Bund für Umwelt und Naturschutz Deutschland
BUND
FRIENDS OF THE EARTH GERMANY

# BUND
MECKLENBURG-VORPOMMERN

# Preservation and planting of trees on dams and dykes

## Conflicts - Solutions - Implementation

PHOTO **Common oak avenue at the Störkanal 2016 (Ralf Ottmann).**


Die Lewitz
Baumfällung


Lasst mich leben!
Sägeweg


Bitte
laß mich
stehen

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## DEAR READERS,

When I first saw the oaks along the Stör-Canal, I was deeply impressed by the beauty and grandeur of these sturdy trees. They have been standing on the dam along the Canal for about 140 years. They always had good growing conditions, enough space for the roots and enough water. No de-icing salt in winter, few cuts, no root digging. The trees could simply develop wonderfully and so they stood there, one as beautiful as the other. But now they should be felled with the renovation of the dams. It was immediately clear to me that BUND, together with many allies, would have to find a solution that would make it possible to preserve this old Canal avenue. In this brochure we show how joint commitment can lead to a good result.

Katharina Dujesiefken
Consultant for tree and avenue protection

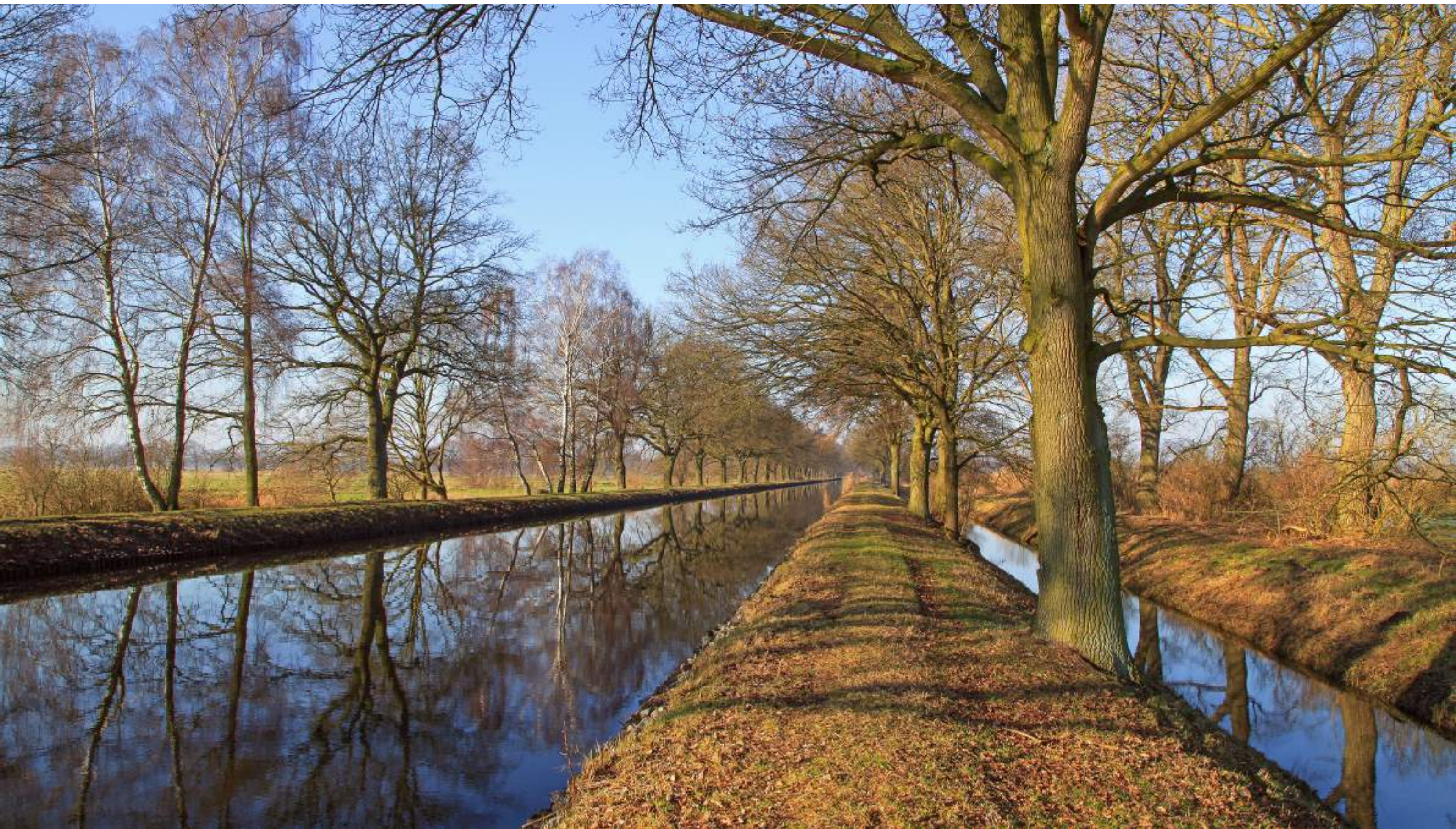
# Preface by Katharina Dujesiefken

The development of human civilization is connected with the desire for more land, navigability and flood protection. Rivers and streams were straightened and dyked. A large number of once meandering rivers and streams now run through the landscape as strictly uniform structures. They were once wider and shallower and spread over an entire river plain. Floodplain forests grew on their banks. There was a great variety of animal species on land and at sea.

Today, these waterways are shortened, straightened, deepened. Transport is therefore faster, without obstacles and is possible for larger ships. This encouraged trade. Cities and industry developed along the rivers. It was promised that the straightening of the rivers would prevent flooding, but the floods have only shifted downstream. When, for example, the Upper Rhine was straightened at the beginning of the 19th century, there were warning voices. They were right, because as a result the Middle and Lower Rhine rivers were overflowing their banks like never before. As long as the rivers do not get more space, floods cannot be avoided.

In the last 250 years, many near-natural habitats such as floodplain forests with their winding arms of water have disappeared and made way for open, bare agricultural land. Straightening and containment led to a decline in the biodiversity of animals and plants. In the course of river straightening, accompanying trees and shrubs were and are often removed. Due to the lack of trees and shrubs, the effect of light on the river becomes much stronger, which promotes the growth of aquatic plants.

PHOTO **Common oak avenue at the Störkanal 2016 (Ralf Ottmann)**



*„In the last 250 years, many near-natural habitats such as floodplain forests with their winding arms of water have disappeared and made way for open, bare agricultural land. Straightening and containment led to a decline in the biodiversity of animals and plants. In the course of river straightening, accompanying trees and shrubs were and are often removed.“*

This effect is supported by the stronger warming of the water. Heating the water also results in a decrease in oxygen, as the warm water can absorb less and less oxygen. In addition, the lack of vegetation on the dams and dykes means that dirt and fertiliser cannot be retained. Of course, with the trees and shrubs along the water, important habitats are missing for many animal species. In addition, the Canalised rivers and streams lack the organisms in the waters and the time for sufficient self-cleaning.

For these reasons, landscape architects, engineers, biologists and many a hydraulic engineer are questioning the demand currently manifested in standards, which states that woody plants (trees, shrubs and hedges) on dykes and dams are fundamentally unacceptable because they apparently impair stability and maintenance (DIN 19712, Merkblatt Standsicherheit von Dämmen an Bundeswasserstraßen, 2011). Those responsible refer to this not only for new construction, but also when it comes to tolerating and planting trees on dams and dykes during renovation measures.

Engineering biology has very good answers to the question of how plants can be used as living building materials to secure dams and dykes. For many decades, representatives of nature conservation and landscape management, associations and local citizens have been calling for environmentally compatible solutions to be implemented.

This brochure uses the example of the rehabilitation of the Stör waterway in the Lewitz with an oak avenue and the preservation of a horse chestnut avenue on a Rhine dyke to show that dam rehabilitation with preservation of the tree population is possible and even sensible. In both cases, it was only after extensive protests that trees were preserved and the necessary work on the dams had to be discussed with a tree expert. In this publication we show the results of the planning, problems and solutions during the implementation. ●

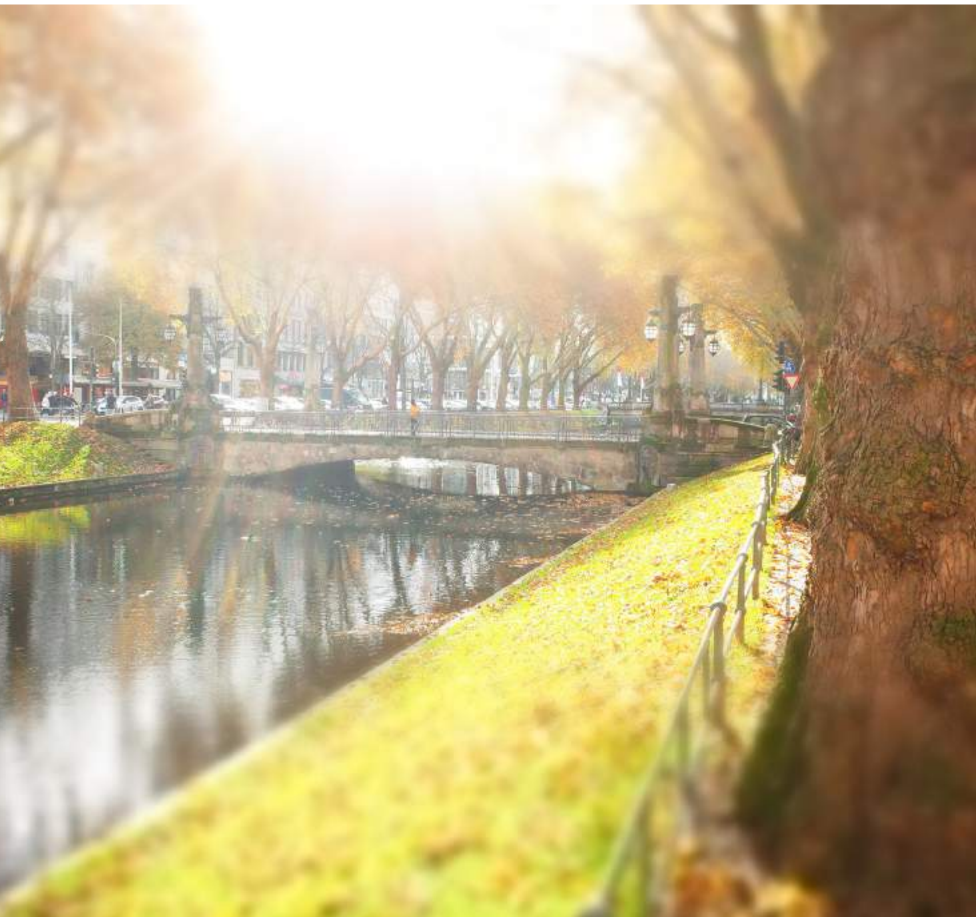


PHOTO **Norman Voigt**

# Different assessment of the effect of trees and shrubs on dams and dykes

DIN 19712 - Flood protection works on rivers (2013) states in paragraph 7.5.5 „Woods and shrubs (trees, bushes and hedges) on dykes impair stability and maintenance and are therefore generally not permitted“. They would impair stability and maintenance.

If trees and shrubs are required on dykes in exceptional cases, this would normally only be possible with an oversized dyke cross-section (over-profile) or if special securing elements (e.g. sheet piling) are installed.

Although the DIN standards are not binding, they are often handled like laws by the responsible authorities and implemented without compromise. In the case of DIN 19712, this applies not only to the construction of dams and dykes, but also to renovation measures. However, the standard does not take local circumstances or situations into account.

In practice, no consideration is usually given to whether the trees on the dykes or dams are protected from the wind or whether they are exposed to the storm, whether there is a strong current or a calm lake. Trees are unpredictable for hydraulic engineers. They can fall over and tear holes in the dyke. It is often more important to take this into account than to include the reinforcing effect of tensile structures, the roots (WESSOLLY, L. 2019).

Each standard can only provide orientation, but must be expertly supplemented or updated on site. Therefore, it is important to question the background and the scientific resilience of a DIN standard. It is also important to determine whether the rough generalisation of the DIN standard is in line with the specific situation.

The introduction to the standard then also contains the sentence: „The principles contained in this standard are to be adapted or supplemented according to the respective local conditions“.

The data sheet of the Federal Waterway Research Institute (BAW) “Merkblatt Standsicherheit von Dämmen an Bundeswasserstraßen, 2011” (Stability of dams on federal waterways; edition 2011) also states that no wood growth on dams should be permitted. According to this, woody plants (trees and shrubs) pose a danger to stability. This is justified as follows:

- Wind induced movements of the tree lead to loosening of the soil.
- Throwing wind from trees can lead to a considerable weakening of the dam cross-section.
- Dead roots of old woody plants can lead to cavities in the dyke.
- The turf is suppressed by the constant shading.
- Woody plants favour the colonisation of rooting animals, whose ducts, as well as the roots of dead trees, are preferred drainage paths.
- Dam observation, which requires complete visibility of the air-side embankment, can be considerably impaired by trees and shrubs.
- Mechanical maintenance of the dyke / dam is made more difficult.

***Legal significance of standards - Is a DIN standard binding?***

*A DIN standard is a voluntary standard drawn up under the direction of a working committee at the German Institute for Standardization (DIN). DIN standards are based on the proven results of science, technology and experience and serve the general public. DIN standards are recommendations and can be applied, but they do not have to be used. In principle, these are „private standards of a recommendatory nature“. As such, they may lag behind the state of the technology, but have the claim that they reflect the state of the art. This claim can be challenged by expert evidence (https://de.wikipedia.org/wiki/DIN-Norm).*

*„Although the DIN standards are not binding, they are often handled like laws by the responsible authorities and implemented without compromise."*

On the other hand, Katzenbach and Werner describe an increase in the strength of rooted earth structures, in particular due to improved shear strength (Katzenbach, R., Werner, A., 2007). The investigation and assessment of roots of felled trees on the Landwehr Canal (Berlin) have shown stabilizing effects of tensile and retaining roots on the slope area (kubus - Technische Universität Berlin: Darstellung der Wurzelverläufe und bodenkundliche Feldansprache nahe der Ufermauer des Berliner Landwehrkanals, 2008).

Wessolly has demonstrated intensive and dam-stabilizing root penetration of the dyke body by the roots of the horse chestnut trees through investigations of the interactions and safety of horse chestnut trees in an avenue on a Rhine dyke. Their stability was even better in the tensile test than on normal sites (Wessolly, L. 2007). ●

PHOTO **Rhein-Allee in Neus (Fotocommunity - Mr. Neuss)**

# What is a dam, what is a dyke?

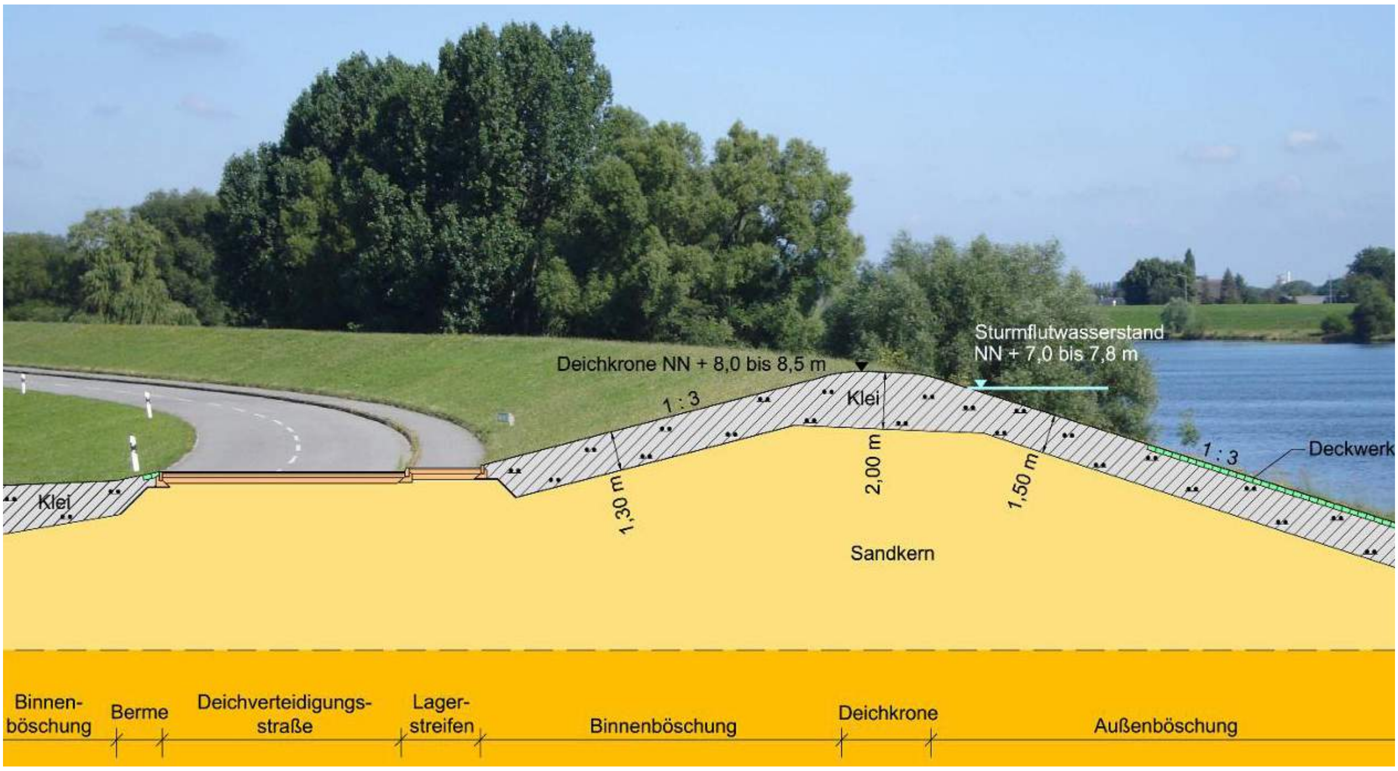
PHOTO **Common oak avenue at the Störkanal 2016 (Ralf Ottmann).**

A dam, as considered in this article, is a structure that supports a water level and, if necessary, provides additional protection against flooding. It is an artificial embankment made of natural or artificial material with a low hydraulic permeability. It serves to prevent or minimise water losses from the waterway. Sometimes sheet piles or other structures support the bank reinforcement. In comparison, a dyke serves to protect the hinterland against flooding and is only under pressure in the event of flooding (Bundesanstalt für Wasserbau, 2011).

A dam is therefore permanently exposed to water pressure, a dyke only in the event of flooding.

There is, for example, the dam that is to dam the water across the river, mostly in combination with energy production. We know also railway dams. These dams are not the subject of this brochure. ●

PHOTO **Cross-section through the Moorwerder main dyle in the south of Wilhelmsburg (Landesberiebe Straßen, Brücken und Ge wässer (LSBG) Hamburg).**



# Rehabilitation of dams with preservation of the tree population using the example of a Stör waterway

*Katharina Dujesiefken, expert for tree and avenue protection at BUND Mecklenburg-Vorpommern*
*Frank Christoph Hagen, Managing Director Hagen Baumbüro GmbH, swarn expert, site manager.*

The dams of the Stör waterway, located in the Lewitz district of Ludwigslust-Parchim, no longer met the static requirements in some sections, especially in flood situations. Therefore, the Magdeburg Waterway and Shipping Authority planned the rehabilitation of these dams from 2011.

Part of the Stör waterway, the Stör-Canal in the Lewitz area, is characterised by an oak avenue standing on the dams. The original planning provided for a complete clearing of the trees and the subsequent overfilling and lateral reinforcement of the old dam. In particular the association Lewitznetzwerk e.V. and the BUND Mecklenburg-Vorpommern turned against this project with actions up to the higher politics. The preservation of the oak avenue was then determined in the landscape planning for the "Plan Approval Decision" in 2013. The necessary implementation of DIN 18920 „Vegetation technology in landscaping - Protection of trees, plantations and vegetation areas during construction work" was also pointed out. These states:

- No soils or other substances may be applied in the root area.
- Trenches, troughs and excavation pits must not be constructed in the root area.
- The root area must not be damaged by loads, e.g. traffic, storage, construction site equipment.

This notwithstanding, a filling of the trees up to 50 cm and a compaction of the tree locations were planned. The Magdeburg Waterways and Shipping Authority did not accept the criticism of the associations with regard to this contradiction in the "Plan Approval Decision" (PFB).

Only after the Lauenburg Waterways and Shipping Authority (WSA Lauenburg) had taken over the project planning of the redevelopment measure was there a willingness to talk.

Now all necessary protective measures for the oaks were discussed. A tree expert was appointed to prepare and accompany the construction work, one of the main demands of the associations.

In cooperation with the engineering offices for project planning and execution planning, possibilities were sought to harmonise the planning approval decision and the implementation of the protective measures for the oaks.

The further planning and implementation of the measures was continued as a transparent procedure. The status of the procedure was and is being discussed at regular intervals in talks with the Lewitznetzwerk e.V., the BUND Mecklenburg-Vorpommern, other associations and all authorities involved.

Today, after a lot of work has been completed, the beautiful oaks can still be admired. The effect of the protective measures is further observed by the tree expert over a period of 10 years.

PHOTO **The Stör-Canal is one of the oldest artificial waterways in Germany with beautiful, sturdy oaks.**

*„The Lewitz is protected under the EU Directive as a Special Protection Area, SPA, to which several nature reserves belong."*

# History of the Stör waterway

The Stör waterway (StW) is a 44.7-kilometre-long shipping lane in the west of Mecklenburg-Western Pomerania an area in the administrative district Ludwigslust-Parchim. It is designated as a federal waterway of waterway class 1 and includes the Stör-Canal, Stör and Lake Schwerin. The first section (km 0.00 to 11.00) is the Stör-Canal. Stör and Stör-Canal discharge their water into the Müritz-Elde waterway.

The Alte Elde and the two important waterways, the Müritz-Elde waterway and the Stör waterway with a symmetrical Canal system, run through the area called Lewitz, The Lewitz is an almost uninhabited lowland of about 13 by 16 km in size between the Mecklenburg towns of Schwerin, Parchim and Neustadt-Glewe. The almost complete seclusion and low population density of the Lewitz area for centuries meant that a unique flora and fauna could unfold undisturbed.

The Lewitz is protected under the EU Directive as a Special Protection Area, SPA, to which several nature reserves belong. The conservation objectives are in particular the preservation and development of the wet lowland landscape and the fens and the landscape with near-natural forests, avenues, rows of trees, hedges and water bodies. They are of particular importance for recreation and as habitats for typical flora and fauna.

Despite its low population density, the Lewitz was also transformed into a cultural landscape. After deforestation, large meadows and arable land were created. The huge rectangular fish ponds are also well known (Fellner, B., 2007).

The city of Schwerin was very interested in an extension of the Stör waterway, which was only partially navigable in the 18th century due to shallow water depths. Initiatives, however, always failed because of the costs. In the 1830s, the Canal was extended with dams to improve navigability, so that the water level could be dammed higher than the surrounding terrain.

PHOTO **Oaktree-avenue at the Stör-Canal 2012 (Ralf Ottmann).**

*„The economic importance of the waterway declined after 1990. Today it is mainly used by pleasure boats and excursion boats.*


PHOTO **Stör Waterway, Müritz-Elde Waterway and Elde Canal at the Elde Triangle (Wikipedia).**

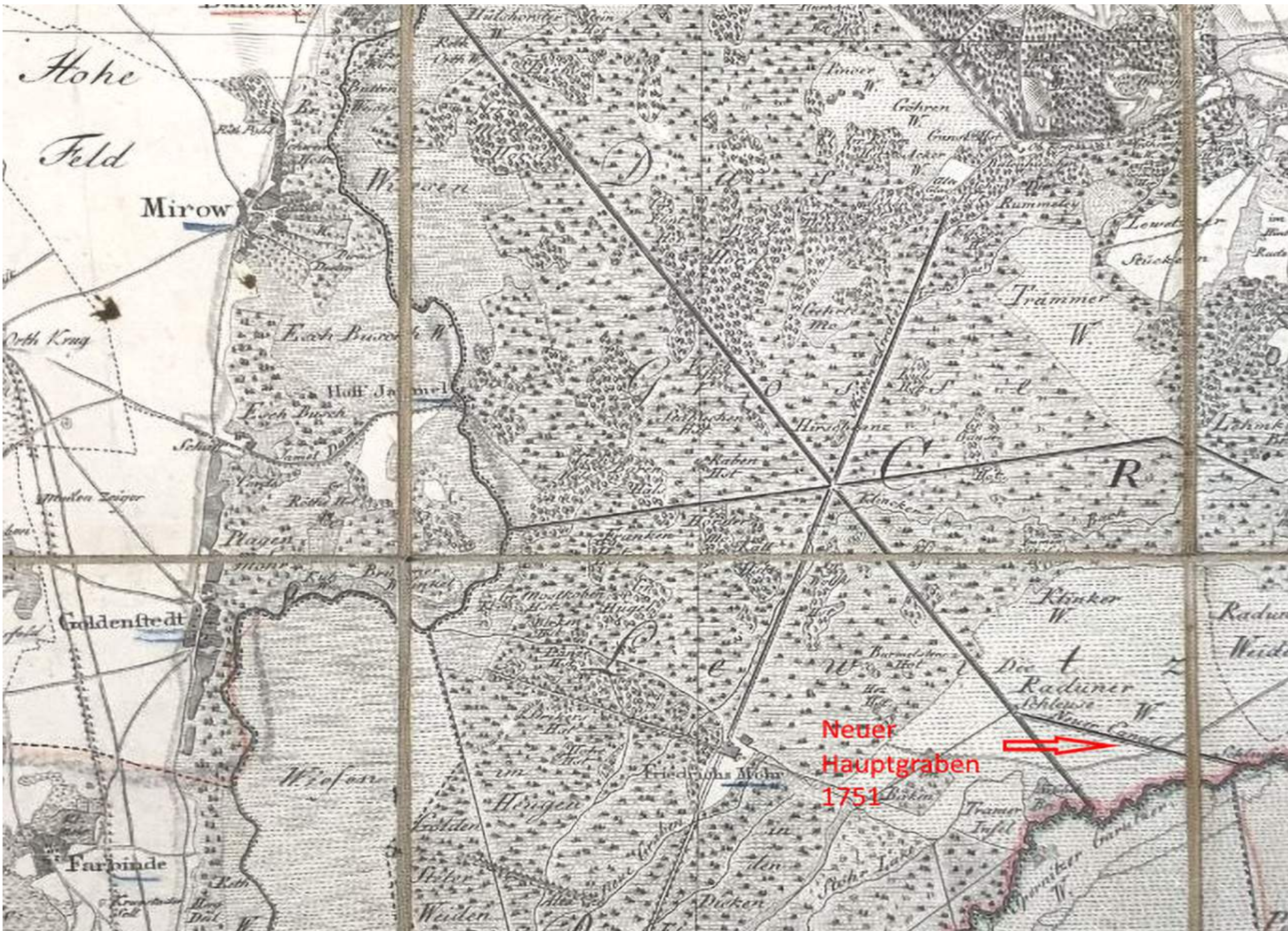
The oaks were planted on the top of the dam as an avenue around 1880. The reasons for the planting have not been clarified. It can be assumed that the roots should reinforce the dam, that the canopy should reduce herbaceous growth and that the trees were planted for aesthetic reasons. Another important reason could have been the shading of the water and the towpath, because the barges were pulled along the Canal by humans (Uhlemann, H.-J., 2016).

Other trees and shrubs were also planted along the dams. In 1839, for example, 700 Schock willow cuttings (4200 pieces) were planted because of the great demand for fodder and firewood. In connection with the renewal of the "Hohe Brücke" (high bridge) in Friedrichsmoor in 1915, the Großherzoglichen Chaussee-Verwaltungs-Kommission, in consultation with the ministries, ordered the planting of birch trees at a distance of 2 m from the northern edge of the planum (Landeshauptarchiv Mecklenburg-Vorpommern).

The economic importance of the waterway declined after 1990. Today it is mainly used by pleasure boats and excursion boats.

Responsibility for both the Stör waterway and the Müritz-Elde waterway lies today with the Lauenburg Water and Shipping Authority.

MAP **Schmettausches Kartenwerk, 1788-1793; Lewitz with New Main Trench**



# Dam reconstruction on the Stör waterway (StW) - the planning approval decision 2013


PHOTO **This publication deals only with the rehabilitation of the Stör-Canal in the section Eldedreieck km 0.00 - Mittelschleuse 2.28, the area with the Kanal-Allee. It lies outside settlements in the middle of fields and meadows.**

The Stör waterway, as part of the Müritz-Elde waterway, begins at the northern end of Lake Schwerin at km 44.70 and flows at the Elde-triangle (km 0.00) into the Müritz-Elde waterway (MEW) km 55.99. A planning approval procedure, PFV (2011) was initiated for the dam rehabilitation project on the MEW from km 50.600 to 55.980 and the Stör waterway from km 0.000 to 6.900. The Water and Shipping Directorate East Magdeburg was responsible for carrying out the planning approval procedure in accordance with § 14 para. 1 sentence 3 WaStrG and the organisational regulations of the Federal Water and Shipping Administration.

**Reason for a rehabilitation of the Stör-Canal**

The dams at the Stör-Canal are used for the targeted canalisation of water and flood protection.

The water level - even without flooding - is higher than the area on the land side of the dams. The reason given for the renovation of the Stör-Canal was that the existing profile and dam heights were for the most part no longer sufficient and that there was a risk of dam bursting or flooding.

All dams in the planning area are pure earth dams, primarily sandy with humus portions. The structure of the dam body is explained in more detail under „Results of the search excavations“. The dams were therefore endangered mainly by local landslides and progressive erosion in the leachate outlet area of the slope on the land side, which was predominantly too steep. The dams are very strongly rooted and only by this their surface is still held (PFB 2013; p. 50). In the area of the dam crest there were troughs and sacks. Some areas had bare patches in the turf. In addition, there were also damage caused by wild boars.

PHOTO **The entire Stör waterway with the Stör-Canal is only used for sport navigation but it also has a function as a receiving water for the Mecklenburg Main Lakes and is also intended to discharge floods at times.**

PHOTO **Sandbags were used to repair the dam.**

*„270 trees of which 130 were oak trees and several shrubs were to be felled. In addition to the loss of these 270 trees, there was the danger that the 213 oaks to be obtained according to PFB (2013) would also not survive the construction measure by backfilling up to 50 cm including compaction in the root area."*

**Planning - raising the dam - expansion and compaction**

The dams are constantly exposed to water pressure. In order to withstand this pressure safely and permanently and to drain leachate without damage, a minimum cross-section of the dams is required, which, according to the planning authority, was not available in many areas.

The dam crown height was set at 1.00 m above normal level or 0.50 m above flood level of the annual series 1971 to 1990. The respective higher value was decisive.

This meant that the dams were to be raised by 20 cm to 50 cm and the crown width was to be widened to 3 to 4 metres and compacted.

270 trees of which 130 were oak trees and several shrubs were to be felled. In addition to the loss of these 270 trees, there was the danger that the 213 oaks to be obtained according to PFB (2013) would also not survive the construction measure by backfilling up to 50 cm including compaction in the root area.

**Resistance to the planned construction measures**

The scope of the planned remediation measures and the handling of the trees along the Stör-Canal were not justified from the point of view of many residents and environmental associations. None of them questioned the necessity of a remediation and the repair of the functioning of the dams. However, they saw considerable conflicts and contradictions in the assessments and demands contained in the project, some of which were contradictory, including the requirements for construction.

According to PFB (2013), „...the dams were to be partially raised by about 50 cm. For this purpose, the soil is removed and replaced by compacted gravel. The dams will be built in such a way that an operating route for...service vehicles will be created on them."

The concerns were that such a filling of the roots, the widening of the dam and the additional compaction in the area of the tree roots would severely damage the oaks on the dam.
Especially the BUND Mecklenburg-Western Pomerania and the Lewitznetzwerk e.V. argued against this planning. The water level of the Müritz-Elde waterway and the Stör waterway can be very finely adjusted. In addition to the existing locks and weirs, the installation of overflows would be a safe way to avoid dam flooding. In this area the Lewitz is crossed by numerous intact ditches. The availability of flood areas in the entire area is possible.

They also criticised the fact that the construction work was not to be accompanied by a tree expert

PHOTO **The Stör-Canal is located in the middle of fields and meadows. Our ancestors were aware of the danger of dam fractures and developed a sophisticated flood protection system. This system of ditches, locks and weirs, completed in the 18th century, perfected in the 19th century and still maintained today, has worked well so far.**


PHOTO **Protest at the Stör-Canal 2013 (Jürgen Brandt).**

or that there were no plans for measures to minimise the impact of the construction work in the root area for the trees. From the point of view of the associations, however, the feasibility of such a construction project would have had to be examined by a tree expert.

The planning authority was forced to preserve the oak trees that form the image of the Canal Avenue. From the point of view of the associations, however, it did so only half-heartedly with an „attempt to preserve the trees by backfilling“.

It was shown that the filling was associated only with a loss of vitality which could be tolerated. However, no expert opinion was provided which, contrary to many years of professional practice, confirmed that the fill was only associated with a reduction in the vitality of otherwise healthy oaks. The question as to how this reduction in vitality would affect the oaks over the next decades was not answered. A representative root search excavation to determine how the roots spread in the covered area was not carried out.

In the documents there was only an opinion that „the trees are predominantly oaks [...] which are still relatively tolerant to fills compared to other tree species ...“.

The backfilling and compaction of roots even contradicts the project requirements of the authority elsewhere. In connection with the preservation of the 213 trees, for example, it says: „They (the trees) are to be protected against mechanical damage during the construction work in accordance with DIN 18920 [...] prevention of deposits, compaction in the root area of the trees (corresponds to the drip zone area plus a lateral distance of 1.5 m)“. (PFB 2013)

In addition to the immediate loss of 270 oaks, which was not fully accepted by the associations, the 213 trees actually to be preserved were also expected to die. This total loss could neither be accepted nor compensated.

The immobility of the Federal Waterways and Shipping Administration, which the associations had to experience at the citizens‘ meeting on 25 June 2013, gave rise to fears of precisely this scenario.

### The preservation of the Lewitz oaks

BUND and the Lewitznetzwerk e.V. also addressed members of the Bundestag and Landtag, invited them to local meetings, held panel discussions and, together with the State Hunting and Fishing Association, wrote an open letter to Dr. Till Backhaus, Minister of Agriculture and Environment of Mecklenburg-Western Pomerania.

In addition to the criticism, the associations also made it clear that they see this project as an opportunity to optimise the project together and with the will to reach a consensus among all those involved, so that the rehabilitation of the dams does justice to all the different interest groups. The rehabilitation of the Stör-Canal in the planning area could thus have an exemplary effect beyond our federal state. They wanted to get involved in this project and asked for a discussion.

We received this offer for discussion from the Lauenburg Waterways and Shipping Authority (WSA Lauenburg), which was responsible for the implementation of the planning approval decision PFB (2013). An initial discussion took place on 15 January 2014 with the interested associations as well as with the authorities of the state of Mecklenburg-Western Pomerania, the responsible ministry, the State Office for Agriculture and Environment West Mecklenburg (StaLU-WM) and the district of Ludwigslust-Parchim.

This discussion promised a willingness to cooperate and openness for further action, which seemed impossible for us after the publication of the PFB (2013) by the Federal Water Shipping Authority Magdeburg. Our great commitment and the joint public relations work had resulted in a willingness to cooperate on the part of the waterways authority, in particular the Lauenburg branch.

Although the authority adhered to the requirements for dam rehabilitation, all possibilities have now been examined within this decision to achieve the second goal, the preservation of the designated trees and the preservation of further trees that were to be felled according to PFB (2013). The preservation of the avenues on the top of the dams was defined by mutual agreement.

The monitoring of all measures of


PHOTOS **Protest in front of the Waterways and Shipping Authority Magdeburg (Kerstin Fritsch).**


PHOTO **Posters and banners were first made on Marienplatz in Schwerin and then attached to the oak trees on the Stör-Canal (Ralf Ottmann 2013).**

the dam rehabilitation by a tree expert from the beginning was assured - a great success of the associations, as it was one of our main points of criticism and dispute and was initially rejected by the Federal Waterways and Shipping Administration.

In the further course of the renovation work there were 10 discussions and local appointments, to which the WSA Lauenburg invited and where the progress of the work was discussed in detail, in particular the necessary maintenance and care and pruning of bushes and trees on and at the dams.

In order to preserve the character of an avenue in the area of the Stör-Canal for the future, the associations wanted to plant new trees on the right side of the Canal or in a green strip next to it as part of a compensatory measure. Unfortunately, the WSA Lauenburg rejects this so far. According to the planned geometry of the dam in this area, no new planting on the dam would be permitted. An oversized embankment would be necessary for this. Furthermore, the WSA Lauenburg has no own green area next to the dam for any new plantings available. However, it has been assured that this demand will be re-examined in the course of a probable further planning approval procedure.

On 29 March 2018, the 10th and for the time being last discussion took place with a visit to the second rehabilitation section in the area of the Stör-Canal km 1.0 to 2.28. The construction progress, interventions in the vegetation and implemented conservation measures for the Lewitz oaks were explained on site. This included the installation of the surcharge filter with the manufacture of a total of 870 tree fans and the upper finish with a rooting animal protection. The work was completed at the end of May 2018.

Andreas Dohms from WSA Lauenburg described the exceptionally good cooperation with the associations. The trees to be preserved in accordance with the planning approval decision (PFB 2013) were preserved. The remaining trees should also be preserved as far as possible and worth preserving.

The dam reinforcement has now reached a safe condition with normal canal water level. However, the goal of flood protection remains open and will probably have to be elaborated and implemented at a later date by means of a further planning approval procedure. A dyke behind the existing dam is under discussion here.

*„Thanks to the strong protests of the associations, a tree expert was commissioned to assess and accompany the entire construction activity for compatibility with the specified preservation of the trees on the dam. Even after the measures have been completed, this tree expert will inspect the trees for a further 10 years.“*

**Practical execution of the dam reconstruction with protection oak avenue**

The planning included only a rough estimate of the impact of the planned renovation work on the row of trees. It was claimed that the uniformly high-water level would very probably limit the root penetration in the direction of the accompanying trench to be covered. An overfilling of the steeply sloping bank edge of approx. 0.5 m could be compensated by the oaks. The condition of the ballast filter and the construction were not explained in detail. Thanks to the strong protests of the associations, a tree expert was commissioned to assess and accompany the entire construction activity for compatibility with the specified preservation of the trees on the dam. Even after the measures have been completed, this tree expert will inspect the trees for a further 10 years. A first step was the investigation of the root course.

**Root excavations**

According to DIN 18 920, the root area is defined as the area of the dripping zone plus 1.5 m on all sides.

As a basis for the planning of the dam rehabilitation, an overview of the actual root occurrence and the extent of the root plates and an assessment of the effects was necessary. This required extensive root search excavations in April 2015.

Due to the length of the section to be investigated, the excavations can only be understood as random samples. Nevertheless, the aim was to map different site conditions.
The trees to be examined were selected according to the following criteria:

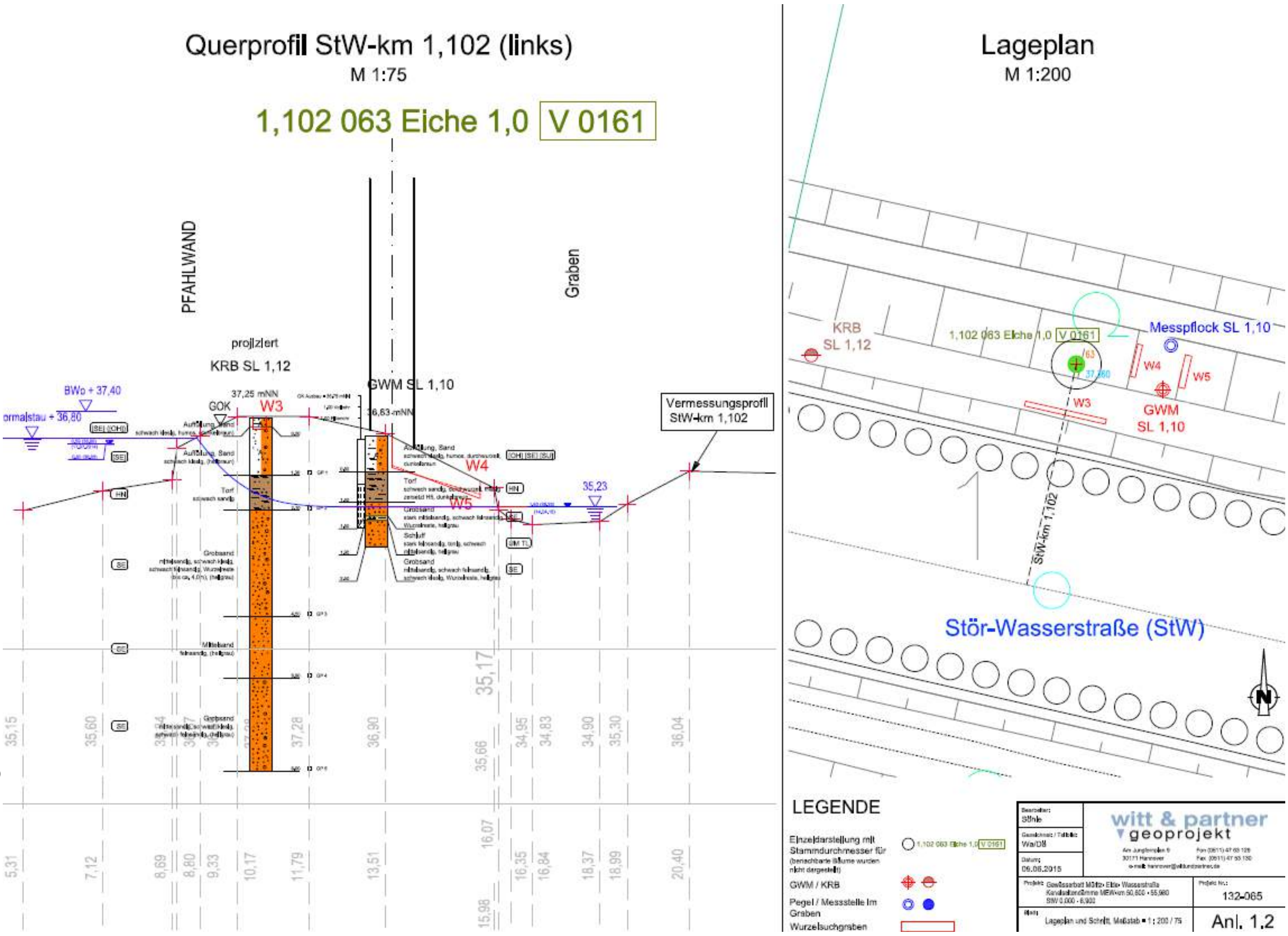
- Trees on wide and narrow dams of different profiles.
- Trees with high function and increased influence by the dam reinforcement.
- Trees without roots of accompanying woody plants, e.g. in the adjacent ditch.
-

In a concept to be submitted beforehand, the search ditches were defined with the projecting office. A total of 19 search ditches were carried out on five oak trees. The 25 to 85 cm deep and approx. 30 cm wide search ditches had lengths of 2 to 5 m and ran lengthwise and crosswise to the dam body in different levels.
The search ditches represented a potential weakening of the structure from the point of view of the dam statics, therefore the client issued strict guidelines for the implementation:

- The dams could only be used to a limited extent by vehicles up to 7.5 t total weight.
- Excavations were only permitted up to 10 - 20 cm above the leakage water line.
- Excavations at the foot of the dam could only be carried out selectively (not larger than 20 cm in diameter). With tense groundwater levels, no search excavations were possible at the foot of the dam.
- In the case of spring formation in the search ditch, a vehicle with 1 $m^3$ of backfill material was to be provided at the excavation site.
- Before a further trench was constructed, the previously constructed ditches had to be filled layer by layer, compacted layer by layer and slurred in.
- All investigation ditches were to be filled on the same day with specified material (washed gravel with a grain size U = 5 - 10, fine grain content d 0.063 < 5%, d 50 < 5 mm).
- Any excavated material should be distributed flat on the dam body. Larger quantities were removed.
- Employees of the WSA Lauenburg accompanied the search excavation constantly and kept 2,500 sandbags on a barge moored in the area of the search excavation in case of an accident.In contrast to the theoretically straight-line course, investigations of the seepage water line revealed a course which first fell rapidly in the dam body and then stagnated at the level of the accompanying ditches.

The position of the search ditches was first marked with chalk spray on the ground according to the concept or the changes agreed on site.

To evaluate the effects of overcrowding on the trees, the fine root fraction and the fine root distribution should also be as-




LAYOUT **Example of the location of a search dig, in this case the Stör-Canal on the right bank at km 1.148).**

sessed. An absorbent method should be used for the trenches up to 80 cm deep. However, the load-bearing capacity and width of the dams were not sufficient for heavy loads, so that large suction vehicles could not be used. The relatively small SaugMax XL suction unit from InnTec GmbH in Rosenheim was therefore used. This is operated by a commercially available compressor on a trailer using the injection method.
The soil was pre-compacted with a compressed air lance, especially in more heavily compacted sections. The loosened soil was sucked out of the trench by an approx. 10 cm thick suction hose and collected in a small container to be emptied downwards at short intervals. The suction unit is portable and can easily be carried by two workers. The pressure hoses to be extended are connected to the compressor on the dam.

The exposed roots were dyed with a chalk spray for better photographic documentation. A measuring stick serves to clarify the proportions.

## Results of the search excavations

The soil found in the dam body is, with a few exceptions, sandy with a humus content on obviously reworked bank edges. In the area of the dry ditches on the southern side of the waterway, the humus content is elevated, partly almost peaty and correspondingly moist at the nearby seepage water line. Here and in the embankments on the field side, a clearly defined horizon of sandy clay with a greyish colour is present in sections at varying depths. In the area of the bank edges, the trees are also rooted in the supposedly subsequently applied packings of armour stones.

The root search excavations have shown an almost continuous, intensive, predominantly uniform root penetration of the embankment body over almost the entire surface, which also extends beyond the crown runners, especially with fine and weak roots. The embankments in particular show a pronounced and deeper root penetration over their entire area, more pronounced than under the compacted tracks. It can be assumed with a high degree of probability that this applies to the entire relevant section of the waterway, i.e. the section passed with the old oaks.

In some cases, a root penetration reaching to greater depths was also visible, which can be explained by the seepage water course

PHOTO **Suction unit in use.**

PHOTO **Example root search excavation right bank Stör-Canal.**

in connection with the sandy structure. In addition, the accompanying ditches south of the right dam, which were dry at the time of the investigation, did not represent a boundary. The root penetration here extends as far as the meadow areas bordering to the south.

In the case of individual trees, it can be assumed that the top of the dam has been filled up; this is indicated by the clearly recognisable layer structure found on a search trench and the different depths of the pronounced root horizon. Roots in the deposited layers are recognisable.

**Assessment of the found root penetration on the dam statics**

The documented intensive and uniform root penetration of the dam bodies is judged by all project participants to stabilise the dam after presentation of the excavation results, in particular also taking into account the sometimes very loose humus sands on the dams. The calculation models for dam safety now take into account, to a certain extent, the increased shear strength caused by root penetration. The positive aspects of the tree population are rated higher than the dangers, e.g. from the introduction of vibrations.

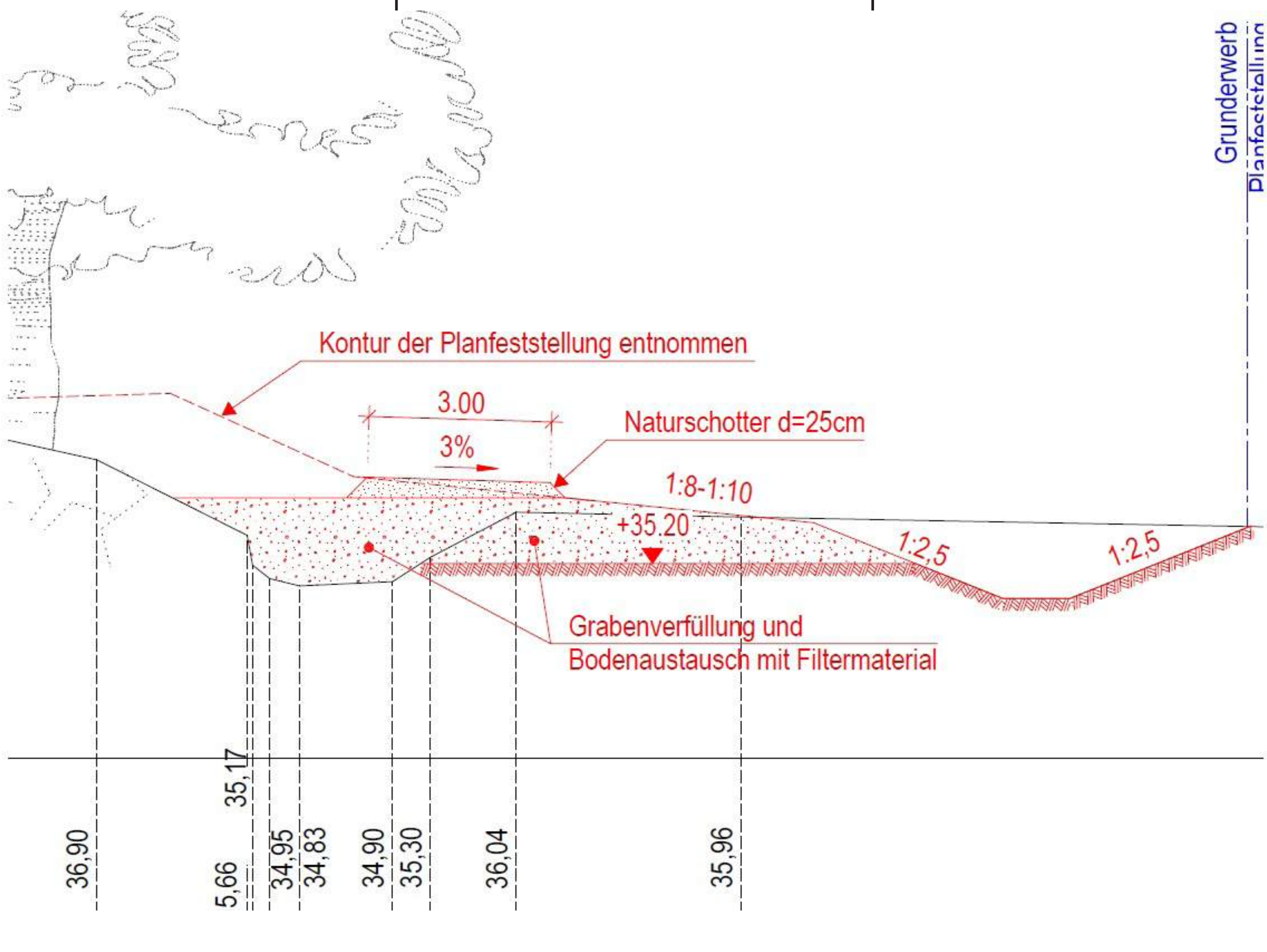
The original design of the dams was not only unsuitable for reasons of tree preservation, but would also lead to major damage to the dam body in the medium to long term. The dying root system would leave behind water-carrying pipes and the core of the dam would collapse under the pressure of the bedding with the decomposition of the roots. Everyone involved in the project agreed that the dams could only be rehabilitated if the trees were preserved.
Alternative solutions were tested in the form of lateral reinforcements, sheet piling or the construction of dams behind them, which would, however, also require extensive changes in planning.

A general transfer of this assessment to other, supposedly similar problems nevertheless appears problematic. A differentiated consideration of the soil conditions, the dam geometry, the dam structure, the tree species and the ground and seepage water conditions would be urgently required and can lead to completely different results.

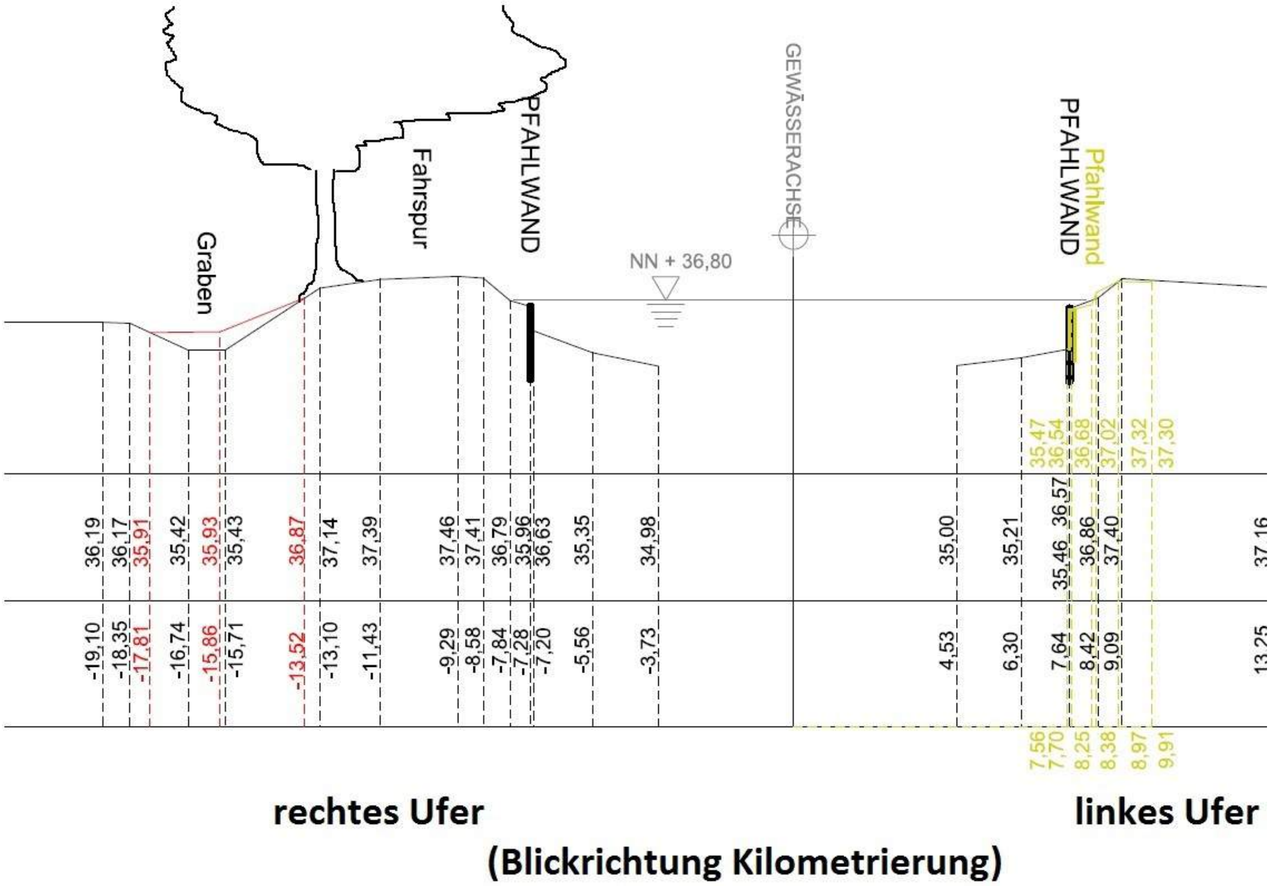
**Dam failure at the northern dam of the Stör-Canal**

The actually desolate static situation of the dams was shown by a failure of the northern dam at km 2.145. Here the dam broke over a length of approx. 6 m exactly between two oak trees standing at a greater distance from each other.

The actual cause of the failure could not be traced, but it is assumed that there was an increased digging of burrowing animals. The stock of Nutrias has increased considerably in recent years and numerous passages in the dam body have already been closed in advance.
In the course of an immediate safety measure, the dam of the northern bank was reinforced by backfilling of the accompanying ditch and a lateral deposit reaching up to 0.5 m high along the embankment of the dam.




SKETCH: **Immediate protection measure on the northern bank of the Stör-Canal.**




SKETCH **Cross section of ballast filter on the southern bank of the Stör-Canal at km 1.90. The kilometre distance is opposite to the water flow direction and starts at the Elde triangle with 0.00).**

PHOTO **View of the filling with built-in tree ventilators, on the left the temporary construction road.**

## Safety measure at the southern dam of the Stör-Canal

The seepage water lines of both dams have been intensively checked since the failure. It became clear that in the southern dam the seepage water line rises in sections. Diving investigations of the pile walls have also revealed scouring behind the pile walls.

Here, too, lateral dam reinforcements were required in the form of a further immediate safety measure, which affected the identified root area more extensively than on the northern side. On the southern shore, the wider dams have shallower slopes on the land side, which lead into a mostly dry accompanying ditch. The search digs have shown a shallow rooting between a very loose humus layer and a clay horizon through the bottom of the trench into the adjacent meadows.
The profiling of the ball
ast filter, which is considered necessary by the dam statics, leads to overfilling heights of up to 1.55 m. On the bank side, the pile wall was to be reinforced by fleece layers and the replacement of missing piles. The

PHOTO **Attaching the protective mesh against burrowing animals.**

space between the edge of the bank and the pile wall was filled by the installation of armour stones.

The unavoidable negative effects of overfilling should be limited by the measures described below:

- The dam could not be driven over with heavy equipment.
- In order to develop the site, a temporary construction road was built on the landside along the trench to be backfilled. For this purpose, the turf of the meadow was removed and a layer of concrete mineral mixture was compacted to a height of approx. 30 cm on a geotextile.
- At the embankment and in the bottom of the trench, only the upper loose humus layer could be removed from the construction road with the help of an excavator shovel under tree-care supervision.

The ballast filter was chosen to be as coarse-grained as possible in accordance with the specifications of the dam statics. An addition of approx. 8 - 10 % humus substances and 0.4 kg /m$^3$ organic-mineral fertilizer based on algae with magnesium, trace elements and mycorrhiza are to promote root ingrowth into the overload filter. The ballast filter was again applied from the site road, the filter was not allowed to be driven on and also not compacted additionally. In order to take into account, the expected compaction, the planned final level was built over by 10 cm. The level at the trunk feet was adjusted to a trough shape.

In order to avoid water accumulation in the root horizon on the clay layer and the associated danger of rotting processes, breakthroughs into the underlying horizons of the dam were necessary.

These breakthroughs were made by drilling accompanied by a tree surveyor. Slotted pipes were installed down to a depth of 1.8 m. The holes were drilled into the dam's walls. The slotted polyethylene pipes have a diameter of 15cm and were filled with gravel 16/32 after installation. A maximum distance of 2 m between the pipes was chosen. The pipes also serve as root ventilators.

A mesh was laid on top of the ballast filter to protect the dam against rooting animals and the surface was finally covered with an approx. 10 cm thick topsoil layer (humus sand, similar to the existing topsoil). The ventilation pipes were connected to the surface with a layer of gravel 16/32.
The installation of the fleece on the pile wall, the addition of missing piles and the installation of the armour stones was carried out from the water side with special equipment on barges.
The lane on the dam was levelled

PHOTO **Vibrating the fleece with a special device.**

only thinly with gravel and lean grassland, the existing differences in gradient were not eliminated.

For the safety measure, the undergrowth and trees which stood between the oaks of the avenue and which were considered by experience to be less tolerant of overfilling had to be felled. The clearance also had to be raised on both the land and water sides. However, the overall visual impression of the avenue could be retained.

PHOTO **Installation of armour stones and covering of the dam crest with humus sand or lean grassland and gravel.**

## Conclusion and outlook

Planning and construction meant a compromise for all involved. The avenue could be preserved. The uninvolved observer may hardly recognise the interference with the site. However, an assessment as to whether the measures are successful in terms of tree preservation cannot be made conclusively at the present time. A regular annual expert control of the oaks over the next 20 years is absolutely necessary. A long-term preservation of the oaks becomes then most likely, if these accept the ballast filter as root space. As a basis for further tree inspections and also as a basis for similar planning, corresponding search excavations would therefore be necessary after a few years.

The approach presented here cannot be regarded as a general solution to similar conflicts between dam/dyke restoration and tree conservation. In any case, however, it is worthwhile to examine the initial situation individually and without prejudice and to seek joint solutions for all those involved. ●

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PHOTO **August 2018 - View of the area of the former construction road and the dam stabilised by the side ballast filter with the southern oak row.**

# Reconstruction of dykes with preservation of the tree population using the example of the Rhine dyke in Neuss

*An article by Dr. Lothar Wessolly, sworn expert for tree road safety*

***After the flood of the millennium on the Danube, Elbe, Mulde and Moldau and also due to the flooding of New Orleans, dyke safety has become highly topical. We pay particular attention to the interaction between trees and dykes. The static investigation methods SIA (Statics Integrated Assessment) and SIM (Statics Integrated Method) contributed to the safety assessment of a tree-covered Rhine dyke. This study was commissioned before the flood of the century.***

### The Rhine dike in Neuss

The Rhine dike in Neuss is a 3 km long section with about 500 horse chestnuts and lime trees with an age of about 65 years. The trees stand on both sides of the path on the top of the dam at 10 m intervals. They are up to 22 m high and have a trunk circumference of up to 1 m. They are designated as natural monuments and also serve the recreation of the population. This is shown by the fact that, unlike unplanted dykes, the dyke path is frequently visited by pedestrians. The trees provide protection and security. Thus, the value of the dyke avenue contradicts the arguments of DIN 19712. On the other hand, the standard speaks from the outset of supplementing the principles according to the respective local circumstances.

Because of this contradictory situation, positive long-term experience on the one hand - the current DIN standard on the other - the responsible dyke ports commissioned the engineering and expert office Wessolly and the dyke experts of Seidl & Partner, planning GmbH, Regensburg with the preparation of a joint safety report. Data from the tree investigations should be included in the calculation approaches of the dyke calculation with the finite elements. In addition, the safety of the avenue was to be recorded in order to prevent trees from breaking out during storms and tearing a hole in the dyke, which might have been under flood pressure. This case was also simulated as the „worst case to be assumed“ in the calculation model.

PHOTO **The dike near Neuss seen from the land side: The avenue emphasises the barrier dyke and gives the landscape a face.**

PHOTO **The dike with the tree population, a natural monument, also offers a place for local recreation for residents and visitors.**

PHOTOS **What if...**
**There must have been people in positions of responsibility who, for good reasons, had dykes stabilised with trees.**

## Method 1 for assessing dyke safety - visual tree inspection

In a first pass, all 489 trees were numbered for retrieval. The Static Integrated Assessment (SIA) was used to determine their basic safety. Trees that had become conspicuous due to symptoms of damage were inspected more closely. Trees with low safety were examined more precisely in a computerised load analysis analogous to DIN 1056. In the end, 21 trees (4.3 % of all trees) with insufficient initial safety remained. This means that they could tear a hole in the dyke during a hurricane. This uncertainty could be eliminated with a slight pruning.

PHOTO **The roots have rotted off. Aboveground fungal fruiting bodies are visible.**

PHOTO **Stability failure in the storm due to missing tree control.**

## Method 2 for assessing dike safety - tensile test

From the total quantity, 35 trees were selected and examined for a tensile test (SIM: inclino and elastomethode), 15 lime trees and 20 horse chestnuts.

PHOTOS **Stability - Inclinomethode Injury-free and safe determination of the tipping load (Wessolly 1987).**

## The result of the tree static analysis

Visually noteworthy was the clear lag of the thickness growth of the lime trees compared to the horse chestnuts. This can be illustrated by the middle moments of resistance, which describe the geometric load-bearing capacity.
In the trunk a middle moment of resistance of 7900 $cm^3$ was determined for the lime trees and 35 000 $cm^3$ for the horse chestnuts. Horse chestnuts often had very shallow roots with the formation of so-called sausage roots.
The evaluation of the tensile tests clearly showed that the flat rooting, adventitious or sausage root formation of the horse chestnuts did not have any negative influence on the stability. The lime trees showed a deficit of 15 % compared to normal sites.

The low basic security of the lime trees is probably due to the strong competitive pressure (horse chestnut trees are formerly leafy). In the case of the lime trees, however, an increased material stiffness and strength could be observed, which has a positive effect on the break resistance, while the anchoring in the soil clearly lags behind due to root growth. The Horse Chestnut thus appears to be the more suitable tree for dyke planting than the lime tree. S. RAU's own investigations into the anchoring quality of various tree species at the BRUNS tree nursery had also shown that horse chestnuts root much better than lime trees.

With a few exceptions, all trees were safe, so that there will be no impairment in accordance with the DIN standard, holes in the dyke.

An impairment by possible root decay and the resulting hollow channels is not applicable for geometrical reasons, because all roots have a direction due to the position of the trees on the top of the dyke, which has the highest point in the trunk and therefore no horizontal flow.
Any disturbance by burrowing activity could be ruled out, as burrowing animals could be controlled very well despite the trees. It could also be conceivable that the trees first offer owls the possibility of sitting on them, which could then decimate the burrowing animal population at night. In addition, the dike top and foreland were used by many dog owners as a walk during the day, which prevents the development of a rabbit population.

Although the shading, also described as impairment in the DIN standard, is given, the quality of the turf was strongly dependent on the direction of the dyke.
The large distance between the trees of 10 m each allows very good access to the top of the dyke, so that the trees do not constitute an obstacle to dyke control.

## The result of the calculations

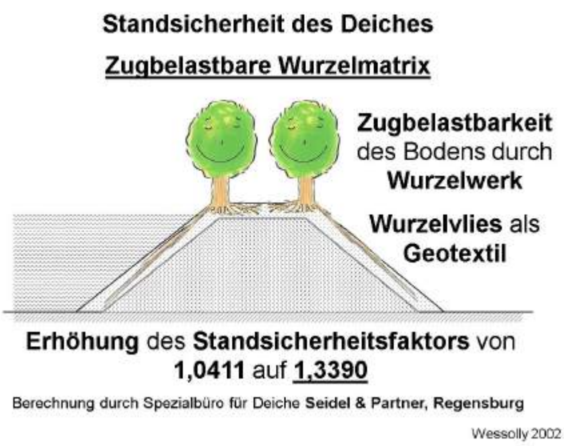
The values of the tree static investigations were used as initial values in the dyke calculation with the finite elements (FE calculations). In addition, boreholes were drilled to investigate the dyke structure.

With the Neuss dyke, it was mathematically irrelevant whether the trees stood or were torn out in the worst case.

Another interesting aspect, however, was the stabilisation of the slope in biological engineering construction.

Further investigations of the root penetration would have to follow in order to secure the result. Then one day it could be said: Trees belong on the dykes and not, as currently stated in DIN 19712, trees are not permitted on dykes.

SKETCHES **Soil cannot be subjected to tensile loads. Roots, on the other hand, are a tensile component. Components that can withstand tension and compression are statically more efficient than those that can withstand only one type of load. Therefore, a root fleece with the characteristic of a geotextile was assumed. The calculation has produced astonishing results: A significant increase in the stability factor from 1.0411 to 1.3390 resulted from the fleece of the roots.**

## Tilting test and free-flushing

To confirm the calculations, a tree that had lost part of its crown in an earlier overturning of a poplar was tilted and flushed.

### The tipping tests

The tipping test itself produced an amazing result on this selected horse chestnut. Its stability was much better developed than comparable trees in normal locations. Although this cannot be generalised, it does indicate that the good ventilation of a dyke promotes root growth in such a way that it is not possible to tear out a tree during strong wind events and thus damage the dyke. Normally, the tree in a normal location is already tilt proof against wind force 12.

### Free flushing

The root was flushed out at 5 m × 5 m = 25 m² to a depth of 1 m = 25 m3. The dyke soil was sucked off by a 30 cm diameter suction nozzle. A compressed air lance was used to help. The root network, which lies under the fleece and can withstand tensile loads, gives the dike body, which can only withstand pressure, additional stability.

The stabilising properties of the fleece could only be stated. On the other hand, the strong roots were measured, their material characteristics investigated and included in the calculation. This has already resulted in a significant improvement in dyke stability.

PHOTOS **show the dense fine root fleece of the horse chestnut under the grass, through which not even the high-pressure flushing device could penetrate. Like a sack, this fleece holds the soil-sand mixture of the dike together, stabilizes the statics in the event of soaking and prevents rinsing (Wessolly 2002).**

*„It turned out that the 500 lime trees and horse chestnut trees did not pose any danger to the dike. On the contrary, the calculation by a specialist office for dykes (Seidl & Partner, Regensburg) has shown that root penetration with tree roots can lead to a significant increase in dyke stability.“*

## Conclusion

The DIN 19712 river dikes are worded in such a way that planting trees is almost impossible. The Rhine dyke, which has existed with trees for 65 years, was a real existing field of investigation. Thus, a long existing condition could be compared to a contradictory, more recent DIN standard.

the civil engineering office of the city of Neuss, in coordination with the other responsible authorities, awarded the contract. It turned out that the 500 lime trees and horse chestnut trees did not pose any danger to the dike. On the contrary, the calculation by a specialist office for dykes (Seidl & Partner, Regensburg) has shown that root penetration with tree roots can lead to a significant increase in dyke stability. This is a single result of a certain dyke with two tree species. But at least they allow the conclusion that the incompatibility of trees and dykes is not inevitable.

It is possible that one day the planting of trees at least on inland dikes might even be desirable in terms of safety. Thus, a considerable number of additional tree sites with considerable welfare effects for the population could be gained. The frequent use of the dyke, for example by walkers with dogs, would also have the advantage of largely preventing damage to the dyke by cave-dwelling animals, as no wild animal could raise its young in such a disturbed environment. In addition, the trees provide a habitat for birds that hunt wild animals, such as hawks and owls.

## Addendum

On 3.4.2019, at the invitation of the Citizens' interest's community "BIG Lindenhof", which is fighting against the planned clear-cutting of the Rhine dyke in Mannheim, about 600 citizens attended an information meeting in the Rheingoldhalle.

Dipl.-Ing. Christian Schmidt presented possibilities of tree preservation on the part of the hydraulic engineer. Dr. Ing. Lothar Wessolly explained the rules and regulations and evaluated the situation from the point of view of tree statics, measurement possibilities and dyke reinforcement by the tree roots.

In addition, representatives of all factions of the city of Mannheim were on the podium. Asked by a TV presenter, they then all agreed to maintain the dyke trees. Everyone hopes that the government and administration will now give in and refrain from clearing. ●

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# Animals at dykes and dams

| Animal species | Preferred habitat | Rummage activity | Influence of woody plants on the occurrence of the animal species; influence on the stability of the dikes | Literature |
|---|---|---|---|---|
| *Talpa europaea*<br><br>European mole | Settlement of pure grass dykes as well as embankments planted with woody plants throughout | Strong digging and digging activity for food search and nest building | **No influence**;<br><br>The criterion of the dike construction material is decisive, above all the thickness of the humus topsoil layer. | KLENNER-FRINGES & SCHRÖPFER (1988)<br><br>NIETHAMMER & KRAPP (1990) |
| Fam. *Soricidae*<br><br>Shrews | Settlement of different habitats depending on the species; potential settlers of dykes | Very limited rooting activity; mainly colonizes already existing mouse- and molehouses | **No influence**;<br><br>The presence of woody plants determines the settlement best. Shrew species; however, due to the low rooting activity there is no influence on the stability. | BRUHM (1986), DIN 19712<br><br>KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Rattus norwegicus*<br><br>Norway rat | River dykes are not typical habitats, but migratory rats have been found there. | Scratching activity similar to rabbits, but earth movements lower, in exceptional cases large packs create extensive corridor systems | **Low negative influence**<br><br>The presence of woody plants optimises the habitat, but is not a necessary prerequisite for its occurrence. | KLENNER-FRINGES & SCHRÖPFER (1988)<br><br>KRÖMER (1998) |

| | | | | |
|---|---|---|---|---|
| *Microtus arvalis*<br><br>Field mouse | River dykes with a short turf provide an optimal habitat all year round. | Heavy digging activity, digs above-ground and underground passage systems. Partly use of mole dwellings | **Positive influence**<br><br>Field mice avoid wooded areas. Woods thus increase stability. | NIETHAMMER & KRAPP (1982)<br><br>KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Arvicola terrestris*<br><br>Large vole, water vole | Very variable, water-influenced banks, moors and swamps to dry pine forests and sand dunes; Voles prefer dykes with trees, since roots of trees and shrubs serve as potential food. | Vole digs only sporadically and avoids otherwise the closed wood existence | **Low negative impact**<br><br>Woody vegetation favours a settlement with voles. Root feeding can cause the shrubs to die. However, voles avoid closed stands. | NIETHAMMER & KRAPP (1982)<br><br>KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Oryctolagus cuniculus*<br><br>Wild rabbits | Steep slopes with light soils. Dykes offer a favourable habitat, wild rabbits love light bushes and avoid closed forests. | Permanent and strong rummaging activity; scratching in the turf creates starting points for erosion. | **No influence**<br><br>Woody vegetation on river dykes does not prevent colonisation by wild rabbits, but makes the habitat less favourable. | BRUHM (1986)<br><br>KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Castor fiber*<br><br>Beaver | Strict binding to the water, shore area up to 20m inland for food search. | Burrowing activity always at the edge of the shore under water. | **No influence**<br><br>Woody vegetation is of no significance for the beaver's construction activity (as it builds on the edge of the bank). | NIETHAMMER & KRAPP (1978)<br><br>DVWK (1997) |

| | | | | |
|---|---|---|---|---|
| *Ondatra zibethicus*<br><br>Muskrat | Wide range of habitat types, but strict binding to water. Even if the muskrat looks for food on the dyke, it is still independent of wood. | There's only danger at the edge of the river. | **No influence**<br><br>A dyke or dam becomes bisam-safe by a sufficiently wide foreland and a wooded bank edge. Woody vegetation on the dyke or dam is not important for the muskrat. | KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Myocastor coypus*<br><br>Nutria | Various types of water bodies; sleeping places primarily on elevated sites or shores, digs only limited earthworks into the shore. | Only sporadic digging motivation. Basic hazard potential of a colonisation and rooting activity of the Nutria is present on dikes. | **No influence**<br><br>Searching for food on the dike is not to be expected. Woody vegetation has no influence on the occurrence or absence of Nutrias. | KLENNER-FRINGES & SCHRÖPFER (1988)<br><br>DVWK (1997) |
| *Vulpes vulpes*<br><br>Red fox | Strongly structured areas with many small fields, forests and boundaries. Dikes can be a habitat if they are covered with trees and shrubs and if the dike body consists of a diggable mixture of sand and clay. | Digging activity available, digs own burrows or extends badger burrows. | **Negative influence**<br><br>The occurrence of the fox in dense wooded areas is rare, but undiscovered rooting can endanger the stability of the dike. | STUBBE & KRAPP (1993)<br><br>GRZIMEK (1968) in BRUHM (1986)<br><br>KLENNER-FRINGES & SCHRÖPFER (1988) |
| *Meles meles*<br><br>Badger | Badgers are tied to woods and inhabit large, richly structured territories; dykes are potential habitats. | High digging activity; the large and extensive constructions endanger the stability of dykes. | **Low negative influence**<br><br>Woody dikes are not optimal habitats (little structured environment, low thickness of the topsoil). | KLENNER-FRINGES & SCHRÖPFER (1988)<br><br>STUBBE & KRAPP (1993) |
| *Mustela erminea, M. nivalis, M. putorius*<br><br>Ermine, weasel, polecat | No binding to certain habitat requirements. | No primary burrowing activity; they use existing caves or build above-ground structures. | **No influence**<br><br>No hazard potential, but rather positive effect than hunter of active diggers. | STUBBE & KRAPP (1993) |
| *Lutra lutra*<br><br>Otters | Occupies all water-influenced habitats, but demanding and rare. Uses above-ground, vegetation-rich burrows and underground shore caves. | Strong binding to the water, therefore no endangerment of the dikes. | **No influence**; | STUBBE & KRAPP (1993) |

Tables: (Pflug, W.; Hacker, E., Publisher, 1999)

# Hints for planting on dams

- A sufficient root space should be provided for plants in the structural cross section in addition to the statically necessary cross profile.
- Root growth can be controlled by the installation of root-inhibiting soil layers (coarse gravel or very dense soils) in such a way that the positive effects of the root system, e.g. protection against erosion and increasing the shear strength of the soil, are also fully effective.
- The application of topsoil rich in nutrients promotes the formation of a very flat root system, which can also be hindered in its deep growth by a strong compaction of the dike body.
- Use of filter mats, which are an obstacle to root growth.
- The construction and maintenance of a grove on a river dyke or dam should be based on that of a windbreak plant so that there is no risk of wind breakage.
- Arrange the planting in such a way that the building control is not obstructed.
- When new dams and dikes are built, the planting should already be included in the planning (Hähne, K., S. 287).

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PHOTO **Postered common oak at the Stör-Canal 2013 (Ralf Ottmann).**