods ground penetrating radar, geonics and by tracking dogs
- (some) cavities in the river levee were detected by ground penetrating radar exclusively
- although the ground penetrating radar and geonics were able to detect some cavities, both geophysical methods cannot be used for large-scale cavity detection at river levees, since a drone-based application is not possible

Discussion

Even though none of the investigated methods led to a clear success, the results obtained represent a good basis for further investigations on this topic.

In addition to general, geonics and tracking dogs, the appropriate use of the thermal imaging and multippectral cameras will be further investigated in the future. Assuming their general capability of detecting beaver-caused cavities, the advantage of both methods is that airborne measurements are possible (drone-mounted).

The hypothesis that beaver-caused cavities can be detected with infrared and/or multippectral cameras under certain environmental conditions will be explored in a field test at a recreation basin in Saxony/Germany. Since the detection of cavities is not only needed for hydraulic engineering, a closer cooperation with other experts, e.g. biologists is desirable.

Research Results and Conclusions

Member of: DRESDEN
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ZALF
Leibniz-Centre for Agricultural Landscape Research (ZALF) e. V.
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IWD
Institut für Wasserbau und Technische Hydromechanik

Interreg Sachsen – Tschechien | Česko – Sasko

Kooperation von der Europäischen Union Spolupráce s Evropskou unií

Cross-border beaver dam management in the context of climate change

BIROB

Main goal of the project

The resilience of landscapes and ecosystems to climate change depends to a large extent on how they react to an extremely fluctuating water supply. The border region between Saxony and the Czech Republic is particularly affected by environmental risks from flooding and drought (frequent flooding, forest dieback, forest fires). Beaver activity can lead to a leveling of the water balance, an increase in biodiversity and thus an increase in regional climate resilience. In addition to the positive effects (e.g. watercourse renaturalisation, increased retention), negative effects (e.g. undermining, unwanted flooding) must also be considered. A particular characteristic of the beaver is its endeavour to create a favourable habitat by building dams in watercourses. This changes the hydraulic, hydrological and

ecological conditions both above and below the dams. Whether and under what conditions these changes are significant for regional surface and groundwater conditions is still unclear. As a result, local authorities as well as water and environmental authorities lack a sound basis for decision-making and argumentation as to whether beaver dams should be left in the watercourse or whether adaptation measures are necessary. The project therefore aims to show the extent to which beaver dams can make a positive contribution to mitigating and overcoming environmental risks caused by climate change

in the border region of SN – CZ. To increase the practical added value of the project, several transfer tools and communication channels are planned, such as the development of recommendations for authorities and citizens, public communication via the project website, social media, trilingual information boards, as well as a mobile model to demonstrate the hydraulic effects of beaver dams on-site, an image film, and much more.

German project partners:
Technical University of Dresden
Landschaftspflegeverband Sächsische Schweiz-Osterzgebirge e.V.
European Project Center

Czech project partners:
ALKA Wildlife, o.p.s.
Česká zemědělská univerzita v Praze
České vysoké učení technické v Praze

Total costs of the project
Total: 1,089,706.15 of which 80% EU funding (ERDF): 871,764.90 Euro

This project was funded by the Interreg Saxony – Czech Republic 2021-2027 program.
More information about the project can be found on our website!

<https://iwdw.imb.gbv17>



Thanks for your Attention!

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