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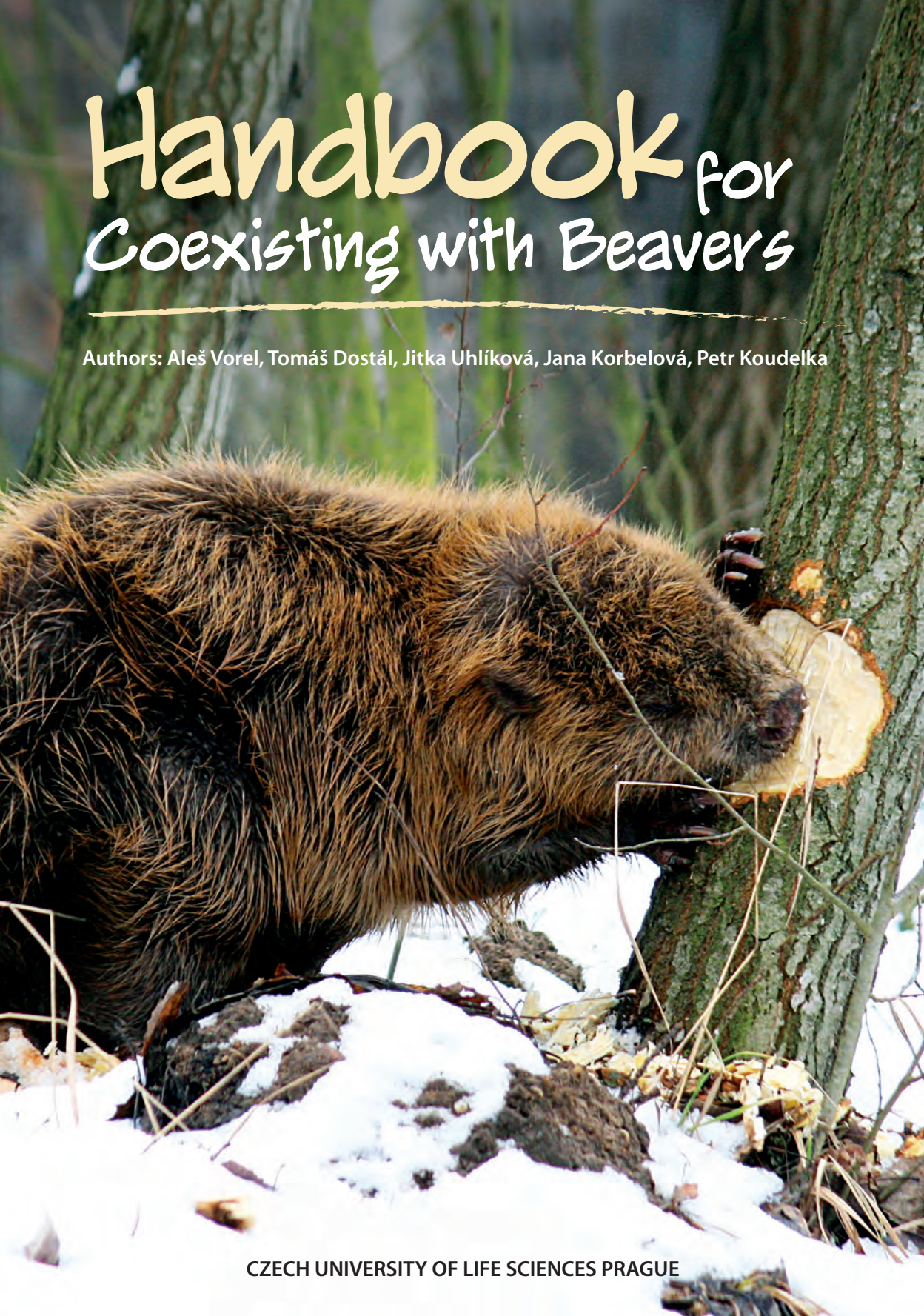

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Handbook for Coexisting with Beavers

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Introduction

Beavers were a natural part of our ecosystem until the middle of the 18th century, when it was exterminated due to excessive hunting. Beavers repopulated our country after successful reintroduction programmes were conducted in neighbouring countries during the 70s in the 20th century. The quantity is increasing and an adored returnee is becoming an unwelcomed neighbour in many places.

Beaver is a key species of wetland and riparian ecosystems, which on some sites may positively affect the quality and storage of water, dramatically transform the environment of watercourses, water areas, and their surroundings. On the other hand, the vital signs of beavers come into conflict with the economic interests of Man in the landscape. The most common conflicts include the consumption of woody plants and crops, waterlogging or flooding of land as a result of damming of watercourses or disruption of pond dams and levees by digging burrows.

Public, state and private entities have currently no available information which measures should be applied to reduce the extent of damage caused by beavers. Therefore, we have prepared this handbook. Its core section contains a set of procedures for how it is possible to prevent or minimize the damage and conflict situations, or at least how it is possible to diminish their extent. To understand the principle and method of implementation of each measure there is also presented basic information about the biology and ecology of beavers in the handbook. Another significant part of the material is a detailed analysis of the legal framework for the protection of the beavers, including a description of the current system of financial compensation of damage. There is also introduced a concept of management of its population in our country, so called the *Management Plan for the Eurasian Beaver in the Czech Republic*.

Most of the measures of the Handbook are based on experience from abroad (mainly from European countries, but not exclusively),

where they have longer and more varied experience with technical approaches on how to get rid of beavers. In the Czech Republic the experience with the mentioned measures is very limited. Despite the efforts to obtain and fit into this material as much information as possible, to collect enough sufficient data failed in some measures (e.g. efficiency, durability, etc.). This insufficiency is adequately commented in the individual measure.

Our handbook cannot introduce all the conflict situations that beavers may cause. However, with knowledge of biology and ecology of the species, and the application of fundamental principles of individual measures, it is possible to find solutions in nonstandard problematic situations that are not listed here. All measures should be administered competently, with the knowledge of the principle of function and crafts erudition. Actions of do-it-yourself character are often doomed to failure, and on the contrary they contribute to the demonization of the beaver as an animal against which no measures will help.

Permanent and complete elimination of beaver settlements could theoretically be the definite solution of any conflict situation. However, the primary purpose of the handbook is to provide guidance on how to share common space with beavers. The beaver is protected under the requirements of international conventions and EU regulations, thus eventual eliminating beaver occurrence is possible only under certain conditions and in principle, more moderate solutions should be always sought after as the primary solutions.

The aim of *Management Plan* is to preserve beavers in our country, so that the level of conflict will not break the acceptable limit. We hope that the content of this handbook will contribute to facilitate the coexistence of Man and beaver in the cultural landscape of Central Europe.

Content

List of Abbreviations in alphabetical order:

ANLP	Act no. 114/1992 Coll. on nature and landscape protection
CHMI	Czech Hydrometeorological Institute
Coll.	Collection of Laws
CR	Czech Republic
CRN	Company Registration Number
CULS	Czech University of Life Sciences Prague
CTS	Czech Technical Standard
CTS EN	Taken European Standard
CZK	Czech Koruna
DIY	Do It Yoursef
EEC	European Economic Community
EU	European Union
FES of CULS	Faculty of Environmental Sciences of the Czech University of Life Sciences Prague
GM	General Measure
ILE	Important Landscape Elements
MA	Ministry of Agriculture of the Czech Republic
ME	Ministry of the Environment of the Czech Republic
MP	Management Programme for the Eurasian Beaver in the Czech Republic
MTA	Military Training Area
NCA CR	Nature Conservation Agency of the Czech Republic
NNHA	National Nature Heritage Area
NNR	National Nature Reservation
NP	National Park
OPE	The Operational Programme Environment
PLA	Protected Landscape Area
PZ	Protected Zones
Q_a	Long-term Average Annual Flow
RA	Regional Authority
SCI	Sites of Community Importance (sites of Natura 2000 network)
SHP	Small Hydropower Plants
SLE	Significant Landscape Element
SPA	Specially Protected Area
SPSA	Specially Protected Species of Animals
UM	Unit of Measurement
U.S.A.	United States of America
VAT	Value-added Tax
WW	Water Work
WWTP	Wastewater Treatment Plants

Laws and regulations which may affect conflict situations:

- Act No. 114/1992 Coll. on the Protection of Nature and the Landscape, as amended
- Act No. 246/1992 Coll. on the Protection of Animals against Cruelty, as amended
- Act No. 334/1992 Coll. on the Protection of Agricultural Land Fund and Covers, as amended
- Act No. 289/1995 Coll. on Forests and Amendments to some Acts (the Forest Act), as amended
- Act No. 115/2000 Coll. on Compensation for Damages Caused by Selected Specially Protected Fauna, as amended
- Act No. 254/2001 Coll. Water Act, as amended
- Act No. 449/2001 Coll. on Game Management, as amended
- Act No. 183/2006 Coll., on town planning and the building code (the Building Act), as amended
- Decree of the Ministry of the Environment of the Czech Republic No. 395/1992 Coll. Implementing Some of the Provisions of the Act No. 114/1992 in the Wording of Later Regulations, as amended
- Decree of the Ministry of Agricultural of the Czech Republic No. 55/1999 Coll. on the Methods for Calculating Loss or Damage Caused on Forest, as amended
- Decree of the Ministry of the Environment of the Czech Republic No. 360/2000 Coll. on Fixing the Method of Calculating the Amount of Damages Caused by Selected Specially Protected Animals to Specified Domestic Animals, Dogs Used for Their Baby, Fish, Bee Colonies, Apiaries, Unharvested Field Crops and Forests, as amended
- Decree No. 432/2005 Coll., which Sets the Conditions and the Course of Granting Financial Compensation for Causing Damage Due to Restrictions to Farming, as well as an Example and Terms of Lodging a Claim, as amended
- Decree No. 335/2006 Coll. which sets the Conditions and the Course of Granting Financial Compensation for Causing Damage due to Restrictions to Forest Management, as well as an Example and Terms of Lodging a Claim, as amended
- Decree No. 189/2013 Coll. on the protection of woody plants, as amended
- Decree No. 53/2016 Coll. which change Decree No. 441/2013 Coll., Implementing the Property Valuation Act, as amended

1 Beaver and a Human

A beaver has always been and still is a subject of considerable interest for Man; people have always had some relationship with this large rodent. Products and parts of beavers were used in the past for food, for clothing, or were used ritually or curatively, the beaver occupied a significant position in the human world. This large rodent has always seemed fascinating for people thanks to its immense diligence and building skills. It is probably the reason why beavers are often attributed with supernatural powers. At the same time, European and later North American civilizations met them intensively, either indirectly when people and beavers were fighting for the same space, or directly, when beavers were hunted for use and profit. Actually, one long stage of development of North American society was closely linked with the existence and long-term exploitation of large beaver populations.

The beaver has always been shrouded in many mythical legends that were also related to various parts and organs of its body. People were trying to pass this mystery and alleged supernatural powers to themselves by using certain products made of beavers. The use of these products has had a long historical tradition that dates back to ancient times before Christ.

Currently, there are still some myths, even with extensive knowledge of the ecology of beavers. At the same time, the competition and rivalry between beavers and humans for space in land use has been continuing. After reintroduction of the majority of beaver populations in Europe and North America the beaver again represents a feature with which people must measure the forces.

This chapter attempts to explain the chronological changes in the relationship of human civilization to the beaver. Understanding the various corners of coexistence can lay the starting line of this relationship and could be used to establish the current position of the beaver in the modern landscape. Although the text contains elements from the field of palaeontology, archaeology, and history; an image that the chapter folds can help to understand what has happened to the beaver during the development of human civilization and what is still happening. The chapter closes with essays about the current position and function of the beaver in the countries of Central Europe, including analysis of positive effects which can bring for example construction of beaver dams.

The essential message of this chapter should be that the beaver has always shared common space with people. Only at the moment when Man lost let us say "limits" of the use of the beaver population, it was fairly quickly exterminated.

1.1 Chronological Development of the Relationship Between Humans and Beavers

Interpretation of historical events is always dependent on interpretive abilities, interpretative framework and the ability to organize, compile, and confront information from various sources. This is the case when we are dealing with at least some written documents. However, the deeper we go against time, the less supporting points we can find. The introduced chronological look back goes against time significantly further, so written sources must be replaced with archaeological or paleontological findings. It is necessary to combine many indirect sources and information which help to compose an idea.

The following reconstruction – which is mainly a Holocene one – works with qualified estimates of the character of landscape of time in the past. Pollen analysis was utilized and it is based on paleontological and archaeological findings. The resulting view, therefore, must necessarily be only an interpretation how and where the relationship between people and beavers has probably developed. Let us imagine it as a gray mist, from which here and there rise some particular points (knowledge)

on which we can rely and from which we can create a construct.

Although there was an enormous effort to bring the most accurate and detailed chronological synthesis of fragmentary knowledge, it is necessary to ask readers for leniency because it was not always possible to give an empirical description of the development. Mentioned view is just one possible interpretation, other authors could probably come to more or less different views.

1.1.1 The Beaver in the Tertiary Era

The existence of the first forms that resembled a beaver and were relatives of today beavers (family Castoridae) has been documented in North America, where these forms lived about 34–23 million years ago, in the Tertiary era. In this line, many other forms that have been closely related to beavers later originated in the American and Eurasian continents. These related species, however, differed significantly from the existing beavers, they differed mainly in size (acquiring a size comparable to today's muskrat (i.e. the weight around 1–2 kg) up to a weight of about 100 kg), and at the same time they also varied in their way of life. For example, some forms were exclusively terrestrial or pure underground. However, in the Quaternary, there was a considerable expansion of the group of Castoridae with dozens of diverse forms. In many cases, these forms were bigger than current beavers (e.g. *Trogontherium*), some related taxa even reached up to five times the size of today's beavers (genus *Castoroides*), but they lived only in North America.

However, genus *Trogontherium* (about one-third greater than today's form of beavers) was documented across Europe and Asia (e.g. in Poland 6–5 million years ago), its expansion followed the development of habitat with thermophilic vegetation that stretched due to warmer interglacial period. This form thus lived like today's beavers near watercourses in woodland and was able to gnaw woody plants. But it is not still clear if these close relatives of beavers were able to build dams and lodges. On the other hand, there are known structures resembling beaver buildings (dams or lodges), which are 4–5 million years old. But they probably came from another member of the family Castoridae, from the genus *Dipoides* that inhabited the North American continent. Since this record is from northern Canada (on the latitude of northern Greenland) – it means the area where is current permanent glaciation, it is a proof that from the historical perspective the climate oscillated significantly. Thus, the record shows that relatives of beavers in the Quaternary inhabited areas far north than the existing beavers, and these areas did probably not freeze all year round. Due to this fact, *Dipoides* could build structures similar to today's beaver lodges and dams.

It is interesting that all the above mentioned forms of beaver relatives were able to gnaw trees and even build burrows like their relatives-contemporaries. However, all these forms (except today's beavers) died out in America or Europe by the end of the Pleistocene (about 15,000 years ago). Thanks to the time coincidence it can be assumed that another Castoridae also had to be hunted down by members of the genus *Homo* (both *Homo sapiens sapiens* and certainly *Homo neanderthalensis*) similarly as beavers of those times. Both recent species of beavers (i.e. Eurasian beaver and North American beaver) belong to the genus *Castor*, which was split probably more than seven million years ago. Their common ancestor colonized large parts of the continent of the northern hemisphere (division into continents in its present form did not exist in that time). The separation of the continents resulted in forming separated populations, which then created two separate and isolated species when each of them independently colonized "their" continent. It was a normal process of creating forms, which often occurred during the Tertiary and Quaternary periods.

Generally, developing the ability to build beaver constructions is evolutionarily linked to

the ability to settle in much colder conditions (this is probably the adaptive behaviour) when beavers progressed in settlements further north to cooler conditions.

The ability and the need to build constructions arose in those unfavourable conditions for surviving. Beavers lived in the underwater surface of dam ponds and constantly needed fresh supplies of trees. Equal important function has a protective ice cover. This allows beavers to move unnoticed under the ice of the water's surface – beavers are able to drain water from dams in the time of freezing, so that air pockets between the ice and the water are created; and beavers are effectively protected from predators.

These two functions are essential in case of long-term snow and ice sheet. Inside residential buildings (beaver lodges) there is also a significantly higher temperature for wintering compared to temperature inside burrowed lodges. It is not clear which ancestors of today's beavers first developed currently known beaver structures, but their ability to build them is the result of adaptation to inhabit very cold conditions. These buildings improve the ability of beavers to inhabit the northern regions, but on the other hand, in warmer conditions the dams either fulfil other functions (preservation of the water column in times of drought), or the beavers do not build the dams at all (in broad lowland rivers). It means that the ability to build dams and lodges allows beavers to inhabit a much wider range of conditions.

1.1.2 The Beaver in the Quaternary

Prehistory (The End of the Ice Age and Palaeolithic)

Man has always hunted beavers whenever they met prehistorically and historically in the same space (meaning at continental level). This is certainly true of the whole latest geological epoch – Holocene (i.e. from 9,500 years B.C. to the present). However, theoretically, ancestors and relatives of beavers met humans in Europe in older eras, too. For example, there is evidence already from the late Palaeolithic (about 15,000–9,500 years B.C.) that in the caves where former hunters and gatherers lived and worked, fragments of beaver bones are presented in dated layers (e.g. Southern England, or Black Sea coast in Romania). Probably the first use of beaver products is recorded in Neolithic (5,500–4,200 years B.C.) again from Southern England – on plank roads built in that time wood used was chewed by beavers. If we seek even older connection with the utility of beavers for humans, it is assumed that beaver dams (barriers against migrating fish, e.g. salmon) served as fishery to Palaeolithic humans and probably Neanderthals. People could probably also use treeless areas of dams clogged by sedimentation that beavers caused and then left (more on that below).

It is also quite likely that Neanderthals, who hunted so-called megafauna (e.g. sabre-toothed felines, rarely mammoths), could meet the ancestors or close relatives of today's beavers (e.g. the above mentioned *Trogontherium*) and also the current beavers which had already existed.

There is clear evidence that *Homo sapiens sapiens* after arriving in Europe (about 45,000 to 43,000 years ago) gradually replaced the Neanderthals (at least 30,000 years ago); and very likely "overtook" their prey and hunting habits. A more modern form of humans gradually colonized the warmer southern European regions, and later also moved into colder regions. Evidence of the existence of beavers at that time (late Pleistocene) was found in these climatically and biotope more convenient (glacial) refuges. Other areas of Europe were either covered with glaciers or permafrost, or there were stretched dry and significantly cold habitats with sparsely growing birches and pines. Occurrence of beavers in Europe in that time quite closely copied the occurrence and possible development of stands, particularly willows, i.e. especially climatically convenient peninsulas of southern Europe.

During the early Holocene continental glaciers dwindled and cold and dry climate of the last glacial period retreat, and this caused mammals that inhabited the mentioned south refuges (Iberian, Apennine and Balkan Peninsula) in the Ice Age were pushed northward Europe. Therefore, beavers also spread to the north, quite probably with the development and progress of more vigorous woody plants. In that time (late Palaeolithic) beavers probably colonized England also, which was connected with Europe due to the low sea levels.

The Ancient History

Climate change since the late glacial period (about 9,500 years B.C.–300 B.C.) brought beavers space to spread north, they gradually inhabited the European landscape and spread from refuges in which they had survived the last Ice Age. However, in that time there was also the spread and development of human populations. Beavers and people spread almost over Europe entirely and inhabited a wide range of habitats.

It is important to realize how the landscape looked like in that time. We would not have found floodplain forests of mid and low positions with slow running networks of meandering parallel stream channels that can be found today in the wide plains of middle and lower slopes of rivers. Rivers, also in the lower parts, resembled a wide, shallow rocky waterway with torrents, which today can be seen in mountain and foothill areas of Central Europe (similar to today's river the Křemelná in the Šumava mountains). It means that narrow and rapidly flowing watercourses with rocky beds considerably prevailed at all altitudes and they did not create a plan of heavily layered fine-grained sediments covering the entire floodplain as it is a characteristic today. These terraced river sediments – in the modern era places for the development of large floodplain forests – arose in later times (in the early and high Middle Ages) as a result of human activity. In other words, floodplain forests known in today's concepts were very rare or simply were not present in Central Europe. However, beavers did not mind; today's meads are their optimal habitat, but beavers are highly adaptable and were able to inhabit character of former watercourses and riparian stands successfully with no problems. Composition of woody plant species at that time was very favourable for beavers (with today's knowledge of their woody plant preferences). Currently a central part of the Holocene is considered to be the forest optimum, when there was probably higher annual average temperature and humidity in Central Europe. This supported development of heliophilous and thermophilic woody plants with a predominance of oak, hazel, elm and linden in most area of Central Europe; the banks were still colonized by willows (apparently poplars, which is strongly preferred by beavers, were also widely present, but it was not thoroughly recorded in pollen analyzes).

As can be seen in the example of the Czech basin, human settlements significantly pulsed both spatially and probably also numerically. The largest settlement in our country was reached by people in the Bronze Age, while in Roman times and in the Slavic Migration, a human settlement of our territory was the thinnest one. Throughout the Ancient period people inhabited climatically the most suitable areas that gave good agricultural yields, i.e. the flat parts with an altitude max. 350 meters and near watercourses. At that time, apparently intense competition between beavers and humans began because both species were interested in the same area – near watercourses, where deciduous forests grow on quality soil. Beavers necessarily had to be weaker opponents in this fight. Either they were hunted as a source of quality meat, or they retreated from habitats transformed by people. People changed the environment significantly and the surroundings of their settlements – they cut forests, the established fields and settlements, farmed, filled parallel stream channels and kept surroundings of settlements treeless by grazing domesticated animals. All

this meant the loss of habitat for beavers, even though human influences were located mainly in the fertile parts, in the valleys and floodplains along the banks of watercourses.

Beaver settlement was during the Ancient period probably of an areal character. In addition to the original settlement of lowlands, it included also larger areas at higher altitudes (mountains and foothills) that Neolithic farmers, according to records, inhabited sparsely and very temporarily at that time. Even if human settlement of farming people significantly pulsed and despite the considerable hunting pressure on beaver populations, there were large parts of the countryside, where beavers could dwell undisturbed. On the other hand, constant movement of groups of hunters-gatherers must be taken into account. In Europe they coexisted and intermingled with Neolithic farmers long after the arrival of the farming tribes. There can be no doubt that farmers or hunters systematically hunted beavers. Farmers used as a source of livelihood not only what they had produced but understandably also wild animals – but rather at places of farming. E.g. in conditions of Bohemia, farming was situated in the so-called 'Old Settlement Basin', it means in low-lying parts near watercourses within central area of Bohemia. In contrast, hunting groups of hunters-gatherers moved to much larger areas, which very likely involved the rest of today's Bohemia and Moravia except the Old Settlement Basin. Principal difference between farmers and hunters lies in a different approach to the exploitation of natural resources by Man, and therefore, the possibility of regenerative ability of these resources.

Evolutionary advantage of farming tribes' strategy (which actually lasts until today) is the ability to repeatedly grow sources after harvesting – faster than natural recovery (field crops), or to maintain sources still alive and use their parts or products (domesticated animals). In contrast, the hunters could not wait for the slow natural recovery after hunting up all potentials, but they had to travel to another area, where there were plenty of sources. From the perspective of beavers, it is an essential aspect, since they were probably quite massively hunted in the Old Settlement Basin and it could lead to rapid decline. However, sufficient ability of beaver populations to regenerate (which is typical for beavers and can be observed even today) allowed basically sustained survival of beavers in the upper parts of streams, where the intensity of colonization by people was minimal (areas inhabited by migrant groups of hunters), and where they were also probably hunted, but the intensity could not be so high to cause their complete elimination. These less exploited habitats of beavers were a source for settlement of parts of the population that were hunted up due to intensive hunting by farmers.

It can be said that the beaver was in those days hunted sustainably. However, the extent of its settlement probably fluctuated. It can even be said that the beaver was in those days for people a vital source of food. In various Holocene periods beavers were hunted rather vigorously and were among the most common species of hunted large wild mammals (documented for Central Europe).

Aside from Central Europe to the Middle East, we can work out the other evidence on the impacts of human civilization on the beaver population. First, there are signs of beaver occurrence due to skeletal remains from Syria from the period of 3,000 B.C. Interesting is a place of discovery, it is a part of the findings of bones in archaeological excavations within human settlements, where beavers probably lived, were hunted and eaten. Although it could be the result of trade with distant countries in the north (where beavers lived abundantly, e.g. Turkey), but (slightly speculatively) transport was not very fast during that time and to transport alive let alone the dead beavers was not realistic (there are already written records of the trade with beaver furs and glands, but without skeletons).

Apart from that, however, skeletal remains of a much larger scale were documented from

Mesopotamia; but these findings are dated long before the development of Mesopotamian culture. This seemingly surprising evidence of the former settlement (areas which are today climactically unsuitable for beavers) should be viewed in the context of the natural conditions of that time. Middle East (Syria, today's Iraq and Iran) had far more convenient natural conditions for the existence of species such as beavers. Although the climate was not very different from the current (compared to the 20th century), it was perhaps a little wetter and colder. More interesting is that beavers appeared in this area in the earliest Mesopotamian texts (2–3 millenniums B.C.). In these oldest human documents had already mentioned the benefits of castoreum (product of beaver glands, see below) and there was also surprising information which showed that beaver dams on the Euphrates from time to time hindered trade, which took place on the river.

Exploitation of beavers in this region was probably intense, and probably ran continuously until the complete elimination of the local population. However, relief of beavers are even documented on ornamental figures from northern Syria in the last millennium BC. Pliny the Elder (77 B.C.) later described in his extensive encyclopedia Naturalis Historia that beavers were fairly abundant in central Turkey at that time.

Furthermore, the beaver appeared in Europe's oldest texts quite often. Already mentioned Pliny the Elder presented also a way of life and a description of food of beavers, talked about their strength, the danger, and the way of gnawing trees. Probably the oldest European document, which mentions the beaver, is a collection of Aesop's fables from the 6th century B.C. Here is probably the origin of the legend that eventually appeared in the ancient and modern time's literature. This legend speaks of fleeing beaver "… Once upon a time, as one of those creatures was hard pursued by the dogs, and knew not how to escape, recollecting with himself the reason of his being thus persecuted, with great resolution and presence of mind, he bit off the part which his hunters wanted, and threw it towards them, and by this means escaped with his life." (It had been thought that castoreum was produced by the genital glands.) Many other Greek and later Roman philosophers described beaver, incl. for example, Aristotle, who likened and connected the beaver with the otter.

Here it is necessary to make a small anatomical and physiological digression, because castoreum was mentioned. This beaver product is playing a key role in further historical overview. Both species have two pairs of glands, which are located at the anus (e.g. dogs have one pair of anal glands). One pair produces a substance called castoreum that is a product of excretion of salicylic acids and resins contained in woody plants (especially willows and poplars). The resulting product – castoreum – contains a considerable amount of phenolic, neutral and acidic substances. A second pair of glands produces a gel-like mass, which primary purpose is protection for beaver fur (like birds have a gland for feather protection), and it also holds identification scent information. Secretion of both glands are used for beaver chemical communication (olfactory communication) within families and among members of the population. Especially castoreum, which became a very precious substance that has found enormous use in pharmacology, cosmetics industry, and we cannot ignore popular sexual use (aphrodisiac properties are attributed to castoreum; but just as unproven as the products of other animals…).

Middle Ages

The relationship of beavers and human civilization continued to develop during Middle Ages in Europe. Beavers were more and more appearing in the pleadings and people changed their approach to nature.

In Central Europe there was Great Migration of the Slavs at the end of the Roman era

which brought a change in land use resulting in its lower use. Landscape overgrew more and human influence on the environment declined, which definitely suited beavers. Nevertheless, hunting performed by the original inhabitants or newcomers Slavs still existed and continued. Beavers were still present in the Czech lands and were important objects of hunting.

To illustrate, we can specify what form of land use had at that time. Both first state groupings which were founded on the territory of our country (the Great Moravian Empire and subsequently Czech Kingdom) were defined countries and were defended with external borders. Otherwise settlement within these countries acted as a set of settlements and towns interconnected by paths. The density of people in the countryside outside the medieval seats was at a low level and we can say that the non-residential landscape still had very natural characteristics. The exceptions were small farming villages, where the landscape and the soil were under direct and intensive human pressure. Extensive border areas, however, were without areal human settlements. Compared to the prehistory and ancient history natural conditions did not change too much until the peak of the medieval period which meant for beavers enough habitats without human influence. Human population expanded from the lower parts to the higher ones at the turn of the 13th–14th centuries. This led to the occupation of mountainous areas in the border regions and to the development of human settlements and farming in those areas.

However, the impact of farming on the landscape grew with the development of the human population in the Middle Ages. An essential aspect is erosion of deforested land and drift of materials into watercourse floodplains. This led to the development of large floodplain sediments, and new habitats – floodplain forests – began to develop near rivers. Originally, countersink stone riverbeds become clogged; they formed broad flat floodplain areas. Due to the frequent and extensive floods, places near rivers which were for centuries inhabited were becoming uninhabitable and abandoned. These accompanying phenomena of changes in land use rather supported the development of beaver populations and strengthened the position of the species on the landscape. Complexes of floodplain forests in broad floodplains full of parallel river channels become impenetrable areas with their own inner life. People entered these areas only because of hunting. Beavers were still heavily hunted, but they had enough space for the development of strong populations and were able to compensate the intensive hunting.

On the other hand, at the end of the Middle Ages, the landscape was divided into smaller feudal units (manors), which were already starting to access natural resources from the point of view of property. The first ways of controlled and regulated hunting in natural habitats were created (beside work on feudal property, giving some products to the monarch). Rights for hunting certain species of animals started to be established, some people were given responsibilities in the management of natural resources. Since the 12th century there was documentation of an institute for specialized beaver hunters, people who were asked to watch beavers, grow and hunt them; these were privileged people dedicated to the work with beavers. Although beavers were (as otters) at the time considered to be fish, they were a highly prized natural hunted source. In the Middle Ages, the quality beaver fur was still of constant demand, for example couriers of Ottokar II of Bohemia carried beaver furs as gifts to rulers in the Middle East. Furthermore, the beavers were hunted as a source of very tasty and coveted meat. The beaver becomes more significant also due to the fact that it was considered to be a fish, and fish generally could be consumed in the Lenten season. The right to hunt beavers was not common; monarchs stipulated caught beavers for their receptions. A beaver tail was considered as a special delicacy. And castoreum was heavily traded.

After the end of the Middle Ages (the 15th –17th centuries) drop of beaver population in Central Europe began to be noticeable. Professionalization of hunters (incl. specialization in hunting of beavers), feudalists requirements for furs and meat, and Renaissance urban development and development of human society had marked influence on the abundance of beavers. In particular, further development and intensive farming, and generally enlargement of the scope of the cultural landscape, dwindled living space of beavers because there was a gradual transformation of floodplains into fertile farmland. Vast floodplains started to be drained massively, parallel river channels, oxbow lakes and pools were land-filled, floodplain forests were grubbed and fired.

In this respect, it was a common phenomenon typical for a large part of continental Europe. Equally intense and uncontrollable hunting of beavers (as in our country) also took place in other European countries (German countries, France, the Netherlands, etc.). For example, in England the beaver was exterminated already in the 14th–15th centuries (in Scotland in the 16th century). In principle, the reasons for reducing were everywhere the same – loss of habitats and massive hunting caused extensive degradation of the grounds of beavers throughout Europe. Indispensable reason was the relentless interest in materials and products from beavers – castoreum and fur – which were transported even at great distances throughout the Middle Ages. When we go back to the Czech lands as early as the 16th century, it was not possible to meet the demand for castoreum from domestic sources, which means that it was necessary to import it.

From an economic perspective, the mentioned situation always led to the growth of prices of the commodity, which in effect meant a growth in demand. In this case, it is clear that the rate of decline of beavers had to grow as beavers disappeared and became rarer and rarer across whole Europe. Moreover – provided that rumours about the effect of castoreum considerably overestimated its real effect – the product became more and more desirable and in accordance with it also adequately expensive. Therefore, the impact and pressure on the remaining settlements of beavers was intense and in some regions even fatal.

Modern History

After the end of the Middle Ages (turn of the 16th–17th centuries) a new phenomenon – now called cultural landscape – occurred in the Lands of the Bohemian Crown. Until the mid–19th century, there was decline in forest cover, increase in human population, appropriately increased pressure on land and the requirement for increasing the acreage for farming. From the perspective of beavers, pressure of human society was in its peak. Previous mentioned historical periods have a common denominator; the beaver was almost entirely eliminated for two reasons. Beavers were always (since Palaeolithic), like other wild mammals and birds, a logical source of meat and other raw materials.

Despite the reduction of natural habitats in the Middle Ages, newly developed floodplain forests (due to deforestation and massive erosion) were for beavers a new, but highly suitable, ecosystem. Thanks to its impenetrability for people, these new habitats become beavers' long-term reservoirs where they could more or less survive. The intensity of the hunt there was probably relatively low considering the difficulty for hunters to move in these stands. However, in the description of previous historical periods there was described a simple economic model, why beavers became a highly prized commodity. A market price of desired castoreum was so attractive that the pressure to capture each beaver was enormous (in Europe). Development of floodplain forests could not permanently secure the beaver population, it probably only slowed down definitive reduction of beavers in our country.

Extensive wetland areas around large Czech and Moravian rivers (e.g. Moravia on Haná, Central Polabí, and lower Poohří) or the South Bohemian fishpond basin were

the last areas where beavers lived the longest. However, neither floodplain forests could completely protect the beaver before a definitive end. Until the mid–18th century beavers were completely exterminated from the wild of our country.

So far not mentioned but significant factor of reduction of beaver population (in addition to hunting and reduction of habitats) was the final development of the cultural landscape in the Renaissance. At the turn of the 16th and 17th centuries Jakub Krčín continued at work of Štěpánek Netolický, and an extensive South Bohemian fishpond basin began to develop. However, since the High Middle Ages fishpond management was in the Lands of the Bohemian Crown more and more preferred method of land use. Pond systems also existed in the areas of Polabí, central Moravia, etc. Given the fact that the former ponds (and also many of them even today) had earth-fill dams, the beaver was an unwelcome resident there. Besides the existing causes of beaver reduction (hunting and loss of habitats), in the Renaissance and Baroque beavers were eliminated also for fear of damage to ponds which were extensively used and managed in that time. In the Lands of the Bohemian Crown in the 19th century, the economy of fishery and fear of damage in towns (e.g. Třeboň) came into direct conflict with efforts to restore extirpated beaver population.

In the 17th and 18th centuries in Europe, beavers became scarce, so these were the first initiatives to protect their status. For example, the Salzburg manor enacted stiff penalties for the killing of beavers, but it did not help and beavers were exterminated. In 1706, Prussian King Frederick I issued two decrees to protect the beavers in the Kingdom of Prussia, but the beavers had a rare presence in the space of today's Germany. The protection of Bavarian beavers was also considered, but it came too late. In Prussia, the protection was later extended to otters – to avoid confusion of otters with beavers when hunting them. The protection came at the last moment, near Magdeburg and successfully preserved and protected the residual population on the Labe (Elbe) River. Another success was the protection of the residual population of beavers in southern France, although it came across similar problems as Czech fish farmers. Since beavers damaged dams, there were announcements of rewards for shooting them, however, beavers were successfully preserved here. The third residual population in Europe was saved from extinction in southern Norway; the Kingdom of Norway issued a law on the protection of beavers in 1845. The motivation of all these protective efforts was to preserve beavers for sustainable source of castoreum. It means it was not an effort to protect beavers as an animal species; it was just a pragmatic business model.

Given the rarity of beavers and their eminent lack of, there arose an effort to return and breed beavers in semi-wild nurseries also in the Lands of the Bohemian Crown. It was a merit of Schwarzenberg manor. In the first decade of the 19th century, beavers returned to South Bohemia to the area of Třeboňsko, where they were first released into enclosures and then released freely in wild countryside. A penalty was also introduced. Beavers prospered quickly and successfully expanded into the wider surrounding (during the flood in 1830 they came even to Prague). But problems related to the activity of beavers were increasing in this important fishpond area. The initial effort to protect them soon changed, and the result was a final liquidation of beaver settlements. An official order for the catch of beavers was issued. At the same time beavers were also hunted illegally, because the price of castoreum was very high. In 1876 the last living beaver was captured in South Bohemia, after this year there were no more beavers in the South Bohemian region.

As the number of beavers fell sharply in Europe and the demand for their products was still less satisfied, other source of beaver fur and castoreum rose in importance. With the discovery and gradual colonization

of America, a huge source of raw materials – including almost "infinite" North American population of North American beavers – opened. Considering the minimal visual differences between North American and Eurasian beavers (both species have anal glands) the replacement of one species with another was natural and simple. Hunting beavers in North America became a huge and profitable industry. Thousands of trappers annually delivered to the eastern shores of North America hundreds of thousands furs of large mammals, among which beaver furs dominated. Most of the goods was then shipped to European markets, where was processed in fur and millinery manufactories. Countless number of companies were founded in connection with fur trading.

We can say that hunting and the fur trade was a significant source of income for many North American states and other groups at that time. A significant role in this trade was played by beavers; American experts even claim that before the discovery of oil the beaver was a trading article which was the most important for the export economies of North America in that time. In the 19th century the Hudson Bay Company prevailed in the trade with beaver furs. An area from which they took furs included a huge area of today's U.S.A. and Canada – from the Rocky Mountains in the west to the east coast, in the north the territory reached the Arctic Circle, in the south the operational radius of the company ended at the level of the Great Lakes. To illustrate it, just between the years 1769–1868 the company's accounting registered nearly 5 million beaver furs; most of them ended up on the European market (a large number of the furs was used for men's fur hats and bow hats which were very fashionable in Europe in that time).

So after nearly absolute extinction of beavers in Europe, demand and attention swung to the North American continent, where the hunting of beavers was possible to a much larger extent. However, beaver population had its limits even here, and in the early 20th century North American beavers were also on the verge of extinction.

After that, efforts to return beavers to the North American continent as well as to Europe and Asia took on intensity. In Russia and Sweden, the first reintroduction appeared already in the 20s and 30s (the first projects to protect and support beavers were introduced in the same period in the U.S.A.). Relict populations in France, Germany, and Norway served as a basis for the spreading. Eurasian beaver also survived in several small populations in Russia (now Belarus at the Ural area) and in Mongolia-Russian borderlands. However, during the 20th century, the activity to return beavers to the European countryside had more than one motivation. The first, mentioned above, forms of the protection of beavers (in the former Prussia, Norway, and South Bohemia) were motivated by saving the species as a source of various products. Although this approach was still valid, even in the 20th century (e.g. in Russia), another view appeared at the turn of the 19th and 20th centuries. Extensive reintroduction of species that occurred in Europe and North America in the second half of the 20th century was motivated by other than only pragmatic motives to preserve the beaver as a source of various materials.

1.2 The Current View on the Beaver

As can be seen, the approach to the beaver has historically changed significantly – from initially pragmatic approach to products from beaver body, which culminated with unavailability of highly desired castoreum, the approach shifted to the first efforts to protect beavers as an important species. At first it was purely rational (in order to preserve valuable material) but later the protection of beavers focused on preservation of the bare existence of the species. In the 20th century this approached culminated in a massive and successful wave of reintroduction.

Now, an approach towards beavers in Western and Central Europe collides in two

philosophical attitudes: protectionist or humanistic. Either the population will continue to be protected (with the possible state support in dealing with conflicts and damage) in an effort to eliminate the risk of a recurrence of extinction (protectionist attitude). Or protection will be cancelled completely; the beaver will become a commonly hunted animal that will be locally reduced in response to emerging conflicts (humanist attitude). These are the extremes of one problem, a solution is somewhere in the middle; a definite position of beavers still must undergo an intensive Europe-wide social debate.

When we return to the first half of the 20th century, it is necessary to mention a fundamental change in the approach to beavers when their protection or reintroduction aimed to rescue the species from extinction (leaving aside preservation of sources of castoreum). In the last century a new approach was developing – purely protectionist – and amateur or professional natural scientists were at its origination. The protection of residual populations of beavers in France, Sweden and Saxony-Anhalt was initiated and supported by the staff of museums and universities.

An approach to nature began to change dramatically with the development of the protectionist point of view. Generally, it is originated in the conservation paradigm that, highly simplified, is based on an effort to help the weaker and oppressed (organisms on the verge of extinction). Especially in the second half of the 20th century, this view evolved into an extensive worldwide protectionist movement. Eventually, the whole mental approach to conservation of nature and natural resources has been institutionalized and it has become a part of the government and international policies.

It is a counterweight to the humanist approach, which has always lasted and as an alternative still lasts. The basic characteristic of this trend is the perception of nature and its parts only through the prism of their performance and usability for people – natural resources are there only for availability of people, who can use them completely and totally. The basic weakness of this approach is the consideration that resources are infinite. The second problem is clear anthropocentrism, when at the time of the dispute between nature and people, the interests of people have obvious and undisputed power (at the expense of nature). And in the 20th century, the protectionist approach became a distinctive counterweight to the humanist approach.

The beaver in these changes and attitudes represents a considerably difficult position. Until the beaver population was seemingly endless, there were not any problems with its exploitation. However, beavers were exterminated in large parts of Europe and later North America. At the same time, formation and development of the cultural landscape in the Renaissance and Baroque put the beaver in a new light, because in addition the beaver became a conflicted and unwanted species.

During the 20th century (and particularly in the second half), the attitude towards beavers swung to the side of protectionism. Ambitious projects for the rescue and rehabilitation of populations arose across Europe, Russia, the U.S.A. and Canada, which have been successfully implemented. It was not a controlled global operation; individual states involved became involved in these activities due to the protectionist elites. In our neighbourhood, the reintroduction took place in each of the neighbouring states – in Bavaria from the 60s to the 90s, in Poland from the 70s to the 90s, in Austria from the 70s to the 80s and in the former East Germany since the 50s of the 20th century. In the mid–90s there were several waves of re-introductions in our country as well. In general, it was a success that relatively quickly rehabilitated local viable populations – initially isolated, but later connecting. Regarding the fact that in the early 20th century, an estimated number of beavers was 1,200 individuals across Eurasia, and today the estimates speak about a minimum of 1 million individuals, we can only talk about

the success (it is a question whose contribution was greater, beavers´ or protectionist, but the result does not change anything).

The success of the beavers' return is based on a combination of several important factors – (I) the beaver is a generalist (it inhabits a wide range of conditions, which is also able to adapt), (II) it is not a food specialist (it eats a wide variety of plants and trees), (III) in the environment of watercourses it has no competitors or predators, (IV) after the Second World War, there was the development and protection of aquatic ecosystems, incl. riparian vegetation (which is environment of beavers), (V) and finally, the beaver was and still is a protected animal.

Generally, we can speak about a highly successful comeback of one species endangered with extinction, which in its return surpassed the wildest protectionist ideas. On the other hand, it is clear that a return to the species with the far-reaching impact and the ability to modify the conditions is not accepted only with enthusiasm. Two, above mentioned, approaches towards natural resources – protectionist vs. humanistic – are colliding here. The protectionist attitude sees beavers more soberly. On the one hand, it welcomes the return of the species which was endangered with extinction, while figures are rational awareness of the problematic and conflict potential beaver. On the other hand, there is rational awareness of the problematic and conflict potential of beavers. On the contrary, the humanistic approach finds beavers useless (due to the modern shift away from the use of beaver materials – castoreum and fur), or rather undesirable. In this approach, negative emotions – from the belief that the beaver does not belong into the current cultural and technological landscape and it is the foreign element – prevail. To support this attitude, the examples of conflicts and financial assessment of the damage are documented across whole Europe.

The future and the already mentioned debate will reveal further fate and direction of beaver populations in Europe. Nevertheless, a substantial contribution is, and will be, consideration of a very valuable benefit that is connected with the colonization of European landscapes.

1.3 The Beaver as a New Element of Central European Landscape

As follows from the previous chapters, the beaver has always played a significant role in human use of the landscape. However, the conflict arises with the intensification of the use of the European cultural landscape – a place for beavers ceases to be here. The initially welcomed source of materials has turned into a hated player that "interferes, is an extra here, and its occurrence is problematic". People see "beavers´ idea of living here" more or less in contrast with their own idea of land use.

After a successful return, the position of beavers is in a new light again. The beaver is viewed in terms of the conflict species that locally but frequently reduces or makes completely impossible current use and care for the landscape. Stronger contours of the problem are seen in the central European landscape where it is more crowded. There arises a strong need to utilize all components of the environment (land use purposes – e.g. agriculture, forestry) or functional role (preservation of protective and infrastructural elements). The functional role of the landscape (e.g. against floods, erosion) is based on clearly defined technical elements. These elements are created in the way to fulfil protective functions with a certain degree of reliability. To ensure flood protection, stability of roads, etc. requires certain technical rules derived from the probability theory. For example, it is possible to count and expect with certain predictability particular rainfall, which will safely divert away with the help of appropriately dimensioned components. However, new species of animals (especially the beaver) behave more randomly and for the technical management of the landscape unpredictably.

The second related problem is the negative impact on the proper function of protective

elements (notwithstanding the possibility of their destruction). Moreover, the existence of beavers is not long enough to have adequate experience with the fact where and how intensely their presence may affect the functionality of the protective elements in the landscape. Although beavers also influence the character of watercourses and they form new elements, for the time being these are un-parametrized, and it is very difficult to predict their (rather random and uncontrolled) effect on the protective function of the landscape. In the current concept of the Central European landscape, it is a technical, legal, and economic issue.

Besides the impact on infrastructure and protective elements in the landscape, beavers today also cause some land use damage. Generally, it is possible to specify three basic types of damage which can be caused by beavers – damage on forests, farms, and fishponds. The reach of this damage is not areal. Even with the full saturation of the landscape by beavers, damage will not occur up to 100% of the area of the Czech Republic. The influence of beavers on the surroundings of watercourses and water areas is up to 20 meters from the bank lines. However, we can expect an event related to beavers in almost all watercourses – starting with headwater areas and ending with large lowland rivers. The resulting damage will consequently linearly permeate the vast majority of the Central European landscapes. In the future it is necessary to anticipate conflict situations anywhere in our ecosystem in the vicinity of watercourses and water areas (except for the extreme habitats and mountainous or underground locations).

1.4 Dynamics and Cyclicality of Habitats Settled by Beavers

An essential aspect of all problematic situations, that beavers create, is that they work temporarily. New elements and induced impacts are not, with some exceptions, of a permanent character (e.g. a beaver dam will disappear sooner or later due to a watercourse activity). It is related to the lifetime of beaver settlements (more about territoriality see **Chapter 5.3.3.3**). Beavers after usually arriving at the site, adjust the parameters of the channel according to their needs (they build dams, lodges, cut down woody plants), and by these means they protect their existing settlements. However, these modifications will be maintained only until the time beavers leave the site, which is in the horizon of two or three decades max.

Each beaver settlement (territory) has its internal dynamics depending on the availability of food resources, which are available at the site (especially woody plants, see **Chapter 5.3.4.1**). An offer of preferred woody plants around watercourses is always finite; beavers sooner or later consume those woody plants that they prefer (though not all, rejected woody plants remain). Even if the loss of woody plants caused by gnawing is partially compensated by regeneration of shrubs and trees, restoration of vegetation is always slower than its consumption by beavers. According to some experts, in our country the existence of the settlement on one site can be expected from 5 to 15 years on average. If the amount of food resources falls below the carrying capacity level, the habitat is abandoned and beavers move their territory to another place (sometimes just a few hundred meters upstream or downstream). This location is then abandoned for several years, when the woody plants can gradually recover. Subsequently (cyclically) the location may be settled again.

The mechanism that enables this cycle has a long evolutionary history of beavers´ relationship to food. This concept is called coevolution, when an adaptation of prey (here a woody plant) occurs due to an influence of a predator's (a beaver's) gnawing. It lies in the ability to produce quickly and vigorously new offspring (coppice production), which is just a defensive response of the woody plant to the massive grazing. This principle is evolutionary attributed in some woody plants near watercourses to the selective effect of gnawing beavers. Trees and shrubs that are most frequently

and to the greatest extent found on the banks of watercourses and areas (soft meadows – willows and poplars) had to build this resistance to continuous grazing. For example, willows are able to rejuvenate from almost any part above ground, at poplars (and other woody plants – maple, etc.) re-restoration is performed by sprouting capacity. This self-preservation reaction (against intensive gnawing) is also supported by the chemical action – chemism of young shoots has allelopathic effects (they are disgusting due to an intense concentration of certain growth phytohormones and tannins). This principle ensures in the habitats where the preferred woody plants were eaten by beavers that there is a quick renewal of the woody plants and at the same time the vegetation has possibility to grow – it means coppice stage of individuals is not gnawed.

In the longer term there is also another cycle which is caused in natural (and current anthropic) landscape by beavers, i.e. it is a principle that has always accompanied the beaver. The cycle is related to beaver dams and to some extent the cycle of renewal of woody plants (described above) is its subset. During the settlement of some habitats beavers help out in their territory by building dams (sometimes a dam system), and by this mean beavers increase the possibility to settle some watercourses (smaller watercourses into maximal width of about 15 meters). One of the fundamental reasons for building dams (more details on why dams are built see **Chapters 3.2**, **3.4** and **5.3.4.3**) is access to the preferred woody plants.

Intense falling of woody plants by beavers occurs in the vicinity of the resulting cascade of dams with water areas and waterlogged soil. At the same time, woody plants that grow in the flooded area and are not consumed by beavers are dying due to waterlogging. At the beginning, considerable treeless areas are generated when an open free water surface which is backwatered by a beaver dam is purged. Then their preferred woody plants are intensely gnawed near the water surface of the pond. The reach of these areas can be up to tens or hundreds of meters from the main watercourse. The next phase of this process is the gradual clogging of the water capacity above the dam, there is an increased sedimentation (as a result of a minimum flow speed in the part above the dam). Sedimentation with suspended load continues until a final sedimentation of the water volume of the pond. This creates a phase which is called beaver meadow, where there is vegetation succession, from the stage of slightly submerged plants (e.g. reed, cattail) it progresses through grass and low vegetation of waterlogged areas (e.g. sedge) to the phase of the shrubs development (esp. willows). The process then culminates in the development of a level of woody plants (willow, poplar, alder, or birch). It means that the whole cycle is closing and returning to its origins – closed stand of woody plants (soft mead). It is the natural dynamics typical for beaver settlements (where beavers build dams). However, this process also probably has Holocene historical value. Because of this effect, beavers can be included into a group of (rather large) herbivores (aurochs, bison, horse), who secured with their activities creation of treeless areas in forest areas. The obvious side-effect of the beaver dams' cycle was the support of habitat of heliophilous species (e.g. daily butterflies) that could survive in the mosaic of these glades (also beaver ones) during the Holocene wooded phases.

1.5 The Beaver as a Significant Natural Factor

After its nearly absolute extinction, the beaver began to spread again, but in the 20th century it returned to a very different landscape and land use framework than when it was leaving the European space.

Human impact on production areas in Europe over the last 70 years has changed considerably; there has been a massive intensification of land use. Transformation of methods of cultivating the fields, management of water regime, fragmentation, and at the same time unification and homogenization

of production areas have serious impacts on the stability and function of the biological elements of the landscape. Some negative feedback of ecosystems is disrupted, etc. There is a gradual disintegration of anthropogenically influenced ecosystems and loss of ecological functionality of intensively farmed landscape (on the contrary, the ability of a man-scientist to identify these problems and quantify them – which is possible only by using modern techniques – is obvious today).

Regarding all these, the beaver activity can be viewed from a different perspective. Indisputable ability to re-naturalize the vicinity of watercourses and their ability to bind to modified habitats groups of dying organisms, plus the ability to affect positively the hydrological balance throughout the watershed – this all makes the beaver a significant helper in many situations. Places where beavers live in the current landscape are clearly visible (even for a layman). Even if it is just about the easiest beaver activity – gnawing trees. Increasingly, it is possible to meet more developed and sophisticated approaches in European landscapes; how beavers respond to the conditions of the cultural landscape. Beavers do not care what origin (natural or anthropic) for the location that they determined to occupy. But always the result is that they are able and fiercely willing to change and maintain parameters of settled areas. Beavers, to their own misfortune, leave behind noticeable marks and they reveal themselves – they do not live a hidden life; so that no one wouldn't be able to notice anything. Everybody, even illiterate in biology or a random stranger, notice beaver dams, pools in their surroundings, and dried or fallen trees. The beaver is after its arrival usually quickly discovered. Naturally, the beavers leave the strongest negative mark in the eyes of the owners of the damaged land, who shake their heads in disbelief and say "There has never been this …" In the cultural landscape of Central Europe, re-naturalisation according to beaver scales acts like a sore thumb.

It is important to note, however, one significant aspect. Creation of "wilderness and clutter" – i.e. not mowed and waterlogged areas with broken and felled trees, which will eventually dry up – is in a linear and mowed landscape really noticeable phenomenon. This would be a completely natural phenomenon in uncultured and uncultivated landscape and we would usually not notice it (in the past or at places distant to human impact). But on the other hand, this element is often biologically and ecologically valuable and it can significantly enrich anthropo-cenosis (the landscape limited only by human needs). The only problem is the scope and scale of the impact on the productive and protective functions of the landscape components. Due to the mentioned activity, the beaver is becoming unwelcome, unwanted, and unpredictable alien element in the Central European landscape.

Now, where is the problem – in people who have transformed the landscape of their own image, or in beavers initiating a more natural habitat? On the one hand, there is Man who has modified the European landscapes to such an extent that today there is a problem with maintaining their sustainability (impact on the hydrological system, erosion of fertile soil, loss of function of agro-ecosystems, etc.). On the opposite side there is the "destroyer" beaver, which, however, influences some of these problematic aspects, and in principle it can be said that from the bio-ecological point of view this influence is positive. It would be possible and even appropriate to say that the presence of beavers in some places of our landscape should also be a welcome stimulus and solution of some problems. The following overview introduces two most important levels and what effects the beaver dams have on the current landscape.

1.5.1 Hydrological Effects of Beaver Wetlands

Beavers are ranked among the key species of settled ecosystems. Through their intensive activities (especially construction of dams)

they are able to create wetlands – complexes of waterlogged treeless areas. They are the initiators of the system of differently big and deep pools with open water level and surrounding large waterlogged areas with low groundwater level. Mainly smaller watercourses (see **Chapter 5.3.3**), which beavers are able to dam, have potential creating systems of dams.

Impacts of an individual beaver dam and mainly a system of dams on a watercourse and its floodplain are significant and affect a wide range of their parameters. This is significant for example, the impact of dams on suspended load regime of watercourses. Dams cause backwater, slowing of the flow velocity, decrease in transport capacity, and thus sedimentation. The rate of clogging created beaver basin with suspended load depends on the intensity of erosion processes in the watershed and stream channel above the dam. However, according to the extension of the dam systems, the clogging can be from tens to thousands of cubic meters of suspended load. The primary objective of a beaver dam is to ensure water depth of about 0.8 meters, which allows access to other attractive areas. In the case of clogging, further elevating of dams can follow, or vice versa burrowing of channels in the surrounding land. Intensive clogging may cause complete filling of created basins and changes in the morphology of the floodplain. Above described processes will be reflected by reducing the load of suspended load in downstream sections of the flow, by reducing the longitudinal inclination of the stream bed, by slowing the flow, and by subsequent changes in the morphology of river channels. With a high degree of probability branching and meandering of the river channel will occur. However, the real state will depend very much on the nature of the floodplain – the cross section, vegetation and other parameters.

Increasing water level in the floodplain due to a beaver dam will cause increasing level of groundwater in the surrounding areas. The range is dependent on the transverse profile of the floodplain and surrounding areas, but waterlogging can reach – depending on the slope of the terrain surface and soil characteristics in the floodplain alluvium (due to the height of the capillary rim) – tens and in extreme cases even hundreds of meters. In natural landscape this process will result in a change in the composition of vegetation (woody and herbaceous); in the agricultural landscape it will be undoubtedly a conflicting point because the affected land is not arable.

A beaver dam, which forms basins – either isolated or in a continuous cascade – creates a considerable retention area. Due to the fact that the beaver's effort is to keep a permanent minimum level in the basin, it is not possible to talk about a direct retention effect in connection with floods (because the available space is still filled with water). However, basins have undoubted transformative effect that will be directly proportional to the area of the water level of the basin. According to the measurements made e.g. in the UK, a transformative effect of cascades of beaver dams on the transformation of peak flows was up to 30% (at a small watercourse with some agricultural watershed, where the beaver dam encompassed about 1/3 of the length of the watercourse), which can be considered as a significant effect. The effect will obviously decrease with the size of the watercourse and the size of the watershed. On the contrary, the risks associated with potential tearing of beaver dams are usually overstated. An individual beaver dam rarely exceeds about 1.5 m and due to its construction with a high proportion of branches, sticks and other parts of plants basically excludes creation of a shock flood wave. The amount of the debris – transported by the watercourse – may be a bigger threat. And it means that the management of the underlying sections (protection against clogging, etc) must be adapted.

Another effect is the impact on the hydrological regime of the watercourse. Beaver dams, respectively the cascades, can act as a retention space, equalizing the flow during the year. Since a beaver dam is never completely impermeable, continuous outflow of water is

ensured. In the case of a reduction of the inflow to the basin, water level begins to drop and the beaver tries to prevent water leaks – either with sealing up an existing dam or its raising. In any case, however, certain drains necessarily occur – and even during dryness situations. According to experimental measurements made in the U.S.A., volume of water retained in the basin of a beaver dam in some cases reached up to 30% of the volume of water available in the watershed (applies again to the upper watershed areas of small to medium-sized watercourses).

Above described brief overview can be hardly generalized and it is undisputed that beaver activity may have its hydrological positives as well as its negatives. The ratio between positive and negative effects and impacts is strongly dependent on the extent of land use. In the natural landscape (or landscape with extensive farming) where there is no pressure on space and intensive use for other purposes, effects of increased retention, and transformation by extensive ways will be seen generally positive. In the intensively cultivated agricultural landscape with a high population density negative impressions will prevail. For these reasons, Eurasian beaver is seen in Central Europe as a fairly conflicted species, even if many positive effects can be found in its activity.

1.5.2 Ecological Effects of Beaver Wetlands

In relation to the dam activities of beavers we can also talk about significant impacts on fauna and flora habitats of the watercourses and water areas. Generally, these impacts can be divided into influences direct and indirect. Beavers, like other grazing predators, consume a considerable amount of plant food. It is a life strategy of large mammals, which has clearly direct impacts (causing direct reduction of biomass of consumed organisms). In the case of beavers, terrestrial and aquatic herbs of aquatic ecosystems are consumed, which results in temporarily intensively grazed areas along the banks of watercourses and water areas. However, gnawing and felling woody plants of riparian vegetation is far more significant beaver activity. This intense feeding activity often results in forming small treeless areas in closed riparian stands. On such sunlit areas there are developed heliophilous woody plants, which in the long term may prevail along watercourses populated by beavers. Selective felling of the elderly individuals also changes the age range of riparian vegetation. As a result, the original riparian vegetation is being replaced (according to the intensity of gnawing) by younger formations of rather heliophilous woody plants (willow, poplar and birch).

Indirect impacts of beavers on biota are associated with the development of dam systems and succession of areas that arise in the surrounding. Changes caused by beavers in floodplains and in watercourses cause far-reaching changes to the flora and fauna across all groups. Enough nutrients and an increased level of groundwater create suitable conditions for herbs bound to water – both for literally underwater plants rooted in the stream bed (e.g. pondweed, myriophyllum, bladderwort, hornwort) as well as for plants with leaves and flowers on the surface of water areas (e.g. water lily, pond lily, lemna, spirodela and pondweed), plants both with submerged bodies and bodies on the water levels (batrachium), and the herbs that grow in the peripheral areas of water surface of the pond and waterlogged areas (sedge, bulrush, glyceria, iris, reed, cattail, meadowsweet, etc.). It means that beaver habitats are colonized by woody plants, either shrubs or woody plants. The dominant species are especially various forms of willow and poplar, on drying areas also birch or hazel, i.e. species preferring damp or even waterlogged sites.

It has been proven that watercourses, where beavers cerate dam systems, are significantly richer in invertebrate animals (e.g. damselfly, dragonfly beetles) than comparable watercourses wit no beaver dams. Significant are – diversification of the watercourse, changing the nature of the stream bed and banks,

flooding of surrounded floodplains, plus increased water temperature in the beaver basins and presence of dead wood. Important parameters are increased carrying capacity and high diversity of microhabitats. Countless number of arthropods (and other groups, e.g. molluscs) obtain considerable amount of varied and rich hunting grounds. Availability and sufficiency of invertebrates attract a number of species of fish that benefit from sufficiency of food, sufficiency of hunting grounds, shelters or places for reproduction. In our conditions, such habitats are preferred and widely searched by species both of flowing water and backwater.

Beaver dams and resulting pool systems are an important habitat for amphibians as well. Tailed forms can find their season-long hunting grounds, frogs use backwater for breeding. Tadpoles hide from predators in dead wood in pools; shallows provide protection from predatory fish. Warmer water in forest areas also plays its role; it accelerates the development of amphibians in the water. A system of beaver basins has its advantage because they are close to each other and have different succession stages. It is necessary to say that the beaver becomes an important initiator of habitats in the cultural landscape for this group. These habitats are then available to amphibians (in our country, the sites where the amphibians can reproduce quickly disappear or become unsuitable due to increased predation of fry).

The birds are also able to respond sensitively to creation and existence of a system of beaver dams, they use these habitats as hunting grounds or for nesting. Logic is the preference of free water level by anseriformes (ducks and grebes). Waterlogged floodplains with submerged vegetation are popular hunting grounds of ciconiiformes (i.e. herons, storks, etc.). Beaver habitats are used by charadriiformes (common snipes, common sandpipers, redshanks, etc). An observer may often register gruiformes (i.e. corncrakes, moorhens, rarely cranes) at the habitats flooded by beavers. Countless number of songbirds prefers wetlands induced by beavers (e.g. reed warblers, grasshopper warblers, etc.). As hunting grounds, these areas are also used by water-tied predators (e.g. marsh harriers, eagles); a rare osprey can even nest in these habitats. Dead wood of deciduous trees is colonized by bark beetles and wood-destroying insects, which is food for nuthatches, reecreepers, woodpeckers – picus, dendrocopos, and black woodpecker. Especially binding of woodpeckers on habitat amended by beavers is interesting. They often hunt in dray tree trunks dying as a result of the flooding with raised water level. Dendrocopos cerate in the torsos of the remaining trunks cavities, in which owls (e.g. pygmy owl) very often nest.

Beavers with their dams increase the attractiveness of wet habitats also for many small and large forms of mammals. Like birds, these forms are bounded to beaver habitats mainly due to the high abundance of their prey. Insectivorous white-toothed pygmy shrews, shrews and water shrews, from rodents – muskrats, nutrias, and water voles can be commonly found in these habitats. These habitats are highly preferred (for the high bid of insects) by the chiropteras (i.e. bats and horseshoe bats). Otters like hunting in waters rich in fish; minks and foxes are attracted also by other species of small vertebrates that are located here (young birds, mammals and amphibians). Habitats modified by beavers are commonly used by ungulates (boar, roe deer, deer, moose, etc.) with regard to the supply of herbs, grasses and young shoots of woody plants. For these large ungulates is another advantage. the fact that wetlands that are significantly warmer in the winter, freeze in cold conditions as the last ones. Another reason is that there is a lower snow cover, and therefore ungulates can get easier to food. Areas flooded by beavers are also preferred by elks which like consuming water plants all year round.

The above described a brief survey that shows which forms are generally tied to water ecosystems and their surroundings. And beavers create these habitats in the landscape. It

is not possible to say that these species would not be present in the landscape without the beaver, but because of the fact that the beaver induces occurrence of the mentioned habitats, it contributes significantly to increase of the number of many mentioned species of plants, and animals. In the cultural landscape the beaver increases species diversity and abundance because it develops and increases vanishing wetland habitats. Moreover, many of the above mentioned forms belong among rare or endangered species, because their natural habitats (or at least a significant part) are disappearing in the current landscape. The introduced summary of the impacts of beaver dams on agrocenosis is seen from a purely biological-ecological perspective, without consideration of impacts on the landscape commonly used by people. This aspect, however, is thoroughly discussed in the following chapters.

2 Management Plan for the Eurasian Beaver in the Czech Republic

In the Czech Republic the Eurasian beaver (*Castor fiber*) is an autochthonous species, which is protected by international conventions (Convention on the Conservation of European Wildlife and Natural Habitats), European legislation (Directive 92/43/EEC), and consequently also according to the Act no. 114/1992 Coll. on nature and landscape protection (hereinafter ANLP). At the same time, activities of this species in the countryside raise a number of conflicts with land use and other interests of a man.

In 2013 Ministry of the Environment of the Czech Republic adopted a management plan for the Eurasian Beaver in the Czech Republic. Management Plan represent a type of a conceptual document that is being prepared for varying degrees of endangered and protected species, which also belong to conflict species. Species, for which management plans are prepared, usually come into direct conflicts with the land use interests of Man. In order to maintain or create a sustainable state, it is necessary to solve or reduce the degree of conflicts. Management plans define a set of management measures, which should contribute to sustainable development of populations, while mitigating the negative effects associated with the occurrence of particular species in our country. Administrative, legislative, and educational measures are the main parts of these programmes. Measures of active care for individuals of a given species (e.g. capturing or releasing of individuals) are applied only to a limited extent. The aim of the management plan for the Eurasian Beaver in the Czech Republic (hereinafter referred to as Management plan or MP) is a setting of population management that would ensure the existence of a viable, socio-economically acceptable beaver population in our country. In particular, this involves the balance of existence of beaver population in the Czech

The terms "**conflict**" and "**conflict species**" are in relation to specially protected species of animals commonly (professionally) used intuitively and their meaning is clear. Nevertheless, for this text it should be appropriate to define them adequately at the beginning.

Conflict species are those species that negatively, directly or indirectly, affect human activities – either worsen and make it impossible to use the landscape and their components, or their impact on the landscape components and functions causes a direct and significant financial damage or other loss. Conflict species are not only specially protected species (such as large carnivores, otter or beaver), but also for example native and non-native species of ungulates (e.g. wild boar, cervus, sika deer, roe deer, etc.), carnivores (e.g. northern raccoon, American mink, marten, etc.), and also birds (e.g. cormorant, starling, etc.). The last mentioned species are particularly problematic in terms of their excessive abundance, which is purely a consequence of human-modified landscapes (i.e. maintaining unnaturally excessive food sources for the species, etc.).

Conflict situations caused by an animal is a situation when an individual (or group of individuals) either:

- directly causes property damage to owners, users, or caretakers (for beavers it could be gnawing woody plants, grazing on field crops, etc.);
- creates conditions for future damage (for beavers it is building of dams that within a few months waterlog production forests, construction of burrows in pond banks, etc.);
- their activity for a long time negatively affects the viability of technical elements in the landscape, there is no financial damage, but protective, functional, and preventive role of technical elements in the landscape is deteriorated (a specific type of conflict for beavers, e.g. worsening of water runoff from wastewater treatment plants, limitations of proper function of seepage canals, flooding of transport infrastructure areas, etc.).

Republic with socially acceptable volume of conflict situations. The set of measures of MP should reduce the conflict rate and contribute to solving problematic situations while maintaining the existing legislation, both in terms of protection of the species and also the system of compensations for damage and loss.

A range and number of conflicts is not currently adequate to a population size of beavers. Conflicts arise with a time lag from the time of the first settlement in an area. Noticeable damage in each region thus corresponds to a higher intensity of settlements. The first beavers in the region primarily occupy locations close to wild nature, away from technical elements in the landscape and usually further away from human settlements. Only the further development (an increasing density of beaver population) leads to the settlement of those localities, where beavers come into conflict with human interests. Now we can observe a higher degree of conflicts especially in the oldest populations in the Czech Republic (i.e. in Southern and Central Moravia and Western Bohemia).

The aim of MP is to reduce conflicts in the Czech Republic, considering expected size and density of the population in the future. Proportion of conflicts in relation to population size should therefore be reduced in the future, although an increase in the volume of conflicts (in absolute numbers and costs) can be assumed. In other words, a controlled development of the population is expected to be ensured, so that in the future the costs of our country and private entities to eliminate conflicts will not be enormous, although it is clear that the damage or various conflict situations cannot be avoided entirely. One of the essential tools how to ensure socio-economic sustainability of the beaver population in our country is to introduce and use the set of measures to prevent, reduce, or eliminate a number of conflicts caused by beavers – and information given in this handbook should contribute significantly.

MP has been approved for a period of 10–15 years, but with the option of revising targets and measures in case of significant changes in population trends. This document does not establish, and in the context of European legislation cannot establish, an areal regulation of the abundance of beavers. From a general biological perspective, spreading and development of populations have their own natural evolution. At the moment when the populations are stabilized (i.e. developing in size and density of populations is already finished), it is just suitable to introduce any potential management (i.e. regulatory catch). Too early and thoughtlessly introduced regulation of abundance could be counterproductive – regulation during population growth may increase fertility rate (female beavers may have more offspring on average, and the excessive loss in the population is compensated). Experience from abroad says that the horizon of 30–50 years of the age of the population leads to its finishing in population growth, when we can expect ecologically stable settlement henceforward. The intensity of management should respect the natural dynamics of the beaver population. Too intensive management can disrupt the population. Also, the degree of regulation should respect the society-wide consensus on the objectives of the catch in relation to the characteristics of the damage and risks in individual areas.

The discussion about the regulation has been lasting for several years; regulation cannot be the only form to reduce the number of conflicts with beavers in a landscape. As already mentioned, depending on the legislative conditions of beaver protection, it is always necessary to seek a milder solution first, and this handbook should contribute to it. At the same time, it is necessary to understand thoroughly the existence and function of beavers in our landscape, before overall regulation (and too fast regulation) is introduced. For our landscape it can be beneficial to learn how to use the positive benefits which are connected with beaver settlements, e.g. spontaneous renaturation of watercourses, restoring of wetlands, etc.

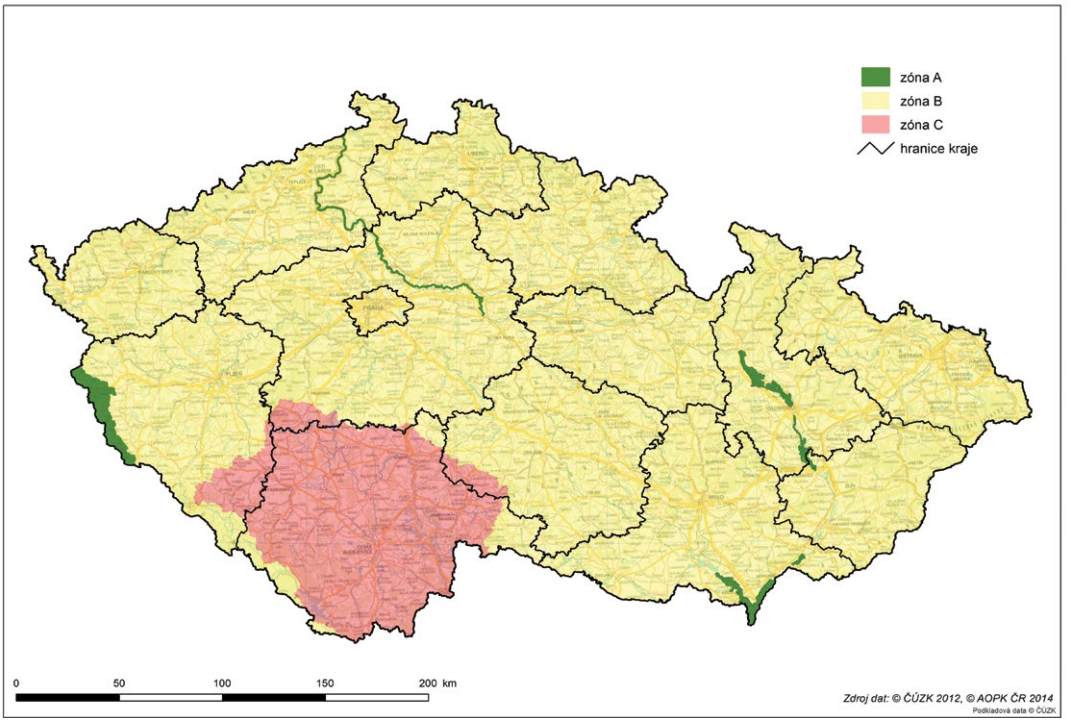
2.1 Zones According to the Management Plan

One of the main tools of the Management plan – is how to ensure acceptable development of Eurasian beaver populations in our country – is dividing the Czech Republic into three types of regions (i.e. A-, B-, C-zones, see **Picture 1**). There is a different emphasis on development and maintaining of beaver populations in each type of the region. A different level of interest in the protection of the species is considered, depending on the degree of risk of serious conflict situations. From this perspective, an approach to beaver population in different types of the region differs considerably.

The highest level of beaver protection is designed only for a few small areas of the Czech Republic (see A-zone), which are important for the species occurrence, and at the same time protection of beavers is necessary there in relation to designation of European Sites of Community Importance in the Natura 2000 network.

In major areas of the Czech Republic the interest in species protection is subordinated to the ways of the use of the landscape, its elements or functions (see B-zone). It should be allowed to develop beaver populations in places where there are not any significant conflicts. Situations with substantial damage should be dealt flexibly.

In a significant part of the Czech Republic (at the vast territory of the South Bohemian fishpond basin – see below) the interests of safety and protection of assets dominate over the interest in protecting the beaver population. It is so distinctive that the only appropriate measure is the elimination of any settlement of beavers (see C-zone). With regard to the character of the area and the concentration of highly vulnerable waterworks (historic fishponds) there is a risk of abnormal losses of over-regional importance.



Picture 1: A map of zones of differentiated protection of Eurasian beaver in the Czech Republic (source: NCA CR).

A-zone

The A-zone is the area with the highest level of beaver protection and it is mainly made up of eight Sites of Community Importance (SCI) included in the Natura 2000 network (the A-zone includes the broader surroundings of SCI). The beaver is a subject of protection in the area, so activities should also take into consideration the demands and requirements of the beaver (in addition to the requirements of other plants and animals). The reason for the existence of the A-zone is to ensure the long-term existence of the population in different types of environments in several parts of the Czech Republic. Any activity affecting beaver settlement should be assessed individually, given the need to maintain the favourable status of the population, and the beaver as the subject of SCI protection. For the solving of conflict situations caused by beavers in this area should be used primarily preventive measures, a set of actions, which are summarized in this handbook. The A-zone covers 1.2% of the Czech Republic and includes these SCIs: Labské údolí, Porta Bohemica, Kateřinský a Nivní potok, Niva Dyje, Soutok–Podluží, Strážnická Morava, Morava–Chropyňský luh and Litovelské Pomoraví. The minimum estimated number of individuals in the A-zone is 2,000 individuals. All SCIs include parts of the oldest populations in the Czech Republic, which can first be expected to adjust the numbers of settlements on a final stabilized level.

B-zone

In a transition B-zone the interest in beaver protecting is subordinated to land use and other interests of people in the landscape. The B-zone covers 85.5% of the area of the Czech Republic. The purpose of the B-zone is limiting negative impacts of beavers, which hamper the development, use, or maintenance of the landscape. It means a set of measures including soft measures presented in this handbook, direct reduction of beaver dams and lodges, and in justified cases local (not overall) elimination of individuals or whole families. Local elimination must, in accordance with the procedure laid down by law, demonstrably failed to prevent the application of soft measures. (Or it may be a part of the measure, e.g. removal of current settlements and at the same time implementation of technical measures to limit further damage or creation of another permanent settlement.) In this zone beavers will have the opportunity to exist, especially where they do not impede routine landscape maintenance and management. Otherwise, it is possible to access to alleviating or eliminating of conflicts without putting emphasis on the protection of the beaver (fulfilling the provisions of ANLP).

At the same time the B-zone should provide population-ecological connectivity of the A-zone areas. Therefore, it should allow the flow and exchange of individuals among different parts of the A-zone. In any case, the protection of beaver populations in the B-zone is not a priority, undisturbed occurrence of these rodents should be allowed only at locations where are no or are not likely in the future any serious conflicts.

C-zone

The C-zone is an area with a high risk of serious land use damage and threats to security for the population. Monolithic South Bohemian region includes extensive system of ponds, which can be easily disturbed by beavers. There is a potential problem of considerable risk of disruption of large fishpond objects at once (especially earth-filled dams), where any massive protection against activity of beavers in the short- and medium-scale is unrealistic. The presence of beavers in the C-zone is unwanted; there should not be the development of a stable population (which has not been developed there yet), and all individuals of the species should be eliminated deliberately (caught or captured).

The C-zone covers 13.3% of the territory of the Czech Republic. Landscape analysis was used to define the zone; boundaries

were determined using the watersheds of watercourses flowing through the South Bohemian fishpond basin (i.e. geomorphologic barriers which are hard to reach for beavers). The C-zone covers the entire river basins which are supplied by the South Bohemian fishpond basin; it means the Otava, Blanice, Lužnice, Malše Rivers and the upper part of the Vltava River, which flow to the Orlík Dam (WW). Šumava National Park (with regard to the conservation objectives of the area) is excluded from the C-zone and falls within the B-zone.

As mentioned above, the possible elimination of beavers is also permissible in other zones of the Czech Republic (but only locally). Elimination may occur after trying all other possibilities how to reduce or stop the negative influence of beavers. At the same time the conflict must pose an acute risk of serious damage or risk to the health and lives of residents. The evaluation of these conditions is always subject of the authorization procedure of the intervention (see **Chapter 4**).

The concept of zoning in MP is an essential tool in the approach to the management of beaver population in the Czech Republic. Defined zones meet the requirements on protection of Eurasian beaver in the context of European legislation, which currently does not allow any reduction in the degree of legal protection.

Three territorially different approaches (according different protection regimes) allow applying the basic level of land use and social interests in the landscape, without being in constant and frequent conflict with beaver protection.

More information about the MP (and its full version in Czech) can be found on the website **www.zachranneprogramy.cz**, in reference to the Eurasian beaver.

3 Measures to Prevent and Eliminate Conflicts with Beavers

Beavers are persistent and tenacious animals, with locally extensive influence on the landscape. Their behaviour is normally opportunistic (i.e. it is variable according to the local conditions). Their activity thus always reacts in response to the current situation in the area. However, the activity of beavers in the landscape can be patterned into three basic ones – beavers feed on herbal vegetation or cut down woody plants; they build dams to ensure their suitable living environment and trails; they build their permanent or temporary homes.

Therefore, we divided the basic set of measures into three groups according to the above mentioned activities of beavers:

(i) conflicts caused by gnawing,

(ii) conflicts caused by increased levels of water due to the building of dams,

(iii) conflicts caused by burrowing lodges

Damage caused by gnawing or consumption of crops (ad i) are summarized in **Chapter 3.1**. How it is possible to modify beaver dams and mitigate the negative effects of increased water levels in watercourses (ad ii) is specified in **Chapter 3.2**. Very serious conflicts (ad iii), which are caused by the effort of beavers to burrow their lodges in banks (of ponds or levees) is specified in **Chapter 3.3**. The issues of accumulation of several conflicts on small water reservoirs are solved in **Chapter 3.4**. An essential condition for a long-term solution of the relationship of Man and beaver in the landscape is planning of facilities and activities, which will already expect the presence of beavers. Requirements that may ensure permanent protection against the adverse effects of beavers, when building new buildings and landscape elements, are included in **Chapter 3.5**. Although it is short and only informative, we consider this as an important prerequisite to ensure the permanent existence of beavers in our landscape.

Solutions of already existing conflicts will never be more effective and cheaper compared to preventive preparation and adapting of landscape elements on the vital signs of beavers. Experience how to live with beavers has vanished due to many years of its absence. It is necessary to include the issue of beavers in landscape into the current and future considerations about the activities in our landscape – as other natural influences, which have already been figuring there for tens and hundreds of years (e.g. diseases and pests of agricultural crops, livestock diseases, weather, and climate changes, etc.), or how they "work" with beavers in countries where they are a permanent part of nature (e.g. North America).

Description of the measure has a uniform structure to make clear what the aim of the measure is, how to proceed with the implementation and what the technical, financial, or legal requirements for implementing of the measures. An expected efficiency of the measure is also given. Almost every measure has a visual documentation. At the beginning of each measure there is a basic principle of beaver activity to such an extent that it becomes clear, why the measure is proposed in a particular form and what is necessary to be careful of when implementing (what response of beavers can be expected). The biological basis of behaviour of beavers is presented in greater detail in **Chapter 5**. Description of mistakes in the implementation (or inappropriate types of measures) we consider as fundamental because properly performed measure is a key prerequisite for a successful solution of the conflict.

The Legal Background of These Measures

For all the proposed measures there are mentioned a concise legal background of their implementation in terms of the provisions of ANLP. However, it is quite clear that a number of measures could be seen as controversial in terms of other legislation. The aim was to outline each measure (in sub-chapters' *Legal Terms*) which other legislations may affect the realization. In general terms, however, it was

not possible for the team of authors to provide a full review of all the legal requirements that may be affected in the implementation of concrete measures. Therefore, only references to the most important rules that are associated with the measure are mentioned. The authors are obviously aware of duties of forest and watercourse managers resulting from the law. They are also aware of the potential risks which arise from inserting any structures in riverbeds, modifications in flood areas, etc. However, all these measures are in various forms and modifications implemented in the neighbouring countries (Germany, Poland, and Austria). The aim of the measures mentioned in the handbook – although they can seem to be controversial – is to prevent potentially much greater damage that beavers can possibly cause.

The handbook is a set of concepts that can be used successfully (from a functional point of view) in coexistence with the beaver. In our country it is a set of new procedures that we would like to introduce to the Czech environment. Successful and proven approaches can then be subsequently accepted by official bodies and, in future, retaken legislatively. However, an implementer of any of the recommended measure has to deal with all legal requirements which relate to the implementation of the measure (at least regarding communication with the state control authorities).

Before the application of any measure, it is crucial to realize that every land, vegetation cover, watercourse, reservoir, or object has its owner and manager who have rights, but also their responsibilities in property administering. A number of obligations and restrictions is also based on the fact that the beaver is a protected species. Therefore, measures cannot be carried out spontaneously, but first it is always necessary to contact the owner, manager, or user of the land, watercourses, ponds, or buildings and discuss with them the implementation of a specific measure in detail (i.e. exact location, shape and scope of the measure, including risks and limitations). Likewise, it is necessary to contact the relevant authorities and bodies of state administration. The goal of nature protection, or this handbook, is not an absolute protection of the beaver, but finding the possibility of coexistence of the animal in the landscape together with a man.

The proposals are processed in such a way, that the measures implemented by them should provide protection against negative effects of human activities on the beaver and minimize the damage caused by beavers. The handbook does not guarantee that all measures will be accepted in all cases by managers, owners, and users of the land, watercourses, or water areas. The argument for implementation may be that – with some restrictions and level of inconvenience – sustainable coexistence of humans and beavers is possible.

3.1 Measures Which Prevent Damage Caused by Gnawing

Beavers are exclusive herbivorous, feeding on terrestrial and aquatic herbs or woody plants. Consumption of various types of vegetation changes during the year. In the period of so-called green vegetation (approximately form May to October), it means in the vegetation period, beavers consume mainly herbs. During the summer months, beavers often graze on agricultural crops (the most favourite are maize, sugar beets, corn, young rape, etc.). From autumn to spring, consumption of woody plants is dominating. Beavers gnaw woody plants throughout the whole year – during summers to a lesser extent, in the cold part of the year (i.e. from October to April) in the so-called non-growing season – woody plants are a vital source of their food. In winter they can also consume aquatic plants (whole plants, roots and tubers). Beavers consume from herbs their entire aboveground and underground parts (leaves, stems, roots and tubers).

In contrast, from woody plants beavers use only bark, inner bark, twigs and leaves during foliage. Beavers do not eat wood; they only chew it to cut down the tree. For beavers, wood is an obstacle that must be overcome in

order to get a greater quantity of bark, branches and inner bark, which are in a treetop. Detailed analysis of preferences of woody plants can be found in **Chapter 5.3.4.1**. The most important woody plants for beavers are always poplars and willows, locally are added regionally present trees (in warmer areas ashes, maples and oaks, in colder – birches and alders). The vast majority of trees cut down by beavers (over 95%) does not exceed 20 cm diameter of a trunk. However, it is possible to meet a cut down tree with one metre in diameter.

The popularity of woody plants depends on their age, for example young oaks (20 cm in diameter measured at a height of 130 cm above the ground) are for the beaver significantly more attractive than the old ones. On the contrary, beavers leave poplar suckers to grow out due to a high concentration of phenolic substance contained in them.

The second reason why the beaver cut down woody plants is the use of branches and trunks (typically of smaller diameters) to build dams or lodges. Beavers usually use in their buildings leftovers of gnawed branches (without bark), but they also often build from freshly cut down pieces which are not used for food. Beavers can use another spectrum of woody plants for building than for eating – less favourite woody plants they use for example only for constructions, while the most favourite kinds of woody plants they first use for food (gnaw), and the remaining material is subsequently used for building dams and castles.

Beavers build, beside basic types of buildings (i.e. castles and dams) also winter food storage places. They place these "pantries" into the water near the dwelling. Thin branches of favourite woody plants, which are available, are stocks for a winter period. Chewed, but still standing, trees are also a form of preparation for winter. In the course of time beavers either cut them down, or they fall down due to wind. If not, chewed trees dry with no further use for beavers.

Gnawing of woody plants and grazing on field crops represent damage for people (there are examples of damage in **Picture 2**). Around

Picture 2: A poplar trunk cut down by a beaver – gnawing of a woody plant without economic value (a); damage on a young oak cover with economic value (b).

water areas and watercourses beavers utilize field crops, tree branches, and bigger parts of trees; the reach of beaver activity may be up to hundreds of meters. The most common effects on vegetation near watercourses and backwater can be expected up to 20 meters. However, beavers are able to "go" for example for maize or poplars up to 150 meters. Damage is not just gnawing of woody plants, party gnawed trees can fall down and damage other properties (e.g. they destroy a fence or building, dam up a watercourse, cause its overflow, endanger traffic on a road, etc.). In parks and ornamental gardens there is damage from a historical and aesthetic perspective.

Unwanted food pressure of beavers can be effectively defeated, both in the case of woody plants and in the case of field crops. In the next chapter (**Chapter 3.1**) ways and means of long-term and short-term protection of forest and agricultural covers can be found. These are different ways which prevent beavers from entering the protected area.

In principle, another measure is to increase the attractiveness of the area by creating of so-called buffer strips, when a part of the production area is provided to beavers. It means that along watercourses in width of at least 20 m are started covers of woody plants which are for beavers attractive (i.e. consist of willows and poplars). Beavers focus their food activity almost entirely to these strips and agricultural cover behind the strip is spared from being gnawed by beavers. The presence of the buffer strip cannot completely prevent the occurrence of damage to agricultural areas behind it because beavers use for food a wider range of woody plants (than exclusively poplar and willow), but the strip can contribute to a significant reduction of gnawing. This measure can be applied in a limited way and it will not be a short-term activity. The concept is successfully used abroad; however, the foundation and support of these stripes – until they are functional – are time consuming. The rate of reduction of damage is affected by composition, age structure, density and width of the buffer strip. Another disadvantage of the measure is that the buffer stripe reduces the area for farming.

The opposite of buffer strips is to reduce the attractiveness of the area by removing vegetation of woody plants in a strip along the banks. From a biological perspective, however, this measure is not appropriate due to significant loss of biota in the area, and it is suitable only for specific cases, e.g. around small hydropower plants (SHP), where the removal of vegetation in the vicinity reduces the risk of clogging of SHPs mechanisms by carried woody debris, which is in case of occurrence of beavers very frequent.

3.1.1 Fencing

The measure is intended to protect a particular tree or plant, their group, or the whole area from being entered by beavers. Technical implementation and security level may vary depending on the object of protection and the conditions of specific locations.

3.1.1.1 Fencing individual trees

The aim of the measure

The aim of fencing individual trees is to prevent beavers from direct access to them, including their buttress roots and low-growing branches. The measure must be performed in the way that it does not hinder the growth of the tree, and that beavers cannot overcome the fence in any way – to crawl, climb, wade through, or refute.

Protection of trees must be ensured at least in the period from September to April (including). Beyond this period gnawing of trees is less likely but cannot be excluded. Sources of food for beavers are covers of woody plants, especially in distance of 20 meters from the banks of watercourses or water areas. Therefore, it is necessary to protect in this zone all deciduous trees that are the target of farming, if their gnawing should be precluded. Willows and poplars, which are potentially endangered because of beaver's food-preference, we recommend fencing to 100 meters from a

watercourse or reservoir. We also recommend protection of important conifers. In parks or other valuable covers (with the presence of exotic woody plants which are for beavers often attractive), the distance of chewed trees from water can be longer (50–100 m).

The technical principle of the solution

Fencing of a tree is performed by placing the wire mesh around a tree trunk (but not directly to the trunk – see below). The minimum recommended height of the fencing is 1 meter above ground level. In areas with a common occurrence of snow, it is necessary to ensure the protection of trees so that at least 1 m of fencing remains above the snow and beavers cannot climb over it. It is also necessary to provide the strength of the wire at least 2 mm and a maximum mesh size of 10×10 cm. Detailed drawing of the measure is given in Annex 1.

If the chosen material of the fencing is not self-supporting, we recommend using at least three supporting posts (see **Pictures 3a**, **3b**). In the case of a self-supporting mesh, just one stabilizing pole is enough (see **Picture 3c**). The fencing must be fixed to the ground so that beavers could not lift or move it. It is possible to fix it either at least at two spots by staples approx. 20 cm in depth, or by at least three shallower staples (minimum 10 cm long). Appropriate and sufficient fixing is for example with the use of U- or J-shaped steel clamps made of reinforcing steel (diameter of 6 mm is sufficient). The mesh cannot touch the trunk directly because beavers can damage the tree by gnawing the bark through the mesh. Additionally – for young and rapidly growing trees – tight fencing can restrict their volume growth. The mesh should be placed away from the tree trunk so that buttress roots and low-growing branches (lower than 1 m) are also protected (again, it is necessary to consider the height of the normal snow cover in the area). In case that it is not possible to meet these requirements, it is advisable to combine the fence with abrasive coating (see **Chapter 3.1.2**).

Used materials

For individual protection either various types of wire mesh or so-called KARI net can be used. Individual variants differ in labour input of installation and costs.

- Farm wire mesh – mesh fencing commonly used in game reserves and tree nurseries, smaller holes in mesh close the ground are an advantage. The wire mesh fencing is relatively cheap, easy to install and it is self-supporting, so one stabilizing pole for fixing is enough (see **Picture 3c**).
- Chicken wire mesh – welded or knitted mesh with a different type of surface protection from the galvanized surface to the

Picture 3: Example of functional fencing of woody plants: mesh fencing with three supporting poles made of wood (a) and metal (b), self-supporting farm mesh with one stabilizing pole (c).

plastic-coated. Completely inappropriate are plastic mesh fences, which are cheap and light, but do not have the required resistance. Softer types of the mesh fencing are not self-supporting, thus require anchoring to the three poles (see **Pictures 3a** and **3b**).

- KARI net – welded mesh of steel wires is an extreme measure to protect individual trees, it is not aesthetical and it is costly. Rolled up steel mesh provides complete protection, is easily anchored to the ground and is self-supporting. It means that the use is primarily limited by aesthetic requirements and financial capabilities.
- Other possible solutions – in parks and gardens, where there are high demands on aesthetics, can be used different custom-made fences, metal grills, etc. Any non-standard type of fencing must meet the basic requirements to resist the attempt of beavers to break through – strength and durability of the material, the height of at least 1 m (usual amount of snow cover must be added), mesh size or spacing smaller than 10×10 cm, wire strength at least 2 mm, and fencing must be anchored to the ground.

Financial demands

Table 1 lists the approximate prices of materials used for the type of the measure. Costs of protecting a tree will depend on the type and quantity of used material. For example, protection of a young tree (i.e. 1.5 m of wire mesh, one supporting pole) will cost about 200 CZK; protection of a large tree (i.e. 3.5 m of wire mesh, three supporting poles) will cost approximately 500 CZK. Prices do not include transport costs and labour; they are approximate and refer to the price level of March 2016.

Operation and maintenance

In terms of operation and maintenance it is a simple and inexpensive measure. Regular checking of functionality of the measure is basically sufficient – it means if the mesh fencing is not damaged, if it does not touch the trunk, if the anchoring is not loose in the ground, or if the mesh is not too rusty. Once or twice a year it is appropriate to mow weed, which has grown inside the fencing.

Expected efficiency

If the fence is made properly, 100% and long-term efficacy can be expected. In terms of efficiency, it is not appropriate to remove chewed trees that do not endanger the safety of surrounding objects (see **Chapter 3.1.5**). It is not necessary or even appropriate to extract such individual trees (e.g. for firewood) because beavers will then have the need to cut down another tree to satisfy their nutritional requirements. Removal of the fallen material from the location may increase the falling range caused by beavers.

Legal Terms

Realization of individual trees protecting by fencing does not require legal approvals from government authorities or state administration bodies.

Table 1: Approximate prices of materials suitable to protect individual trees against gnawing

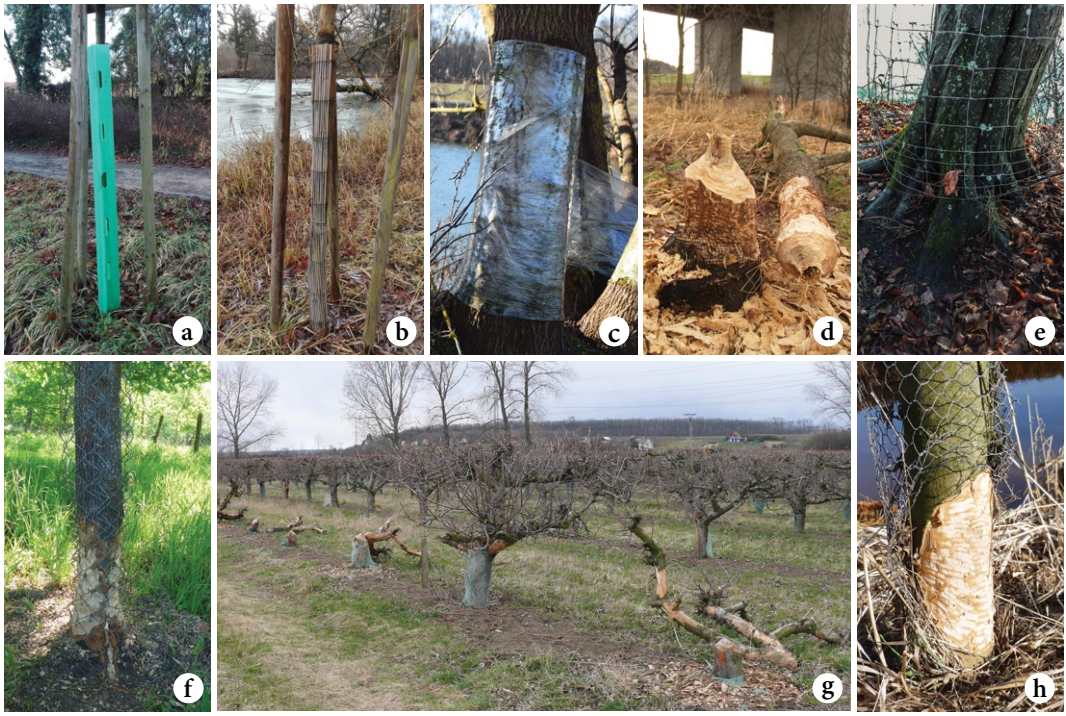
Material	Diameter [mm]	Unit of measurement [UM]	Approximate price incl. VAT [CZK/UM]
Reinforcing steel – bar stock (for anchoring staples)	6	rm	5,–
Wooden logs (the supporting poles)	80	rm	50,–
Supporting larch stake, 200 cm, 5×3 cm	–	pc	35,–
Galvanized wire mesh, height 125 cm, mesh size 50×50 mm, wire diameter 2 mm, wire tensioner	2	rm	55,–
KARI net – hole 100×100 mm, 2×3 m	6	pc	600,–

rm – running meter, pc – a piece

Inappropriate and inefficient measures, mistakes when implementing the measure

Unsuitable types of the measure are shown in **Pictures 4a-h**.

- The use of materials with lower than the above-mentioned resistance, "DIY" or other amateur solutions (e.g. plastic protectors, rabbit mesh fencing, wire wrapped around a trunk, wrapping a trunk with reeds or other natural or artificial materials) – beavers damage or remove the protection and gain access to the woody plant.
- Failure to protect a minimum height of 1 m above ground or snow – the beaver chews unprotected parts of woody plants.
- Protective mesh rests directly on the bark of a tree – beavers get through the mesh holes to the bark and gnaw the tree. Too tight mesh also does not enable volume growth of the trunk.
- Protective mesh that is not self-supporting and is not equipped with supporting poles – a beaver leans against the mesh, presses it to the woody plant and gets through the holes to the bark; the beaver can possibly deform the mesh in various ways.
- No protection of buttress roots – damage of buttress roots can damage the whole tree.
- Protection of branches at a height of less than 1 m above the ground and snow is not ensured.



Picture 4: Wrong fencing of woody plants: plastic protection (a); reed protection (b); plastic sheet protection (c); plastic mesh protection (d); incorrectly attached mesh – a beaver gets to the buttress roots, it can crawl under the protection or lift it; mesh directly on the trunk (f) – a beaver got through holes and chewed the trunk; inappropriate material of fencing in an orchard (g) – low-lying branches are not protected; using rabbit mesh (h) – a beaver deformed it and got to a tree trunk.

3.1.1.2 Fencing of Forest and Agricultural Covers

The aim of the measure

The aim of this measure is to prevent beavers from direct access to covers by installing fencing which on one side withstands intrusion attempts of beavers and on the second side does not restrict or significantly complicate farming and maintenance of the area. This type of measure is traditionally the most widespread in forestry, where it functions as protection of covers against game. The aim in this case is to protect the cover against gnawing in its initial stage. After growing up, there is no danger from forest animals any more, and a fence is either removed or it is designed to self-disintegration. The required lifetime is about 10 years.

Regarding beavers, it is necessary to modify fences so that they are able to resist penetration of these rodents. The cover is for beavers attractive much longer, for example for oaks and ashes that can be even 30–50 years, therefore there is necessary to recover the fencing. Fences are used on farmland very rarely because they excessively complicate the cultivation of the land and the natural movement of wildlife. The following principles of cover protection must be followed e.g. when protecting private gardens or orchards.

The technical principle of the solution

Detailed drawing of the measure is attached in Annex 2. Technically, the cover is fenced off with various types of mesh fences, either along the whole perimeter or just away from the water areas and watercourses (if it is not needed to protect the cover against other animals). In fencing carried out only against beaver gnawing (i.e. from the water) there is a risk that the beaver walks around it (attractiveness of some woody plants can greatly extend the beaver's journey for food). In this case the fence should be raised either along the bank at least 100 m far from the edge of the protected cover, or to a distance of at least 100 m perpendicularly to the bank. Only in this way the probability that beavers will walk around the fence is reduced. It is not a completely reliable measure – the authors recommend using it particularly when it is not possible to fence a protected cover around its perimeter. This variant of the fence has not been tested yet, so it is not possible to define its reliability.

Fencing must always resist the attempts of the beaver to overcome it – tearing, lifting or burrowing. In most cases, it means simultaneous and combined protection against beavers and other forest animals.

The mesh is placed on the border of the protected area. If the aim is to protect it against other animals, the mesh is placed around the perimeter. There are usually used different types of mesh or steel nets, attached to wooden or steel poles. In terms of protection against beavers, the mesh with a height of 1 m is sufficient. If the aim is a combined protection (i.e. against more animal species), it is necessary to use higher mesh. Similarly, in the case of combined protection from the standpoint of

Picture 5: Damage caused by beavers on the farm (a) and forest (b) covers.

firmness, dimension for wild boars is crucial. In areas with a common occurrence of snow it is necessary to ensure higher protection so that beavers could not climb over it. It is therefore necessary to add to the normal amount of snow at least 1 meter of fence. The strength of the wire mesh that can safely withstand the beaver is 2 mm, and the size of the holes should not exceed 10×10 cm.

When setting up fencing it must be reckoned with the fact that the beavers are able to burrow under the fence. This can be prevented by modifying the fencing. Fencing must be embedded in the ground to a depth of at least 50 cm, which eliminates the risk that it is burrowed from the surface. Regarding to the fact that in the forest cover there is often impossible to embed the mesh deep enough (because of roots of grown trees), it is possible to implement an alternative variant – to bend outward the mesh fencing on the ground, anchor it to the ground with steel clamps at a distance of at least 1.5 m, and cover its horizontal part with a layer of soil to avoid injury to animals. The length of the horizontal part of the fence must be at least 50 cm; depth of a soil layer at the outer end of the collar should be at least 20 cm (**Picture 6**) to prevent injury to other animals.

A special case is a location of the fence on the edge of a slope, which is also a bank of a watercourse. The beaver burrows its lodges and the passages always out of the water and in the direction of an upward angle to the shore. For the realization of fencing on the edge of the slope, it is needed to move the fence at least 10 meters from the bank edge, to fix the mesh fencing up to the level of the bed of the watercourse (shallow watercourses), or 1 m below the lowest water level in deep watercourses.

According to these rules it is possible to complete an already existing fence, which parameters are not sufficient for protection against beavers, e.g. it is not firm enough, it does not have the required thickness of the wire or the meshes are too large. It is appropriate to complete the existing fence with an addition mesh belt, which will be bent outward at the ground (at least 50 cm long) and the horizontal part of the fencing will be covered with at least 20 cm thick layer of soil (**Picture 6b**).

Used materials

To protect forest and farm covers commonly used types of fencing can be used. In most cases, protection of forest covers against beavers is combined with protection against other animals, so parameters of the proposed fence must correspond to the risk (animal species). However, it is necessary to keep the above mentioned parameters of fencing against intrusion of beavers – minimum wire thickness of 2 mm and a maximum mesh size of 10×10 cm. Individual variants differ in labour input of installation, maintenance, durability and price.

- Farm wire mesh – mesh fencing commonly used in game reserves and tree nurseries, smaller holes in mesh close the ground are

Picture 6: Fencing of a cover with a mesh, which is embedded into the ground and bent into an L-shape before the horizontal part is covered with the soil (a); an existing fence is strengthened with a new mesh (b).

an advantage (there is a need to ensure that the size of the mesh to one meter above the ground is not bigger than 10×10 cm). In terms of durability it is necessary to pay attention to surface treatment, the method of application and thickness of zinc or other protective layer.
- Chicken wire mesh – welded or knitted mesh with a different type of surface protection from the galvanized surface to the plastic-coated. Completely inappropriate are plastic mesh fences, which are cheap and light, but do not have the required resistance. It is necessary to tighten it at mid-height and top with a wire tensioner.
- KARI net – welded mesh of steel wires is an extreme measure to protect covers, it is not aesthetical and it is costly. It means that the use is primarily limited by aesthetic requirements and financial capabilities.

Poles are used to support KARI nets or mesh fences. The poles are manually or mechanically driven into the ground to a minimum depth of 50–80 cm. To protect the wooden poles against beaver gnawing, they must be placed inside the fences, and it is appropriate to impregnate the whole poles to prolong the period of service.

Financial demands

Table 2 lists the approximate prices of some chosen materials used for the type of the measure. Prices do not include transport costs and labour; they are approximate and refer to the price level of March 2016.

Operation and maintenance

In terms of operation and maintenance, it is a simple and inexpensive measure. Maintenance involves only the occasional checks that the mesh is not damaged, e.g. by animals or falling branches. Any identified defects must be repaired as soon as possible. At the end of the period of service, it is necessary to check the mesh more frequently and repair or replace its unsatisfactory parts.

Expected efficiency

If the fence is made properly, the efficiency is absolute – beaver's intrusion through the fence is virtually impossible.

Legal Terms

If the fencing significantly restricts beavers´ access to food, which means that basic conditions for the protection of the beaver are broken, then it is necessary to comply with the provisions of ANLP (see **Chapter 4**).

Extent of fencing must also be taken into account in terms of environmental stabilizing function of the forest (as a significant landscape element), to prevent e.g. a significant impediment to the movement of wild animals, etc. Any interference with the functions and

Table 2: Approximate prices of materials suitable for areal protection of woody plants against gnawing

Material	Diameter [mm]	Unit of measurement [UM]	Approximate price incl. VAT [CZK/UM]
Wooden logs (the supporting poles)	80	rm	50,–
Wooden logs (the supporting poles)	120	rm	85,–
Galvanized wire mesh, height 150 cm, mesh size 50×50 mm, wire diameter 2 mm, wire tensioner	2	rm	66,–
Galvanized wire mesh, height 200 cm, mesh size 50×50 mm, wire diameter 2 mm, wire tensioner	2	rm	81,–
Farm wire mesh, height 160 cm, 2.0/2.8 mm, 15 wires	2.0/2.8	rm	31,–
Farm wire mesh, height 200 cm, 2.0/2.8 mm, 17 wires	2.0/2.8	rm	39,–

rm – running meter

values of SLEs is possible only on the basis of the standpoint of the nature conservation authority.

Inappropriate and inefficient measures, mistakes when implementing the measure

- Fencing is not embedded at the required depth in the ground, or bent at the required length at the ground – a beaver burrows under the fencing and gets inside (**Pictures 7a, b**).
- Unsuitable type of mesh fencing is used (non-metal or thin mesh, mesh with big holes) – a beaver forms a hole and gets access to the cover.
- Fencing adheres to a woody plant – a beaver chews the bark of the tree (**Picture 7c**).
- Fencing is on the edge of the slope and embedded not deep enough in the ground – a beaver burrows obliquely upwards from a watercourse and can burrow under the fences.
- Fencing (or its repair) is made of wooden materials – a beaver gnaws it.

3.1.2 Abrasive Coating

The aim of the measure

The aim of the measure is to prevent treated woody plants from gnawing by beavers. The surface of the bark of protected woody plants is coated with an emulsion, which contains abrasive ingredients causing discomfort, teeth gnashing, and abrasion.

The technical principle of the solution

A prepared mixture is applied on a tree trunk (e.g. product Wöbra, **Picture 8**). A layer should look aesthetically (due to a potential use in parks and gardens) and should reliably withstand predetermined period of time under normal climatic conditions of the Czech Republic. Application is carried out at least to a height of 1 m above ground level (it is necessary to add usual layer of snow). It can protect not only trunks, but also buttress roots or low-lying branches of trees. If there are no other available food sources nearby, abrasive coating is not an unbeatable protection against gnawing.

Picture 8: Abrasive coat of Wöbra 4 hours after coating (a) and 5 years after coating (b), (source: Flügel GmbH).

Protection of young trees (i.e. diameter of about 10 cm measured at a height of 130 cm above ground) with abrasive coating may not be sufficient because the beaver can cut the tree by a few gnaws and therefore it can try to overcome the coating.

Picture 7: Incorrect fencing of a cover: a mesh is not embedded in the ground, a beaver burrowed under the mesh (a), even under the concrete threshold (b); fencing adheres to woody plants and a beaver damaged them by gnawing (c).

For these reasons, the abrasive coating is more suitable for an individual rather than areal protection of woody plants. Coatings are suitable for older valuable trees having aesthetic, production, conservation, firming, or other significant functions.

Used materials

It is possible to use both commercially manufactured product Wöbra (it is successfully used in Bavaria and Lower Austria) and self-made products based on latex paint (used in the US) or dispersion adhesives:

- Abrasive coating Wöbra – protective coating is applied according to the manufacturer of the product.
- Self-made abrasive coating – a mixture of fine silica sand and universal or outdoor latex paint in a ratio of 1:7–1:8 (ratio depends on the density of the latex paint and the type of sand, so it can be slightly different). The mixing ratio must be selected according to the type of sand and density of colour. Too thick mixture adheres to the surface and scrolls down; too thin mixture runs off and does not include enough abrasive particles. Both components are mixed just before application. During coating, it is necessary to stir the mixture because the heavier sand sinks to the bottom. It is suitable to apply the coating in the conditions according to the manufacturer of the latex paint. In our conditions, however, this type of coating as protection against beaver's gnawing has not been tested yet.
- Self-made abrasive coating – a mixture of dispersion adhesives and fine silica sand. The mixing ratio must be chosen according to the consistency of dispersion adhesives. Too thick of a mixture would not adhere to the surface; too thin would run off. In our conditions, however, this type of coating as protection against beaver's gnawing has not been tested yet.

Financial demands

Wöbra abrasive coating is available in packs of 5 kg (365 CZK/kg) and 10 kg (330 CZK/kg). Its coating depends on the diameter of the tree, required height of coating and complexity of the bark. Coating may be from about 200–300 g (i.e. 70 to 100 CZK) for a young tree with a trunk diameter of about 15 cm, to kilograms for grown individuals. Prices are approximate and refer to the price level of March 2016.

If using self-made mixture of latex paint and sand, price is about one quarter compared to Wöbra, in the case of a mixture of dispersion adhesive and sand only one fifth.

Operation and maintenance

Protection of trees with abrasive coating is simple and easy, but with limited efficacy. Coatings must be renewed, depending on how quickly the tree grows. Where a tree is in frequent contact with water, more frequent renewal of the coating is necessary.

Expected efficiency

The effective period of abrasive coatings against beaver's gnawing has not been tested in our condition yet.

The leaflet of RIDEX Company, Ltd., a distributor of Wöbra products, indicates that reliable and long-term protection of trees against beaver's gnawing is 10–15 years. However, in a documentation study for Wöbra coating against peeling woody plants by animals, it is assumed that a minimum efficiency is over 6 years. And photographs which are presented in this study document the condition of the paint 5 years after its application. Based on the study it can be assumed that Wöbra coating ensures functional and reliable protection of trees for at least five years. Then it is necessary to evaluate the condition of the paint and if necessary renew it. Frequent contact with water (e.g. trees growing on the banks of watercourses with fluctuating water level) significantly shortens the efficacy of the product.

According to information from users of self-made protective coating of a mixture of latex paint or dispersion adhesive and sand, effective protection of a tree is ensured for 2–3 years. Duration of protection for self-made coating of a mixture of dispersion adhesive and sand is not known, but it can be assumed that it is similar to the previous mixture. There is no unbiased study which confirm the data.

Legal Terms

Protection of trees with abrasive coating does not need to comply with the provisions of the ANLP (protective conditions of beavers are not impaired). Protective conditions of other species within the ANLP are also not impaired because we do not assume using of abrasive surface coating to the extent that would break the protective provisions under the ANLP. The coating also does not represent (unless substances toxic for plants are used in self-made products) damage to trees and a violation of their legal protection.

Inappropriate and inefficient measures, mistakes when implementing the measure

- Abrasive coating is not regularly renewed – protection loses its effectiveness against beaver's gnawing.
- The product is not applied to the required height or on buttress roots and low-lying branches – beaver's gnawing damages unprotected parts of woody plants.
- Non-abrasive coating, e.g. lime coating (**Picture 9**), oil or beech tar coating.
- Combined coating made of a repellent and a teeth-creaking product (e.g. Morsuvin).

Picture 9: Ineffective lime coating

3.1.3 Electric Fence

The aim of the measure

The measure is intended to protect any land from being entered by beavers, and a properly installed electric fence makes a barrier. An electric fence as a protection against beavers is most often used in case for crop plants during their ripening period, so it is used temporarily rather than year-round. However, in rare cases, an electric fence is used for individual or group protection of trees, the only difference is in the length of the fence and the time of use.

The technical principle of the solution

Detailed drawing of the measure is attached in Annex 3. The electric fence is a measure commonly used to maintain the livestock at the required place. A light barrier is installed as an obstacle (a strip, cable, band, rope, wire, mesh), it contains conductive fibres, into which at short intervals the source transmits pulses of electric current of high voltage (2,500–15,000 V) and low power (about 2 watts). Their intensity has to be high enough so that electric shock is for the target animal distinctly uncomfortable. On the other hand, it cannot hurt the animals, even in unfavourable combination of factors. The intensity of perception is significantly affected partly by a real voltage of the wire, partly by the quality of the grounding of the animal, dampness of the ground and surrounding, or thickness and quality of hair. An electric fence should be clearly visible – an animal learns from its experience that the contact with the fence is unpleasant and respects it even if it is for example temporarily without power.

An essential parameter in the design of the electric fence is a type of the target animal and the length of the fence. The larger, respectively better insulated, the animal is, and the greater length of the fence is required, the more powerful source and impulse is needed. The smallest version is sufficient for beavers in most cases because beaver's coat fits close to the body, so in most cases it will be wet, as well as its feet and soil surface, across which it will move.

The length of the fence also will not be long (in common agricultural conditions, the length of about 10 km is considered to be long).

In terms of the spatial disposition, it is usually not necessary to fence the whole lot, but installation of the fence line along the watercourse could be sufficient. According to the authors, in this case the electric fence should begin and end at a sufficient distance from the target cover (i.e. at least 100 meters on each side from the target cover), either along a watercourse/water area or perpendicularly from the water (analogously to the fencing in **Chapter 3.1.1.2**), so that beavers could not walk around it. However, this is only a recommendation because the application has not been properly tested yet, so the success of this approach cannot be demonstrated.

Placement and installation

Installing an electric fence is technically very simple – a fence band is attached on pillars or posts, and then connected to a grounded source. The land is safely protected against beavers with two lines of conductors, one at a height of 15–20 cm above the ground, the second at a height of 30–40 cm above the ground (**Picture 10**). However, even a single line at a height of 15–20 cm above the ground is sufficient. The density of the posts must conform to uneven terrain and material which is used for the fence. Fencing must not touch the ground or vegetation, and at the same time it must maintain a constant distance from the ground, so that the beaver cannot burrow underneath. In a flat terrain the posts can be placed at a distance of about 4 meters, in more uneven areas it is necessary to use shorter distances between poles.

It is possible to entry the space protected by an electric fence with the use of special clips with a handle, which allows temporary disconnection of the fence and then resealing.

Used materials

Installation of an electric fence is a combination of catalogue elements – a source (electric, battery, solar or combined), posts, and fencing. All these components are usually manufactured in many varieties. If a special plastic or laminate pole is not used, it is necessary to use insulators to fix a fence to a pole (e.g. to a wooden pole). Fencing (strip, cable, mesh, etc.) should be clearly visible, due to its location close to the ground.

Financial demands

Price of fence sources depends on a type of a source and its power, and roughly it is from 3,000 CZK or more. It is necessary to add an accumulator to battery and combined sources; its price is around 3,000 CZK. On the market there are many types of fencing, their price is dependent on the type, thickness and length (e.g. price of 3 mm thick wire, 500 meters in length is approximately 550 CZK, price of 20 mm wide strip, length of 400 m is about 500 CZK). Posts for an electric fence cost from 35 CZK per piece. Prices are approximate and refer to the price level of March 2016.

Picture 10: Properly installed electric fence protecting areas against beavers.

Operation and maintenance

Protection of a cover with an electric fence is relatively maintenance-intensive because it requires very frequent checking (ideally daily) if there is not a power failure, interruption of the fencing, or power supply cable.

For proper function it is necessary to prevent accidental grounding of fencing, e.g. by contact with the ground, vegetation or snow. Therefore, it is necessary to check the fencing periodically if it is not too slack or torn down (e.g. by fallen branches). It is also appropriate to mow the strip of vegetation along the fence, so that the plants do not touch the wire. In some areas the fence can by destroyed by wild boars.

Expected efficiency

Assuming that above mentioned maintenance requirements are fulfilled, the use of an electric fence is a simple and very effective measure. It is more suitable for temporary protection of covers (e.g. in the ripening period of agricultural crop). In Bavaria an electric fence is switched on for 14 days (in areas where they protect crop), and then it is disconnected from the source. After that beavers avoid the area for a few weeks and this period is usually sufficient to complete the harvest. In case that after the disconnection of the source new damage emerges, it is necessary to restore the function of the electric fence promptly. Year-round use is not recommended due to the high cost of regular maintenance, during the winter months can be assumed worse functionality.

Legal Terms

Realization of cover protection by electric fences does not require legal approvals from government authorities or state administration bodies. When installing the fence, it is necessary to observe all safety rules. Instructions and requirements for the installation and connection of electric fences are included in amendments BB and CC of the Standard CTS EN 60335-2-76 ed. 2.

Inappropriate and inefficient measures, mistakes when implementing the measure

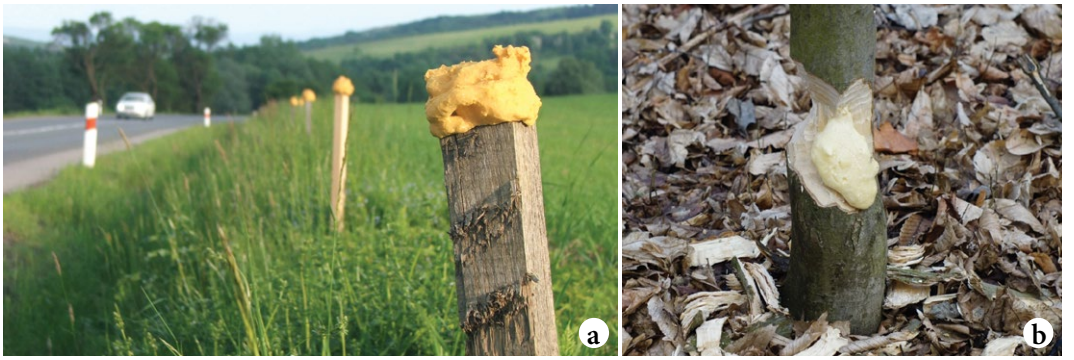
- Fencing touches the ground, vegetation or snow – the voltage in the fence is being reduced, in extreme cases the fence can be completely without voltage.
- Fencing does not copy sufficiently the ground surface (**Picture 11**) – beavers can crawl under the fencing.

Picture 11: Incorrectly implemented measure – beavers can crawl under the fencing.

3.1.4 Irritating Scent Repellents

Irritating scent repellents belong among the measures that are in practice often used to discourage various game species from entering areas where their presence is unwanted. The most common example is the installation of so-called irritating scent fences along roads or the use of repellents as prevention of the occurrence of martens in human dwellings. In principle, it means the application of a substance which smell is very unpleasant or instinctively raises fear in animals, so that they rather avoid the place.

In the Czech Republic commercial scent repellents – so called "scent fences" – are generally used along roads to reduce collisions of game with vehicles (see **Picture 12a**), for example. Hagopur (Germany), Antifer (CR) Morsuvin (CR) Pacholek (CR). Often used are also manually prepared mixtures or raw materials – dung and urine of large predators or human hair. Above mentioned measures, however, have not fully provided satisfactory results yet; effectiveness is dependent on many



Picture 12: Hagopur – used as a scent fence along a road (a) and as protection against beaver's gnawing (b).

factors which are difficult to evaluate (wind direction, exposure to sunlight, the condition of animals, etc.).

Based on Hagopur testing in Litovelské Pomoraví PLA (see **Picture 12b**), this product did not work either as the protection of trees against gnawing or as a mean of ousting of beavers from the location (said by O. Mikulka).

None of the other above-mentioned products has shown reliable efficiency against gnawing or occurrence of beavers. Therefore, they cannot be recommended as an effective measure against beaver's gnawing in terms of protection of individual trees or whole covers.

3.1.5 Protecting People and Property from the Risk of Falling Trees

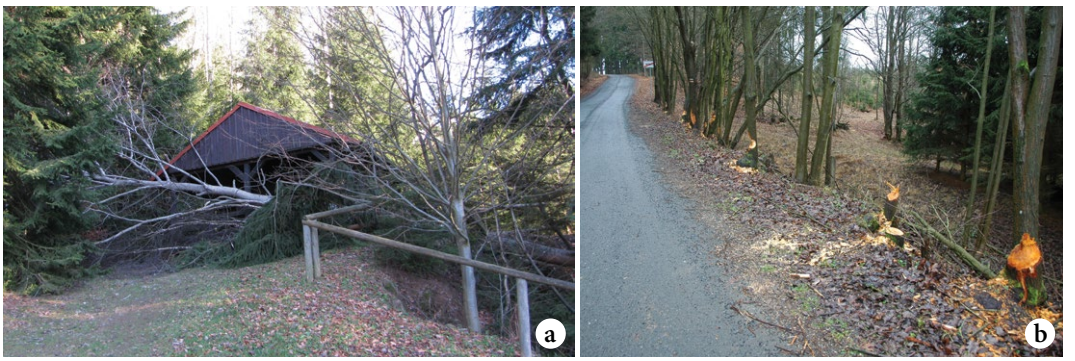
The aim of the measure

Trees gnawed by beavers may endanger both people and property, e.g. vehicles, buildings, etc. (**Picture 13**). Protection against a falling tree can be implemented in two ways: preventative protection of healthy trees or felling trees already gnawed. The most reliable protection against gnawing and subsequent fall of the tree is properly made fencing (see **Chapter 3.1.1.1**). If trees cannot be for any reason fenced or a tree is already gnawed and there is danger of falling, it can only be recommended to cut down endangering trees with the assistance of an expert.

Besides the risk of fall, there is also the risk of damage to wooden structures caused by gnawing (e.g. tree stands, wooden signs etc.), see **Picture 14**. Therefore, it is suitable to protect them by fencing or abrasive coating, depending on the type of an object.

The technical principle of the solution

A method of tree protecting against beaver's gnawing with fencing is described in **Chapter 3.1.1.1**. It is appropriate to leave preventive felling or fallen trees that have been damaged to professionally qualified people.



Picture 13: A tree – fallen by a beaver – that narrowly missed a log cabin (a); gnawed trees along a road (b).

Picture 14: Damaged wooden toll-bar of a fencing entry (a); damaged ladder of a tree-stand (b).

Financial demands

The financial demands of felling depend both on the size of the tree and its position in relation to buildings. Price for felling can range from hundreds of crowns in simple situations up to thousands of crowns in situations when it is necessary to proceed to felling with the use of rope techniques or an elevated work platform.

Legal Terms

The issue of felling trees, including legislative conditions, is described in **Chapter 4.4**. Realization of fencing of an individual tree does not require legal approvals from government authorities or state administration bodies.

3.2 Protection Against Flooding of Plots, Infrastructure, and Buildings

Beavers build several types of buildings; the most famous are so-called lodges and dams. Lodges are underground constructions of branches and mud that are used as their homes and that have virtually no effect on their surroundings. In contrast, dams (also consisting of branches, logs, mud and stones) are cross-structures in watercourses, with the ability to retain water (see **Picture 15**), and therefore, they have considerable potential for conflicts because of water overflows, influencing the direction of the flow, etc.

It is difficult to define general parameters and limits under which beaver dams are built. However, in general, we can specify some basic patterns of beaver dams. Dams occur at small and medium-sized watercourses. In Central Europe, dams on rivers wider than 10–15 metres have not been observed so far. The depth of water in a watercourse is for beavers an important parameter for building a dam. If it is too low, beavers tend to meet their needs and increase its level. Minimum (secondary) water column needed to meet the vital needs of beavers is, based on experience from abroad, 80 cm (Hartman & Törnlöv 2006, Schwab 2014).

Beavers build dams on watercourses with low or fluctuating flow. When beavers construct dams, they achieve a reduction in the rate of water flow, increase of water level and enlargement of water level when the watercourse

Picture 15: Beaver dam and retained water above it (a, b).

overflows. By these, the rodents provide a secure cover of entrances of their homes below the water level, possibility of quick escape in case of danger, the appropriate conditions for the movement and diving, less laborious transportation of building materials, and food. By flooding surrounding areas, beavers gain secured access to new sources of food.

Location of dams is influenced by multiple factors, e.g. the width of the watercourse, the presence of attractive food on banks, or proximity to residential dwellings. Beavers get sealing material, i.e. mud and stones, at a distance of three meters from a constructed dam. If the beaver does not have woody plants, even stronger stalks of plants or field crops, e.g. maize, can be used as building material. The size of dams varies considerably, depending on the parameters of the stream channel, the current flow and the surrounding terrain. It is possible to find dams increasing the level only by a few tens of centimetres, but there are also cascades of more dams, with a total surge of several meters. The length of the dam is determined by the width of the flow channel. If water overflows, then the dam length depends on the current flow, and the width and transverse tilting of the floodplain.

The general aim of the beaver is to secure along the entire length of the watercourse, which falls within its territory, the depth of water suitable for life and movement, and possibly surge and spill water on the surrounding land to reach required food, without leaving the aquatic environment (which is for the beaver protection against potential predators). In the territory of one beaver family, with the average length of 500–2,000 m, it can therefore be even more dams forming a cascade. Their number depends on the size of flows, the slope of the stream and the attractiveness of riparian vegetation and does not reflect the number of animals in the family.

The construction and repair of dams occur throughout the year. The intensity of the construction work and repairs depends on the purpose of the dam (i.e. whether the dam secures access to beaver homes or only facilitates access to food) and in the season. Generally, building intensifies in late summer and autumn, when beavers prepare for the arrival of their unfavourable time of year – winter. Beavers' need is to preserve dams throughout the winter (approximately from October to February). In this period, an early resumption of damaged dams can be expected. The construction and repair of dams are related to the increase in the amount of felled woody plants. When beavers build dams, they use only freshly felled woody plants. Wood from destroyed dams is generally not used again.

Increased water level in watercourses, due to construction of dams, brings a number of problematic situations (**Picture 16**). Long-term waterlogging or flooding cause, that machinery has difficulties with movement on the surrounding production and non-production areas (roads, fields, forests, gardens). In terms of land use, long-term waterlogging of forest and agricultural covers causes their dying. In extreme cases, farming on waterlogged land is completely impossible. Surge of water above the beaver dam can also cause waterlogging of parts of infrastructure (roads, railways) and endanger technical elements near watercourses (e.g. culverts, water supply wells, etc.). Beaver dams can also interfere with the operation of wastewater treatment plants (by influencing the flow and level of flow) and small hydro power plants (by influencing the flow and unwanted presence of dead wood in the supply channel).

Long-acting measures to resolve such conflict situations should be directed towards finding mutually acceptable water levels. The minimum height of the water column, which beavers require to meet their basic living needs, is about 80 cm (see above). If a compromise cannot be found and dams are removed, beavers repeatedly and constantly renew them, or in exceptional cases will leave the site. It is certain, however, that the location will very soon be repopulated by beavers-newcomers. Alternative solutions are measures that make building of dams completely impossible (e.g. placing of floating buoys (**Chapter 3.2.2**),

Picture 16: Damage caused by beavers because of surge of water level: a flooded forest (a); a flooded field (b); a flooded meadow (c); a beaver dam and castle in a flooded cover (d); a flooded road due to an expansion of a beaver dam in the vicinity (e).

backfilling of canals with coarse-grained material (**Chapter 3.2.3**), etc.).

In the following chapters there are a few types of measures that reduce the risk of flooding and waterlogging of land adjacent to the river. The authors were inspired by measures that are commonly and high-efficiently used abroad. Implementing these measures, however, can be problematic in terms of the Czech legal environment, for example Water Act (no. 254/2001 Coll.), Building Act (no. 183/2006 Coll.), etc.

Therefore, the implementation of all measures that in any way interfere with the profile of a watercourse or waterworks should be consulted in advance with the watercourse managers or owner of the work, and also with the water management authority. According to the specific situation, it is always considered whether the implementation of the measure will minimize damage (and also reduce the rate of conflict), or whether, in contrast, could potentially cause greater damage. We also strongly recommend that the design and implementation of measures are carried out by qualified people with at least elementary knowledge of hydraulics and water engineering. Even small errors in implementation may subsequently cause malfunction of installed measures. The right to modify or change

stream channels or waterworks is solely for the managers of watercourses or the owners of waterworks (resp. after their approval, for people performing maintenance and repair). Therefore, any changes of stream channels, riverbanks and water areas can be made only with the consent of those people (watercourse managers, owners of waterworks).

Beavers are also able to increase water level of water reservoirs and in order to avoid water leakage they clog the drain of the draining device. Therefore, it is impossible to tamper with the water level and safety of reservoirs and canals led above the surrounding terrain is worsened. More about the issues of water surge on water areas is specified in **Chapter 3.4**.

In principle, a completely different measure – which has not been tested in the Czech Republic yet and therefore is not mentioned in the following overview – is a stimulated construction of dams (**Picture 17**). This measure is used in Saxony. This is an intentional bottleneck of a stream channel in a non-conflict place of a flow (e.g. by hammered stakes or felling a tree across the stream). This narrowing can be for beavers a suitable place for a construction of a dam. The measure is used at locations where an existing dam causes a conflict situation, whereas nearby there is an alternative profile where a dam built by beavers would not cause any troubles. Beavers are offered, after removing the problematic dam, an alternative site for its smooth reconstruction.

3.2.1 Drainage of Beaver Dams

The aim of the measure

Drainage of beaver dams is intended to reduce the water level of beaver basins. The principle is to place a pipe with a protective cage to an inflow part so that the final level is acceptable for both these rodents and other users of the landscape. The experience from abroad shows that drainage will be a functional measure if retained height of the water column in a basin is at least 80 cm, after the drainage. However, this is only an indicative number, for beavers required depth depends on the conditions of specific locations, on the season and on current needs of beavers and the individuality of individuals (i.e. target required depth may vary). If the water level after the drainage decreases to less than 50–60 cm, it is quite likely that beavers will not accept the measure (see below). Assessment of the particular situation and the design of implementation of the measure (incl. estimation of appropriate parameters for a given location) should be ensured in cooperation with experts.

The aim of the drainage of dams is not draining of the whole beaver basin; the measure only ensures a reduction of the water level and as a result of that flooding and waterlogging of adjacent land is mitigated. The measure is suitable for more powerful watercourses (width at the level of 2.5 m or more), where there is enough space above the dam for the installation of a drainage pipe and protective cage on its inflow. The measure is not

Picture 17: A stimulated construction of a dam by hammered stakes (a) and a felled tree across a stream channel (b).

appropriate for watercourses with large longitudinal gradient, where the basin is too short and shallow. Noise and a stream of escaping water cause that beavers make enormous effort to block the drains and construct new dams above or below the drained dam.

The technical principle of the solution

Detailed drawing of the measure is attached in Annexes 4 and 5. Reducing the level of the draining beaver dam is done by fitting a pipe in the dam body, so that part of the water from the basin can drain freely. Important is both the height of the pipe and its diameter. Inflow into the pipe must be protected against blockage by a protective cage.

For proper implementation of this measure is necessary:

1. To dimension the size of the pipe and the protective cage depending on local conditions.
2. To fit and stabilize the pipe into the dam.
3. To fit and stabilize the protective cage into the inflow of the pipe.
4. To finish building of the dam into original state.

Beaver's reaction to the installed pipe is to restore the original height of the water column, therefore, it is trying to identify the location of water leakage from the basin and clog it. Therefore, it is important to place the inflow and outflow so that the noise of running water is minimized, i.e. water should flow in smoothly and flow out, if possible, below the level of the lower water. There are many technical solutions and it is up to the designer to choose the most suitable for the location.

It is necessary to fit the inflow into the pipe as far away from the dam as possible, so that the location of water leaking for beavers is difficult to identify (**Picture 18**). Beavers obtain sealing material (i.e. mud and stones) for the construction of the dam in particular within a distance of 3 meters from it. The closer to the dam the inflow into the pipe will be located, the greater risk of unwanted clogging with mud, branches and stones. Moreover, if the inflow part is too close to the dam, over the years it can become a part of the dam and thus loses its functionality.

Generally, in order to ensure the effectiveness of draining, two essential requirements can be mentioned:

- To place the inflow as far away from a dam so that there is the maximum possible depth under it; it must be high enough above the bottom so that beavers could not fill the basin with mud and clog the inflow completely (overlap it).
- To create a protective cage (made of mesh or netting) around the inflow that is long enough so that beavers cannot clog it up in the entire length.

Since the measure is relatively expensive, labour-intensive, and it needs subsequent maintenance, it is desirable that after

Picture 18: Drainage of a beaver dam: into a dam inserted pipe with a knee in an inflow and with a protective cage (a); detailed inflow of the pipe and protective cage (b).

completion it is functional as long as possible, which can be ensured with proper installation. Therefore, the authors strongly recommend that the design and implementation of the measure are carried out by qualified people with at least elementary knowledge of hydraulics and water engineering. Below we give overviews on the general procedures for designing and constructing of the measure, at the end of this chapter there is an overview of common errors that can cause malfunction of the object.

1. Dimensioning of a pipe and a protective cage

Dimensioning of a pipe

The correct procedure for sizing the pipe depends on the elementary hydraulic calculations, and it is needed:

- To find out basic hydrological data for a given profile (self-measurement or from the Czech Hydrometeorological Institute CHMI).
- Dimensioning of the flow according to Q_a (i.e. long-term average annual flow).
- Proposed flow should flow through the pipe at the free water level, so that there is not any pressure flow in the pipe; therefore, the pipe should be filled up to 0.8–0.95% of its diameter.
- Recommended gradient of the pipe 1–3%.

An example of a capacitive flow of a pipe in a plastic piping at a flow with free water level is given in **Table 3**.

Pipe parameters must be designed so that they are safely transferred to the normal flow at free water level. At the same time, even in the dryness situations where the capacity of the pipe significantly exceeds the size of the real inflow, a certain level of water storage (optimally at least 80 cm) should remain above a beaver dam. Excessive fall of a water level could cause that beavers begin some activities to prevent water runoff from the place (e.g. construction of a new dam nearby). Any flood flows will be free to overflow over the dam crest.

Table 3: Capacitive filling of pipes at a flow with free water level – different diameters and gradients of pipes.

Diameter of a pipe [mm]	Gradient of a pipe [%]	Capacitive flow of a pipe [$m^3 \cdot s^{-1}$]
200	1	0.03
200	2	0.04
200	3	0.05
300	1	0.08
300	2	0.12
300	3	0.15
400	1	0.18
400	2	0.26
400	3	0.31
500	1	0.33
500	2	0.46
500	3	0.57

In practice, however, empirical realization without actual design and dimensioning is often chosen, when the diameter of the pipe is selected most frequently by estimations on the basis of availability, cost and weight of the material because of easier handling. In this case, we recommend using the largest possible diameter (preferably 500 mm, according to local conditions). By fitting the bottom edge of the pipe about 3–5 cm below the water the required state will be achieved. If it is necessary to transfer the higher flow rates, it is possible to fit two pipes together.

Dimensioning of a protective cage

A protective cage is a cage made of mesh, KARI net or gabion panels. Generally, there is no single universal right shape of a protective cage and one method of its realization. When sizing a protective cage, it is necessary to consider the conditions of the location (the size, depth and width of the flow, characteristics of the flow rate, likelihood that it will be clogged or blocked with the natural debris or by beaver's activities, etc.). The least problematic form of a protective cage – because of clogging with debris – is a triangular shape with the apex directed upstream or a cage of

a circular plan (e.g. drop-shaped). Generally, there is a rule that the bigger the cage, the better, since it reduces the likelihood of its clogging and blockage. Often used shapes of a cage are rectangular or square shapes (with the size of the shortest side at least 1×1 m); however, these are more likely to be clogged with debris. When installing a protective cage, it is always necessary to have free at least 1/3, preferably 1/2, of the transverse profile of the flow, because of increased flows and debris going through.

The size of a mesh of a protective cage must not be larger than 10×10 cm, so that a beaver cannot get inside. A smaller mesh size (e.g. 5×5 cm) increases the risk of unwanted clogging with debris.

A protective cage must be completely impenetrable for beavers. From the bottom it must have either its own bottom, or be thoroughly embedded in the stream bed. So a beaver does not get inside from above, cage walls must be brought out either above the maximum expected level, or it is necessary to close the cage also with a grill from above. For gravel streams and streams with stony bottoms, the cage with both a lid and a bottom can be a suitable alternative. It is not necessary to embed this cage into the stream bed; it is enough just to anchor the cage to the stream bed to fix its position even in the event of flood flows.

It is not essential to ensure corrosion protection; because of relatively short lifetime of all used materials. Very likely beavers´ activities will change before the construction corrodes; the construction will be used up or non-functional due to increased flows or as a result of repairs and cleaning.

2. Placement and installation of a pipe

A Pipe (or more pipes) is fitted to an existing beaver dam in the upper third of its height, so that the regular flows at the free water level flow through it. A dam crest is taken apart in some of its part and the pipe is placed so its upper edge is at a level of about from 0.2 to 0.4 meters below the original dam crest (where applicable). Real location of the pipe should correspond to the required decrease of the water level above the dam. It is important to maintain the pipe slope of 1–3%.

When planning the timing of drainage, it must be reckoned with the fact that it will be possible to settle the pipe into the dam after the stored water runs off. It may take from several tens of minutes to several hours, depending on the volume of stored water.

The pipe should be fitted so that it is either ended in the dam itself (the noise of the drain blends with the natural sound of water flowing through the dam) or it should end at least 1 m from the downstream side of the dam. If the pipe ends in the dam, then it is advisable to cover it with branches (i.e. to complete the dam back to its original shape). If the pipe ends under the dam, it should ideally end under the water level of the watercourse. This can be achieved e.g. by placing the knee (45° or 90°) to the outflow of the pipe or by using a flexible pipe; it always depends on the situation at the place of the dam and its surrounding.

Inflow should be led as far away from the dam as possible, at least 3 m or more (according to possibilities of the location and the length of the pipe). In literature the recommended length of a pipe over the upstream side of the dam is at least 4 m. The further the inflow is from the dam, the less likely it is that a beaver will find it and will try to clog it. In the U.S.A. pipes with a length up to 12 m are used for this reason. Draining of the dam by using more pipes (compared to installing a single piece) may complicate the proper installation and anchoring. Also it is not possible to implement a long inflow in streams with a high longitudinal slope, where created water storage is too short.

Appropriate may be directing of the inflow to the stream bed (by fitting a knee 45° or 90° rotated to the bed). This will ensure that the inflow is glutted and the accompanying sound effects of outgoing water are minimized. Another variant solution is to extend the inflow pipe with flexible a polyethylene pipe; its inflow is turned towards the dam, and it is not exposed directly to debris.

Another possibility is that the pipe is extended with fixed adapter with a blind inflow and holes are drilled into the pipe from the sides. The advantage is that the inflow does not concentrate noticeable water flow and for beavers it is more difficult to identify the site of water leakage. The disadvantage is the possibility of easier clogging of smaller holes by dirt (e.g. leaves) and more intensive sound effects. Based on foreign experience, however, this solution for our conditions (i.e. eutrophic watercourses with a large number of small carried debris and other impurities) is not recommended.

It is necessary to stabilize the pipe in the dam, so that it does not move at higher flows, when the flowing water can – both inside and outside – produce dynamic effects. It is necessary to ensure that the pipe cannot move (i.e. cannot change the longitudinal slope, or cannot change its height considering the stream bed and the position in the transverse flow profile). The pipe must be fixed to at least three locations. The easiest way is to hammer along the stream bed three pairs of steel rods (pipes, rebars) and the pipe is fixed between them with e.g. binding wire. A pair of rods should be on the inflow, outflow and in the middle (in the dam profile). Fixation of the pipe is difficult because the pipe is buoyed up by water.

If a flexible pipe is used or more plastic pipes are connected in a row, it is necessary to pay great attention to the fixation of the slope and connections to avoid major fractures in the longitudinal profile.

Usual flows should be transferred through the pipe; flood flows will freely overflow the dam crest. If a flood damages the dam, this process is natural and does not require any solution. A beaver dam can be completely carried away by a spring flood. If beavers do not start building the dam in the same place again, then it is advisable to remove the entire measure. Any flood wave will often be negligible – regarding the flow increase, a bigger problem may be caused by carried debris form the broken dam which may catch on objects lying below the flow.

3. Placement and installation of a protective cage

A protective cage must be fixed separately (independently from the fixation of the pipe). The cage is first fitted onto the inflow of the pipe, but there cannot be a gap larger than 10×10 cm so that beavers cannot get to the inflow. It is appropriate to fix the protective cage in the stream bed by 3 or 4 metal profiles (pipes or rebar) and attach it by the binding wire. Even in the case of cages with a closed bottom (KARI nets weldments, gabions) it is required to fix the cage to the stream bed, as in previous cases.

4. Finishing a dam to its original state

After settling and stabilizing the pipe and protective cage, it is necessary to return the dam to the previous level. The aim should be to maximize the restoration of the dam. There are two reasons for this: from the perspective of a beaver the dam will not be significantly impaired; therefore, it will pay attention to it and will not build a new one. Secondly, a beaver will not be cutting down new material for repairing the original dam (beavers usually do not re-use the old material).

Used materials

For drainage itself, either a plastic pipe (polyvinyl chloride – PVC, polypropylene – PP) or a steel pipe can be used. The advantage of plastic is its toughness and relatively easy manipulation without the use of heavier equipment. Using a steel pipe is costly and poses an increased risk of theft, and moreover, a steel pipe is difficult for manipulation and its setting needs some machinery, therefore we do not recommend this material.

Since the device will be in the aquatic environment for a long time, often with fluctuating water levels, all used materials should resist corrosion.

A protective cage can be made of:

- Farm or chicken wire mesh with a mesh size 5×5 to 10×10 cm; the mesh is not self-supporting, therefore inside the cage there

must be e.g. a wooden construction, which strength should withstand flood flows, even in the case that the mesh is clogged with debris.

- KARI net, mesh size up to 10×10 cm; KARI net is self-supporting, the simplest plan shape in its case is a circle or drop; it is necessary to protect the KARI net against beaver's intrusion from the bottom – by embedding into the stream bed and anchoring; and also from the top – either elevating the KARI net above the water level, or covering it by a grille.
- Gabion cages with a mesh size of at least 10×10 cm – it may be used either one cage or a system comprised of several cages; the advantage is toughness, easy connection by a spiral system, good corrosion protection and easy manipulation, the disadvantage is the higher price.

To anchor the protective cage. it is possible to use metal rods (e.g. rebar) or pipes. If wood is used, it is necessary to place stabilizing poles inside the cage, to prevent damages caused by beavers.

Financial demands

Dam draining is a mid-priced measure. The prices for different types of pipes and other materials used for the drainage of the dam are shown in **Table 4** and **5**.

Table 4: Approximate prices of pipes suitable for the drainage of beaver dams.

Material of pipes	Diameter [mm]	Weight [kg/rm]	Approximate price incl. VAT [CZK / 5 m]
Plastics PVC, PP)	200	3.5	900,–
	300	11.0	2,100,–
	400	21.0	3,300,–
	500	34.5	5,800,–
Steel	219×6.3	33.0	7,000,–
	324×8	64.4	16,400,–

rm – running meter

Table 5: Approximate prices of other materials used in the drainage of beaver dams.

Material	Diameter [mm]	Unit of measurement [UM]	Weight of UM [kg/UM]	Approximate price of UM incl. VAT [CZK /UM]
Reinforcing steel - poles (for the stabilization of the pipes or cage)	18	rm	2.00	42,–
Reinforcing steel - poles (for the stabilization of the pipes or cage)	25	rm	3.85	80,–
Wooden logs (to stabilize the cage)	80	rm	2.80	50,–
KARI net, a mesh 100×100 mm/2×3 m	6	pc	26.6	600,–
Gabion netting, a mesh 100×100 mm / 1.0×1.0 m	4	pc	1.50	170,–
Gabion netting, a mesh 100×100 mm /2.0×1.0 m	4	pc	2.00	350,–
Connecting gabion spiral 1.1 m	4	pc	0.15	15,–
Connecting gabion spiral 2.1 m	4	pc	0.28	30,–
Knitted galvanized wire mesh, height 150 cm, a mesh size 50×50 mm	2	rm	2.00	60,–

rm – running meter, pc – a piece

For a better idea, here is an example of quantifying material costs: 1 piece of a plastic pipe with a diameter of 500 mm, length 5 m (5,800 CZK), anchoring the pipe with a rebar of 18 mm thickness, and length 1.5 m (500 CZK), protection of the inflow made of the KARI net – a mesh 10×10 cm, wire strength 6 mm (800 CZK), anchoring the KARI net with a rebar 25 mm thick, 2 m long (900 CZK), a binding wire (200 CZK), i.e. a total of 8,200 CZK. Prices do not include transport, costs of the construction, or labour; they are approximate and refer to the price level of March 2016.

Operation and maintenance

Drainage of dams is a measure quite difficult to maintain. If beavers do not accept the reduction of the water level, they will most likely try to clog the inflow of the pipe. The beavers may attempt to get into the protective cage and clog the pipes. It can also seal the entire perimeter of the protective cage, fill the water storage, or cover the entire construction with branches and mud. Besides the risk of clogging caused by beavers, the protective cage and possibly the pipe itself (especially the variant with drilled holes) are prone to clogging with natural debris (twigs, leaves). Therefore, regular checks and maintenance of the facility in the case of clogging are necessary. Checks should be performed at least once a week, and if beavers accept the lowering of the water level, the check and possible cleaning every two to three weeks are sufficient. It is also advisable to check and clean the equipment after every flood situation.

If beavers do not accept the lowering of the water level, and despite all efforts they fail to clog the pipe, an alternative dam over or under the drained dam is often built. The entire measure thus becomes inefficient and must be re-implemented on the new dam.

Expected efficiency

The authors have not been aware (till the publication of the handbook) of any properly made drainage of a beaver dam in our country, which would have been functional for more than one season. The authors therefore built on foreign sources, and also on the mistakes that they have seen in the implementation of this measure, both abroad and in our country. If the pipes and protective cage are installed properly, subsequently the dam is completed, regular maintenance is ensured and the depth of water above the dam is at least 80 cm, this measure can be long-term efficient, as cited foreign sources in the list of literature show.

Legal Terms

Installing pipes is problematic in terms of the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the implementation of the measure with a manager of a watercourse and water management authority.

If the drainage is made as described above (incl. maintaining min. 80 cm of water column above the dam after installing the drain), and it is performed in a gentle way, i.e. beavers are not significantly disturbed by noise, machinery and so on, it should not represent harmful interference with the natural behaving of beavers within the meaning of the ANLP, and therefore it should not be necessary to apply for an exemption to protective conditions of the ANLP (see **Chapter 4**). But it is always appropriate to consult the specific procedure with the local nature conservation authority.

Inappropriate and inefficient measures, mistakes when implementing the measure

- The pipe is placed at the bed of the flow – there is no increase in the water level left for beavers and beavers build a new dam at another place.
- The inflow is not sufficiently indented from the dam – it is easier for beavers to determine where the water drains out and they clog the cage intensively.
- Connection of two pipes is not firm and tight – the device is deformed at the connection.
- Poor fixing of pipes – water is buoying up the pipe, changing its position, and this means that the functionality of the measure is worsened or the measure is totally dysfunctional.
- Absence of the protective cage – beavers clog the inflow of the pipe.
- Small protective cage – the cage is quickly clogged with debris or because of beavers´ activity.
- Protective cage is not covered from its top or bottom – the cage is open for beavers and the inflow is clogged.
- The dam is not returned to the original level after the pipe was installed (**Picture 19**).
- Regular maintenance is neglected – (functionality of the device is lost).

Picture 19: Improperly made drainage of a dam - the pipe after the installation was not covered (i.e. the dam was not finished), and moreover, water falls from height behind the dam, causing unwanted noise.

3.2.2 Floating Buoys as a Precaution Against the Occurrence of a Dam

The aim of the measure

The measure aims to put a greater floating object in the flow profile in a place where it is undesirable to build a beaver's dam (e.g. culverts under roads which could be clogged, inflows and outflows of wastewater treatment plants and small hydropower plant, etc.). These may be flow profiles that might be for beavers suitable for building a dam. A floating object or a set of objects – and their constant movement in the flow – make impossible for beavers to build and stabilize a dam.

The measure is suitable for wider watercourses (about over 2 m).

The technical principle of the solution

Detailed drawings of two variants of this measure are presented in Annex 6. Technically, it is a floating buoy hanging on a steel cable or metal chain on a cross-beam installed above the edges of a stream channel. Another possibility is to anchor a buoy to a streambed. It is suitable to weight a buoy, e.g. put inside some stones, so that it is partially plunged, but not completely sunk.

For a buoy, it is possible to use any waterproof floating object of required size in the shape of a sphere, or other shape, with a diameter of at least 0.4 m – e.g. a buoy, barrel, boat fender, etc.

The floating object is fixed to a streambed or cross-beam with a steel cable or chain. The length of anchoring to a streambed should be greater than the maximum depth of the water during the flood in the area. The length of anchoring to a cross-beam should guarantee at least partially submerged buoys under water. A cross-beam should be placed above the water level of usual flood flows.

Anchoring to a streambed is possible with a weight (e.g. a large stone, concrete block) or a steel rod with an eye hammered in a streambed. Generally, more preferable is a steel rod hammered in a streambed because buoys

Picture 20: A floating buoy as protection against undesirable clogging of a culvert by an activity of beavers (a) and as adjunctive protection of a draining device of a small reservoir (b).

anchored to the weights could be easier carried away by water during increased flow rates. The weight must be very heavy (about 100 kg or more), so that the anchoring is sufficiently resistant.

Anchoring of a buoy to a horizontal beam (**Picture 20**) must be fixed, and also a rod must be fixed well to a bank, so that it cannot change its position during increased flow rates.

A variant of the transverse beam is preferable in terms of minor interference in the flow profile and in terms of the passage of floods, on the other hand, there is a greater risk that a part of the object will be stolen or damaged by vandals.

Financial demands

The measure is not too expensive. Cost of the material will be in the range of about 500 to 1,000 CZK. Indicative prices for materials used for the measure are presented in **Table 6**. Prices are approximate and refer to the price level of March 2016.

Operation and maintenance

In terms of operation and maintenance it is an easy measure. The only risk is that debris can be caught on the anchor cable or directly on the buoy. Therefore, it is necessary to check the measure about once per week and after each flood event. There is also a risk of theft of buoys.

Expected efficiency

This measure has not been used in the Czech Republic yet. Floating buoys are used in Bavaria, for example in inflows to treatment plants or to protect culverts. Floating buoys prevent the construction of a dam only on a particular critical profile.

Legal Terms

Installing a floating buoy is problematic in terms of the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the implementation of the measure

Table 6: Approximate prices of different materials used for a floating buoy.

Material	Diameter [mm]	Unit of measurement [UM]	Weight of UM [kg/UM]	Approximate price of UM incl. VAT [CZK /UM]
Buoy 320 mm, height 80 cm	–	pc	–	450,–
Fender 38×48 cm	–	pc	2.00	800,–
Waterproof barrel capacity of 26 l, with handles	–	pc	–	830,–
Steel cable, 5 mm	5	rm	0.08	10,–
Reinforcing steel (poles)	18	rm	2.00	42,–

rm – running meter, pc – a piece

with a manager of a watercourse and water management authority.

Inappropriate and inefficient measures, mistakes when implementing the measure

There is no practical experience with the measure in the Czech Republic; therefore, we cannot describe mistakes in its implementation. Theoretically, weaknesses and risks can be seen mainly in:

- The possibility of theft of buoys.
- In the case of anchoring in a streambed – debris or damaged hinge; profile clogging due to carried material.
- The entire hinge is damaged during a flood.

3.2.3 Backfilling of Canals with Coarse-Grained Material

The aim of the measure

This is a preventive measure against a construction of dams only on **intermittent streams**, i.e. drainage canals and ditches along roads. The aim is to fill a ditch profile with coarse-grained material so that water will flow through backfilling and there will not be an available open water surface for beaver dam construction. It means that the location will become non-attractive for beavers. The measure can be used where there are consistently low flows and floods are not too high and frequent. A limiting condition for the implementation of the measures is that there is too much suspended load in the inflowing water.

The technical principle of the solution

Detailed drawing of the measure is presented in Annex 6 (upper drawing). The measure is carried out by filling the canal with coarse-grained material, so that usual water flows are straining through the aggregate and free water level is not available. During implementation, first it is necessary to increase twofold (approximately) the transverse profile of the canal than it would be sufficient in the case of free flow profile. First, so-called inverted filter (i.e. finer fraction of the aggregate) is placed into a stream channel. Then, coarse aggregate is placed on it so that the upper part of the transverse profile is left free to convert any flood flows (**Picture 21**).

For the filling of the canal itself, a suitable material is quarried stone, grain size of about 20–50 cm. The advantage is even-grained material due to the higher porosity. It must be sufficiently high so that it could accommodate usual flow Q_a, plus at least 20%. Increased flows then either run through the gaps between the stones, or they flow over the rest of the transverse profile of the stream channel, which remains free.

Financial demands

Financial demands of the measure are quite high. These are mainly deepening of the canal, and the purchase and importation of aggregate for backfill. Price for ground work, associated with modifying the dimensions of the canal and then redistributing the material excavated on adjacent land, will be about 400 CZK per 1 m^3. The price does not include the costs associated with obtaining approvals for the imposition of soil on adjacent land.

Price for filling the canal profile with aggregates will be around 1,400 CZK per 1 m^3 of aggregate. Price includes materials and labour. When transporting the material to a greater distance it is also necessary to calculate the price for imports of the material. Prices are approximate and refer to the price level of March 2016.

Picture 21: A road ditch filled with coarse-grained material, before there was an intermittent watercourse where beavers built dams and surge water, which endangered the road.

Operation and maintenance

The measure is in terms of operation and maintenance simple, provided that there is no clogging with suspended load. The base is occasional checking whether usual flows still run below the surface of the stone backfill. It is also necessary to check it after every flood episode (e.g. after extreme torrential rainfall), whether there is not relocation of stones or clogging with suspended load from surrounding areas.

Expected efficiency

The measure is simple and has a high efficiency. Due to the measure, open water disappears from the site and beavers do not have space for their activities which surge water. The negative aspect of the measure is that there is a loss of the free water level in the landscape, which in large scale might have a negative ecological impact. With this measure intermittent streams lose a migration throughput to aquatic organisms.

Legal Terms

The characteristics and location of the canal will determine which statutory provisions establish the conditions for implementing this measure. Obviously the Water Act no. 254/2001 Coll. may be involved. In terms of protection of watercourses and floodplains as important landscape features and because of the possible occurrence of specially protected species of flora and fauna in the backfilling canal, the ANLP may be also involved.

Inappropriate and inefficient measures, mistakes when implementing the measure

- Application of the measure on watercourses with higher running of suspended load – the gaps will be clogged, the ability to carry out usual flows will decrease, and water will not be strained through and will flow over the surface.
- Using too fine aggregate – due to small porosity and a slow infiltration water will flow over the surface.
- A road ditch filled up to its edges – flood flows will spill over the surrounding land.

3.2.4 Increasing the Level of the Plot

The aim of the measure

The aim of increasing the level of the plot is to mitigate the impact of the water level – which was surged by a beaver dam – on the surrounding land. This reduces the risk of flooding and waterlogging of neighbouring agricultural areas. The measure of such a degree should be performed at locations where we can expect long-term occurrence of beavers and also where there is a high probability of a construction of dams. It makes sense to carry out the measure on plots which are productively used as pastures or fields.

The technical principle of the solution

Detailed drawing of the measure is presented in Annex 7 (lower drawing). Increasing the level of the plot (**Picture 22**) is made with earth backfill. First it is first necessary to carry out a pedological research aimed at determining the thickness of the topsoil layer of the particular plot. Subsequently, the topsoil layer is removed, and the formed plain is covered with material that is compacted to the required value (i.e. to the proposed bulk density of the consolidated soil profile). As a material for filling may be basically used any uncontaminated soil, ideally in the neighbourhood. The knowledge of the physical properties of the material – too low hydraulic conductivity can cause waterlogging of the plot, and on the contrary too high hydraulic conductivity can cause drying of the area. The original layer of topsoil is spread back on parted and adequately compacted material. It is necessary to maintain a minimum slope of the land (1–2%) towards the watercourse.

The slope linking the increased plot and the floodplain of the stream should match the angle of internal friction of the soil (not more than 1:1) and should have a minimum height of 1–1.5 m, so that the measure is efficient. To ensure protection of the slope against beaver burrows, it is appropriate to fortify the parts that are in contact with water with stones or rock-fill (see **Chapter 3.3.1**); or put up some

mesh fencing on the slope and cover it with soil (see **Chapter 3.3.2**).

Picture 22: A floodplain left for beaver activities, on its right edge, roughly in the middle of the photo, there is a visible edge of an increased plot.

Financial demands

The price for increasing level of a plot will depend on the amount of removed and transported material, and also on the price of earthworks. Indicative prices for the realization of a particular earthwork for 1 m³ of the soil are summarized in **Table 7**. Prices are approximate and refer to the price level of March 2016.

Example: The price – for stripping the topsoil layer in a thickness of 30 cm, bringing in the soil (including compaction) in a thickness of 1 m and then again overlapping the topsoil layer – would be approximately 550 CZK per 1 m² of cultivated surface. The measure is economically viable only in areas where the material for the embankment is free and there are short transport distances.

Operation and maintenance

Increasing the level of the plot is a very costly measure, but when it is made correctly, there is no maintenance.

Expected efficiency

There has been no practical experience with this type of measure in the Czech Republic yet; the measure is taken from Bavaria. If the plot is increased sufficiently, good and lasting results can be expected.

Legal Terms

By implementing this measure, Act no. 183/2006 Coll. on territorial planning and building regulations and the Water Act no. 254/2001 Coll. are involved. In terms of protection of watercourses and floodplains as important landscape features and because of the possible occurrence of specially protected species of flora and fauna on cultivated areas, it is necessary to comply with the provisions of the ANLP. It is a measure that can be perceived problematically in the context of efforts to good morphological-ecological state of a watercourse and floodplain. It is necessary to discuss its implementation with the water management authority, the nature conservation authority and the building authority.

Inappropriate and inefficient measures, mistakes when implementing the measure

- Not appropriate choice of fill material – the plot is wet or too dry.
- The slope of the increased part of the plot is not towards the watercourse – rainwater does not flow away and hold in the decreased part of the plot, it leads to waterlogging and more difficult farming.
- Small increase of the plot – water level surged by a beaver dam continues to cause waterlogging of the area.

Table 7: Approximate prices for the increasing the level of the plot

Item	Unit of measurement (UM)	Approximate price of UM incl. VAT [CZK /UM]
Stripping topsoil, moving to an intermediate stockpile	m³	250,–
Bringing in and storage of loose rocks, incl. compaction	m³	400,–
Overlapping layer of topsoil, relocation of intermediate stockpile and adjustments of the plain	m³	150,–

3.2.5 The Removal or Reduction of Beaver Dams

The aim of the measure

The measure aims to avoid permanent water surge in watercourses which is caused by beaver dams. It is performed either by removing the entire dam, or by removing just a part of it. In the first case there is a return of the watercourse to the original water level. In the second case there is a decrease of the water level to the required level and thereby reducing of waterlogging of surrounding area. In both cases it is an action with immediate effect. However, it is very likely that beavers will immediately or after some time react to this measure; and they will build a new dam or complete the demolished dam to its original level. The new dam can occur in the same place or in the vicinity of the original dam. Applying this measure, the risk of increased felling of trees always rises, because beavers use primarily for a construction of a dam freshly felled woody plants; they do usually not use the material from the demolished dam which is left on the bank.

The technical principle of the solution

Removal of a beaver dam means that all the material of the dam is moved away from the watercourse. For larger and more accessible dams, due to their solid construction, we recommend the use of mechanization – an excavator, manipulator, feeder, etc. Manual removal is very difficult, however, in some areas the only possible. Removal of dams is mostly performed repeatedly.

The material from the removed dam, the volume of which varies in units of m^3, can be either stored directly on the bank of the watercourse where it was excavated, or, if possible, it is preferable to take the material away.

Beavers usually do not accept this type of measure and make a great effort to rebuild the dam at the original place or in its vicinity. The construction of the new dam may occur during the first night after the removal. Removal of the dam must therefore be performed repeatedly at short intervals, for an indefinite period of time. When removing the dam during autumn and non-freezing winter days, a quick response can be expected. In this period the dams are for beavers a key element for overwintering. On the contrary, beavers do not have to replace (repair) immediately the dams removed during the spring and summer. However, it is very likely that with the onset of autumn beavers can restore the removed dam again. Generally, to increase the probability that the dam does not arise again it is recommended to use floating buoys (see **Chapter 3.2.2**).

Height reduction of a beaver dam is an alternative to complete removal of the dam, and leads to a reduction of the water column to the required level. This measure is often used in Saxony. Only the required layer of material is removed from the dam crest, either from the whole length of the dam, or just from its centre (**Picture 23**). It is not recommended to remove material only from littoral parts of the dam because subsequent strong flow of water along the banks could cause their increased erosion.

Picture 23: Partial demolition of a beaver dam, so-called a dam opening (a); removing a dam using machinery (b).

Financial demands

This type of measure requires labour costs and possibly working time of machinery.

Operation and maintenance

A place where the dam was partially demolished or completely demolished (and its surroundings) must be checked regularly. In autumn and non-freezing winter days, beavers are more interested in building dams, so at this time we recommend checking at least once a week. If the new dam is built or the original one is restored to undesirable height, there is no other choice than to carry out the measure again. Partial demolition of the dam is less demanding, however, it requires more frequent monitoring because beavers maintain it faster.

Expected efficiency

In the case of removal or reduction of the dam long-term efficiency cannot be ensured. Beavers may accept the intervention only temporary. This measure can ensure only rarely that beavers will leave the location. In that case the measure is effective but only until other beavers inhabit the site again. Experience shows that if the site is attractive, or near there is no other suitable and available place, beavers remain at the site. Despite repeated and long-term removals of the dams, beavers will be renewing them continually.

Legal Terms

Implementation of removal or reduction of beaver dams is conditional on compliance with legislative provisions of the ANLP; the measure should be implemented only after the granting of exemptions from the protective conditions of beavers (see **Chapter 4**). Furthermore, the provisions of the Water Act no. 254/2001 Coll. are prejudiced and interventions in the dam must be discussed with the manager of the watercourse.

The possibility of removing dams allows so-called General measure (GM), which had previously been adopted by some regions (see **Chapter 4.2.2**). How to proceed in the regions where the GM was not released is described in **Chapter 4.2.1**.

Inappropriate and inefficient measures, mistakes when implementing the measure

Reducing the dam by repeatedly removing material only on the banks of the watercourse may cause undesirable erosion.

3.2.6 The Protection of Bridges and Culverts

The aim of the measure

Any smaller bridge or culvert, i.e. a constriction on the watercourse, represents for beavers an ideal place to build the dam and water surge (**Picture 24**). Surged water level may waterlog parts of roads or rails, or flood surrounding areas. When a part of a road is overflowed, it may cause its damage and it may also become endangering, moreover, adjacent areas or objects may be endangered as well. In many cases sealing with branches, stones and mud is so solid that unblocking is not possible without the use of specialized equipment. Therefore, it is necessary to pay attention to protection of small bridges and culverts, especially from the side of management and maintenance of these buildings. The measure aims to protect small bridges and culverts and preserve their function in spite of a beaver activity.

Picture 24: Partially clogged culvert by unwanted beaver activities.

The technical principle of the solution

Detailed drawings of two variants of the measure are presented in the Annexes 8 and 9. In principle, this measure is identical to the measure of the drainage of a beaver dam (see **Chapter 3.2.1**). The technical solution consists of the construction of a protective cage, which allows continuous inflow or outflow; even in the case there is a bigger amount of debris (i.e. floating twigs, leaves, etc.), e.g. during flood flows. A protective cage is a massive object placed in front of the small bridge and culvert, which must withstand both high pressure of water and high pressure of carried debris. A protective cage may be either embedded in the streambed so that the beaver cannot burrow under it or it must have its own bottom; and it must also be closed from its top. Dimension of a protective cage depends on the specific conditions of the location, shape and size of the culvert or bridge, characteristics of the stream channel, the water levels of the watercourse, etc. Therefore, this measure is very difficult to standardize. Generally, however, the size must match the size of the culvert and stream channel, and water levels of the watercourse.

The protective cage may be a weldment of steel profiles in the shape of a sloped cuboid or a pyramid, provided with a cover from KARI net with a maximum mesh size 10×10 cm (thickness of the rod 6 mm), similarly as illustrated in **Picture 25**. A plan shape of the cage should provide the longest flow length of the mesh fencing, therefore it is appropriate that it runs against the flow direction and does not block the entire width of the stream channel. The construction is on the upstream side firmly placed to the front of the culvert or the small bridge. The whole construction should be fixed to the streambed, e.g. with steel rebar, to prevent any undesirable movement of the cage.

Another type of a spatial arrangement of the protective cage may be a duckbill shape (see Annex 12, drawing on the right) jutting against water. The advantage is a greater flow length of the mesh fencing.

Picture 25: A culvert protection, using a hanging indent steel cage on the inflow. Two plastic pipes pulled high above the culvert inflow ensure the flow rate. Their inflow is also protected by a protective wire cage.

Installation of a pipe embedded in the culvert can be an alternative to the protection of the whole inflow, but only in the case of significantly oversized culverts. The pipe is inserted into the culvert so that its inflow is at a distance of at least 3 meters away from the culvert and the longitudinal gradient of 1–3% is kept. It is also important to protect the inflow of the inserted pipe with the cage (the protective cage is described in detail in **Chapter 3.2.1**). The capacity of the pipe must also absorb flood flows. Beavers can clog the culvert, but all flows are transferred through the pipe. In the specific case – where the terrain configuration and size of the space above the water level allows installing of floating buoys – it is possible to proceed as described in **Chapter 3.2.2**.

At the design and realization, it is necessary to take into account the possibility that the mesh may be clogged with debris, especially during floods. It is also necessary to take into account the water pressure (both hydrostatic and hydrodynamic) in the case of partial or complete clogging of the mesh fencing with debris during flood situations. Therefore, these are usually massive objects which use wooden stakes, steel beams and KARI nets.

Appropriately and gently made installation does not constitute an interference with protective conditions of Eurasian beavers. In the case of busy roads, it is necessary to take into

account the risk of limiting migration permeability of the watercourse and "guiding" the animals on the road with the risk of clashes.

Used materials and financial demands

Protecting small bridges and culverts is a mid-priced measure. Indicative prices for the material used for the measure are shown in **Table 8**. The prices do not include transport and construction of the building; they are approximate and refer to the price level of March 2016.

For clarity, we describe the following example of quantifying material cost for the culvert protection – the cage with the shape of a cuboid sloped against water which fits tightly to the culvert body (dimensions of the cage are: base 1×2 m, top 1×1 m, height 1 m). The skeleton of the cage of the L-shaped bracket, length 20 m (1,800 CZK), KARI net with an area of 6.5 square meters (650 CZK), the cage fixed with reinforcing steel 6 pcs (250 CZK), a total of approximately 2,700 CZK. The prices do not include transport and construction of the building; they are approximate and refer to the price level of March 2016.

Operation and maintenance

The measure is in terms of maintenance and operation quite demanding, because it is essential to check it regularly, at least once a week, whether there has been damage to the structure or there has not been too much debris. It is required to remove the debris during each check. Checking and maintenance must be done after every flood episode as well.

Expected efficiency

In the case of a correct implementation, adequate monitoring and maintenance, protecting small bridges and culverts is an effective measure against unwanted flooding due to clogging of narrow flow profiles. But it requires regular inspection and maintenance.

Legal Terms

Implementation of this measure can be problematic in terms of The Water Act no. 254/2001 Coll. For this reason; before its implementation it is necessary to contact the manager of the watercourse and the water management authority. Because of the potential risk of limiting migration permeability of the watercourse and "guiding" the animals on the road with the risk of clashes with vehicles, it is appropriate to discuss the measure with the local nature conservation authority (see **Table 12** in **Chapter 6**). This step should be followed especially for busy roads (i.e. the roads of I and II Class).

Inappropriate and inefficient measures, mistakes when implementing the measure

- The protective cage does not extend well before the culvert – beavers clog the cage and use it as a support for the dam (**Picture 26**).
- The cage is not secured against intrusion of beavers – beavers clog the culvert.
- The maintenance and cleaning of the cage is neglected – the cage is clogged with debris or by beaver activities, water can spill out of the stream channel.

Picture 26: Improper protection of a culvert – the grill can be quickly blocked and the stability of the culvert and the road could be endangered. This solution is very risky by itself, even if there are no beavers in the location.

Table 8: Approximate prices of the used materials.

Material	Diameter [mm]	Unit of measurement [UM]	Weight of UM [kg/UM]	Approximate price of UM incl. VAT [CZK /UM]
Reinforcing steel - poles (for fixing the structure)	18	rm	2.00	42,–
Steel equal bracket: L 50×50×5 mm	–	rm	4.03	90,–
KARI net, a mesh 10×10 cm/2×3 m	6	pc	26.60	600,–

rm – running meter, pc – a piece

3.2.7 Protection Against Limiting the Functionality of Water Management Structures

Objects of water management infrastructure are often situated in close contact with watercourses or water areas. Measures against unwanted flooding should be included in the designing (e.g. backflow valves on the effluent from sewage treatment plants or overflow chambers, etc.). Many water management structures require keeping a particular water level, which may substantially more difficult after arrival of beavers and the water surge. In terms of protection of water management structures, it is generally possible to work with the previous types of measures (**Chapters 3.2.1** to **3.2.6**); in some cases, it is necessary to observe other specific demands and requirements.

Increased vigilance in the preventive protection applies especially to the following facilities:

- Wastewater treatment plants (WWTP) – water surge can cause flooding of the waste drain of the WWTP, which means that the facility becomes out of order. In extreme cases, it can lead to flooding of a technology degree – it becomes non-functional and subsequently there can be an ecological accident on the watercourse.
- Small hydro power plants (SHP) – a construction of a dam on the inflow limits the water inflow to the SHP with a possible failure of the turbine. The water surge in the outflow from the SHP may cause, that the gradient can be decreased and there may be a potential failure of the turbine. The turbine can also be damaged by an increased amount of woody debris (i.e. mainly floating twigs), which is carried by water in the inflow due to a food beaver activity in the section above the SHP.
- Sources of drinking water, especially water supply wells – they are endangered by the construction of beaver dams that cause the surge and overflow of water in the places the wells.

3.3 Protection Against Burrowing Burrows (Lodges) and Channels, Disruption of the Bank's Stability

Beavers can create, according to the configuration of the terrain, two types of settlements: burrows and lodges. A burrow is the most common type of a beaver dwelling. The burrows are divided into two types – burrows created for settlement purposes or as a shelter. Shelter burrows serve only as a temporary shelter, reaching the lengths of up to several meters. There is a large number of them in a beaver territory.

A settlement burrow is a permanent dwelling, where a family live together especially during winter time. The cubs are also given birth in there, and they spend the first 4–6 weeks of their life with the female beaver inside. The length of the settlement burrow may reach several tens of meters. The centre of the underground system is an expanded space, in which the family resides. The settlement burrow in the territory is mostly just one, but larger families may inhabit more settlement burrows.

Both types of burrows are slanted upward in banks of watercourses or water reservoirs, so that their living partitions are situated above the water level (even above the lower water level). Furthermore, it is the same for both of them that their entrances lead underwater. In the dry season, however, these entrances may be exposed (as can be seen in **Picture 27**), which can cause that beavers feel intense urge to build dams also in the dry summer periods.

If the terrain does not enable to burrow burrows (low banks, high level of low water, wetland areas), beavers build lodges. These are constructions made of branches, vegetation, mud and stones that can reach a considerable size. The residential part of the lodge is situated above the water level. Ideally, beavers build their lodges within the areas flooded by dams. Very often, however, the lodges are also created on banks in the close proximity to watercourses and water areas. Again, there is a rule that entrances are safely hidden under the water. Therefore, where there is no water, beavers do not build their dwellings there.

For overland journeys for food and building material beavers often use the same routes. Beavers can convert these routes to their own water transport route by digging a long irrigated canals leading into the water. The canals are about half a meter wide and 80 cm deep. Deep cuts are another disruption of banks; these slides arise by moving of beavers along steep banks. In the very steep almost vertical banks beavers create from water to land manholes, which may arise especially when the water surface freeze during winters. By digging the tunnels beavers get to bank-vegetation.

Beaver dwellings have different potential for conflict situations. While lodges surrounded by water do not have, from a human perspective, almost any negative effect; burrows, lodges on the ground and connecting corridors may give rise to a wide range of conflicts.

The burrows are burrowed in riverbanks, in levees, in dams and banks of ponds or artificial canals. The basic problem of these dwellings is that they are generally invisible and very unstable, and eventually they cave in. Therefore, in the case of dams, the stability and sealing function of the dam itself is endangered. Moreover, where a dam crest serves as an occasional or service road, movement of machinery along the dam can be worsened. Other problem of the caved in structures can be increased erosion of the banks of watercourses and formation of riparian gullies (in the case of natural stream channels or revitalized streams this may be a part of their morphological development, but surrounding areas are obviously affected). The protective measure includes the application of a mechanical barrier that prevents the formation of burrows. Preventing the formation of chutes and manholes again includes the mechanical protection of the banks.

Picture 27: Burrows dug in banks of a pond (a), and a flood dam (b).

3.3.1 Fortification of the Dam or the Bank with Stones (Rock-fill)

The aim of the measure

The measure aims to prevent the beaver in burrowing, creating an impermeable layer of aggregate. The size and weight of the individual stones are unsurpassed for beavers and deter them from burrowing lodges. Another suitable method is the application of the mesh fencing from the upstream side of a dam together with gravel rock-fill, which prevents distortion of objects by burrowing.

The technical principle of the solution

Detailed drawing of the measure is presented in Annex 8. Technically it is possible to fortify dams and banks with gravel or stone rock-fill and coarse rock-fill. In the case of small fractions of aggregate (gravel rock-fill), it is necessary to fortify the object also with mesh fencing, because we do not have any information about how thick layer of the rock-fill can discourage beavers from burrowing their lodges. This type of the measure is commonly also used as a flexible type of fortification of watercourses or as a protection of banks and dams of reservoirs against the effects of waves. The rock-fill gradually overgrow with vegetation, disintegrates, and after a few years it does not interfere in the landscape.

When implementing the measure on existing structures (dams or banks) the existing layer of soil with vegetation must be removed down to clean soil. The surface does not have to be aligned into direct plains; it is possible to monitor irregular shapes of older dams. Such an arrangement is commonly used in water management to stabilize the banks and dams. The design and implementation must be carried out by a qualified person or organization for compliance with common standards (CTS 75 2410 Small water reservoirs).

Coarse rock-fill is formed by an underlay of larger stones (**Picture 28**). Stones are placed so that they form a continuous layer without large gaps with relatively flat surface. Based on experience from Bavaria, stones weighing at least 40 kg – i.e. grain size 40 cm and more – are suitable; beavers are not able to manipulate with them when burrowing their lodges. Stones are placed in the ballast bed which also serves as a filter layer against washout of the material from the dam, and the joints between the stones are not filled. It is necessary to set up the fortification from the foot of the slope and stabilize the foot from the stone backfill with a base sleeper, so that the whole layer is stabilized and cannot slip on the drenched surface of the earth body. It is necessary to build the fortification at least to the usual water level. In the case of the possible occurrence of elevated water levels, it is necessary to raise the fortification to the maximum possible water level. When building small reservoirs, very often are designed fortifications of the upstream face of the dam up to the crest. In terms of financial demands, there is an increase in costs, but the safety of the dam will be much higher than if there is only the fortification of the slope just to the level of usual water levels.

Picture 28: Coarse rock-fill.

Stone rock-fill is a layer of heavier stones loosely thrown together; with given fraction in thickness which is normally at least three grains of average size of the backfill (**Picture 29**). The surface of the rock-fill is then mechanically settled into the desired shape, thickness and inclination. In terms of the stone rock-fill, there in not any confirmed information about the thickness of the stone, discouraging beavers from burrowing their lodges. According to information from Bavaria, aggregate layer of 1 m should be sufficient.

For the use of the stone rock-fill we can thus only recommend aggregate with the weights of individual stones more than 40 kg. In principle, it means that the protection against burrowing is based on the weight and not the thickness of the aggregate layer.

Picture 29: Heavy stone rock-fill.

In the case of gravel rock-fill it is advisable to use any medium or coarse gravel fraction of at least 64/125, and more, in combination with mesh fencing (see **Chapter 3.3.2**). A recommended thickness of the layer is at least 40 cm – this ensures the mesh fencing is covered and beavers can get to it only with difficulty. Application of the mesh fencing beneath the gravel rock-fill is therefore necessary because beavers might burrow through the gravel rock-fill.

Under each type of the fortification it is necessary to make a gravel filter (often multilayer) which will prevent the washing-out of the material of the dam. Thickness and fractions of individual filter layers are proposed according to CTS 75 2410, whereby their thickness should be at least 25 cm. It is necessary to base the fortification (as in the case of the coarse rock-fill) on the base sleeper in the level of the slope foot. In terms of the protection against temporary shelters of beavers during floods, it is appropriate to build it at the level of the maximum proposed levels.

Financial demands

Fortification of banks and dams with coarse rock-fill, stone rock-fill and gravel rock-fill, including mesh fencing, is relatively expensive measures. The price depends on the quantity and type of the used material. To illustrate, here is the unit price of the material: coarse rock-fill 2,500 CZK/m^3, gravel rock-fill fraction 64/125 mm 1,100 CZK/m^3, filter layer 1,050 CZK/m^3. Additionally, there is an added cost of labour (removing the top layer of soil, transportation and arranging of material, for gravel rock-fill – extra cost for materials and labour for the installation of mesh fencing, etc.).

Operation and maintenance

If the measure is performed properly, it is almost maintenance-free. Well-made stone rock-fills or coarse rock-fills can withstand for decades. All maintenance consists of occasional checks if there is not any damage the rock-fill, and eventual local repair. The advantage is the flexibility – loosely put stones enable that the body can be modified without disrupting its function.

Expected efficiency

If the measure is performed properly, absolute efficiency can be expected. To maximize safety, it is recommended to use heavier aggregate.

Legal Terms

Implementation of this measure relates to the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the measure with the manager of the watercourse and the water management authority. Another relevant law is Act no. 183/2006 Coll., on territorial planning and building regulations.

Watercourses and ponds are important landscape elements according to the ANLP, and to implement interventions it is necessary to obtain the standpoint of the nature conservation authority. In the case that there is any beaver dwelling in the modified part of the watercourse or pond (i.e. a burrow or lodge) and beavers are currently found in the area, the implementation of the measure is conditioned also by fulfilment of the relevant provisions of the ANLP (see **Chapter 4**), incl. situations when the reservoir must be drained

for the implementation of the measure. Moreover, it must comply with the provisions of the Act no. 246/1992 Coll., on protection of animals against cruelty, i.e. any injury or death of animals in the implementation of the measure must be avoided.

Inappropriate and inefficient measures, mistakes when implementing the measure

- The fortification is not made up to the maximum water level – in elevated water levels beavers disrupt with the burrows the unprotected part of the bank or dam.
- The layer of gravel without using the mesh fencing is used for the fortification – beavers burrow into the dam body or into the bank.
- Stones of the rock-fill are too small and therefore lightweight (less than 40 kg) – beavers are able to roll the stones away and burrow their lodges.

3.3.2 The Mesh Fencing in the Dam Body or in the Bank

The aim of the measure

The aim of the measure is to create an impenetrable barrier for beavers (steel mesh placed shallowly beneath the surface) so as to avoid the possibility of burrowing lodges and disruption of the stability of the dam or the bank.

The technical principle of the solution

Detailed drawing of the measure is presented in Annex 11. On the surface of the dam or the bank, without vegetation and the top soil layer, the steel mesh fencing is placed. It is anchored by steel buckles to the body of the dam or the bank. On the dames, the mesh fencing is then covered with the filter layers and final fortification of the upstream side (**Picture 30**). The gravel filter (often multi-layered) prevents washing out the material from the dam or from the bank. The thickness and the fraction of each filter layer is designed according to CTS 75 2410, whereby their thickness should be at least 25 cm.

The fortification of the upstream side of the dam or the bank should be performed from the bed to the constant storage level. For the case of the possible occurrence of elevated water levels it is necessary to put the mesh well above the usual water level to prevent burrowing temporary beaver shelters.

Basically, any mesh with long-term resistant to corrosion can be used, for example gabion nets, fence galvanized wire mesh or KARI mesh. It is important to keep the minimum strength of the wire 2 mm and the maximum size of a mesh to 10×10 cm. The advantage of the KARI nets is their long life; on the other hand, the KARI nets do not adapt themselves so willingly to shapes of the terrain, therefore they are more suitable for new buildings. In the case of the protection of existing structures, it is preferable to use more flexible mesh, e.g. gabion nets.

Regarding the flood dam or banks of watercourses, where it is not necessary to fortify the surface with stones, it may not be necessary to apply the filter layer. It always depends on the particular conditions of the locality. In this case, the mesh fencing is placed from the bed to the maximum water level; it is covered with a sufficient layer of soil and seeded with suitable seed mixtures, so as subsequently there will be a grass cover, which also performs the stabilizing function.

The measures should be designed and carried out by a qualified person or organization, based on common standards (e.g. CTS 75 2410 Small water reservoirs).

Financial demands

Inserting the mesh fencing into the bank or the body of the dam is a very costly measure. The price will depend on the type of the mesh and the price of the gravel and filter layers (unit prices see **Chapter 3.3.1**). The price is directly proportional to the length the fortified object.

Picture 30: Placing the mesh fencing into the body of the flood dam on the Kyjovka River - the slopes are protected with the mesh fencing against burrowing, the riverbed is protected with the coarse rock-fill against the bank erosion.

Operation and maintenance

Basically, maintenance of the mesh fencing in the dam is not needed. What is needed is only occasionally checking whether somewhere there is not a landslide of the slope, and the mesh fencing is not exposed or even damaged. In this case, then a local repair is necessary. Because of corrosion of the mesh fencing, the mesh with a resistant coating should be chosen.

Expected efficiency

If the measure is performed properly, absolute efficiency can be expected. The measure will prevent beavers from disruptions of dams or banks by burrowing their lodges. However, there is no information on how long the individual types of mesh fencings resist corrosion and ensure the protection against the creation of the lodges.

Legal Terms

Implementation of this measure relates to the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the measure with the manager of the watercourse and the water management authority. Another relevant law is Act no. 183/2006 Coll., on territorial planning and building regulations.

Watercourses and ponds are important landscape elements according to the ANLP, and to implement interventions it is necessary to obtain the standpoint of the nature conservation authority. In the case that there is any beaver dwelling in the modified part of the watercourse or pond (i.e. a burrow, lodges) and beavers are currently found in the area, the implementation of the measure is conditioned also by fulfilment of the relevant provisions of the ANLP (see **Chapter 4**), incl. situations when the reservoir must be drained for the implementation of the measure. Moreover, it must comply with the provisions of the Act no. 246/1992 Coll., on protection of animals against cruelty, i.e. any injury or death of animals in the implementation of the measure must be avoided.

Inappropriate and inefficient measures, mistakes when implementing the measure

- Protection with the mesh fencing is not performed up to the maximum water level – beaver disrupt with the burrows the unprotected part of the bank or dam, which is located below water level (particularly in the case of flood situations).
- The mesh fencing with a wire diameter of less than 2 mm or no corrosion protection is used – the mesh will have shorter durability and it will not protect the dam or bank against burrowing of beavers for a long time.
- A foil is used instead of the mesh fencing – a sliding surface is formed and the layer of soil, which is on the foil, can easily slide away.

3.3.3 Sheet Piles

The aim of the measure

A radical measure, such as a plastic or steel sheet piles is generally used to prevent water seepage through a body of a dam. On the one hand, sheet piles ensure the tightness of the dam, side effect (not the principal) is to protect the dam against burrowing of beavers. Using this measure purely to protect against the effects of beavers can be considered quite inadequate, although of course it ensures a reliable safety of the dam. On the other hand, the sheet piles due to its location in the middle

of the body of the dam cannot eliminate burrowing of beaver lodges in the direction from the water, so the risk of the collapse of the part of the dam is still real.

The technical principle of the solution

The sheet piles are used to form and stabilize the vertical lines in the ground (**Picture 31**). Piles are in a selected length driven by a special machine to earth body as a seal against water leakage, for full sealing a bentonite mixture is used.

Sheet piles are usually driven into the centre of the dam crest. From the upstream side thus beavers cannot burrow their lodges; the stability of the flood dam is not compromised. However, the stability of the dam between the water level and the sheet piles is compromised. With the slope of the upstream side of 1: 1.5, the increase of the dam crest above the normal level of 1.5 m and a width of the dam of 2 m, beavers can burrow in the water level up to a distance of about 3.5 meters before they hit an obstacle, which is for their life quite sufficient. Thus, the measure protects the dame against leaks or tear, but also on the upstream side will allow beaver to burrow the lodges.

The measures must be carried out only by an organization with the necessary qualifications, equipped with special machinery.

Financial demands

The price of the steel sheet piles depends on the price of steel. The average price of steel (the price level of March 2016) is 18 CZK/kg. For the most common type of the sheet piles 1 m^2 weighing about 155 kg, the price of 1 m^2 then comes to 2,790 CZK. According to the computer system URS, the price of placing one square meter of the sheet piles is 2,000–2,500 CZK, according to the demands of the terrain and geological composition of the site. Plastic sheet piles are about 30% cheaper and their installation when using high-frequency vibro-hydraulically driven hammers is also cheaper. The measure is extremely technically and financially demanding, therefore, it cannot be recommended primarily as a protection against beavers. Using the sheet piles is useful if it is necessary to stabilize the body of the dam, strengthen anti-tearing, landslide or prevent seepage.

Operation and maintenance

If the measure is implemented properly and fulfils its primary purpose, especially to protect against leaks, it does not need any checking or maintenance. On the upstream side there can occur burrowing and slumping of burrows, but the stability of the entire dam and its complex function is not compromised. Maintenance in this case involves filling of fallen through burrows.

Picture 31: Steel sheet piles in a body of a flood dam (a), plastic sheet piles are driven into the ground (b).

Expected efficiency

Efficacy against breaking through or slipping of the dam is absolute; but beavers can still burrow their lodges into the upstream side of the dam.

Legal Terms

Implementation of this measure relates to the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the measure with the manager of the watercourse and the water management authority. Another relevant law is Act no. 183/2006 Coll., on territorial planning and building regulations.

Installing the sheet piles into the dam does not directly influence watercourses or floodplains, which are important landscape elements according to the ANLP. The standpoint of the nature conservation authority may be necessary only if the measure affects the water regime of the floodplain or the watercourse, i.e. the movement of groundwater (but this is not desirable either from the water management point of view or from the standpoint of stability of the dam itself). In the case that there is any beaver dwelling in the modified part of the watercourse or pond (i.e. a burrow or lodge) and beavers are currently found in the area, the implementation of the measure is conditioned also by fulfilment of the relevant provisions of the ANLP (see **Chapter 4**), incl. situations when the reservoir must be drained for the implementation of the measure. Moreover, it must comply with the provisions of the Act no. 246/1992 Coll., on protection of animals against cruelty, i.e. any injury or death of animals in the implementation of the measure must be avoided.

3.3.4 Filling of Fallen Through Burrows and Tunnels

The aim of the measure

The measure aims to prevent secondary damage (to health of people, animals and property) arising from falling through to the beaver tunnels, shelters or burrows (**Picture 32**). The measure doesn't solve the activity or occurrence of beavers on the location, it is just to repair the damage and reduce the risk of consequential damage.

The technical principle of the solution

Technically, this is the filling of an already fallen through of underground passages and burrows of beavers.

Fallen through burrows on the roads are mostly filled with gravel because the compaction is easy. Fallen through burrows on arable land or areas with permanent grass cover are filled with ordinary soil, the material must be stored in layers and compacted to avoid subsequent creation of a terrain depression.

Financial demands

The financial demands of this measure are not very high, it depends on the price of the machines used for earthworks (may be around 2,000 CZK/an hour) and the prices of materials and services (hundreds of CZK/m^3).

Picture 32: A fallen through burrow in a watercourse bank (a), a fallen through path (b).

Operation and maintenance

Given that the measure does not directly prevent damage caused by beavers, it is not possible to talk about the operation and maintenance, or about the effectiveness of the measure. If the material gets down, it is necessary to add the material and compact it.

Legal Terms

If a locality is inhabited by beavers, it is necessary to comply with the provisions of the ANLP (see **Chapter 4**). Moreover, it must comply with the provisions of the Act no. 246/1992 Coll., on protection of animals against cruelty, i.e. any injury or death of animals in the implementation of the measure must be avoided. It is likely that the nature conservation authority – when granting exemptions from the ANLP – sets a time period in which the measure can be implemented. Filling temporary burrows created in dams or in the high banks above the usual flow at the time of floods (after a drop in water level) is not tampering protective conditions of beavers and therefore does not require an exemption under the ANLP.

3.3.5 Protection Against Interference of Banks with Canals and Slides

Beaver channels – that are not acceptable for humans – must be filled up with the soil and subsequently compacted (as in the case of fallen through burrows described in **Chapter 3.3.4**).

Prevention of the chutes is essential in the stabilization of the slopes, so that beavers could use their trails but their activities do not cause formation of notches in the banks (**Picture 33**). From the technical point of view, it is basically the same measure as in the case of prevention of burrowing of lodges, it means either the fortification of the affected site and its surroundings with rock-fill (see **Chapter 3.3.1**), or by placing the mesh fencing into the bank (see **Chapter 3.3.2**). In the case of the mesh fencing, it is necessary to expect that frequent movements of beavers can cause its local exposure. In this case, the mesh may constitute a danger for the beaver, other animals, or for humans, it is therefore necessary to cover the exposed mesh with a layer of soil again.

Picture 33: Coarse rock-fill.

3.4 Protection of Small Water Reservoirs

The protection of small water reservoirs (lakes, etc.) is a very specific issue with extensive security risks. Problems can be divided into two groups, the first includes the activities of beavers limiting the functionality of technical elements, and second group includes the effect of beavers on the banks of the dam and reservoir.

Sound of leaking water from the water reservoir can cause beavers to avoid the runoff, despite the fact that the depth of water is more than insufficient for beavers. In terms of small water reservoirs, beavers usually clog drain devices or monks, rarely an emergency spillway. Beavers can clog the upper inflow of the monk at the opening hole under the lid with branches, stones and mud. Endangered are both the monk outflows and outflows with slide gates if beavers manage to get to them through the inflow. Similarly, drain devices based on the principle of a gate valve may be endangered.

Blockage of the drain device does not affect the safety of the water reservoirs, but will reduce the possibility of manipulating the water level, and thus worsening management conditions of the reservoir. To protect the outflow, it is possible to use a fencing around the monk, which is designed for the purpose (a beaver deceiver), or at least at the inflow part of the monk (more in **Chapter 3.4.1**).

Another problem – that occurs in wooden outflows of ponds – is that they can be damaged by gnawing; damaged can be both individual woody planks and the whole outflows (see **Picture 34a**). This issue is described in **Chapter 3.4.2**.

A more critical situation is if the capacity of the emergency spillway is limited. Each increased level beyond the capacity of the monk should be smoothly transferred over the spillway. If the flow of water through the spillway is reduced (not only due to beaver activities), the security of the whole dam is endangered. Any restriction of the emergency spillway throughput means a condition that is not acceptable (**Picture 34b**).

Another problem of the existence of a beaver on water reservoirs is the need to burrow burrows in dams and banks. A shape of the dam of water reservoirs is for attractive for beavers, when beavers settle down in the reservoir; they usually burrow their lodges in the dam. The presence of the burrow may cause disruption of the tightness and stability of the dam and thus the functionality and security of the entire water work. For this reason, it is necessary to protect the dams of reservoirs on the upstream side against burrowing the lodges. On reservoirs with outflow channels or side reservoirs, it is necessary to ensure the protection of the bank or the pond dam on all sides, which are or could be in a contact with water (i.e. also the downstream side of the main or side dams if their foot is or could be flooded).

3.4.1 Protection Against Limiting the Role of Technical Elements of Reservoirs – Protection Against Undesirable Increase of Water Levels of Small Water Reservoirs

The aim of the measure

Beavers may try to manipulate water levels in reservoirs, especially deteriorating or disabling the proper function of the drain device or safety spillway. The aim of the measure therefore, is to make it impossible for beavers to influence the function of these objects.

In the U.S.A., so-called "beaver deceiver" is used to solve this problem and its designer is a biologist named Skip Lisle. The deceiver ensures stable operation of the drain device of small water reservoirs. In principle, it means that the whole inflow is fenced (in rectangular or trapezoidal shapes). The fencing is dimensioned so that despite the blockage caused by beavers it carries water to the drain device to an extent where there is no unwanted increase in the water level in the reservoir (under usual flow conditions) and at the same time the drain device is able to manipulate the water level in its usual way. Proper technical implementation makes it impossible for beavers to enter the place where the water flows away, which means that the likelihood of active clogging of the device by beavers, activities is reduced (although in principle it is counted with it). The precondition of the functionality of the deceiver is that it must be far enough from the point where water inflows into the drain device.

Picture 34: A monk damaged by beavers (a), a beaver dam on a security spillway (b).

The technical principle of the solution

Protecting of the drain device

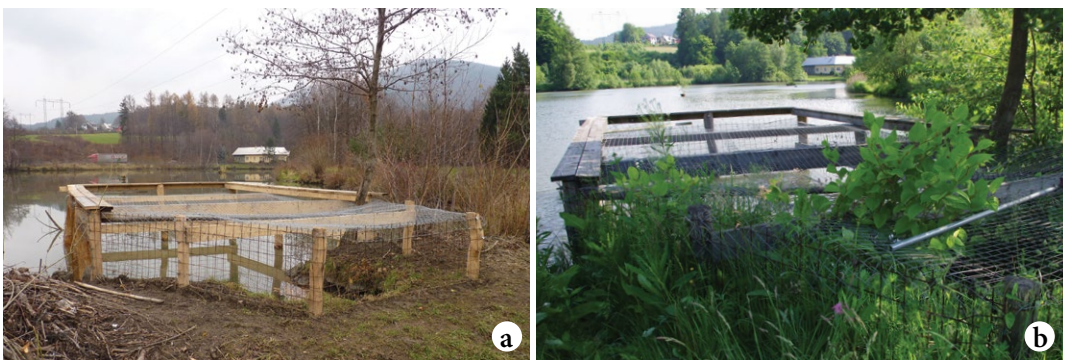
It is necessary to protect the drain device with the cages (i.e. already mentioned beaver deceiver, see **Picture 35**), mostly consisting of wooden construction made of prisms. Dimension of the structure depends on the height and size of the object. Detailed drawing of the measure (variant of an open outlet/monk) is presented in Annexes 12 and 13; a beaver deceiver is presented in Annex 14.

It is necessary to protect the wooden construction of the deceiver against gnawing; stakes must be hammered into the bed of the reservoir. The construction is from the sides and top covered by the KARI net or corrosion-resistant mesh fencing, with a mesh size up to 10×10 cm. The minimum strength of the wire must be at least 2 mm; however, it is supposed that thicker KARI nets and meshes will be used with regard to their strength to hold woody debris or to support beaver dams. Kari nets or mesh fencing must be fitted to the construction so that the beaver cannot enter an enclosed space of the barrier by burrowing under it, get inside from the top or from the sides by removing a part of the mesh or KARI net. To protect it against burrowing under, the net must be embedded deep into the bed. The alternative is that the structure will have its own bottom part or the mesh at the bed of the reservoir is bent outwardly from the monk, anchored by staples and loaded with heavy stones, respectively covered with soil. The width of the recessed or outwardly bent strip according to the character of the bet should be 50–100 cm (in the reinforced or stony bed 50 cm is sufficient, for the muddy bed the width should be at 100 cm).

When sizing the deceiver, it is essential that the fence is placed far enough away from the drain device, and at such a deep part of the reservoir that beavers perceive the flow of water just minimally. Their instinctive behaviour to stop the leakage of water from the reservoir will not be stimulated. Nevertheless, it is necessary to consider the eventuality that beavers will tend to surround the entire deceiver by their own dam (and thus increase the water level in the reservoir). The construction of the deceiver must therefore be robust to withstand possible pressure of retained water. The second requirement is that the perimeter of the deceiver must have a sufficient capacity at the water level to carry usual flows even when the whole deceiver is surrounded by a beaver dam.

Using of the deceiver varies; either the device covers inside the whole monk (see Annex 14), or it is attached from the side to the firm (usually concrete or metal) walls of the monk (see Annexes 12 and 13). The first option is technically more difficult because it is necessary to ensure access to the monk and its operation.

Designing the device, it is suitable to work with a modular system of equally large parts. One part should be sized 1.5–2.5 m in the width, the height of the parts will depend on the specific situation in the reservoir. These modules then enable to create differently shaped and large deceivers.



Picture 35: A beaver deceiver in Rožnov pod Radhoštěm during its construction in 2012 (a) and after three years of operation (b).

The height of the beaver deceiver must exceed the depth of the maximal water storage in the reservoir and the top cover of the safety cage must allow access to the lid of the monk and woody planks, so that it is possible to manipulate freely with the water level in the reservoir. A probability that the safety cage is clogged with woody debris is in this case relatively small, due to small rate of flow of water on the water level. More important is to expect a building response of beavers (building the dam around the whole perimeter of the deceiver). To increase the stability of the device it is possible to create a deceiver in the shape of a trapezium which longer side is placed at the dam.

Protecting the safety spillway

The most endangered are safety spillways (i.e. a simple depression of the body of the dam, which is mostly fortified only weakly), and then direct frontal or frontal tube spillways, fitted directly to the body of the dam. The frontal spillway usually has a wide spillway edge and is often used as a functional replacement of the drain device to maximize water storage. In this case the drain device is fully enclosed and usual flows run through the safety spillway.

In terms of blocking the spillway by beavers, the side or composited spillways and spillways in the shape of a fountain are practically safe because they have narrow and mostly rounded overflow edge, where beavers actually have no possibility to establish and stabilize their dams.

Protecting the safety spillway against the blockage is in principle similar to a devise preventing the escape of fish from the pond – so-called bar screen (**Picture 36**). Detailed drawing of the measure is described in Annexes 15 and 16. This is a moved-forward screen wall or protective cage made of wooden beams and covered with KARI net. The technical parameters may be the same as for the protection of the drain device. It is important that the protective wall in front of the spillway is moved from the spillway edge towards the reservoir as far as possible and is well anchored to the bed. Greater length of the screen wall minimizes the risk of clogging the wall with debris during floods. In many cases the protection of the safety spillway is almost impossible because beavers can get to the safety spillway over the dam crest or from the downstream side of the dam. If there is a risk that beavers can go round the screen wall and will reach the safety spillway object, it is necessary to protect it also from the sides. It is always necessary to make a proposal of protection tailored for the specific site.

It should be noted that in terms of current legislation and safety of the water work, any limited functionality of the safety spillway is unacceptable. We strongly advised that these type of measures should be consulted in advance with the manager of the water work, and it should be designed and performed by a person with sufficient knowledge in the field of civil engineering and water management.

Picture 36: A screen wall in front of a safety spillway.

Financial demands

The total cost of the protection facilities will consist of the cost of materials and the cost of labour and delivery. The price for the material will be in most cases the minority part and will depend on the used material (wood vs. steel, stainless steel; mesh vs. KARI net) and on the size of the object itself. In most cases the majority share will be the delivery and installation of the measures. Roughly estimated it can be said that the price will range from

a thousand CZK (in the case of small objects and simple measures) to tens of thousands of CZK for large objects and precious materials.

Operation and maintenance

The measures may in varying degrees restrict the operation of the reservoirs. It is necessary to check the installed equipment about once a week whether the mesh is not broken or clogged with debris or beaver activities. Probability that the protective fencing of the monk is clogged with debris (i.e. floating twigs, leaves, etc.) is in this case relatively small due to the small flow rate of water on the water level. Any identified build-up must be removed and, if necessary, the defects must be repaired immediately.

Expected efficiency

The measures will in any case largely restrict and complicate operation on water reservoirs and ponds. From a legislative point of view, any restriction of the flow capacity of the safety spillway is prohibited. These restrictions are obviously represented by any screen or grid walls which are moved-forward the spillway body and which can be clogged by debris during floods and can cause the decommission the spillway. Fatal consequences of such events are known from practice.

However, if the described protective measures are well performed and implemented, high efficiency can be expected – in exchange for greater effort in their checking and maintenance.

Legal Terms

For the implementation of the measure it is necessary to comply with the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to consult the implementation of the measure with the water management authority. Another relevant law is the Act no. 183/2006 Coll., on territorial planning and building regulations. If the reservoir is inhabited by beavers, and if the water – when installing the protection of the drain device or safety spillway – is drained, it is necessary to comply with the provisions of the ANLP. The environmental-stabilization function of ponds as significant landscape elements according to the ANLP should not be influenced by the measure, so from that perspective the standpoint of the nature conservation authority is not necessary.

Inappropriate and inefficient measures, mistakes when implementing the measure

- The construction of the deceiver is not sufficiently moved-forward the drain device, beavers detect the flow and that is why they clog the construction constantly.
- To protect the drain device the mesh fencing is used with a mesh larger than 10×10 cm. Beavers penetrate through the mesh and clog the drain device.
- The mesh of the deceiver is not sufficiently fitted into the bed. Beavers burrow under the mesh, get to the drain device and clog it.
- The mesh deceiver is connected to under the water and the connection is not strong enough – beavers can part the connection of the mesh fencing and through the gap they get to the drain device and clog it.
- The mesh used for protection has a low resistance to corrosion – the structure will not protect the drain device for a long time.
- The maintenance of the deceiver or screen wall is not ensured – they are clogged or locked which causes an undesirable increase in the water level.

3.4.2 Protection Against Lowering Water Level in Small Reservoirs

The aim of the measure

A large part of small water reservoirs is equipped with a monk which serves as a drain device. The monks have their barrier wall made of wooden (e.g. oak) planks. Smaller and older reservoirs usually have the whole monk made of wood. Beavers can damage these wooden structures or their parts by

gnawing (**Picture 37** and **34a**). The result is then a leaking monk and falling water level in the reservoir.

Picture 37: A plank damaged by a beaver.

There are basically two types of protective measures:

1. Protection of the monk by fencing beaver deceiver (described in detail in **Chapter 3.4.1**) – the aim is that beavers cannot get to the monk and they cannot clog or gnaw it.
2. Reinforcement of the monk and woody planks so that they cannot by damaged by beavers.

The technical principle of the solution

It is technically possible to resolve the situation by building a concrete base of the monk (newly constructed ponds usually have it). The problem is the protection of the wooden planks. Wooden planks can be replaced by plastic, but even those can be destroyed by beavers. Another option is to replace them with aluminium profiles, which, however, are much more expensive and can be stolen. The last option is to use metal plates to cover wooden planks. This is probably the cheapest and easiest option, but the challenge will be to ensure the tightness of the planks wall.

Financial demands

Financial demands depend on the size and type of protection that will be created (see **Chapter 3.4.1**).

Operation and maintenance

In the case of plating the planks the measure is maintenance-free. It is required to check the fencing of the monk at least once a week to see if there has not been excessive clogging or even some damage.

Expected efficiency

Protecting wooden planks by metal plates is the sure protection against beaver gnawing. Protecting the drain device by fencing will restrict operation of reservoirs in varying degrees (see **Chapter 3.4.1**), but when performed correctly, it is the effective protection against beavers.

Legal Terms

Install a fence around the monk must comply with the provisions of the Water Act no. 254/2001 Coll. For this reason, it is necessary to arrange the realization of the measure with the water management authority. Another relevant law is the Act no. 183/2006 Coll., on territorial planning and building regulations. If the reservoir is inhabited by beavers, and if the water – when installing the protection of the drain device – is drained, it is necessary to comply with the provisions of the ANLP. The environmental-stabilization function of ponds as significant landscape elements according to the ANLP should not be influenced by the measure, so from that perspective the standpoint of the nature conservation authority is not necessary.

Mechanical protection wooden planks against beaver gnawing cannot be regarded as a breach of the protective conditions of beavers, so it is not necessary to follow the provisions of the ANLP.

3.4.3 Protection of Dams and Banks of Small Water Reservoirs Against Burrowing of Lodges

If beavers live in the reservoir, they burrow their lodges or temporary shelters in its banks. For the location of their dwelling with the entrance hidden below the water level, they will search for the place where the bank has a greater slope. A good place is almost always the dam or bank of the water reservoir. Therefore, the upstream faces of the dams and banks are endangered by burrowing of the burrows. In the dam crest or on the air side a beaver burrow can fall dawn a part of water storage may drain and possibly a whole dam can collapse. A specific case is a side water reservoir or through-flown water reservoir with bypass channel. In both situations, beavers can build their burrows from both sides of the dam or the bank, or even build connecting tunnels between the channel /watercourse and the reservoir itself. Consequence is that some amount of storage water can drain or the dam can collapse. For this reason, it is necessary to protect all sides of dams and banks which are in a contact with water.

All these problems must be resolved by fortification of the dams – with the mesh fencing, gabion nets or aggregate; from one or both sides, according to the presence of water. This issue is described in detail in **Chapters 3.3.1** and **3.3.2**.

3.5 Planning New Objects

After many years, beavers returned to the Czech Republic (the historical, current and possible future extension is described in detail in **Chapter 5.2**). Beavers have not settled all accessible locations yet; the settlement is not across the whole area. In the coming years we can expect further spreading and this species will practically repopulate throughout the entire Czech Republic. Due to conflict prevention, it would be appropriate, when planning new buildings and activities, to implement measures which will in the future avoid or minimize conflicts caused by unwanted beaver activity.

The authors of the text therefore recommend that when planning basically any activity (e.g. construction or revitalization of ponds, repairing dams, etc.) which could in the future get into a conflict with beaver activities, to take into account the possible presence of beaver activity at the location. Since we can expect areal settlement of the entire Czech Republic, it is always necessary to take into consideration whether to include measures (as summarized herein), which will reduce or eliminate the negative impact of beavers. A preventive application of the measures may significantly reduce the risk of the conflict situations in the future.

In all cases, these are the implementations of measures already described in previous chapters; therefore, in the following text the measures are only listed and refer to the appropriate chapter of the text.

Construction of small water reservoirs

Planning and construction of small water reservoirs in areas where beavers already occur or in areas where beavers have not been found yet, but their occurrence can be expected (the vast majority of the Czech Republic), it is recommended:

- To fortify the upstream face of the dam, so that beavers cannot burrow their lodges there. It is recommended to use the coarse rock-fill or heavy stone rock-fill, in the entire length of the slope of the upstream face of the dam (for details see **Chapter 3.3.1**). Alternatively, the upstream face of the dam can be protected with the mesh fencing placed under the gravel backfill (**Chapter 3.3.2**). The standard CTS 75 2410 for small water reservoirs recommends to fortify it from the dam crest at least 0.8 meters below the water level of the constant storage. In areas with possible occurrences of beavers we recommend to fortify the entire height of the dam.
- In the case of cascades-arranged water reservoirs, where it is flooded, the air dam foot by water surge of the underlying reservoir,

it is necessary to protect against burrowing also the air face of the dam.

- In the specific cases (e.g. side water reservoir or through-flown water reservoir with bypass channel) it is necessary to protect against burrowing all ground bodies which are in the direct contact with water. It is necessary to prevent burrowing of the side dam between the reservoir and the watercourse, or the bank between the reservoir and the drain channel.
- The parts of the banks (not only the dams), where there is high probability of beaver activity, can be protected with the heavy stone rock-fill, coarse rock-fill, gravel rock-fill in combination with the mesh fencing, or the mesh fencing.
- Objects on small water reservoirs should be designed in the way that beavers cannot damage them:
  - The safety spillway should have a sharp (narrow) and rounded overflow edge, and its type should be fountain-like, side, or composed.
  - The drain device should be closed – the gullet with several wooden planks walls or slide valve so that beavers cannot get to the open shaft. In the bed and on the object there should be fitted preparation for the installation of the protective cage (see **Chapter 3.2.6**). In these cases, concrete is a preferable material.

Construction of roads

During the planning and construction of road and rail bodies located near a watercourse, it is suitable to protect the slopes of the body, which could be flooded with the water surge, against possible burrowing by using the coarse rock-fill, heavy stone rock-fill or the mesh fencing placed about 10 cm below the surface (see **Chapters 3.3.1** and **3.3.2**). The alternative is to build embankments of the roads in a sufficient distance from watercourses, so that waterlogging does not compromise their function.

Creation of gardens and orchards

During the creation of gardens and orchards in areas where beavers already exist or will exist, it is recommended fencing around the property according to the principles set out in **Chapter 3.1.1.2**. This is a protection with the fencing, when the mesh is embedded and anchored into the ground or bent outwards from the plot, anchored to the ground and covered with soil. The second element in the creation of gardens and orchards is placing the cultural areas farther from the bank; this will reduce the rick of burrowing under the fencing, particularly in the case of a steep slope of the bank. An alternative of the complex protection of covers is to fence only a few individual trees (see **Chapter 3.1.1.1**).

Construction of buildings

When constructing new buildings adjacent to watercourses it is appropriate:

- To build or protect the building so it is not endangered with a possible flooding of water spilled from the watercourse when beaver dams are built (e.g. to build it on an elevated position, to make ant-flood fences, etc.).
- To protect pipes which go through the watercourse (a pipe diameter 400 mm and larger) under the building against intrusion of beavers (e.g. by fitting suitable special grids at the inflow and at the outflow).

Construction of small hydropower plants, wastewater treatment plants, sewerage systems and other infrastructure

All buildings on watercourses (small hydro power plants, wastewater treatment plants, etc.) – in areas where beavers already exist or will exist – should be designed and built with the knowledge that beavers can cause a surge in water levels near the building, and flood it or disable the continuous outflow of the water. Therefore, it is strongly recommended to fit the objects either directly with a protective device, or at least to make preparation for its installation. These protective measures mean

– check valves, screen walls protective wire cages (see **Chapter 3.2.6**) and so on. These measures should be placed in buildings so as it is not endangered with any water surge.

Construction of levees (flood barriers)

When building or reconstructing levees near watercourses where beavers already exist or in the future will exist, it is strongly recommended primarily to move the levee farther from the bank. This protection against burrowing of lodges is safer from the long term perspective. It is also useful for the capacity increase for overflows of watercourses during increased flows. Such a flood barrier is not in contact with water during usual flows, therefore there is no risk of distortion by burrowing. In the case of flood flows when the dam is in contact with water, it cannot be completely excluding burrowing of beaver ledges. To ensure the protection of the moved-backward dam it is useful to apply the mesh fencing beneath a grassed surface of the dam.

If it is not possible to ensure sufficient moving-backward (at least 20 m from the bank), it is necessary to fortify the upstream side of the dam; in the case of parallel foot drains (i.e. the open ditches with water, where beavers can build a dam) also the air side. It is recommended to make the fortification with the coarse rock-fill or stone rock-fill, possibly with the mesh fencing placed shallowly beneath the surface of the dam (a detailed description of these measures is in **Chapters 3.3.1** and **3.3.2**). The dam should be designed and constructed so that its stability is not endangered by flooding the air foot of the dam if beavers build their dam in the open ditch of the foot drain.

Recommendations for forest production

In areas where beavers occur, actual or potentially, it is recommended:

- To fence preventively all covers located near watercourses, in accordance with the principles set out in **Chapter 3.1.1.2** (the mesh with a long service life bent against the direction of arrival of a beaver or embedded deep into the ground).
- To consider starting of buffer strips made of the trees preferred by beavers (willows, poplars) along watercourses, which reduce the damage caused by beavers in production forests.
- Where the felling of trees by beavers happens repeatedly, it is possible to consider the transfer of the forest cover to non-forest area, which is no longer valid obligations of the Act no. 289/1995 Coll., on forests.

4 Legal Regulations Related to the Protection of a Beaver and Conflict Resolution

The legislation which is in varying degrees engaged in the existence and occurrence of beavers in our country can be divided into several levels. First, these are the rules that summarize and define the legal protection and determine the manner and scope of solutions of damages or conflicts caused by beavers. Furthermore, beavers are included among the game species in hunting legislation. Included are also requirements associated with resolving the damage caused to the woody plants.

4.1 Protection of the Eurasian beaver in accordance with the Act No. 114/1992 Coll. (ANLP)

The Eurasian beaver is in relation to EU legislation and international conventions protected on the territory of most European countries. The Convention on the Conservation of European flora, wildlife and natural habitats (i.e. The Berne Convention), with Annex 3 included beavers among the protected species. Furthermore, this species is protected within the EU under Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (i.e. The Habitats Directive). Under this directive beaver is included in Annex II, i.e. among species requiring special protection areas within the Natura 2000 network. This applies in all EU countries except Finland, Sweden and the Baltic States. Furthermore, the beaver is included in Annex IV, i.e. among species requiring strict protection throughout the Member States. It also does not apply to Finland, Sweden, Poland and the Baltic States, where the beaver was already widespread in the time of their accession to the EU. On the basis of the classification of the beaver in Annex II, on our territory there are defined eight European Sites of Community Importance (hereafter SCI) of the Natura 2000 network, where the species is a subject of protection. Namely, these are SCIs Kateřinský and Nivní potok, Labské údolí and Porta Bohemica, Strážnická Morava, Niva Dyje, Soutok–Podluží, Litovelské Pomoraví and Morava–Chropyňský luh. Information on these sites can be found on the NCA CR website (**www.nature.cz**) in reference to Natura 2000. The requirement of Annex IV of the Habitats Directive, i.e. the strict protection of this species, is reflected in our legislation by including a beaver among specially protected species of animals (hereinafter SPSA) in the category of "strongly endangered" (Annex 3 of the Decree no. 395/1992 Coll., as amended).

Basic protection conditions of SPSA, and therefore beavers, are set out in § 50, articles 1 and 2 of the ANLP. On the basis of these conditions it is prohibited detrimentally interfere with their natural development, particularly disturb, capture, injure, kill, and breed in captivity. It is also prohibited the possession, transporting, selling, bartering, and beavers offered for sale or exchange. With regard to § 48, article 4 of the ANLP the protection (i.e. mentioned prohibitions) applies to dead individuals, their parts or products from them. In addition to the direct protection of individuals, there is also the prohibition of deterioration or destruction of beaver settlements, i.e. their burrows and lodges. Diagrammatic analysis of the conditions stipulated by law, conditions about protection of the Eurasian beaver, and their exceptions are listed in Box 2.

An overview of the basic conditions for the protection of a beaver

Basic conditions for the protection of the European beaver are set out in § 50, articles 1 and 2 of the ANLP.

These conditions consist in protecting all its developmental stages, both natural and man-made sites and biotopes being used by it. It is prohibited to interfere harmfully with the natural development of beavers, for example to catch them, breed in captivity, disturb, injure or kill. Due to the general prohibition of harmful interference with the natural development, disturbing is an activity which negatively affects the development of the individual or individuals beyond the normal level. I.e. it is harmful, it is reducing the possibility of using food resources, and it affects the necessary movement in the territory and migration.

Only a nature conservation authority is entitled – according to the specific situation – to decide what activity constitutes a legally prohibited harmful interference with natural development.

Examples of activities that DO NOT CHANGE living conditions of beavers (i.e. do not represent the negative interference with the natural development of beavers):

- Areal removal of riparian vegetation from less than half of the relevant territory of the Eurasian Beaver.
- Areal fencing of productive forest growth, if riparian vegetation remains accessible for beavers.
- Fencing of a drain device or monk of a pond, which prevents access of beavers to the drain device.
- Drainage of a beaver dam – if after installing the drain the water column is high 80 cm and more.

Examples of activities that CHANGE living conditions of beavers (i.e. represent the negative interference with the natural development of beavers):

- A permanent reduction and removal of beaver dams.
- Drainage of a pond with the current appearance of beavers.
- Removal of mud from a pond or watercourse with the current appearance of the beaver.
- Interventions in the banks of a pond or watercourse directly at the place of actual residence of beavers.
- Areal removal of riparian vegetation of deciduous trees in more than a half of the relevant territory of beavers.
- Analogous to the previous point, fencing of all riparian vegetation of deciduous trees.
- Drainage of a beaver dam – if after installing the drain the water column is less than 80 cm high.

In the ANLP there are listed in § 50 bans of other activities with a negative impact on the given species:

- A ban on the collection, destruction, damage or relocation of dwellings occupied by beavers.
- Prohibition of possession, transporting, selling, bartering and offering individuals for sale or exchange, which apply also to the dead individuals and their parts or products from them (§ 48, article 4).

Exemptions from the legal conditions of protection of beavers

An exemption from the described prohibitions can be authorized under the conditions and for the reasons stated in § 56 of the ANLP.

Since the Eurasian beaver is the species protected under European Community law, it is possible to permit an exception because of another overriding public interest (than the protection of a beaver), or in the interest of nature conservation, if:

- There is no other satisfactory solution (more moderate etc.)
- Permitting action will not influence the achievement and maintaining of a favourable conversation status of the species in terms of its protection (see § 3, article 1, section T), ANLP)
- Permitting activity also corresponds to one of the specific reasons or purposes according to §56, article 2, ANLP (e.g. prevention of a serious damage, public safety and health, research and education).

A nature conservation authority may in accordance with § 56 ANLP grant an exemption from the prohibitions referred to in § 50 ANLP upon request of:

- natural persons,
- legal entities.

Or a nature conservation authority may grant an exception to an unspecified group of persons according to so-called General Measure.

Exemption is issued in the form of a decision in the administrative procedure, which is initiated by the submission of the application. Since the exception permits prohibited activities, the applicant must prove the merits of reason (§ 56, article 2, ANLP) on which the application is based.

Resting period of a beaver

Two "sensitive" periods when the implementation of activities has a negative impact on the prosperity and survival of beavers can be defined:

a. wintering period from 1/11 to 1/3

b. the breeding period from 1/5 to 15/7

Elimination of Eurasian beaver individuals

Elimination of beaver settlement by trapping or catching beavers is proposed in the framework of the Management Plan (see **Chapter 2**) in a so-called realization of the C- Zone, where the occurrence of the species is unwanted. Elimination of the settlement (as possible, but only a temporary solution to the conflict situation) is not excluded on the remaining territory of the Czech Republic, especially in the B-Zone. In assessing the reasons for the catch of present beavers it is particularly necessary to consider whether there is no other satisfactory solution. In practice, the catch will be in mostly a part of a package of measures to prevent serious damage and ensuring public safety. There is, however, necessary to draw attention to the fact that after a successful catch the site will be very soon (within a year or two) inhabited by beavers again. Eliminating beaver settlements should therefore be associated with the application of preventive measures that would prevent re-emergence of conflict situations.

Table 9 shows a simplified overview of legal provisions that affect the application of the measures described in this manual. This overview includes conditions of beaver protection in accordance to the ANLP and refers to other legislation, which can be affected by the application of the measures. For more detailed information the reader must browse the chapter with the appropriate measure.

4.2 Exceptions to the Protective Conditions for Specially Protected Species

Exemption from the prohibitions referred to in § 50 of the ANLP may be allowed by a nature conservation authority at the request of a natural person or legal entities, or it may be allowed to an unspecified group of persons by so-called General measure.

4.2.1 Exemption from Prohibitions on Request

In the case that for example in order to avoid serious damage is an activity that would violate the prohibitions referred to in § 50 of the ANLP (removal of beaver burrows, etc.), it is necessary to submit at the relevant nature conservation authority an application for exemption from the prohibitions for the realization of this activity. To be sure whether the activity is not in conflict with the basic conditions of protection of beavers, it is suitable to contact the relevant nature conservation authority before its implementation. The planned activity can also have a negative impact on other specially protected plant and animal species, or may be in breach of the conservation conditions of the protected area (if it is located there) and these aspects also must be dealt with.

Table 9: A list of measures in the handbook and the overview of the relevant legal provisions in the application of the measures. It is a brief general overview; detailed analysis of the individual measures is described in the appropriate chapters.

Name of the measure and number of the chapter in the text	Is it necessary to apply for an exemption to protective conditions of beavers according to the ANLP?	Other recommendations
Fencing individual trees (3.1.1.1)	No	
Fencing of forest and agricultural covers (3.1.1.2)	Yes - according to the extent; an exception is needed only if the measure significantly limits access to food for beavers	It is necessary to discuss the implementation of the measure with the competent nature conservation authority and proceed according to the Building Act (no. 183/2006 Coll.)
Abrasive coating (3.1.2)	No	
Electric fence (3.1.3)	No	safety rules must be observed; appendices BB and CC of standards CTS 60335-2-76 ed. 2 contain the guidelines and requirements

Table 9: continue

Name of the measure and number of the chapter in the text	Is it necessary to apply for an exemption to protective conditions of beavers according to the ANLP?	Other recommendations
Felling of trees damaged by beavers (3.1.5), (4.4)	Depending on the specific situation, for details see Chapter 4.4, Table of the decision making process - see Picture 38	
Drainage of a beaver dam (3.2.1)	According to competent nature conservation authority- if the measure is implemented as described in Chapter 3.2.1 (incl. maintaining the height of the water column min. 80 cm above the beaver dam) and is run in a friendly manner, it is not an interference with protective conditions	It is necessary to discuss the implementation of measures with a manager of the watercourse, the water management authority and competent nature conservation authority
Placing floating buoys (3.2.2)	No	It is necessary to discuss the implementation of the measure with a manager of the watercourse and the water management authority
Backfilling of canals with coarse-grained material (3.2.3)	According to the specific situation	It is necessary to discuss the implementation of the measure with the competent nature conservation authority
Increasing the level of the plot (3.2.4)	Yes	It is necessary to discuss the implementation of the measure with the competent nature conservation authority, the water management authority and the building authority
The removal or reduction of beaver dams (3.2.5)	Yes, for details see Chapters 3.2.1 and 3.2.2, in some regions it is possible to proceed according to the issued General measures, see Box 3	It is necessary to discuss the implementation of the measure with the manager of the watercourse
The protection of bridges and culverts (3.2.6)	No	It is suitable to discuss the implementation of the measure with the manager of the watercourse, the water management authority and the competent nature conservation authority
Protection of water management objects (3.2.7)	According to the selected type of the measure (Chapters 3.2.1 to 3.2.6)	
Fortification of the dam or the bank with stones (3.3.1); The mesh fencing in the dam body (3.3.2); Sheet piles (3.3.3)	Yes, if there is a beaver dwelling in the modified area	It is necessary to discuss the implementation of the measure with the manager of the watercourse, the water management authority, the competent nature conservation authority and the building authority, it is necessary to comply with the provisions of the law on protection of animals against cruelty

Table 9: continue

Name of the measure and number of the chapter in the text	Is it necessary to apply for an exemption to protective conditions of beavers according to the ANLP?	Other recommendations
Filling fallen through burrows and tunnels (**3.3.4**)	Yes, if the site is inhabited by beavers; the exception is not necessary in the case of the abandoned burrows of temporary in levees, where the water level has been already reduced	It is necessary to comply with the provisions of the law on protection of animals against cruelty
Protection of small water reservoirs against increase of water level (**3.4.1**), lowering water level (**3.4.2**)	Yes, if the reservoir is inhabited by beavers, and if the water from the reservoir is drained during the implementation of the measure	It is necessary to discuss the implementation of the measure with the manager of the watercourse or the owner of the water work, with the water management authority, building authority and the competent nature conservation authority
Protection of small water reservoirs against burrowing of lodges (**3.4.3**)	According to the selected type of the measure (**Chapters 3.3.1**, **3.3.2** to **3.3.3**)	It is necessary to discuss the implementation of the measure with the manager of the watercourse, the water management authority, the competent nature conservation authority and the building authority, it is necessary to comply with the provisions of the law on protection of animals against cruelty

What the application for the exemption must contain:

a) Basic identification data of the applicant:
   - Name and surname / name of the applicant
   - Permanent address / residence
   - Postal address (if different)
   - Legal form (only for legal entities)
   - CRN (only for legal entities)
   - Date of birth (for natural persons)
   - Name and surname of the legal representative (for legal entities)
   - For potential communication it is appropriate to indicate also the e-mail address and telephone number.

b) A description of the activities covered by the application, namely:
   The applicant shall indicate the Eurasian beaver as the subject of an application for exemption from the basic conditions for the protection of this species, describes the planned activity (and its conflict with the terms of protection according to § 50 of the ANLP), he/she justifies the request (particularly in relation to the conditions specified in § 56 of the ANLP, i.e. whether the reason is e.g. to prevent serious damage, the harm threatened, etc.), he/she specifies the request locally (e.g. the number of the plot), he/she lays down the time balance sheet of the plan (local and time circumstances are relevant to determining the scope of the proceedings and examination of the application in terms of impacts, which may vary for example during the breeding season and beyond, etc.), if necessary he/she attaches other documents and materials and designates participants (known to him/her) in the administrative proceedings.

   Other participants in the proceedings on the protection of species are locally relevant municipalities. Participants (a nature conservation authority informs them) may also be civic associations which

primary mission under the statutes is to protect nature and the countryside, in the case that they notify their participation in the administrative proceedings to the administrative authority.

In the case of capture or catch of a beaver, a user of the hunting area is also a participant in the administrative proceedings, and the state hunting management authority is a concerned authority. In the case of activities where there is an intrusion into waterways, etc., a manager of the watercourse is a participant, and the water management authority is a concerned authority – in accordance with § 104, par. 9, Water Act.

c) The application must be signed by the applicant.

Legal protection of the European beaver applies to both the living and the dead individuals of this species or products from them (§ 48, article 4, ANLP). For this reason, it is necessary for holding parts of found or caught beavers, e.g. desmoplastic preparations, skulls, skins, etc. to apply (either individually or indicate this in the context of a "broader" application) locally competent nature conservation authority for the exemption from the ban on holding the specimen or its parts. According to § 54 of the ANLP everyone is obliged to prove to the call of a nature conservation authority a lawful origin of the held individuals, including the dead individuals and their parts.

How to submit the application:

Submission of the application can be done in writing or in physical or electronic form signed by electronic signature.

Who the application is submitted to:

Position of the location where the activity breaching the prohibitions according to § 50 of the ANLP would be performed determines the place of submission for the application. For easier orientation, there are the relevant nature conservation authorities in **Table 10**.

Table 10: Jurisdiction of the nature conservation authorities when applying for an exemption from the protective conditions of beavers.

Position of the locality	Relevant authority
Outside the specially protected areas, their protective zones and outside the military training areas	Regional Authority
On the territory of nature reserves or nature monuments, their protection zones lying outside the PLAs or NPs, their protective zones, and outside the military training areas	Regional Authority
National parks and their protection zones outside military districts	National Park Authority
On the protected landscape areas or on the territory of national nature reserves, national nature monuments areas, and their protection zones outside the military training areas	Regional offices of NCA CR
Military training areas	Military training area office

4.2.2 Exemption from the Prohibitions with a General Measure

In accordance with § 56, article 4, ANLP it is also possible to enable an exception also to an unspecified group of persons with a general measure. This general measure is given by a nature conservation authority – on its own initiative – if there is a need to deal with situations for which the exemption is necessary and at the same time they relate to several different entities, e.g. many individuals and corporations throughout the administrative district etc. When implementing the Management plan (see **Chapter 2**), a form of a general measure is used as a tool to facilitate conflict prevention within the zones of differentiated protection of the species on our territory. Contents of currently valid measures reflect the regime of each zone, so they are listed below according to the territorial validity in the zone. The following summary contains only basic information on individual measures and their contents. Current information on the action taken so far and their text can be found on the website of Management plan of European beaver in the Czech Republic (**www.zachranneprogramy.cz**), under "Opatření obecné povahy (General measures)" – only in Czech.

The measures valid in the B-zone

In the B-zone, protection of beavers would make possible to respond to emerging damage and conflicts so as to avoid significant constraint on commercial use of the area. Meanwhile, in the appropriate places of with no conflicts development and spread of beaver settlements are possible. It is appropriate to solve most common and severe cases of damage – e.g. disruption of levees with burrows or other threats to waterworks and surrounding objects – by the use of a general measures, which enables preventive and operational approach.

Within the B-zone, an exemption from the statutory protective conditions of beavers was granted with the general measure in the three regions: South Moravian Region, the Zlín and Olomouc Regions. Detailed information on the individual measures is given in Box 3.

	South Moravian Region	**Zlín Region**	**Olomouc Region**
From	5th January 2012	6th March 2013	27th May 2014
Validity	6 years	Validity is not limited	5 years
Possibility to download	Websites of the Regional Authority of the South Moravian Region under the name „Výjimka ze zákazů u bobra evropského" (**www.kr-jihomoravsky.cz**)	Websites of the Regional Authority of the Zlin Region called "Opatření obecné povahy – výjimka ze zákazu odstraňování sídel bobra evropského" (**www.kr-zlinsky.cz**)	Websites of the Regional Authority of the Olomouc Region under the name "Opatření obecné povahy – výjimka – bobr" (**www.kr-olomoucky.cz**)
WHAT is permitted	Elimination of beaver burrows and removal of lodges; removal of beaver dams or making possible flow through them	Elimination of beaver burrows and removal of lodges; removal of beaver dams or making possible flow through them	Elimination of beavers dwellings, removal of beaver dams or making possible flow through them
WHO is it permitted TO	Managers of watercourses, owners or managers of waterworks referred to in Article. III GM, owners or managers of other buildings listed in Article V b) GM	Managers of watercourses, owners or managers of waterworks referred to in Article. III GM, owners or managers of other buildings listed in Article V b) GM	Managers of watercourses, owners or managers of waterworks referred to in Article. III GM, owners or managers of other buildings listed in Article V b) GM

	South Moravian Region	**Zlín Region**	**Olomouc Region**
WHERE is it permitted	At the South Moravian Region where Regional Authority administers the protection of nature and landscape with exception of SPA (including PZ) and SCI where the beaver is under protection, namely at: a) artificial canals and regulated rivers outside the natural channel b) ponds and artificial water reservoirs c) levees d) facilities providing to waterworks listed under point b) and c) a protective or complementary function (i.e. drainage systems, drainage, sealing elements, etc.)	At the Zlín Region where Regional Authority administers the protection of nature and with exception SPA (including PZ) and SCI where the beaver is under protection, namely at: a) watercourses and artificial canals b) ponds and artificial water reservoirs c) levees d) facilities providing to waterworks listed under point b) and c) a protective or complementary function (i.e. drainage systems, drainage, sealing elements, etc.)	At the Olomouc Region where Regional Authority administers the protection of nature and with exception to SPA (including PZ) and SCI where the beaver is under protection, namely at: a) watercourses outside sections of watercourses in the natural channels b) ponds c) and artificial water reservoirs d) levees e) facilities providing to waterworks listed under point b) and c) a protective or complementary function (i.e. drainage systems, drainage, sealing elements, etc.) f) buildings of public infrastructure
WHEN is it permitted	from 15th March to 15th April from 1st August to 31st October	from 1st March to 15th April from 1st August to 31st October	from 1st March to 15th April (only interventions in dams) from 1st August to 31st October (interventions in dams and elimination of dwellings)
DEADLINE for reporting to a Regional Authority	To report at least 15 days before the planned intervention (except in cases of immediate threat) and within 15 days of its termination send a notice of the action taken	Report at least 15 days before the planned intervention (except in cases of immediate threat) and within 15 days of its termination send a notice of the action taken	To report later in the day when the action is carried out in writing or electronically; until the end of the year (until 31st Dec.) send a written report of all actions
Case of an immediate threat	No time limits; the exception may also applied to buildings that do not fall under the definition set out in GM (Art. III, a) - d))	No time limits; the exception may also be applied to buildings that do not fall under the definition set out in GM (Art. III)	No time limits; the exception may also be applied to buildings that do not fall under the definition set out in GM (Art. III); interventions outside the permissible period can only be done with the participation of qualified persons (biological control); interventions can also be applied to parts of the watercourses in the natural river channels
In the appropriate GM are listed additional conditions under which it is possible to apply the exemption; among others there is a given obligation of notification to persons authorized by the GM about the activities undertaken under the GM. These activities must be reported to RA of the relevant region within the given deadlines. **Prior to the commencement of the activities within the GM it is necessary to study the full version in order to meet all the conditions laid down by it!**			

The measures valid in the C-zone

In the C-zone (see **Chapter 2**) in the Czech Republic identified the highest concentration of risks associated with the presence of European beaver, especially on the waterworks (ponds). Formation of any permanent beaver settlement is therefore undesirable there. In the framework of the Management Plan it was therefore advised to grant in the C-zone the exemption to basic protective conditions of beaver, using an "overall" permission by means of the General measure. Within the C-zone, the exemption through the GM has been already granted in the South Bohemia Region, on the part of the Vysočina Region, in the territory of Třeboňsko PLA and Blanský les PLA. The contents of the General measures in the C-zone are not fundamentally different, therefore, in Box 4, there is given the summary information about the content of the four previously issued General measures.

Note: For the military training area Boletice, which is also a part of the C-zone, the exemption has been granted – in a form of the decision – in accordance with §56 of the ANLP for elimination of individuals of the Eurasian beaver. The executor is the Military Forests and Farms, as the manager of watercourses and at the same time user of hunting area in the MTA. The decision is substantively identical to those in force in the C-zone.

	South Bohemia Region	**Vysočina Region**	**Třeboňsko PLA**	**Blanský les PLA**
From	25th June 2015	18th February 2015	4th June 2015	21st June 2016
Validity	to 1st January 2020	to 1st January 2020	to 1st January 2020	to 1st January 2020
Possibility to download	Websites of the Regional Authority of the South Bohemian Region	Websites of the Regional Authority of the Vysočina Region called "Opatření obecné povahy", using "bobr" in a search engine **www.kr-vysocina.cz**	Websites of NCA CR – the Regional Office of South Bohemia, link Aktuality	Websites of NCA CR – Management plan, link Program péče o bobra evropského v ČR
WHAT is permitted	- trapping beavers in traps and the subsequent humane killing, in accordance with relevant laws (see text of the measure); - firearm hunting; - humane killing of found, injured or otherwise handicapped individuals in accordance with applicable laws, - removing of Eurasian beaver dams that endanger the health and safety of individuals, endanger structures and prevent commercial use of the land in accordance with the type and method of use of the land; - elimination of dwellings of the Eurasian beaver, which threaten the security and stability of buildings or undermine the commercial use of the land in accordance with the type and method of use of the land.			
WHO is it permitted TO	- killing of individuals or catching in order to kill - persons authorized under the Act no. 449/2001 Coll., On hunting, as amended, and pursuant to the Act no. 246/1992 Coll., On protection of animals against cruelty, as amended; - removing of dams and elimination of dwellings - owners or managers of land, watercourses, waterworks and other structures and persons authorized by them.			
Where is it permitted	A pictorial representation of the territory in which the measures are valid is available for download on the website **www.zachranneprogramy.cz**, the references "Živočichové, Bobr evropský, Opatření obecné povahy".			
WHEN is it permitted	Year-round			

In the appropriate GM there are listed additional conditions under which it is possible to apply the exemption; among others there is a given obligation of notification to persons authorized by the GM about the activities undertaken under the GM. These activities must be reported to RA of the relevant region within the given deadlines. **Prior to the commencement of the activities within the GM it is necessary to study the full version in order to meet all the conditions laid down by it!**
Before issuing this handbook the Regional Authority of the Pilsen Region initiated proceedings on the issue of exemptions to eliminate the Eurasian beaver individuals. The exemption will be issued for part of the C-zone, located on the territory of the region and falls within the administrative responsibilities of the Regional Authority of the Pilsen Region. Information about the decision will be listed on the website of the Management Plan, under "general measures".

4.3 Eurasian Beaver in Hunting Legislation

Eurasian beaver is according to the Act no. 449/2001 Coll., on hunting, as amended (hereinafter the "Act on Hunting"), classified as an animal that cannot be hunted, because it is a specially protected animal (the provisions of § 2, C) Act on Hunting. Hunting is possible only if the exemption has been granted in accordance with § 56 of the ANLP and then the state hunting management authority has granted the authorization according to § 39 of the Act on Hunting. This authorization is given if it is not possible to reduce the damage caused by wild animals by technically adequate and economically viable manners. The state hunting management authority obligates – to the proposal of the owner of the hunting area, the tenant of the hunting area, the nature conservation authority or the state forest management authority – reduction of animals up to the minimum level, or it cancels breeding of the species that causes the damage.

Hunting is permitted only to persons who are authorized in accordance with the Act on Hunting, i.e. the holders of a valid hunting license, hunting permits and liability insurance for damage caused by hunting. This provision also applies to trapping of beavers. Since under the current interpretation of the Ministry of Agriculture trapping is, even for scientific purposes, the type of hunting, and therefore it is covered by the Act on Hunting. The person performing trapping of a beaver must hold a valid hunting license, hunting permits and the relevant insurance. Hunting and trapping of beavers is further subject to § 45 of the Act on Hunting, which lists prohibited hunting methods. In terms of dealing with beavers it is necessary to consider their protection and the conditions resulting from the exceptions in accordance with § 56 of the ANLP for so-called special regulation that is decisive for example for keeping dead individuals.

4.4 Felling of Trees Damaged by Gnawing

A wood plant damaged by beaver gnawing may under certain circumstances constitute a potential but also the imminent risk of damage to a significant extent, or, in escalated cases, threat to human health. It is usually necessary to fell the woody plant when there is a direct risk of its fall and some damage. It may also be appropriate to intervene in time (preventively) in the case of less damaged trees, so that due to the damage there will not be e.g. their gradual dying, attack of fungi, etc. When felling woody plants, it is necessary to respect the requirements of the legislation, which varies in different situations.

In the case of woody plants that are not damaged by beavers but after beaver gnawing may represent risks described above, it is desirable to use good fencing – according to **Chapter 3.1.1**.

4.4.1 Preventive Felling

In the case that the impaired woody plant does not pose a threat, the process of felling is similar as if it was a healthy tree and it is therefore necessary to decide whether the permission of the competent nature conservation authorities is required for its felling. The basic

question here is whether the woody plant is growing on a forest or non-forest area.

Woody plants growing outside forests

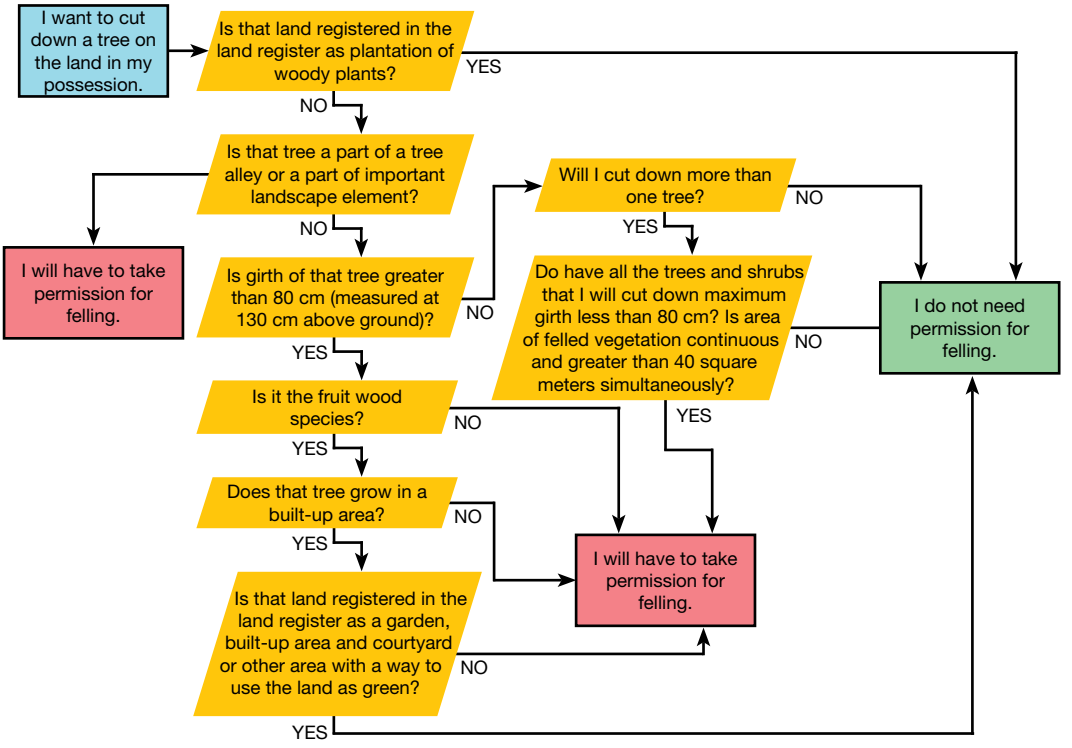
If it is a woody plant growing outside a forest (decisive here is the status listed in the land register), subject to the ANLP and ME Decree no. 189/2013 Coll., on the protection of woody plants and permitting their felling, as amended.

Permission for felling is not required for trees with maximum girth of 80 cm (measured at a height of 130 cm above the ground), closed stands (i.e. shrubs and trees) with a total area of 40 m², for woody plants grown on areas which are in to the land register- described as plantations of woody plants, and for fruit wood species growing on the land in built-up areas registered in the land register as a kind of garden land, built-up area and a courtyard or other area which is used as greenery.

The above is not valid for memorial trees and woody plants growing as a part of important landscape elements (hereinafter ILE). These are either from the low forests, bogs, watercourses, ponds, lakes and floodplains, or other parts of the country which the competent nature conservation authority registers as an ILE. For a ILE – with the exception of the forest where is decisive wording of the Act no. 289/1995 Coll., as amended – prior assessment of the extent of required felling by the nature conservation authority in terms of its impact on environmental stabilization function of the ILE is necessary.

For better orientation and finding out whether the planned felling need the appropriate authorization, use the diagram in **Picture 38**.

The nature conservation authority gives the permission for felling of woody plants on serious grounds after the evaluation of the functional and the aesthetic importance of woody plants (of course the damage caused by beavers can affect these aspects). The competence of the nature conservation



*Picture 38: A scheme facilitating a decision on whether the cutting down of the tree requires the permit (Source: **www.peceostromy.net**, modified).*

authority is determined by the position of the land on which the woody plants are located (see **Table 11**).

The application for a permit to cut down woody plants outside forests may be made by the owner of the land on which the woody plants are growing in, respectively the tenant or other authorized user with the permission from the owner. The application shall be submitted to the appropriate municipal authority; the form is usually available on the website of the nature conservation authority. The application must include:

- The name and address of the applicant
- Designation of the cadastral territory and the parcel, description of the location of the woody plants, including situational drawing
- Proof of ownership rights (if these cannot be verified in the land registry) or tenancy or user relationship of the applicant to the land with the landowner's consent with the felling
- Specification of woody plants growing outside forests which should be cut down, especially their species or genus, their number and a trunk circumference at a height of 130 cm above ground, for felling of closed stands – instead of the number of felled trees it is possible to include an area of the felled areas with the specious, possibly genus, proportion of the wood plants.
- Justification for the application (factual reasons and possibly arguments in relation to the conditions given for permission for felling according to the law, it means to the seriousness of reasons and functional and aesthetic significance of the woody plant).

Who will cut down the woody plants – in case of a positive decision – it is a matter of their owner.

The permission for felling of trees growing outside forests is granted in the form of a decision in the administrative procedure, which is initiated by the submission of the application. Felling is usually allowed in the period called "dormancy", i.e. from 1st November to 31st March.

Removing felled trees, i.e. food source for beavers, increases the likelihood that beavers will damage surrounding woody plants by gnawing. If the woody plant or its parts (branches, crown) are left on the site, beavers uses it for food for some time and the likelihood of gnawing nearby woody plants is reduced.

Woody plants growing on forest lands

If the wood plant grows on a forest land (more precisely, on a land intended to fulfil forest functions) it is proceeded according to the Act no. 289/1995 Coll., on forests and amending certain laws, as amended, and it is therefore advisable to consult the forest manager or owner of the forest.

Table 11: Competent nature conservation authorities for authorization of felling of woody plants.

Position of the locality	Relevant authority
Outside the specially protected areas and their protective zones and outside the military training areas	Municipal Authority
On the territory of nature reserves or nature monuments and their protection zones lying outside the military training areas	Regional Authority
National parks and their protection zones and their protective zones	National Park Authority
On the territory of national nature reserves and national nature monument areas and their protection zones outside the military training areas	Regional offices of NCA CR
Military training areas	Military training area office

4.4.2 Emergency Felling

In exceptional cases, e.g. if there is the imminent danger to life or health or the threat of some damage of a considerable extent due to the state of the woody plant, there is no need for felling permits. Whoever under these conditions will cut down a woody plant is obliged to notify it to the nature conservation authority within 15 days after the felling.

Notification of the so-called emergency felling should contain:

- The name and address
- Designation of the cadastral territory and parcel
- Specification of felled trees, proving facts suggesting that the conditions for felling in the emergency state are fulfilled, suitable is some photographic documentation of the state before the intervention.

4.5 Compensation for Damage and Loss

Financial compensation for selected types of damage caused by the Eurasian beaver or for limitation of farming due to the presence of the Eurasian beaver can be applied on the basis of two provisions:

1. Act no. 115/2000 Coll., Compensations for damage caused by selected specially protected animals, as amended.
2. ANLP specifically § 58 which addresses compensation for aggravation of agricultural or forest management.

The difference in the application of the above mentioned statutory provisions is specified in **Chapter 4.5.3**.

In the following text for the above-mentioned statutory provisions there are listed in detail the terms and conditions to claim for damages or caused loss.

4.5.1 Compensation for Damage Pursuant to the Act no. 115/2000 Coll., Compensations for Damage Caused by Selected Specially Protected Animals

Legislative framework

The Act no. 115/2000 Coll. allows applying for compensation for damage caused by selected specially protected animals (e.g. Eurasian beaver) for specified types of assets that are related to agriculture and forest management. The law covers only the actual damage caused to the property, not lost profits or costs related to the preparation of the expert opinion on the amount of damage (such an opinion is not for beaver damage, unlike other cases, required by the law). There are not also paid induced costs, e.g. in the case of the beaver damage costs of removing the felled vegetation, to restore the original state (i.e. new plantings and fencing) and so on.

According to the current wording of the Act no. 115/2000 Coll., financially compensated is the damage caused by the European beaver on so-called permanent covers and unharvested field crops. The Act no. 115/2000 Coll. does not define the term "permanent cover". Originally, under the wording of the Act no. 115/2000 Coll. at the time of its adoption in 2000, they were given only forests and subsequently (in an amendment in the year. 2001) formulation was changed to "permanent covers". The term "permanent cover" is not in the Czech legislation explicitly defined. In addition to the Act no. 115/2000 Coll. the term permanent cover is also used in the Decree no. 53/2016 Coll., implementing the Act on Property Valuation, as amended (hereinafter the "Valuation Decree"). The Part Five is devoted to the valuation of permanent covers where are permanent covers divided to forest and non-forest. According to § 40, the forest cover are trees or trees and shrubs which are on land designated to fulfil forest functions. In § 44 of the Valuation Decree there is determined the valuation process of permanent

non-forest covers, which are defined as "ornamental, fruit and other trees and shrubs, including forest trees which in built-up and non-built-up areas also fulfils functions other than vegetation growing on land designated for filling forest functions, especially as the greenery in built-up areas and areas in open countryside, accompanying greenery along watercourses including riparian vegetation and accompanying greenery of roads". Implementing decree of the Act no. 115/2000 Coll. is the Decree no. 360/2000 Coll., on determining the method for calculating the amount of damages caused by selected specially protected animals to specified domestic animals, dogs used for their guarding, fish, bee colonies, apiaries, unharvested field crops and forest covers, as wording, as amended. It regulates the amount of damages under the Act no. 115/2000 Coll.

Content requirements of the application as well as documents and evidence that the sufferer attaches to the application are listed in the Annex to the Act and they are also listed in **Chapter 4**, in Sub-Chapter Announcement of the damage and the application procedure.

For damage caused by beavers is not required to determine the amount with professional or expert opinion, it is necessary to start the procedures laid down in legislation.

In the case of forest covers, the Decree no. 360/2000 Coll. refers to a procedure for determining the amount of damages according to forestry regulations, i.e. the Decree no. 55/1999 Coll., on the method of calculating the amount of loss or damage caused to forests, subsequently amended. However, for determining the amount of damage to forests, all the provisions and procedures of calculation in accordance with Decree no. 55/1999 Coll. cannot be used, but only those that correspond to actually incurred direct property damage. The Decree no. 55/1999 Coll. addresses a broad range of other situations, and therefore contains calculation methods that are not applicable in the case of damage compensated according to the Act no. 115/2000 Coll.

For non-forest covers the procedure of determining the amount of damages is not directly determined and it is therefore required to follow the generally applicable regulations, in particular the Valuation Decree. In the case of permanent covers, which are not mentioned in the Valuation Decree, such as grass covers it is necessary to determine the amount of damage to hay or haylage as when determining the amount of damage to field crops.

The Act no. 115/2000 Coll. does not issue compensations for damage if the exemption from the basic protective conditions of beavers in accordance with the ANLP to eliminate the cause of the damage (e.g. beaver dams causing waterlogging of a plot) has been granted. A claim for damages does not expires with the permit of the exemption, but it is clear that it is possible to apply only for compensation of the damage which happened despite the application of the exemption or with regards to the limits that have been set in the exemption (i.e. the compensation may cover only actual damages incurred to the extent that was possible to reduce due to the application of the permitted exemption).

Announcement of the damage, the application procedure

1. After finding the damage, it is necessary to report the damage within 48 hours to the locally competent authority for nature conservation (i.e. on the municipal authority with extended powers or the management authority of PLA in the area of PLA, including the protection zone, or the management authority of NP in national parks, including the protection zone). Locally competent authority shall conduct a local investigation and verify whether the damage was caused by the Eurasian beaver and possibly may record the extent of damage under the Protocol, which is sourced from the investigation. These documents are then forwarded the nature conservation authority if the competent regional

authority or Prague City Hall. Damage caused by beavers arise, however, usually over a longer period of time and the damage is recorded subsequently, so the sufferer must observe the following deadlines for submission of applications, especially within 6 months (see below).

2. The request for compensation with requirements pursuant to section 4 is submitted to the appropriate regional authority (in Prague at City Hall). The competence of the regional authority for the administration of the application is determined by the location of the property on which the damage occurred. Requests for damages are received by RA, mostly environmental department, where:
   a) The application must be submitted **within 15 days from the date when the sufferer learned about the damage** – according to the current legal interpretation of ME "to learn about the damage" means also to learn about the amount of damages, i.e. to make its final calculation for the "loss period" (which shall not exceed 6 months – see below). In the case of determining the amount of damages by professional or expert opinion, the 15–day period is counted from the date of notification of the opinion to the customer, i.e. from the day when the customer learnt from the opinion the quantification of the damage.
   b) The application must also be submitted **no later than six months from the date when the damage occurred** – this condition determines the maximum length of the "loss period of loss" for which it is possible to claim damages. In terms of the calculation of this period, it can usually be based on the date of notification of the damage (see point 1), unless it is clear that the damage was detected with considerable delay. If this is the case, estimated time of the occurrence of damage should be specified within the local investigation of the nature conservation authority and included in the protocol. **Both of these deadlines are crucial and if they are missed, the possibility of compensation expires.**
3. The compensation may be asked by the owner or tenant of the land (commonly known as "sufferer", who must submit a financial relationship with a damaged thing or the land on which the damage occurred – see below).
4. The application must in accordance with the Annex to Act no. 115/2000 Coll. include the following information (a quote part of the Annex, in which the requirement is specified, is given in italics after the appropriate figure in brackets):
   - Identification of the applicant *(article 1, section a, b)*:
     - natural person – the name, address, birth number
     - legal entity – the name, address, CRN
   - Description of the causes of the occurrence of damage *(article 1, section c)*
   - An indication of the extent of damage (i.e. the amount of damage in CZK as calculated in accordance with the Decree no. 360/2000 Coll., respectively the Decree no. 55/1999 Coll., and the Valuation Decree – the calculation is carried out by the applicant themselves or is a part of a professional or expert opinion) *(article 1, section c)*
   - Designation of the damage-caused animal *(article 1, section d)* – i.e. the European beaver
   - Applicant's measures to prevent damage *(article 1, section e.)* – e.g. fencing the woody trees due to the previous losses; in the case of the first damage – appropriate information e.g. even about a normal fencing of the garden where the woody plants were felled by beavers.

- Method of providing compensation (e.g. when transferred to the bank account, the account number must be included) *(article 1, section f)*.
- Proof of user rights to movable or immovable property, where the damage occurred (i.e. in the case of beaver damage, the document on a given plot from the Land Register or eventual lease agreement for the use of the land) *(article 2, section f)*.

Note: The application includes the protocol of local investigation, but it is delivered by locally the relevant nature conservation authority *(article 3)*.

Administrative procedure of the Regional Authority

After submitting the application, the Regional Authority performs its check in terms of eligibility, the sufficiency of documents and evidence as well as in terms of determining the amount of damage. The Regional Authority may, in the case of missing data or doubts, ask the applicant to complete the application with the relevant information or documents within the deadline fixed by the Authority. On the basis of the checking of the application may be adjusted the requested amount, e.g. due to miscalculation. The most common mistake is that an unpaid item is included into entitlements – e.g. a hypothetical loss of future revenue of felled fruit trees, the costs of removing the felled trees, planting of substitute trees, etc. Application for compensation may also be rejected, most often due to failure to comply with statutory deadlines or claiming compensation for damage for which compensation is not possible – according to the Act no. 115/2000 Coll., (e.g. the damage to fish arisen after a disruption of pond dams by beavers, property damage caused by a falling tree damaged by beavers).

Provided that the conditions laid down in the Act no. 115/2000 Coll. are fulfilled and if there is no doubt about the damage and about the amount of financial compensation, the Regional Authority asks the Ministry of Finance to mobilize and pays the compensation to the sufferer within 4 months after receiving the application.

Any objections regarding the recognition or non-recognition of the applications for the compensation or the amount of the compensation shall be applied by a civil way (i.e. a legal action).

4.5.2 Compensation for Hindering Agricultural or Forest Production According to § 58 of the ANLP

Legislative framework

Due to the legal protection of the European beaver and the resulting restrictions on agricultural or forest management, the competent subject could suffer a financial loss due to the restrictions. According to § 58 of the ANLP that subject may be paid a compensation under conditions stipulated by law.

More detailed specification of conditions, details of the claim, and in particular the methods of calculating the amount of compensation are defined in the related implementing legislation. Namely, these are two joint decrees of the ME and MA:

a) The Decree no. 432/2005 Coll., laying down the conditions and procedures for granting financial compensation for the loss suffered by limiting farming, the sample form and the particulars of claim, as amended. It establishes the conditions and procedures for granting financial compensation for the loss suffered by limiting farming. In § 1 of the Decree no. 432/2005 Coll. in sections a)–i) are listed limitations for which it is possible to claim the compensation. In the case of occurrence of a beaver and the consequences of its actions, compensation for the restrictions set out in section c) may be entitled – i.e. temporary exclusion of management on grass covers where it is not possible to mow grass or graze cattle

in the long term because of waterlogging. Restrictions set out in section d) – to stop the entry of livestock to a part of the plot – cannot be taken into account, as it means e.g. restriction of entry of animals because of the negative impact of their occurrence and the creation of fences or electric fences are reimbursed. In rare cases and after an assessment, compensation for the exclusion of fish stocks mentioned in section g) could be legitimate, or compensation for exceptional or cost-intensive measures (e.g. the need for manual mowing or using a more complex method of balancing sawed materials, etc.), which is mentioned in section i). Calculation of the amount of compensation for individual restrictions is given in Annex 3 of the Decree no. 432/2005 Coll. The values of variables of the used formulas are calculated in the Bulletin of the ME, no. 12, year 2005, the notification number 39. In the situation that it is the other restriction of farming than those mentioned in § 1, § 4 sets out in article 4 the requirements for the application for compensation. On the basis of this provision, there are for example possible damages for the inability of long-term cultivation of arable land.

b) The Decree no. 335/2006 Coll., laying down the conditions and procedures for granting financial compensation for the loss suffered by limiting forest management, the sample form and the particulars of claim, as amended. It establishes the conditions and procedures for granting financial compensation for the loss suffered by limiting management in the cases that are not listed in the Decree no. 55/1999 Coll., on the method of calculating the amount of loss or damage caused to forests, as amended. In the situation that these are the other restrictions of forest management than those mentioned in § 1, § 3 sets out in section 3 the requirements for the application for compensation. According to the type of forest management restriction, the amount of compensation is determined either in accordance with Annex 3 of the Decree no. 335/2006 Coll. or in accordance with the Decree no. 55/1999 Coll.

Assessment of applications for compensation for the loss is not discussed within the administrative procedure. A claim compensation for loss according to § 58 of the ANLP has a private-legal status. Based on this fact, potential disputes concerning the eligibility or the amount of compensation are solved at a competent local court. In the interpretation of the nature of the loss (the notification no. 09/04, Bulletin no. 16, chapter 5, year 2006) is stated "… compensation for the loss belongs only to the owner or tenant of land, who was limited in his/her agricultural or forest management because he/she has to respect the provisions of the law (§ 50 Act no. 114/1992 Coll.) or the administrative act of protecting individual species of specially protected animals. The loss here is due to the very fact of occurrence of an individual of a species of specially protected animals due to the fact, that the owner or tenant of the land (or in the vicinity) on which the individual (or its natural or artificial seat or habitat) are located cannot carry out his/her management activity exercised in full (he/she is obstructed)." In this interpretation, it is possible to infer that if the nature conservation authority grants an exemption from basic conditions for the protection of European beaver listed in § 50 of the ANLP for an activity that allows to remove the cause of the limitation of farming, entitlement for compensation for loss then ceases to be legitimate. E.g. beaver dams on a watercourse cause waterlogging of land where is not possible to farm. If the nature conservation authority allows eliminating these dams, a possibility of compensation for the loss ceases to be legitimate. Otherwise, if the nature conservation authorities do

not allow the removal of the dams and the result of the decision is hampered farming activity, the entitlement for compensation for loss is legally legitimate.

Types of farming for which it is possible to apply for compensation for loss according to § 58 of the ANLP

a) Forest management – according to § 2 of the Act no. 289/1995 Coll., on forests, as amended, means "restoration, protection, education and forest logging and other activities ensuring fulfilment of forest functions".

b) Farming – agricultural land is under the Act no. 334/1992 Coll., on protection of agricultural land fund, as amended, "the land that could be farmed, it is arable land, hop fields, vineyards, gardens, orchards, meadows, pastures". Fish farming is also considered as a kind of farming.

When and for what period of time the application is submitted

Compensation for the loss is paid retroactively for the calendar year; it can not be exercised for several years. The applicant must deliver the claim to the competent nature conservation authority by 31st March of the year following the year in which the loss occurred or lasted. In the case that the application or its necessary attachments are delivered later, i.e. after 31st March of the year following the year in which the damage occurred or lasted, the entitlement for the compensation lapses.

The fixed term does not exclude the possibility of applying for it earlier in the year in which the loss occurred; in this case, however, it can be awarded only a maximum amount not exceeding the date of application (i.e. for the already past time of year).

Who can apply for loss compensation

The claim may be applied – pursuant to § 58, article 2 of the ANLP – either by the owner or by the tenant of the land who uses the land legitimately. Financial compensation cannot be provided simultaneously to the owner and the tenant of the same property. If both of them ask for the financial compensation, it is provided to the owner (§ 58, article 3 of the ANLP).

According to the existing legislation, an entity which has the right to manage state assets has a similar position as the owner.

Which formalities the application must include

Conditions for granting financial compensation, model claim sample, particulars of the claim and the methods how to determine the amount of compensation are laid down in the Decrees no. 432/2005 Coll. and no. 335/2006 Coll.

The application must include a justification for the claim, i.e. from which specific legal provision or binding opinions or decisions issued under the Act the applicant's restrictions in managing originated. In the case of the European beaver, the relevant provision is § 50 of the ANLP, where are specified the basic conditions for the protection of particularly protected species. A decision may be e.g. a decision granting exemption to protective conditions of beavers listed in § 50 of the ANLP.

It is also necessary to prove that the activity would truly violate the basic protective conditions of the species, and thus if there is really the restriction by law; and also whether the restriction on the activities does primarily not follow another law.

Where the application is submitted

The application for compensation for hindered land use should be sent to the locally competent nature conservation authority; the competence of the authority is determined by the position of the land affected by the restriction:

- In national parks – appropriate management authorities of national parks in the administrative district according to the ANLP are the nature conservation authorities

- In the PLA Šumava – the competent authority for nature protection for submitting an application for financial compensation according to § 58 of the ANLP is Management NP.
- The rest of the Czech Republic – locally relevant regional authorities of the ANCLP deal with applications.

Within NCA CR the receipt and administration of the applications is made through regional office of NCA CR. Contact information of regional offices are listed on the website (**www.nature.cz**), in reference to "Regions".

4.5.3 The difference in the application of the Act no. 115/2000 Coll. and § 58 of Act no. 114/1992 Coll

By the Act no. 115/2000 Coll. it is possible to provide damages caused by the activities of beavers – .i.e. gnawing and felling trees, eating field crops. It is also possible to pay for damage to crops that were destroyed in the early stages of growth before harvesting or due to flooding or waterlogging commonly farmed areas. But waterlogging must be caused by the beaver activity (e.g. beaver dams, clogged culvert of beaver dams) on the nearby watercourse and consequently incurred overflow of the watercourse or increased groundwater level on the relevant agricultural areas. Furthermore, it is likewise possible to pay damages on woody plants that died due to flooding or waterlogging. For a relationship between the Act no. 115/2000 Coll. and § 58 of the ANLP, there is a valid interpretation of the Ministry of the Environment, published in the Bulletin of the Ministry of Environment (notification no. 04/09, Bulletin no. 16, chapter 5, 2006). According to it, the damage caused by specially protected animals is not loss according to § 58. For this reason, according to § 58 of the ANLP it is possible to pay compensation for worsened agricultural or forest management, so-called "loss", only if the beaver with its presence obstructs or impedes the management as a whole. E.g. beaver dams cause overflow of a watercourse and flooding of land, or increased groundwater level causes waterlogging of commonly farmed land. On this land, then it is not possible to plant crops, mowing, grazing and also to manage the forest under the applicable law.

4.6 Grant Title "the Operational Programme Environment"

It is possible to obtain funding – on preventive measures against damage caused by the European beaver – in the current programming period 2014–2020 of the Operational Programme Environment (hereinafter the "OPE").

4.6.1 Basic Information

a. All information about OPE are listed on the website **www.opzp.cz**.
   There are also given calls for applications for support.
b. Financial support for the above activities can be obtained by submitting an application under:
   Priority Axis 4: Protecting and caring for nature and landscape
   Objective 4.2: Strengthening biodiversity
   Activity 4.2.4: Prevention, minimization and recovery from damage caused by specially protected species of animals on the property (Ref: **www.opzp.cz/podporovane-oblasti/4-2-posilit-biodiverzitu?id=28**)
c. An application for support is electronic and is filled through the application IS KP14. This application is available on the website **mseu.mssf.cz**.
d. Who can be an applicant within the activity 4.2.4?
   According to the Rules for Applicants (document link see below) a natural person is excluded from the circle of applicants for this activity. The applicant may be, among others, a natural person doing business.

e. What amount of support can be achieved through the Activity 4.2.4?
   Support is provided with a maximum limit of 85% of expenditure. Therefore, the applicant's co-financing of the project amounting to 15% of total project costs is requested.
f. For detailed information please contact the regional office of NCA CR. On the website **www.dotace.nature.cz/opzp-kontakty.html** there are listed contact persons with whom you can consult the preparation of the application. Questions may also be sent to the e-mail address **dotazy-PO4@nature.cz**. Further information can be obtained at the toll-free information line (telephone: 800 260 500, Mon–Fri 7: 30–16: 00) or e-mail **dotazy@sfzp.cz**.

4.6.2 Important Links and Documents on the OPE

Basic information on the application and implementation of the project are in the Rules for Applicants, available at: **www.opzp.cz/obecne-pokyny/dokumenty**. Information on operational programs and training dates for operating the electronic application submission are available at: **www.strukturalni-fondy.cz/cs/Uvodni-strana**.

5 Biology and Ecology of Beavers

This chapter provides detailed information on the biology and ecology of the beaver to supplement the introductory chapters (**Chapters 3.1**, **3.2** and **3.3**) describing the biological context of the application of individual types of measures. The beaver is a very adaptable animal with complex ties to the environment and thus an exhaustive overview of all aspects of its life cannot be found. For a deeper study of the biology and ecology of the beaver we refer to the specialized literature listed at the end of this handbook.

5.1 Genus Castor – Origin and Species

Today, there are two extant species – the Eurasian beaver (*Castor fiber*) and North American Beaver (*Castor canadensis*). They belong among rodents (order – Rodentia, family – Castoridae). Family Castoridae already appeared in the older Tertiary period (40–50 million years ago). Predecessors of today's beavers belonged to fossorial rodents, but later their adapted to the aquatic environment. Tertiary most famous representatives of the family are the North American genus *Paleocastor* and European genus *Steneofiber* that was evolutionary predecessor of the genus *Castor*. Genus *Castor* originated approximately in the lower Pliocene 7.5 million years ago and later colonized almost whole Eurasia and North America. Consequently, long-term isolation of the two continents has produced two species living today; they are visually indistinguishable and resemble each other in their behaviour and way of life. They differ e.g. in the number of chromosomes, which prevents their mutual successful crossbreeding. The North American beaver is reproductively mightier because it has on average 1–2 cubs more in the litter than its European relative. In the case of its occurrence in Europe, this species is non-native and unwanted and could competitively displace the original Eurasian beaver.

5.1.1 North American beaver

The second extant species of beaver, North American beaver, is relationally linked with Eurasian beaver. Originally, there was apparently one common form, which was the forerunner of both today's species. The area of this predecessor included the entire Northern hemisphere. Later, with the gradual separation of North America and Eurasia, there has been a parallel development of two separate populations. Their mutual isolation has caused some changes in the gene pool of both species (but with minimal changes in their morphology, physiology and biology). A common past of both species indicates the Beaver beetle (Platypsyllus castoris), which is existentially bound to a beaver fur and the quarters of these rodents. Despite their close relationship, inbreeding of both species prevents a different number of chromosomes. A result of Russian experiments with mutual crossbreeding was born dead fetus. Both forms of beavers are absolutely identical in appearance (e.g. their largeness, colouring, morphological adaptations etc.); they do not differ in terms of ecology. A considerable difference between these both species lies in the different reproductive strategy; the North American Beaver has an average litter of 1-2 cubs more than its Eurasian relative.

The North American Beaver was introduced to Europe, to Finland, in 1937, when both forms were considered as one species (their differentiating occurred in 1973). The local population prospered very well, it successfully spread to all Finland and reached the adjacent areas of Russian Karelia. So there arose a large population of non-native species of a beaver. Even this population was at least once the source for reintroduction during restoration of the area of beavers in Europe in the second half of the twentieth century. In the 80s there were several transfers (legal or illicit) from Finland to Austria, to Vienna region. After the releasing of the individuals

their origin and accuracy of this displacement were questioned. However, similar episodic and "guerrilla" operations took place in several spots of Europe - of uncertain origin is e.g. population on the Belgian-German border etc. In Austria, all individuals were subsequently back captured or hunted from the "contaminated" area because of the fear from the introduction of non-native species in Central Europe. According to the available data, all suspicious individuals were eliminated. It was thus minimize the risk of spread of non-native species to our country. It is therefore possible to refute the oft-repeated falsehood that the beavers, who settled South Moravia (where they spread from Austria), are North American beavers. According to the analyses conducted in our country there was not seen even one individual of non-native species of beavers.

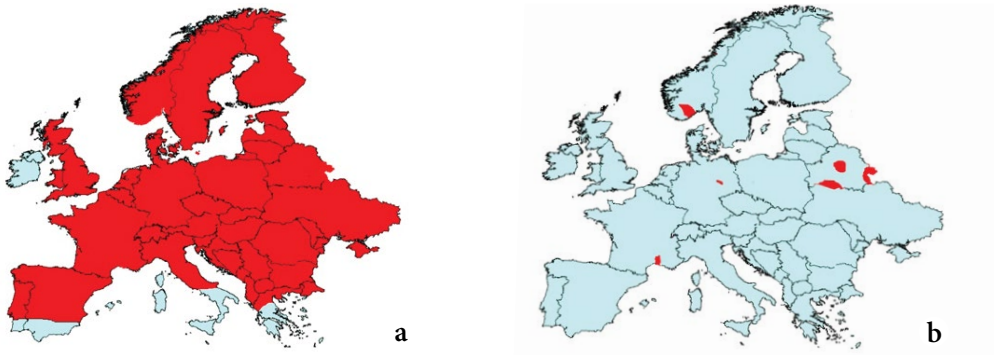
At this point it should be emphasized that in Europe the North American beaver belongs to non-native species, which would there emerge all the negatives as an invasive species, which can accompany biological invasions. The occurrence of the North American beaver is therefore highly undesirable in whole Europe. Ecological theory describes that two species with similar ecological requirements cannot coexist together in one place and therefore there is need to eliminate one of the two rivals. The non-native species usually beats the original one.

5.2 Historical and Current Status in Europe and in the Czech Republic

The Eurasian beaver originally inhabited most of Europe and much of the Asian continent. To the west and east its area was bounded only by oceans. Prehistorically it occurred in Mesopotamia and the Nile Delta, currently rainfall-poor and very hot areas. Even today we can find it in the warmest lowland watercourses of Central and Southern Europe, but its extension reach to the very cold polar or alpine areas.

5.2.1 Current Occurrence of Beavers in Europe

At the beginning of the 20th century beaver survived on the territory of Eurasia in the number of 1,200 individuals in eight residual populations (see **Picture 39b**). Subsequently its strict protection was introduced, and in many European countries its – often confusing but mostly successful – reintroduction went through. At the beginning of the 21st century, its quantity has been estimated at less than one million individuals and the beaver continues to return to the places of its historical occurrence. Today we can find it in the European part of Russia, Ukraine and Belarus, the Baltic States, and Scandinavia. Likewise, it is already very common species in Central and Western Europe (France, Benelux, Germany, the Czech Republic, Slovakia, Poland, Austria, Slovenia, and Hungary). Beavers have also



Picture 39: Map of the historical occurrence of the beaver in Europe: theoretical extension of beavers after the last glacial period (a); state at the end of the 19th century (b), adapted according to Halley & Rosell, 2002.

been naturalized in Scotland and England. In the last two decades, beavers are successfully spreading across Southeast Europe. Stable settlements we can find in Croatia, Serbia, Bosnia and Romania. Unstable settlement of uncertain origin is in north–eastern Spain.

In terms of altitude the beaver occurs from the level of the seas, sometimes even from brackish environments, to high mountain sites. The limit of the settlement in mountain areas is not temperature but the availability of a suitable species composition of food. In our country in the Šumava Mts., the beaver finds suitable conditions for a lasting settlement to an altitude of about 900 m. With its occurrence we can meet even at higher altitudes, but it is only a temporary settlement. Similarly, in Slovakia beavers climb to an altitude of 1,500 m, but there are not the appropriate conditions for its long-term occurrence.

5.2.2 Historical Occurrence of the Beaver in our Country

The beaver has always been a natural representative of our fauna, as evidenced by a series of paleontological finds from prehistory and antiquity. Records of the presence of beavers in our country are also mentioned in medieval documents or in numerous illustrations. Clear evidence of the presence of beavers in our country is the presence of the base word "bobr (beaver)" in geographical terms (e.g. Beaver Creek – Bobří potok, villages – Bobr, Bobrovníky, Bobrová, etc.).

The beaver, as a wild species, was persecuted and hunted from early antiquity. There were several reasons behind its gradual reduction. Beavers were for humans a source of tasty meat and thick fur since the Neolithic Age, as demonstrated by the results of archaeozoological studies. Later, so-called castoreum – a product of the scent glands located close to the anal opening – became the reason for its hunting; it was used as an ingredient in drugs, drug itself, or as an ingredient in perfumes. It can be assumed that the utility hunting was primarily the cause of the disappearance of beavers in the wild, but the cause of the reduction can also be seen in fear of the caused damage. There are also indirect factors that probably played a significant role in reducing the number of the species, such as the loss of suitable habitats, particularly riparian vegetation, or conversion of floodplain to farmland.

Originally, the beaver naturally lived in most of our country. Due to its persecution, the distribution area in our country reduced and the last remaining populations survived in large and not easily accessible floodplains of the Morava, the Elbe and in South Bohemia. In South Bohemia beavers probably survived the longest to their extinction in the 18th century. The fact that the vital signs of beavers were inconsistent with planar development of farming on fish ponds (traditional) in this area helped to the extinction. In the first half of the 19th century beavers temporarily returned to our countryside. At the request of Joseph Schwarzenberg, they were delivered to his South Bohemian Manor. The newly established population successfully spread through the Lužnice River basin and during floods these rodents got even to Prague. However, because of the damage caused by beavers on the fish ponds, owners of the Manor gave the command to kill them, and this was finished in 1876.

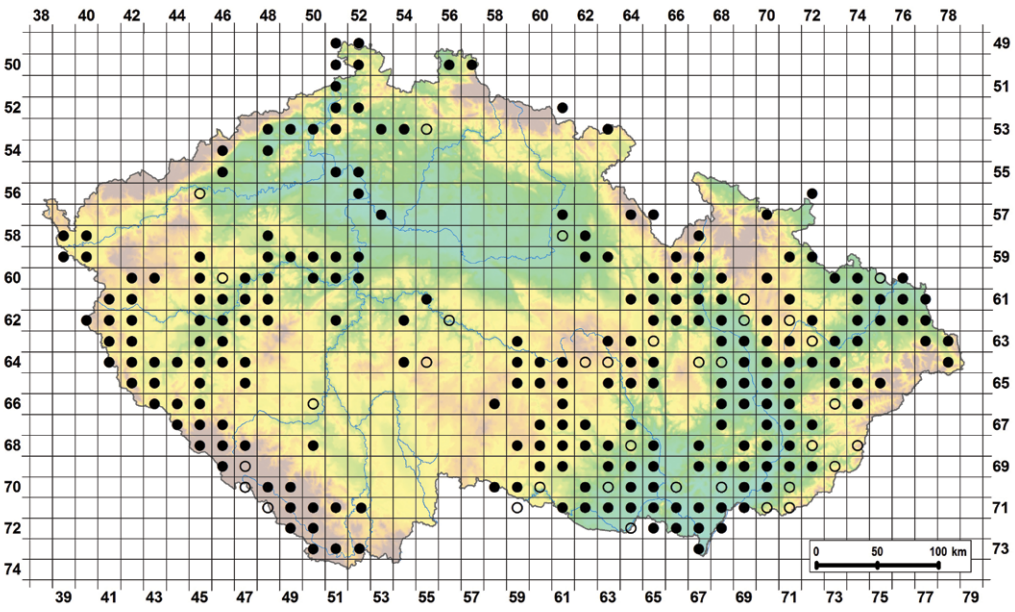
5.2.3 Current Occurrence of the Beaver in the Czech Republic

The recent settlements of the Czech Republic by Eurasian beavers began in the second half of the 20th century. The cause of the return of beavers in the former Czechoslovakia was an increase in numbers of beaver populations in neighbouring countries. These include both the reintroduced populations that were in Austria or Bavaria and the re-naturalized populations in Poland. In the case of the Elbe (Labe) population individuals were spreading from the original residual population in Saxony–Anhalt. In our country there was the only reintroduction of the species, when in the 90s of the last century nearly three dozen of the

species were delivered in the Morava River basin and the Odra River basin. However, due to the intense migration of beavers from neighbouring countries, this delivery had no significant effect on the timing and speed of resettlement of Moravian part of the Czech Republic.

Current beaver settlement can be divided into several sub-populations, though they interconnect very quickly (**Picture 40**). The Morava River is inhabited by beavers practically throughout the whole channel, including most of its tributaries. This rodent is also rapidly expanding from the Morava River basin in south–eastern and central parts of the Bohemian–Moravian Highlands and begins to colonize the basin of watercourses flowing into the Vltava River. The spread of beavers is also in Silesia, where beavers have colonized the Odra, Olše and Opava rivers. Another, today already large, population is located in the western and south–western Bohemia. Beavers are present at the Berounka River and its major tributaries. In northern Bohemia beavers occur on the Elbe and its tributaries, the Ploučnice and the Bilina. Currently, settlement of the basins of headwaters of the Vltava and the Elbe is ongoing. These rodents are thus spreading into South, East and Central Bohemia which were not previously populated area-wide.

The first documented occurrence of beavers in our country was an individual who was killed under unclear circumstances in 1967 or 1968 on the Kamenice River. Very likely it was the immigrant who came upstream the Elbe from the population preserved in Saxony–Anhalt. Post-war protection of the population led to an increase in the number of local beavers and their spreading upstream the Elbe. Individuals from this population re-occurred in our country in 1992; and since 1994 they have permanently settled a riparian forest near Dečín. Since 2000 we can talk about stable and permanent settlements around the Elbe from the state border to Střekov. Since 2005 beavers from this population have been spreading into tributaries of the Bílina, Ploučnice and other small watercourses (e.g. the river Sebnitz, which extends to Šluknov region). In 2010, the occurrence of beavers was noticed further upstream the Elbe above Střekov; it is a settlement between Roudnice nad Labem and Liběchov which lasts until today. At present,



Picture 40: Current distribution of the Eurasian beaver in the Czech Republic – status up to end of 2015, solid circles marking permanent occupation of the square, empty circles marking temporary settlement (Source: Vorel and Šafář, unpubl.)

the North Bohemian population extends to Kralupy nad Vltavou and the Čelákovice.

In 1978 the first signs of a permanent beaver settlement occurred on the Morava River near Hodonín and Břeclav under the Dyje. These individuals came from the reintroduction carried out in Austria, near Vienna. Since the 80s the settlement in South Moravia has gradually expanded and since the 90s we can speak about the strong and stable settlement of a large part of the South Moravian Region. Floodplain forests in the floodplains of the rivers Dyje and Moravia became the backbone of the settlement. At the same time the reintroduction of beavers from Poland and Lithuania took place in Litovelské Pomoraví. Both the expanding populations soon interconnected, so from the beginning of the new millennium it is possible to speak about the continuous settlement of the upper, middle and lower parts of the Morava and the lower parts of the Dyje, Svratka and Jihlava rivers. Gradually there has been the settlement of the Desná, Bečva, Rožnovská Bečva, Dřevnice and Olšava rivers; the settlement here extends to the mountain areas. The first spreading through the watershed divide to the river basins of the Sázava, Doubrava and Tichá Orlice has also appeared. At present, we can say that the whole Morava River is close to full saturation of the territory of the species and it is our strongest and largest population. In zoogeographical it represents a Moravian spur of a large population, which includes almost the entire upper half of the Danube and the settlements in its continuum ends in southern Hungary.

The second largest population began to emerge in 1985 on the Radbuza. There arose a pioneer settlement migration of individuals from Bavaria, where an extensive reintroduction programme was held. Permanent settlement in western Bohemia began to emerge in the early 90s, in the Danube basin in the Czech Forest. Besides the Radbuza, other tributaries of the Berounka (especially the Úhlava) have been colonized in later years. Reliable information about the settlement on the river Berounka itself are from the year 2005. Individuals who in 2015 settled one of Prague's islands on the Vltava came as well from the Berounka River. A pioneer settlement of the Šumava Mountains was recorded in 1997; however, a permanent settlement of the mountains and upper streams of watercourses which spring here has developed. This Czech population (currently isolated from other Czech settlements) also follows through Bavaria to the Danube population.

A contemporary settlement of the Odra River Basin is less intense. Beavers appeared there in the late 90s and came from the reintroduced population in Poland. At the same time, several individuals from Pomoraví were transferred to the military training area Libavá. Approximately in 2005, populations of both sources joined together and formed such a complex settlement of the Odra including surrounding smaller tributaries. Beavers from the Odra population have further expanded upstream the Olše and Opava rivers. Settlements have also appeared on the water areas created after the black coal mining in this area.

5.2.4 Perspective of Further Colonization of the Czech Republic by Beavers

In the near future we can expect interconnection of settlements from the confluence of the Elbe and Vltava with the East Bohemian settlement. Colonization of the Liberec, Hradec Králové and Pardubice Regions will continue as well. Interconnection of the Elbe population with the settlement of the upper and middle parts of the Ohře can be expected. Postmining areas of Chomutov, Most and Bílina will be probably also colonized. Regardless of the planned elimination of beavers in the South Bohemian Region, beavers will come to the area through watercourses springing in the Šumava, Upper Austria and the Czech–Moravian Highlands. The given scenario should have been fulfilled within 10 years.

The Czech Republic is – due to its topography, morphology of watercourses, numerous water reservoirs, quantity, and species

composition of riparian vegetation – suitable for the nationwide settlement of the species; the only exception are the highest parts of Czech, Moravian and Silesian mountains. The capacity of the landscape of the Czech Republic – based on an analysis conducted by the FES of CULS – was estimated at 17,000–20,000 beaver individuals. The estimation of the final size of our beaver population, however, is not considering the possibility of eliminating beaver settlement, which is scheduled across the board in the South Bohemia Region (see **Chapter 2**).

5.3 Biology and Ecology of Beavers

5.3.1 Appearance and Morphology

The beaver is Europe's largest rodent. Weight of an adult reaches 25–30 kg. The body length with a tail at this weight ranges from 110–130 cm, colour of hairs can vary from light brown to black, while in one litter can be both brown and black little ones.

Beavers have a smaller head and their neck briefly, almost imperceptible, sets to a stocky body. Ears and eyes are in proportion to a body size small; proportionate to the importance of those senses. The most developed sense is a sense of smell. They can orient well by hearing, however, seeing is weaker, probably due to the prevailing crepuscular and night activities.

The unmistakable sign of the beaver is almost hairless, above flattened tail covered with hexagonal scarring pattern. This can be up to 40 cm long and 16 cm wide. Front and hind feet have five toes, and hind feet are webbed.

Teeth are composed of twenty teeth and incisors grow continuously. They are composed of hard orange enamel on the front and a softer dentin on the back. When gnawing the teeth are therefore continuously and unevenly grinded, resulting in a chisel-like shape with a sharp edge. The incisors and powerful jaw muscles enable beavers to chew very hard wood. Molars are high with cemental lophes on occlusion front, which reduces the degree of wear and provides good food dilution.

Males and females do not differ significantly, just before giving birth and lactation the female has visible teats of the mammary glands. Beavers have under a base of the tail two pairs of glands. Sebaceous secretion of the smaller one, so-called anal gland is used to impregnate the fur. Its colour and texture is also reliable distinguishing feature of beaver gender – males have more fluid and yellowish, females have denser and white-gray. The larger gland secretes characteristically smelling yellowish-brown mass (so-called castoreum).

In the countryside the beaver may be interchangeable with a coypu (*Myocastor coypus*), but its weight around 10 kg reaches the size of the annual beaver (**Picture 41b**, **41d**). The main distinguishing feature, however, is the shape of the tail that the coypu has rather triangular on the crosscut. Furthermore, the beaver differs with its long white beard and white coloured hair at the nostrils. Beaver juveniles may resemble adult muskrat (*Ondatra zibethicus*), see **Picture 41c**, especially when swimming in water (adult muskrat weighs about 1–2 kg). Muskrats, however, have side-flattened tail that is used while swimming, and therefore there is specifically rippling water behind them when moving in water.

5.3.2 Adaptation to the Aquatic Environment

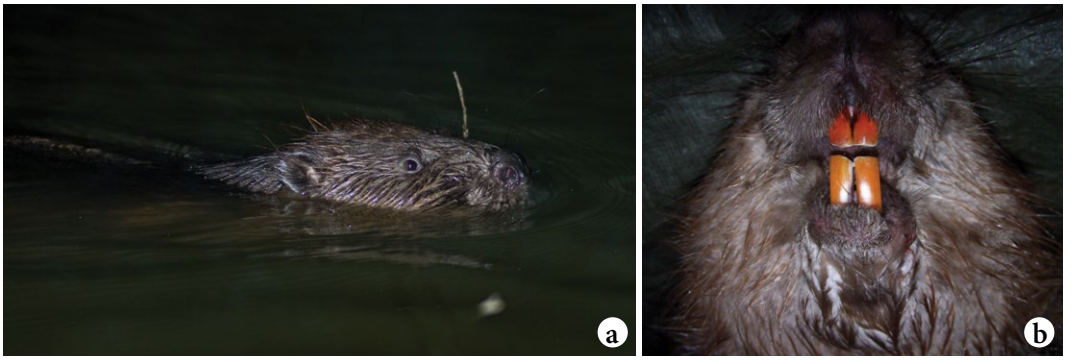
The beaver is an animal closely tied to the aquatic environment; it is well adapted to life in water. Hydrodynamic body shape helps with easy movement in water. During swimming the beaver has most of the body under water, but the position of the nostrils, eyes and ears in the same plane (**Picture 42a**) allows him to use basic senses even in this situation. The beaver is mainly nocturnal, spending most of the day in its home. This can be either a burrow, which is burrowed into a higher bank, or a lodge built of branches, mud and stones.

To move within their home range, beavers use primarily aquatic environment, where are more manoeuvrable than on land. An important advantage of the movement in the aquatic

Picture 41: Eurasian beaver (a), Myocastor coypus (b, d), Ondatra zibethicus(c).

environment is also greater protection against possible predators. The beaver comes out on land only when seeks or gets food or building material. The beaver gets food in a narrow strip along the water. The vast majority of chewed trees or plants can be found within 20 m from a bank. However, for the most favourite woody plants (e.g. poplar, willow and fruit trees), the beaver can go at a greater distance, even more than 100 m far from the water.

Sufficient height of water column for the safe movement and transportation of woody plants, if necessary, this rodent ensures with the construction of dams. The beaver is able to sink for a very long time; in case of threat to life it can stay under water on one breath up to 15 minutes (allowing him to escape and find a suitable shelter from danger). When diving, the beaver seals its nostrils and ear holes; the eye is protected by a transparent membrane, i.e. the third eyelid (a haw). Under water the beaver can chew on branches thanks to its labial muscles, which can be closed up behind the incisors (**Picture 42b**).



Picture 42: A swimming beaver (a) – just part of its head is above the water level; orange-coloured incisors (b).

The beaver can stay in water due to its non-wetting dense coat that is impregnated with fatty secretions of the anal glands. In winter, the density of hair is up to 27,000 hairs/cm² (in comparison – a person has on the head on average of only 600 hair/cm²). This density can be achieved because the hairs do not grow individually, as in humans, but in bundles.

Forelimbs with partially forepaw fifth digit are equipped with powerful claws (**Picture 43a**), which allow burrowing. The hind legs are larger (a foot is up to 18 cm long), and also have long claws and the feet are webbed (**Picture 43b**), which enable and facilitate swimming to beavers. The second digit of the hind limbs has a grooming claw, which is used for grooming (**Picture 43c**). For easier manoeuvring in water the beaver also uses its big flat tail (**Picture 43d**). It also has a thermoregulatory function – in the summer, regulation of blood circulation in the tail helps the body cool and prevent overheating. Beavers also use the tail to warn other individuals from imminent danger – they slap forcefully the water level with it. When moving on land the beaver uses all four limbs, but in certain activities (e.g. chewing above-lying branches, transferring juveniles or building material) the beaver is able to stand or walk on its hind legs for shorter time. During such movement it uses the tail as a support.

The only opening for excretory, reproductive and digestive systems and anus in a skin fold (similar to a cloaca), which reduces the risk of infection, is another adaptation to aquatic life.

5.3.3 Social Behaviour

5.3.3.1 Family Structure

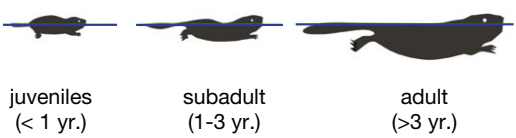
The basic social unit of beavers is a family. It consists of an adult pair and one to two generations of their offspring. In some cases, even three years old offspring remain with the family. The family may, in long-term research conducted in the Czech Republic, consists of

Picture 43: The front limb of a beaver (a); a webbed hind feet (b); a grooming claw on the hind foot (c); detail of a beaver tail (d).

5–7 individuals on average. The family occupies and defends territory which – witch suitable woody plant species – can be inhabited by beavers for many years.

Beavers are mostly monogamous animals, i.e. most of the life they spend in a pair with one partner. Beaver mating season takes place in water or in a burrow in the period from January to March. During May–June (after 105–109 days of pregnancy) 2–5 fully developed, well-seeing and hairy kits are born. The female suckles the kits for about three months, approximately one week after the birth the kits begin to taste also vegetable food, which other family members provide them with. After the first 4–6 weeks of leaving the kits leave the burrow. During the first year of their life there is recorded high mortality (it is associated with the arrival of the first winter and the switch to a woody food); on average 1–2 individuals of the litter survive to adulthood. Beavers sexually mature at the age of two to three years, at this age the maturing beavers leave their families and establish a family of their own. This process of spreading is described in more detail in **Chapter 5.3.3.4**.

In the wild the beaver can live to the age of 7–8 years on average. Captive beavers can live much longer, even more than 20 years. These rodents are reproductively capable up to the age of 13. Accurate identification of the age of wild specimens is almost impossible. Approximately, it is possible to determine the age according the degree of immersion of the body in the water while swimming. Each individual can thus be put into one of three age classes – the young (aged up to one year) swims with a spine protruding above the water level, the immature individual (aged one to three years) also has a part of the back visible above the water level, and the adult (aged three years) swims with the back completely submerged, so that the water lurks just the upper part of the head (**Picture 44**). Precise age determination is possible only with mortalities, e.g. on the basis of cement layers deposited in the teeth.



Picture 44: Approximate age categorization of beavers according to swimming at the free water level (Source: Adrian Czernik).

5.3.3.2 Seasonal and Diurnal Activity

Beavers are active year-round; winters they do not hibernate. The extent and duration of their activities during the year varies depending on food availability, time of breeding, caring for offspring, etc. For beavers, as well as for most other mammals, it is typical seasonally-linked partly variable behaviour during the year. From January to March, mating takes place – the beginning and the length of this period are influenced by climatic factors. In colder areas, mating starts later so that the young are born in a period that is for them more favourable in terms of temperature and food offer. At the beginning and during the spring, maturing individuals also leave the family to find suitable territories for their own families. In this period an activity in defending the border of territories increases significantly. Beavers produce greater amounts of scent marks to define the boundaries of the territory against young intruders.

When herbs start growing in riparian vegetation, beavers switch from woody food to herbal. Period of giving birth begins at the turn of spring and summer. In the first two months after giving birth to kits, beavers are most sensitive to disruption of their homes; whether by man or adverse weather conditions (e.g. sudden summer flood can result in high infant mortality). In autumn beavers begin to repair their homes and dams, they start with food based on woody plants, and usually set up food store places – they prepare for severe winter season. For repairs and new buildings large quantities of wood are needed. The intensity of tree felling therefore rapidly increases in autumn, and felling lasts through winter until late spring. In severe freezing

temperatures, when the water level freezes, beavers stay around their homes, or they even do not leave them. As a food source they use their prepared food store places.

In terms of daily routine, beavers activate mainly at night, from dusk to dawn. They spend the day in their homes. During the night they look for food, restore the boundary marking of their territories and repair their buildings or build new ones.

5.3.3.3 Territoriality

Beavers are territorial animals. Each family lives in an area known as "home range". Inside the home range there is an area called territory, which the family actively defends against strange individuals. The average length of the beaver territory in our conditions ranges between one and two kilometres of the watercourse, depending on the carrying capacity of the environment. In there is sufficiently rich riparian vegetation, beaver territories are rather short; if the territories are food-poorer, they may be longer. Their length can be up to 5 km.

The size of the territory changes during the year. The smallest is in winter when beavers minimize the activity outside their houses because in the cold days they have higher metabolic rate. Conversely, the biggest territories beavers have in spring, in an effort to defend a territory as large as possible against migrating individuals from neighbouring families. Territories between neighbouring families do usually not overlap, while home ranges may overlap. Common area then can be used by members of both families.

Inside the territory beavers have their homes – burrows or lodges. In one territory beavers may have more different shelters. In summer family members stay in several homes (e.g. a female with kits usually has a separate shelter), the winter they usually move into one. The entrance is hidden beneath the water level to reduce the risk of intrusion of predators into the home. From the entrance a corridor leads diagonally upward into a dry den. Beavers can have several shelters next to each other, as well as more corridors can vent from one shelter. The most common type of beaver house is burrows (lodges) which are burrowed into higher banks.

In places where beavers cannot burrow a burrow due to improper terrain or banks of bulk material, they build lodges – up to 2 m high buildings from branches, mud and stones. The lodges are often located in the area flooded by beavers, when the watercourse was dammed up by a beaver dam and there is backwater, so these buildings are inaccessible and surrounded with water from all sides.

Beavers mark the boundaries of their territories with scent marks, as well as surrounding of their homes. These marks are in the form of small piles of mud, grass or twigs, with applied secretion of both under-tail glands. Scent marks carry information on their originator – about its age, sex and social status. All family members are involved in marking. During the spring spread of beavers marking activity is more intense than in the rest of the year. Holders of territories must strongly mark the boundaries and important parts of the territory, thereby protecting their territory against strange young individuals who are looking for a new place to live (see **Chapter 5.3.3.4**).

Due to beaver territorial behaviour they cannot overpopulate as other rodent species (e.g. voles, hamsters or house mice). Number of possible beaver territories in a given area has its ceiling because beavers their territories do not diminish as a result of rising population density. Each territory, populated by beavers, has its limited capacity. In dense populations there is increase of aggression and interspecies competition; stress then results in a smaller number of kits in a litter, higher incidence of disease and higher mortality. Subsequent result is a decline of population density.

5.3.3.4 Spreading

Young beavers leave the maternal family in the early spring, when they sexually mature. An adult pair mates at this time. Maturing individuals (in two thirds of cases, these are two

years old individuals, the rest are three-year or one-year individuals) leave the family to find their own territory (i.e. still unoccupied location with sufficient food base) and later also a partner. The settlement of the location by beavers occurs mainly in the spring months, the arrival of beavers in the summer or early autumn, however, is not excluded. Beavers most often spread through waterways. If necessary, they can travel long distances on land (they even cross mountain boundaries of watershed divides).

While spreading, however, first they explore close surrounding of their native territory; a large percentage of individuals is successful and settles near the original family. Only if they cannot find a suitable place, they undertake trips over greater distances, and they can overcome up to tens of kilometres. Pressure of spreading sub-adults is so strong that "home" beavers must actively defend their territory against spreading young individuals. The primary way of fight is the chemical communication by scent marks, only if this form is ineffective, there are active aggressive conflicts of individuals (both males and females are able to defence equally). Within these battles for territory, many individuals are injured (**Picture 45**), sometimes fatally.

Picture 45: A young beaver with bitten tail

Different situations can arise when beavers are spreading. In the case that the young beaver does not find a suitable place for its territory, it may temporarily settle for a suboptimal location, where it stays for emergency wintering and in spring it continues its journey. In saturated dense populations, where most suitable sites are already occupied, the unsuccessful individual can return to its family, where it spends another season without participating in the reproduction. Searching for a new location is for young individuals physically very exhausting, beavers suffer from effects of higher stress. A hallmark of the non-standard behaviour, which is often linked to the exhaustion, is the loss of timidity, moving activities into daily stages, etc.

In spring, due to the migration of individuals, there is an increased number of collisions of beavers with vehicles, exhausted beavers can be found at unusual places (in waste pits, construction sites, in villages, in water tanks, etc.).

5.3.4 Position in the Ecosystem

5.3.4.1 Food Behaviour

Beavers are exclusively herbivorous, feeding on the riverside and underwater plants and wood plants, while the consumption of various types of vegetation is seasonally variable. During the vegetation period (i.e. during May–September) they consume mainly herbs, up to 150 different species. Felling trees in this period is in a lesser extent than during autumn or winter. In the second half of the vegetation period, especially in the months of August and September, beavers often use agricultural crops (maize, grains, sugar beet, potatoes, etc.), if they are around their territories available.

During the autumn and in winter months in particular, the ratio of representation of herbs and woody plants in food varies significantly, beavers start to eat woody plants due to unavailability of the green parts of the plants during the winter. Woody plants accounts for 90% of their food during winter. From the felled trees beavers consume bark, inner bark, and thin branches and at the time foliage also leaves. Beavers gnaw the wood itself (and spit it out) just to cut down the tree. After they use of the felled tree everything digestible, there are left only trunks and thick branches. There

is usually left only a stump on the bank because beavers remove (on land and water) both thin and thicker branches to places where they use the material for food and building.

It was found that beavers consume over 80 species of woody plants. The beaver prefers soft, for it easier to digest, woody plants – especially poplars and willows. At some locations willows constitute more than 90% of its diet (in the amount of biomass consumed, not just in the number of chewed trees and branches). Willows have, compared to other species, the advantage that they quickly renew with young shoots and they can survive constant gnawing for relatively long time. Poplars also renew very fast, but their shoots contain phenolic substances, for which the beaver avoid them.

Beavers widely use other tree species, such as oak, maple, ash, linden, hazel, fruit trees, birch, blackthorn, hawthorn, beech, alder, and from shrubs – cornel, lilac, etc. (**Picture 46**). In the case of oak young growth, the beaver is able to "harvest" dozens of individuals.

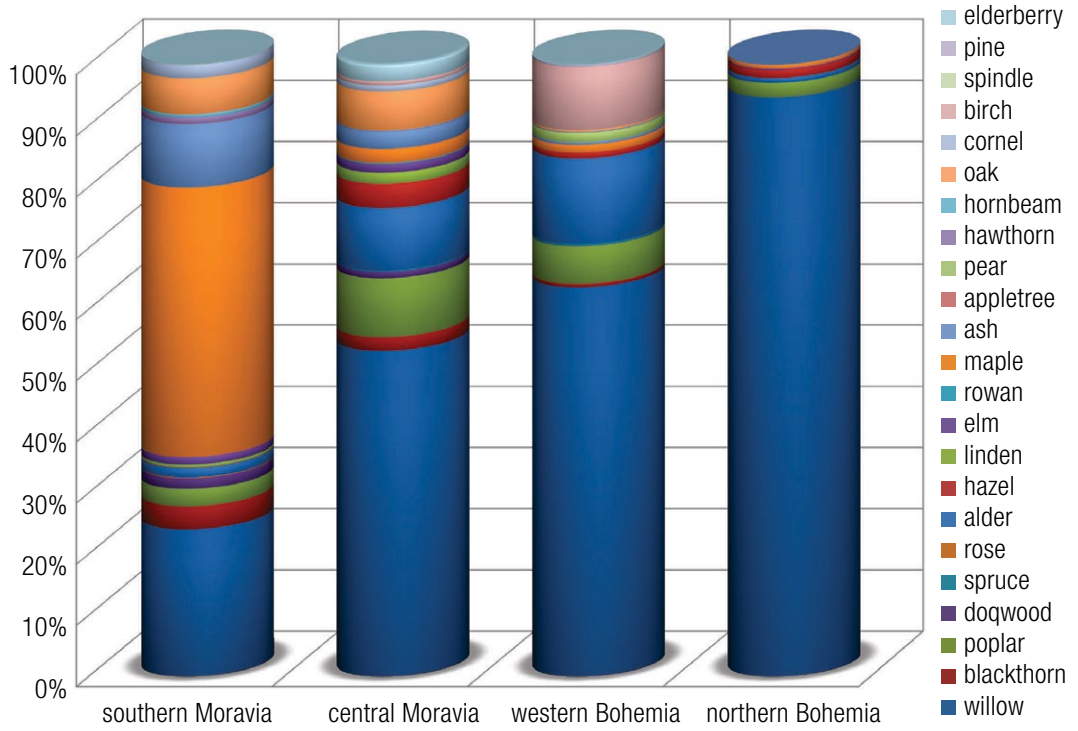
In production forests located near watercourses, where the beaver is present or may occur in the future, it is therefore particularly important to ensure appropriately performed protection of the cover (see **Chapter 3.1.1.2**), to prevent high damage. Among rarely chewed woody plants belong rosehips, nut trees and acacias, as well as conifers. Coniferous (mainly spruce and pine) are gnawed mostly in the spring months. One reason may be the need to supply after winter vitamins and minerals that are found in the bark and needles.

In terms of food, the beaver prefers woody plants of smaller diameters. With less energy it can obtain tastier food than the older woody plants offer. However, this rodent is able to cut down large trees with a diameter of one meter. Felling large tree, the beaver gets to a large number of thinner branches and leaves that are in a tree crown inaccessible. In one day during winter period the beaver consumes on average of 0.5 to 2.5 kg of bark, inner bark, twigs and young shoots. On average, more than 95% of all gnawed woody plants in then beaver territory do not exceed 20 cm diameter, see **Picture 47**.

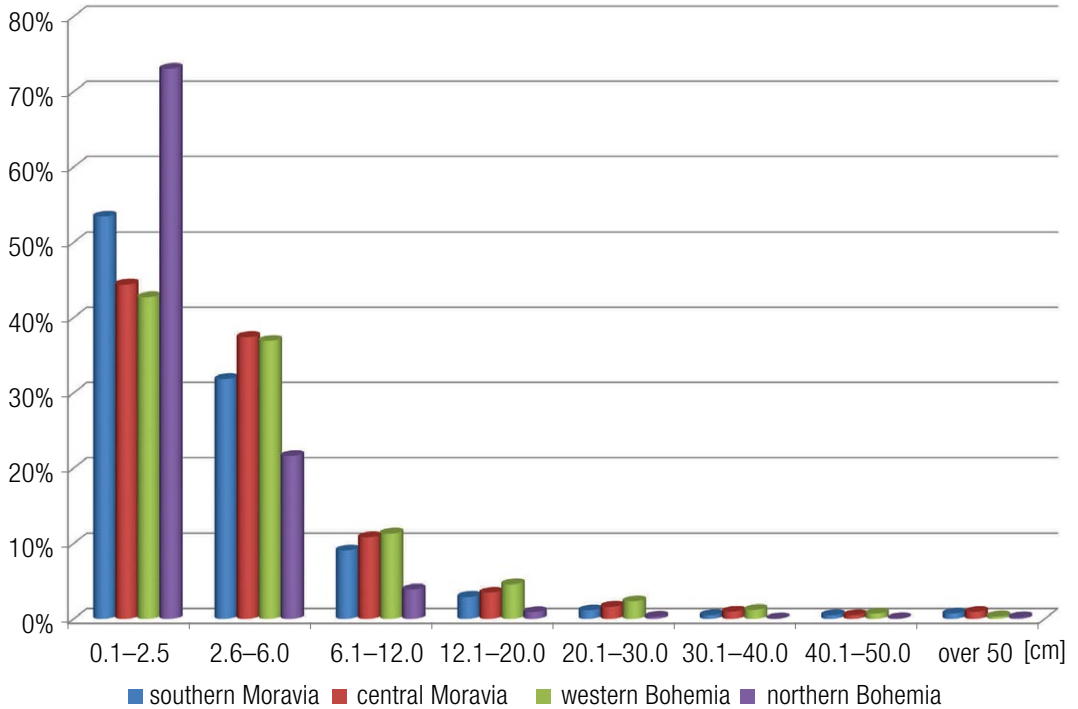
It is not true that beavers cut down trees purposefully toward the water. Trees growing on the edge of the cover have more branches growing into the free space above the water and therefore on they are on this side heavier and fall towards the watercourse. With the arrival of fall, the rate tree-felling increases. Beavers try to stock up and prepare for the unfavourable period of the year. One method of preparation for winter is increase of a layer of subcutaneous fat. The layer is then used during the winter as a source of stored energy and at the same time it protects the beaver from cold. On the ventral side its thickness may even triple, and before winter fat constitutes a significant share in the volume of a beaver tail.

Another way to prepare for the winter season is the creation of food reserves, but these are not present in all territories. When building a storage place, beavers cut down a large amount of trees and branches of smaller diameters (10 cm), which they stick into the watercourse bed in front of the entrance to their homes. Branches, that are not debarked, will remain fresh for a long time. During the most severe freezing the beavers are not forced to go to banks and cut down trees in order to obtain food. So they only pull into their lodges branches from adjacent winter storage and consume them hidden in their dens.

Food, however, is not the only reason for felling woody plants. Beavers use wood as a building material when they build or repair their homes, and at some locations they also use it to build dams.



Picture 46: Percentage distribution of woody plants used by beaver in different areas of CR (Source: CULS Prague).



Picture 47: Percentage of woody plants gnawed by beavers inside beaver territories according to their diameters in each diametric category (Source: CULS Prague).

5.3.4.2 Predation

In the Czech Republic the beavers can still meet infrequently with their natural predators (i.e. wolf, lynx or bear). Kits can be attacked by a fox or other medium small carnivores (martes, minks, etc.). In our country, the area of occurrence of large carnivores and beavers overlap only in the Šumava Mountains, Czech Forest – where is permanently present population of Eurasian lynx – and in northern Bohemia, where the wolf population is being formed.

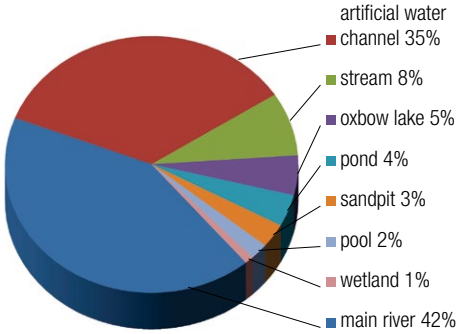
Picture 48: A wolf carrying a caught beaver (Source: Landesamt für Umweltschutz Sachsen-Anhalt / Landesforstbetrieb / WWF).

Therefore, it cannot be expected that for the time being predators could significantly affect the abundance of beaver population in our country. Major impact of large carnivores on the population dynamics of beavers has not even been detected in areas where populations of carnivores are much higher. In our country more significant factors in beaver mortality than their own predation is and will be collisions with vehicles on roads or illegal hunting.

5.3.4.3 Environmental Requirements

With the colonization of new territories, beavers are primarily sought after location with sufficient food offer, ideally with softwoods and hardwoods of floodplain forests (i.e. willows, poplars, maples, ashes, oaks, etc.). Optimal habitat for the beaver is stable or slow moving water with sufficient depth. That is why we often find beavers on water reservoirs, ponds, flooded sand pits, in pools, wetlands and oxbow lakes. With increasing population density beavers also accept sub-optimal conditions, thus inhabits the upper sections of watercourses with fast flowing water, drainage ditches, watercourses in urban areas, etc. The percentage of use of various types of aquatic environment is in a graph in **Picture 49**. Temporarily, this rodent can settle on the little locations with carrying capacity.

After being reintroduced into our country, the beaver primarily seeks to colonize more natural habitats. But with sufficient food offer it can live permanently in farmland or in an urban villages and towns. For example, since the autumn of 2015, beavers have been living on one of the islands in the Vltava River in the capital city of Prague. Beavers are able to go on land or overcome even man-made migration barriers on watercourses (e.g. weirs, sluices or dams of large waterworks) when they are spreading.



Picture 49: The percentage of use of various types of aquatic environments summarized in four stable beaver populations in the Czech Republic, i.e. South Moravia, Central Moravia, in the western and northern Bohemia (Source: CULS Prague).

Under conditions of the Czech Republic the beavers permanently inhabit watercourses up to an altitude of 800–900 m. The limiting factor here is not the low temperature (area of distribution beaver goes up beyond the Arctic Circle, see **Chapter 5.2.1**), but the lack of suitable food it offers. At higher altitudes species composition of riparian vegetation changes (mostly coniferous covers), and watercourses have for the beaver too steep longitudinal

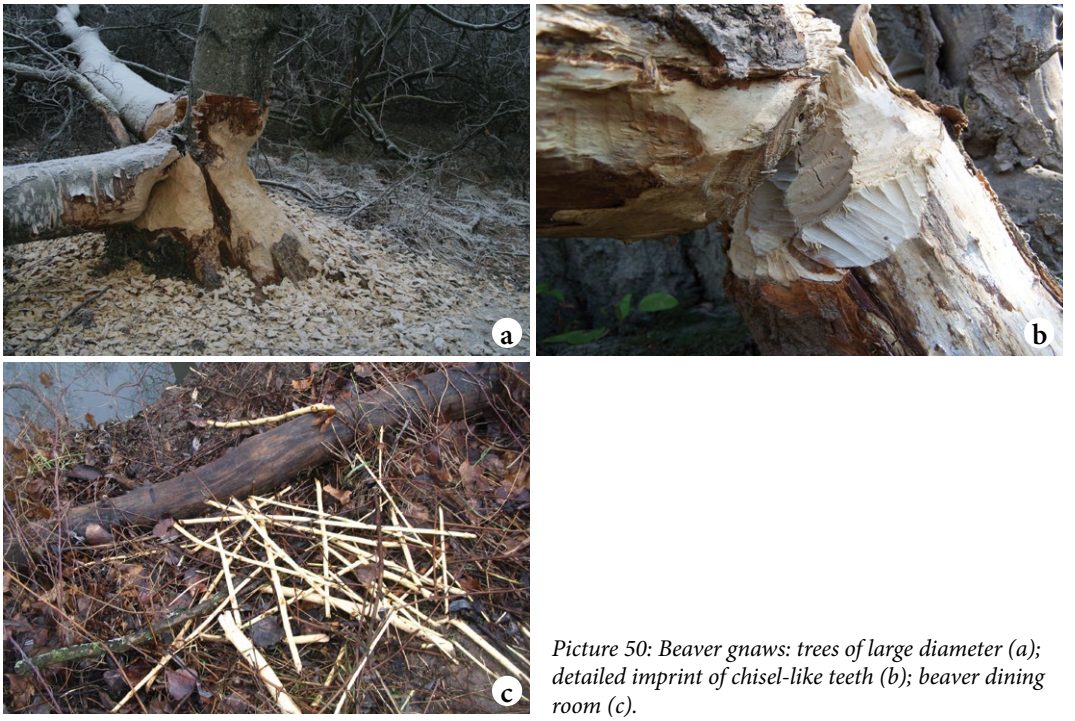
slopes. The limiting factor for the occurrence of the beaver is not water purity. In the long term beavers inhabit e.g. lower part of the Elbe, where there is a large concentration of industrial plants. On this stretch of the stream, elevated concentrations of heavy metals and other pollutants are measured for a long time. In spite of this, beavers have had their territories for more than 20 years here. In this and in many other localities the beaver also adapts itself with often fluctuating water levels. Risk to the existence of beavers is only a flash flood at the time of birth of kits when small beavers are not able to swim and dive yet.

Admirable is how the beaver responds to less suitable habitat conditions. Building dams on watercourses with insufficient water capacity and consequent backwater; beavers achieve the required depth for safely hidden entrances to their homes. Another advantage of such adaptation is slowing of the flow, which means that swimming upstream is for beavers less strenuous. Building a dam thus allows beavers to settle less suitable watercourses (with low height of water column, with a steeper longitudinal profile). Overflow due to the presence of the dam subsequently increases offer and provides secure availability of remoter woody plants, i.e. a source of food and building materials.

Beaver is, besides humans, to be the only animal species that significantly and deliberately modifies ambient conditions according to its needs. This species does not try to use the "remnants" of the natural environment, which remained after considerable human intervention in the landscape. On the contrary, the beaver inhabits the landscape completely and tries to change the conditions so that they suit him. Consequently, intensity of their settlement is higher than intensity of other species which are sensitive to the presence of humans (e.g. otters). And this is also the nature of conflicts between humans and beavers.

5.4 How to Learn That the Site is Inhabited by the Beaver?

In many cases, especially when considering the implementation of some measures, it is crucial for further decisions, if the site is



Picture 50: Beaver gnaws: trees of large diameter (a); detailed imprint of chisel-like teeth (b); beaver dining room (c).

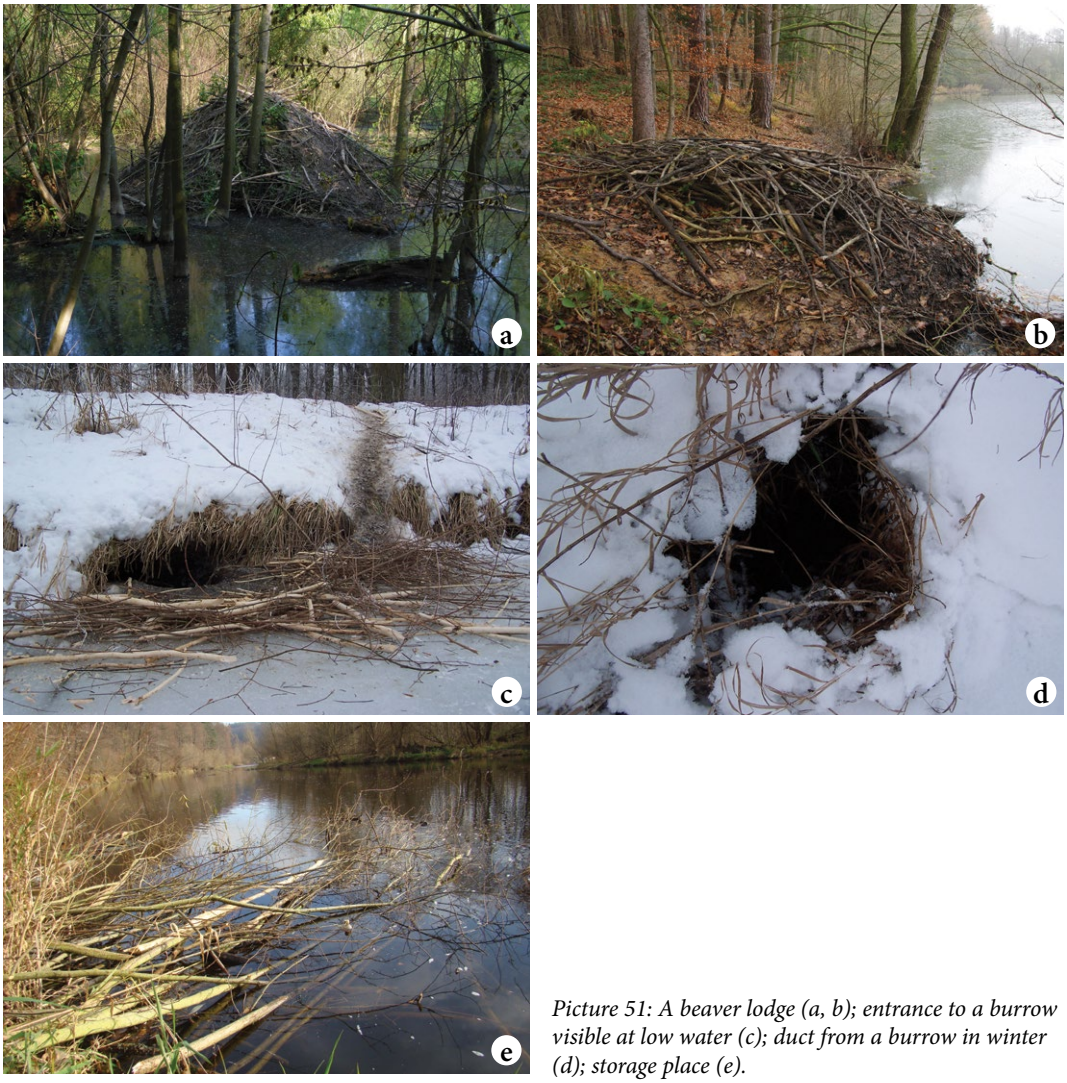
inhabited by beavers or not. The activity of beavers (both damaging and non-damaging) consecutively always leaves remarkable residential marks. Their appearance always talks about the time of the occurrence, either these are fresh signs (footprints, scent marks, fresh gnawing, newly repaired buildings) or they are already obsolete.

To plan a measure, however, makes sense only in the case when the activity of beavers in the location is current. Therefore, to recognize the age of residential marks is essential for the meaningful implementation of almost any measure. If there are only old residential marks in the location (stale greyed gnaws, broken and unrepaired buildings), then it makes sense to consider the implementation of only those measures that are meaningful in the future (e.g. bank fortification of dams, etc.) considering that beavers sooner or later will be extended across the board (see **Chapter 5.2**). Provided that the locality is inhabited newly or permanently, according to estimated nature of potential damage it makes sense to use the measures which can be considerate for the locality. In this case, it is necessary to act immediately, but always pay attention to the procedure in accordance with legal requirements (see **Table 9**).

The presence of the beaver on the locality can be confirmed in several ways. The easiest is its direct observation. However, this becomes – due to its nocturnal activity – more seldom. Furthermore, observing the beaver in the locality does absolutely not reflect the fact that the place is really inhabited by the beaver for long time – the observed beaver can be e.g. an individual migrant, or an individual beyond its territory. But clear and visible residence marks – which the beaver with its activity leaves behind – can be evidence, that the location is currently inhabited by beavers. That the location is currently inhabited can be assessed by determining the age of residential marks and frequency of their increase.

The proof of the presence of the beaver are freshly gnawed woody plants (freshness can be proved with light wood, which is not weathered and greyed with age, **Picture 50a,b**). Branches and trees of smaller diameters have slanted surface of gnaws. Gnaws on trees of larger diameters have a typical hourglass shape – in both cases, there are obvious chisel-like teeth marks on a disrupted surface. Among food residential signs belong also dining rooms, which are piles of barked twigs present in close proximity to water (**Picture 50c**). In summer, these residential marks are less noticeable due to the vast consumption of herbs.

Another sign of the current settlements are beaver buildings – lodges (**Picture 51a** and **Picture 51b**) and dams (**Picture 53**), which are built from branches chewed by beavers, mud and stones. Before winter, beavers repair their buildings using freshly gnawed branches and mud. In spring and summer, these buildings can seem deserted, which does not mean that beavers have left the locality. In localities with higher banks, beavers burrow burrows (**Picture 51c**), which can be very difficult to identify because the entrances are safely hidden under the water level, and vent holes (so-called "duct") of residential burrows are not visible in grown-over terrain (**Picture 51d**). In wintertime, the residential burrow can be revealed because of a storage place (**Picture 51e**), a pile branches of stuck up in the streambed near the entrance to the burrow.



Picture 51: A beaver lodge (a, b); entrance to a burrow visible at low water (c); duct from a burrow in winter (d); storage place (e).

Picture 52: A scent mark.

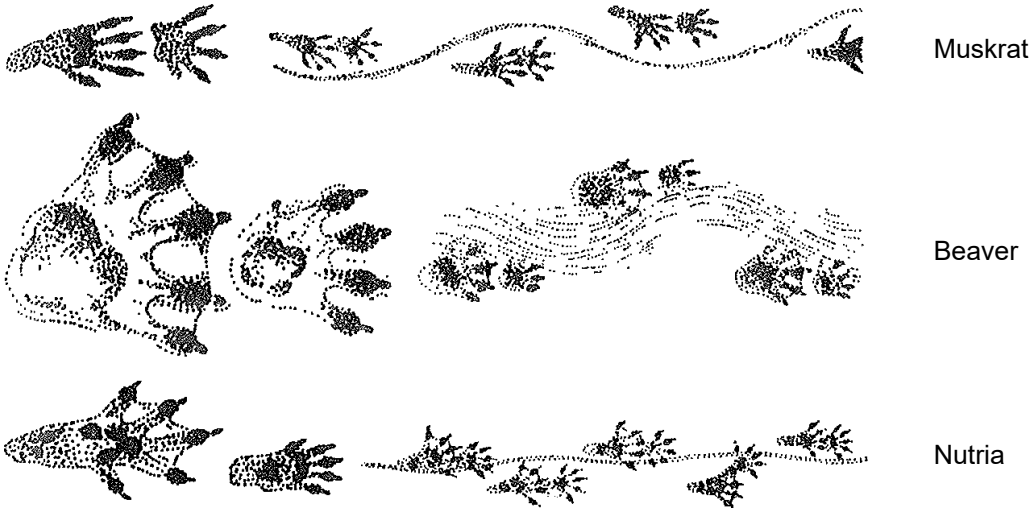
Surrounding of the burrows and the boundaries of their territories beavers indicate with the scent marks (**Picture 52**), piles of mud, clumps of grass or loosely laid twigs, on which they inject characteristically smelling secretion of under-tail glands. Most often we can meet them in spring, in the time of defending territories.

Beavers build dams (**Picture 53**) only in certain types of landscape, especially in shallow watercourses, that are at least slightly recessed in the surrounding terrain.

Picture 53: A beaver dam.

The proof of the existence of a beaver on the location may be footprints in sand, mud or snow (**Picture 54**). A webbed membrane is evident at the back foot imprint. Foot length in an adult reaches 16–18 cm. Visible may be an imprint of a flat tail that a beaver drag behind.

Picture 54: A beaver foot imprint.



Picture 55: Line of footprints of beaver, nutria and muskrat, source Anděra & Horáček (2005).

6 Useful Information

6.1 What to do in case of finding a Wounded beaver

The Act on nature and landscape protection (ANLP) or any other law do not impose an obligation to provide assistance and care to injured or other handicapped wild animals. The regulations generally respect the need to preserve natural processes. However, if someone takes an animal, he/she is according to § 5, article 8 of the ANLP obliged to provide care so as to not prohibit the animal from returning to the wild. In the case of a specially protected animal, including the beaver, which is not able to survive temporarily or permanently in the wild due to injury, illness, or other circumstances, shall the one who took him in accordance with § 52, article 2 of the ANLP pass it immediately for treatment to a rescue station.

The list of rescue stations is indicated on the website of the Ministry of the Environment – **www.mzp.cz**, and also, for example on the website **www.zvirevnouzi.cz**.

In an emergency, you can call central dispatching of rescue stations to obtain the contact information for the rescue station, telephone: 774 155 155.

When finding a wounded beaver, it is necessary to take into account that the reactions of the injured animal are unpredictable and the force of a beaver bite is big. Manipulation with individuals should be left on people working in rescue stations and other professionals.

6.2 What to do for finding a Dead Beaver

According to § 48, article 4 of the ANLP, even dead individuals are protected and therefore it is not possible to pick them up or dispose with them without appropriate permits. If you find a dead individual of Eurasian beaver, inform the nature protection authority (**Table 12**). The location of the site on which the beaver was found determines the competent nature conservation authority.

In cases when the dead individual can endanger water sources, or can cause sanitation problems, it is necessary to inform immediately the town / municipal authority, after open hours – municipal police, possibly the watercourse manager or user of the hunting area.

Table 12: The competent nature conservation authorities.

Position of the locality	Relevant authority
Outside the specially protected areas and their protective zones and outside the military training areas	Regional Authority
On the territory of nature reserves or nature monuments and their protection zones lying outside the PLAs or NPs and their protective zones and outside the military training areas	Regional Authority
National parks and their protection zones outside military districts	National Park Authority
On the protected landscape areas or on the territory of national nature reserves and national natural monument areas and their protection zones outside the military training areas	Regional offices of NCA CR
Military training areas	Military training area office

6.3 Contacts

Findings of the newly settled locations or dead beavers are very valuable data. They allow predicting the rate of future development of settlements, lead to refinement of the information about the species, their genetic variability and the factors causing death of beavers. For this reason, it is useful to inform about finding newly populated locality or a dead beaver also the scientific workplace that deals with the research of beavers nationwide:

Aleš Vorel

Department of Ecology, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, (**www.fzp.czu.cz**),
tel.: 224 382 853 or e-mail: **vorel@fzp.czu.cz**

It is always advisable to keep the photo of the finding, specify the location and date, name and contact of the finder (e-mail, phone number).

In the case of unavailability of the abovementioned contact, it is possible to use contacts of coordinators of Management plan for the Eurasian Beaver in the Czech Republic (NCA CR, Division of animal species protection, **www.zachranneprogramy.cz**) local or regional offices of NCA CR.

Other useful contacts:

- Contact information for each regional office of NCA CR can be found on the website: **www.ochranaprirody.cz/regionalni-pracoviste**.
- Implementation of many measures requires contacting the manager of a watercourse, which are either state enterprises of individual basins or state enterprise Lesy České republiky. More information can be found on the website: **eagri.cz/public/web/mze/voda/spravci-vodnich-toku**.
- Contact information for water management authorities can be found e.g. on the website: **www.vodovod.info/index.php/katalog/informacni-zdroje/vodopravni-urady#.V5tCALiLTDc**.
- Contact information for building authorities can be found on the website: **www.statnisprava.cz/rstsp/ciselniky.nsf/i/d0061**.

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Other:

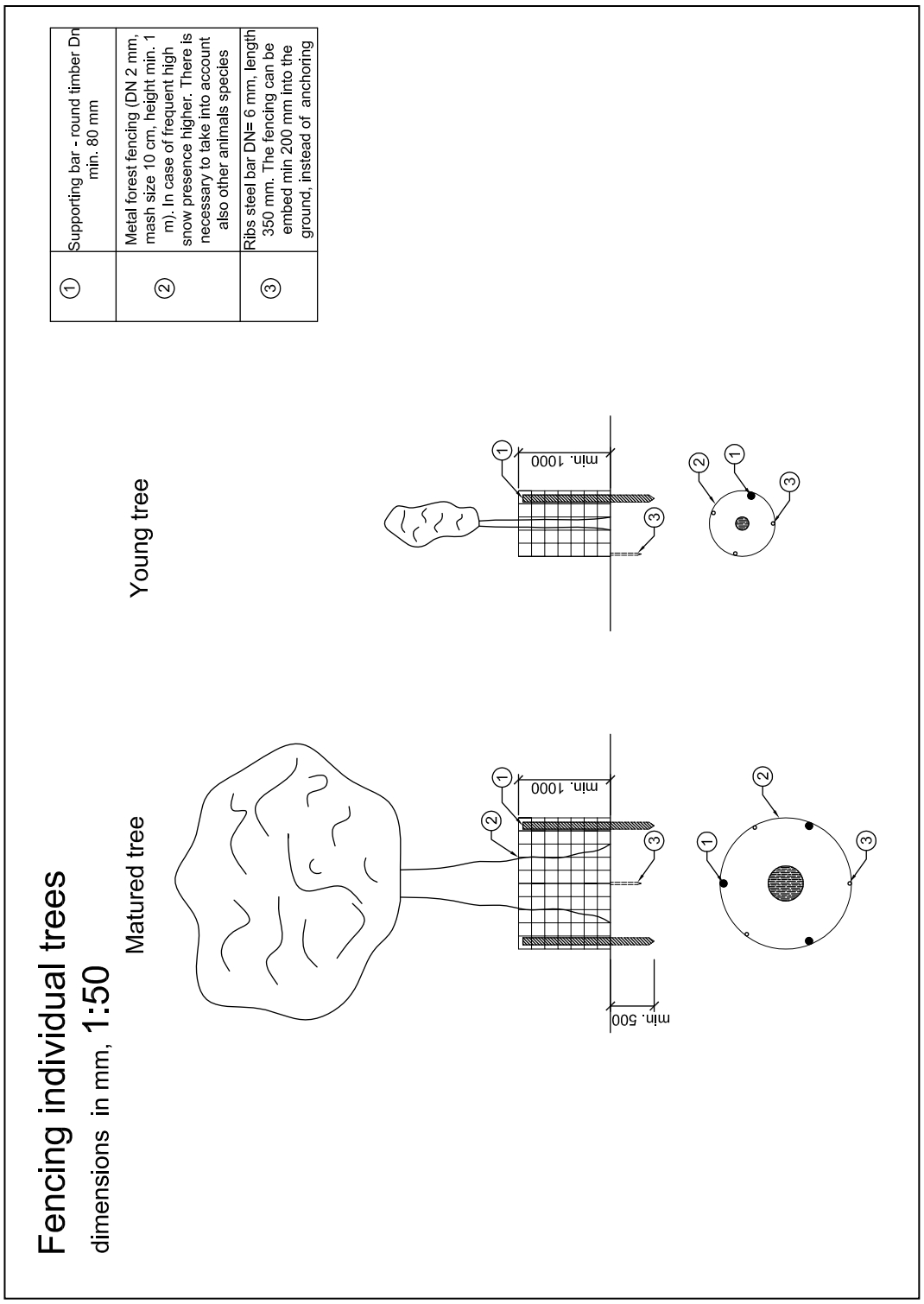
CTS 75 2410. Small water reservoirs.

CTS EN 60335-2-76 ed. 2. Household and similar electrical appliances - Safety -

Part 2-76: Particular requirements for electrical power supplies for electric fences.

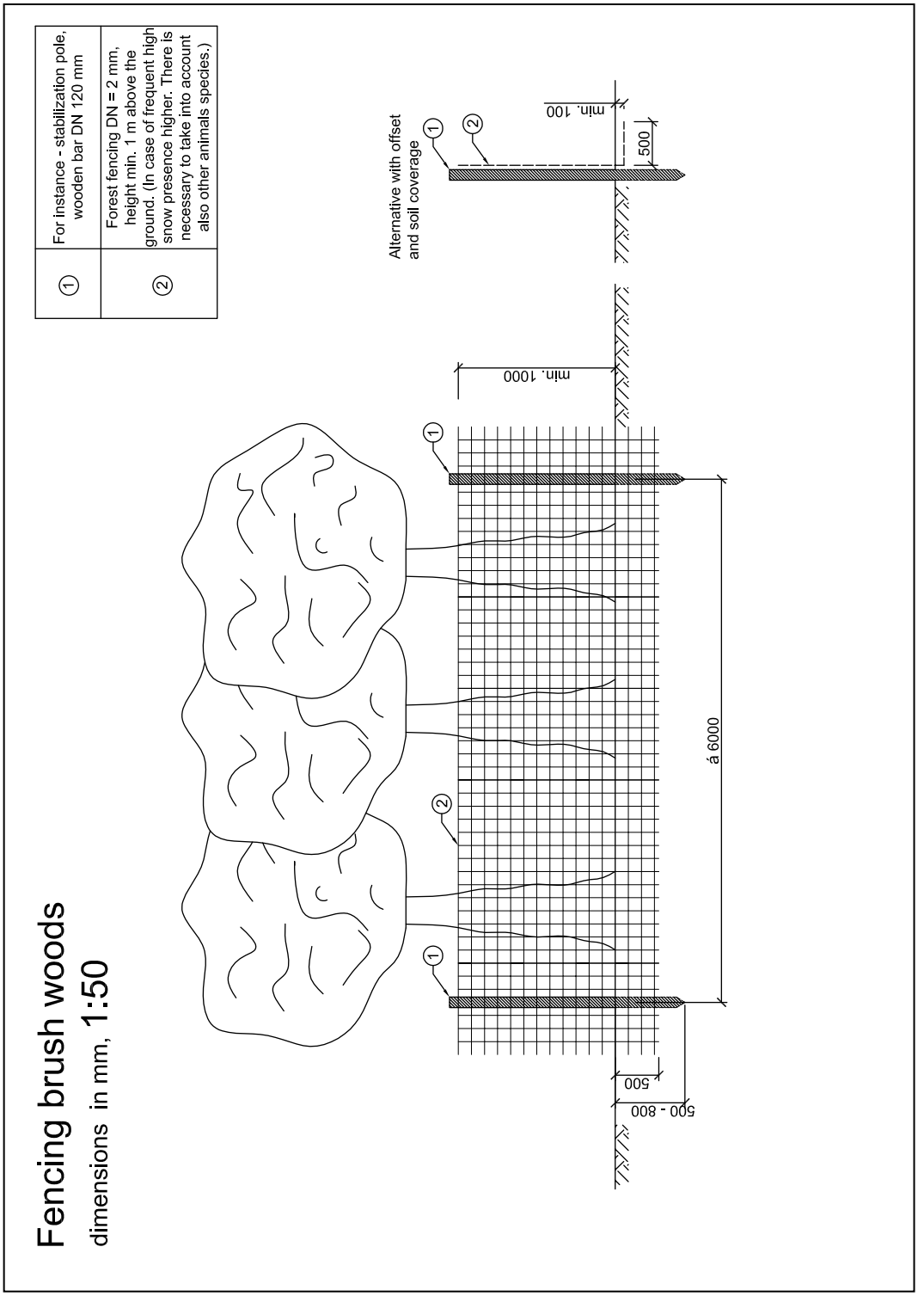
Wöbra – documentation of protective agent against exfoliation. Ridex s.r.o.

Annex 1

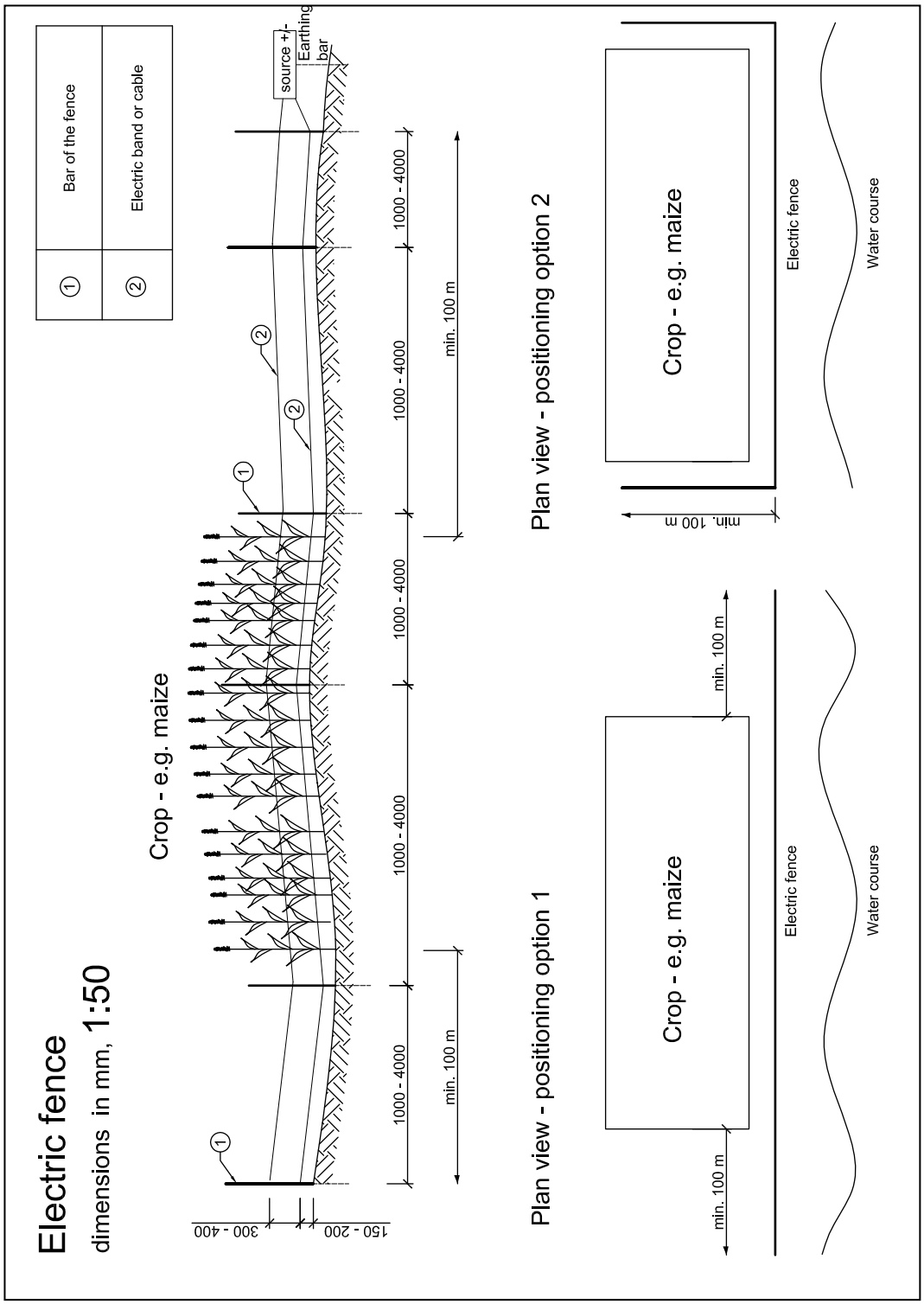


①	Supporting bar - round timber Dn min. 80 mm
②	Metal forest fencing (DN 2 mm, mash size 10 cm, height min. 1 m). In case of frequent high snow presence higher. There is necessary to take into account also other animals species
③	Ribs steel bar DN= 6 mm, length 350 mm. The fencing can be embed min 200 mm into the ground, instead of anchoring

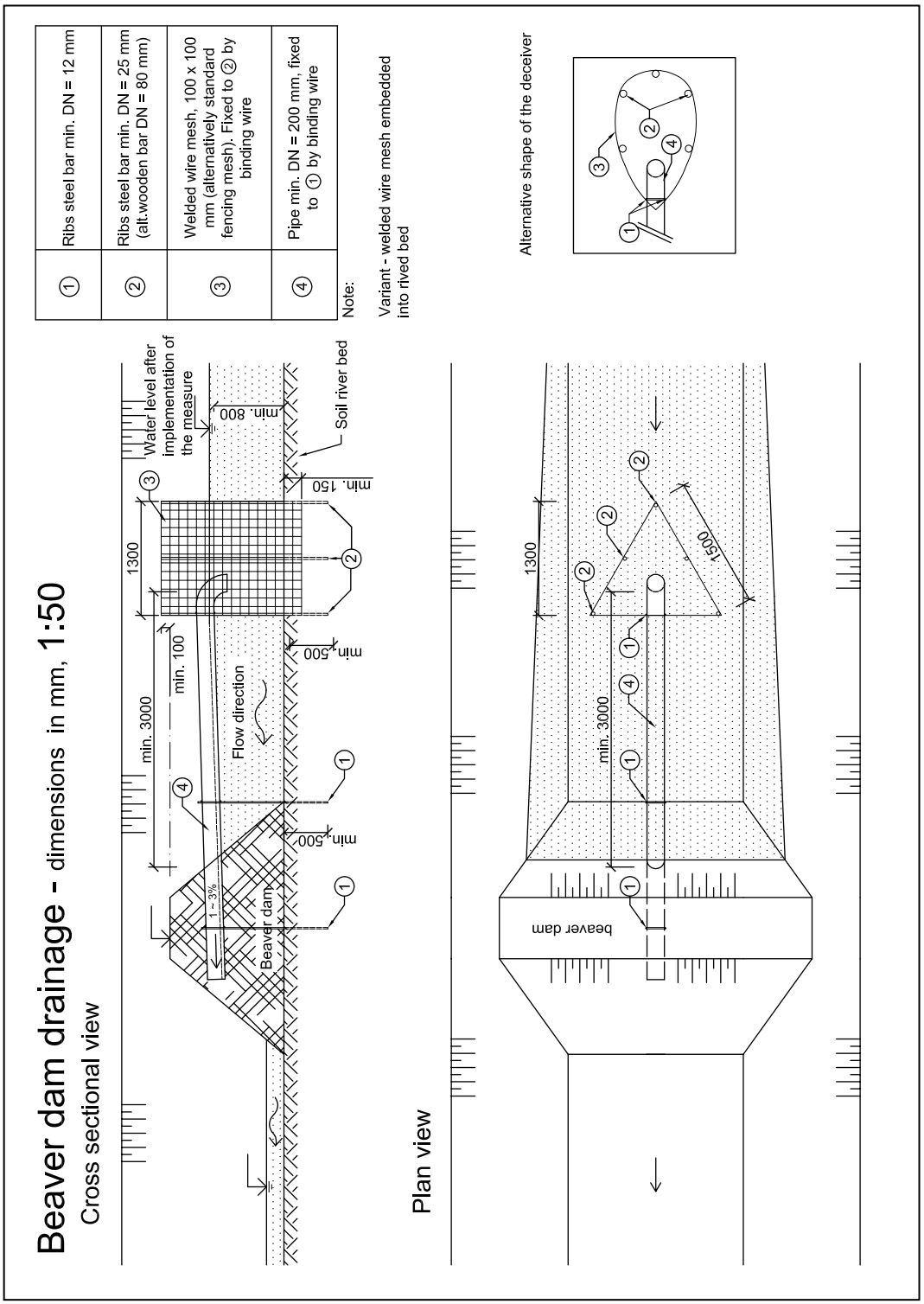
Annex 2


Fencing brush woods
dimensions in mm, 1:50
① For instance - stabilization pole, wooden bar DN 120 mm
② Forest fencing DN = 2 mm, height min. 1 m above the ground. (In case of frequent high snow presence higher. There is necessary to take into account also other animals species.)
Alternative with offset and soil coverage
min. 100
500
min. 1000
á 6000
500
500 - 800

Annex 3

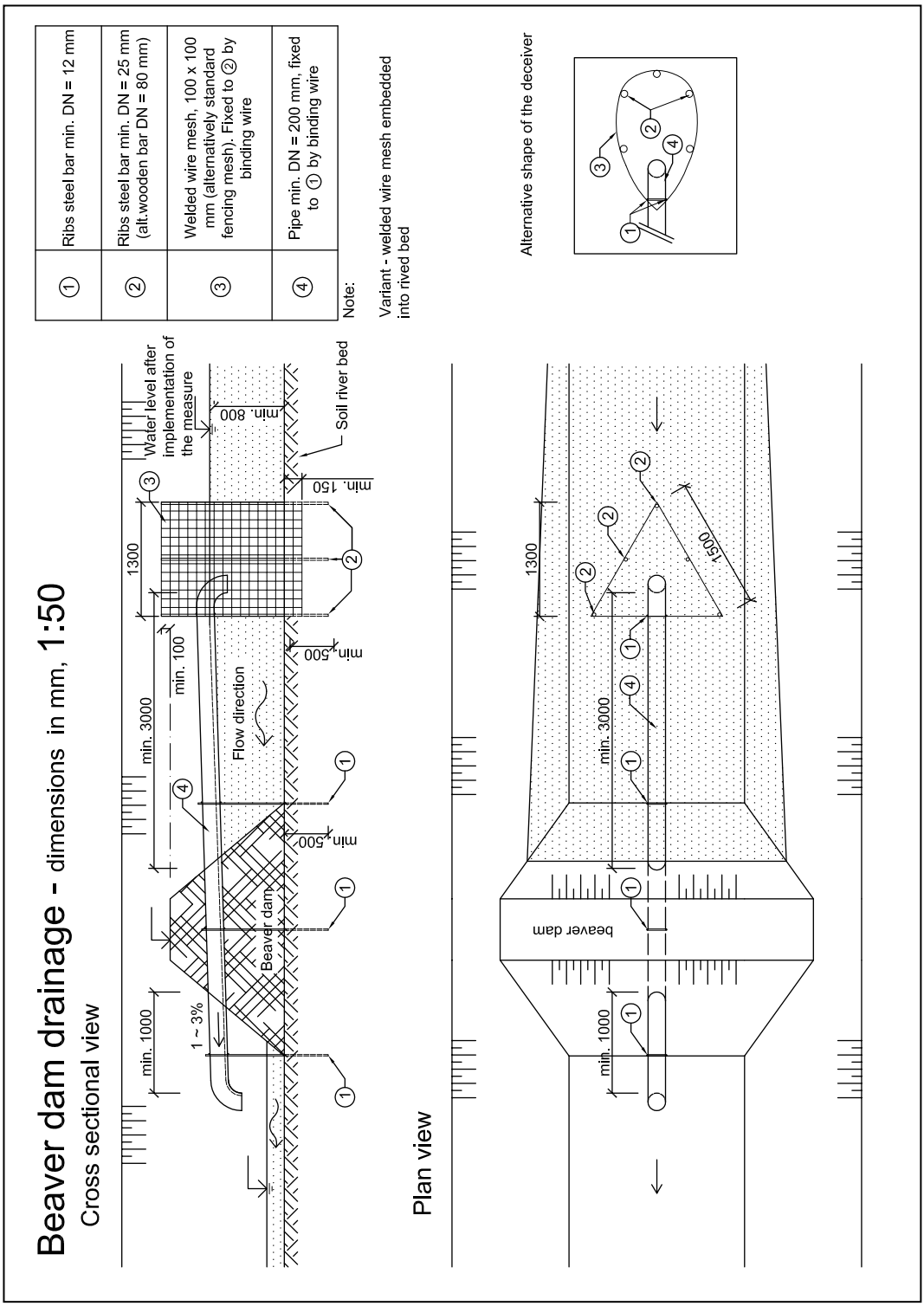

Electric fence
dimensions in mm, 1:50
① Bar of the fence
② Electric band or cable
Crop - e.g. maize
source +/-
Earthing bar
1000 - 4000
min. 100 m
300 - 400
150 - 200
Plan view - positioning option 1
Plan view - positioning option 2
Crop - e.g. maize
min. 100 m
Electric fence
Water course

Annex 4

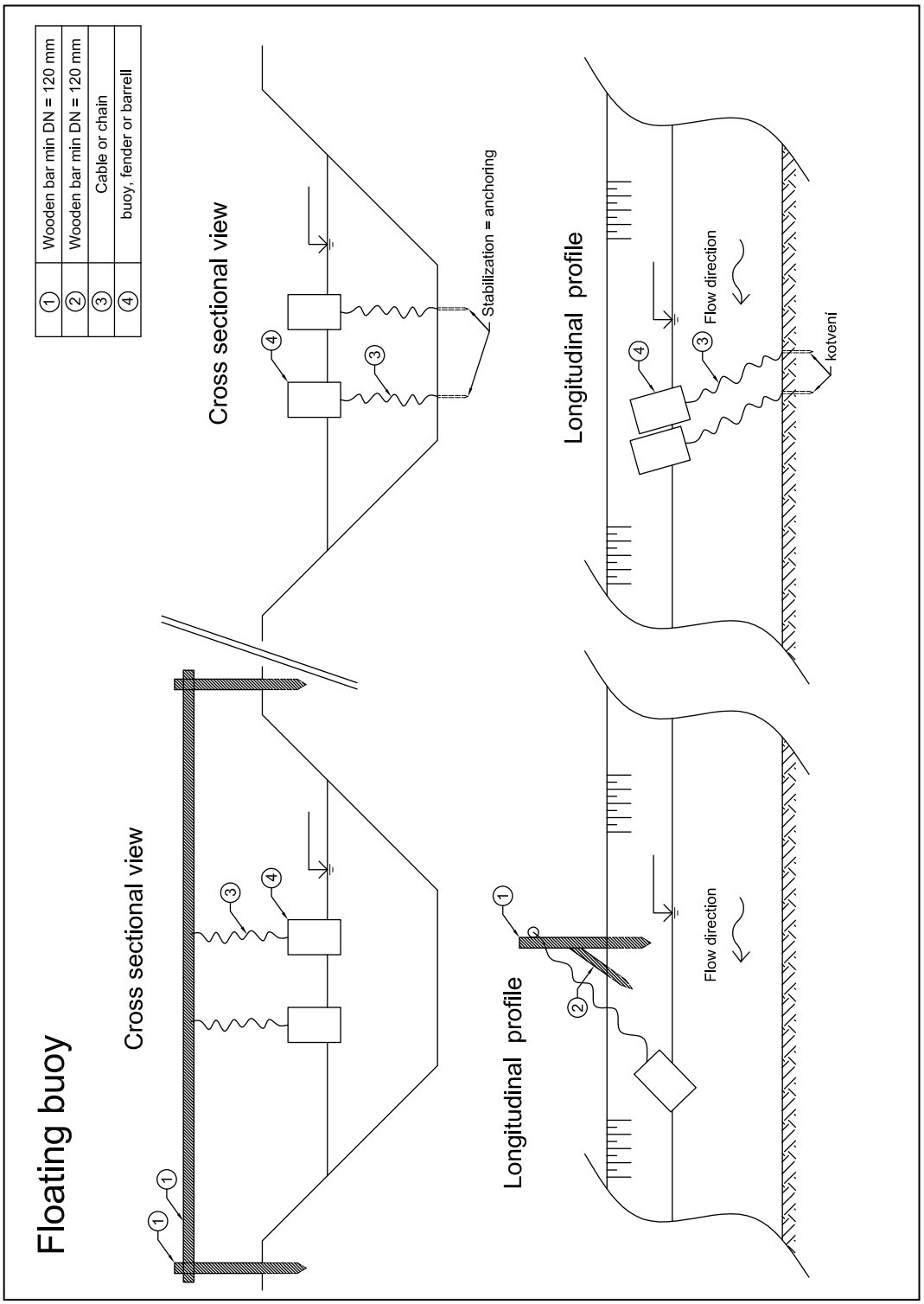


①	Ribs steel bar min. DN = 12 mm
②	Ribs steel bar min. DN = 25 mm (alt.wooden bar DN = 80 mm)
③	Welded wire mesh, 100 x 100 mm (alternatively standard fencing mesh). Fixed to ② by binding wire
④	Pipe min. DN = 200 mm, fixed to ① by binding wire

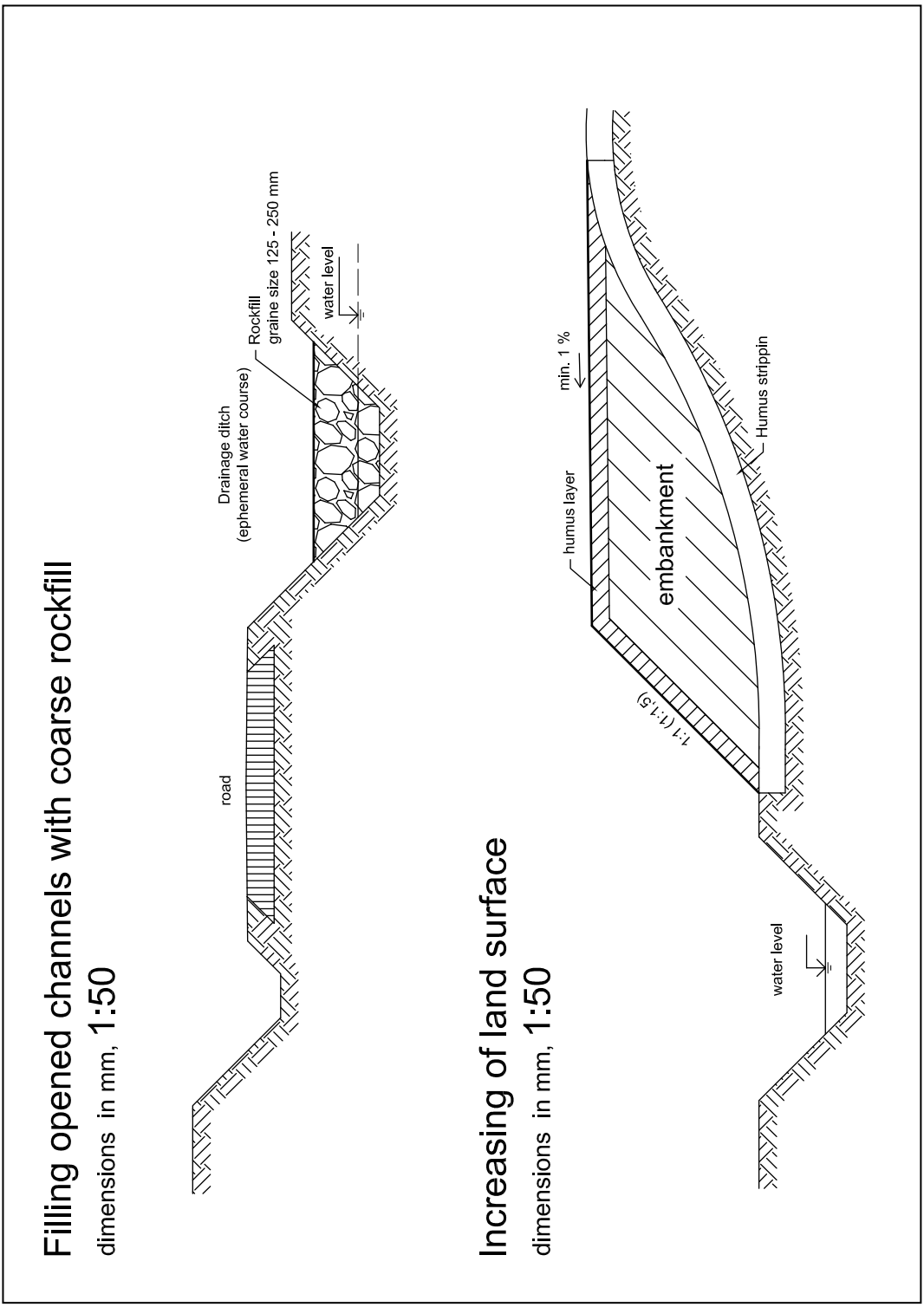
Annex 5


Beaver dam drainage - dimensions in mm, 1:50
Cross sectional view
Plan view
Beaver dam
Flow direction
Water level after implementation of the measure
Soil river bed
min. 1000
min. 3000
min. 100
1 ~ 3%
1300
min. 800
min. 150
min. 500
1500
Alternative shape of the deceiver
Note:
Variant - welded wire mesh embedded into rived bed
① Ribs steel bar min. DN = 12 mm
② Ribs steel bar min. DN = 25 mm (alt.wooden bar DN = 80 mm)
③ Welded wire mesh, 100 x 100 mm (alternatively standard fencing mesh). Fixed to ② by binding wire
④ Pipe min. DN = 200 mm, fixed to ① by binding wire

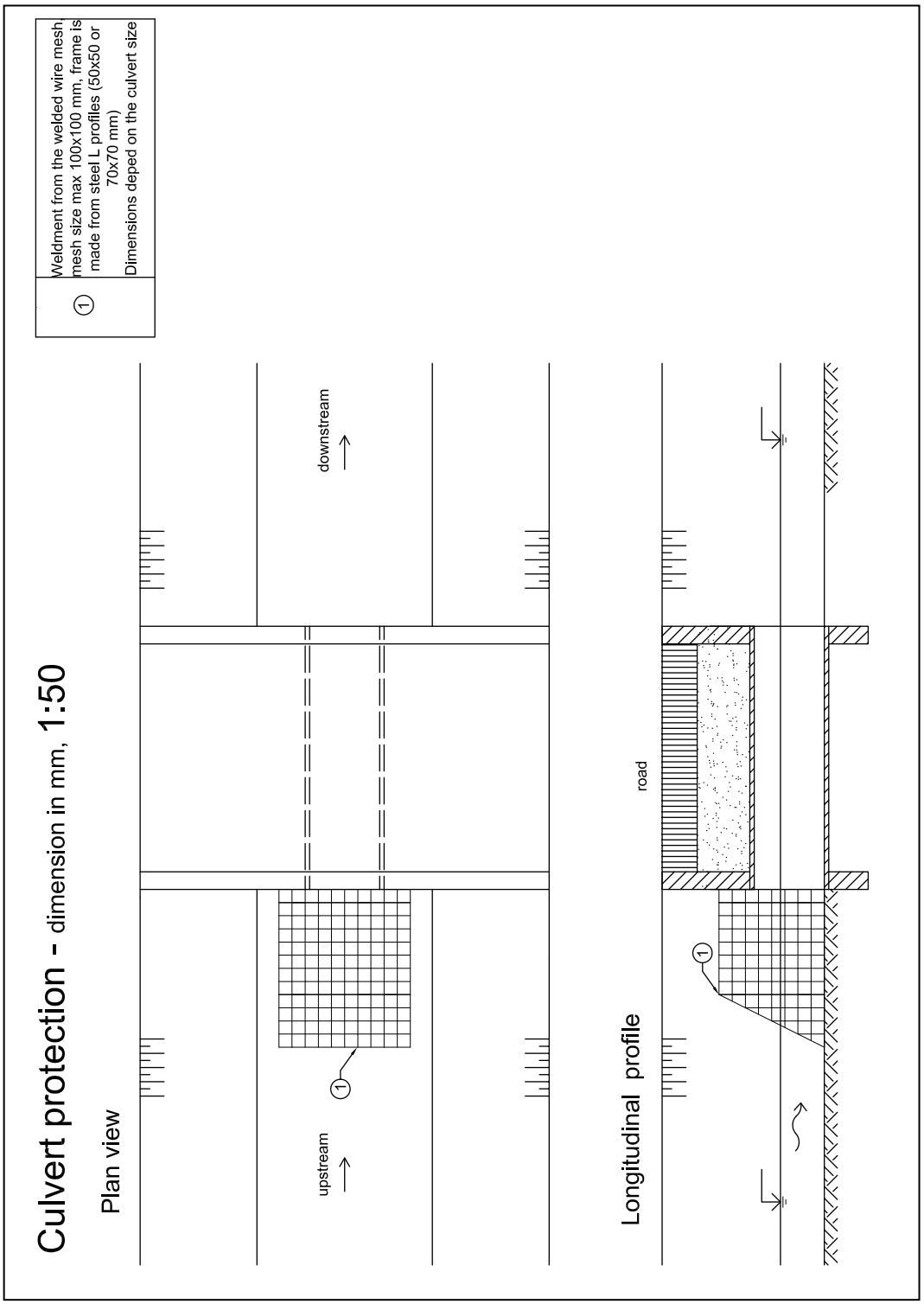
Annex 6


Floating buoy
Cross sectional view
Cross sectional view
Stabilization = anchoring
Longitudinal profile
Flow direction
Longitudinal profile
Flow direction
kotvení
① Wooden bar min DN = 120 mm
② Wooden bar min DN = 120 mm
③ Cable or chain
④ buoy, fender or barrell

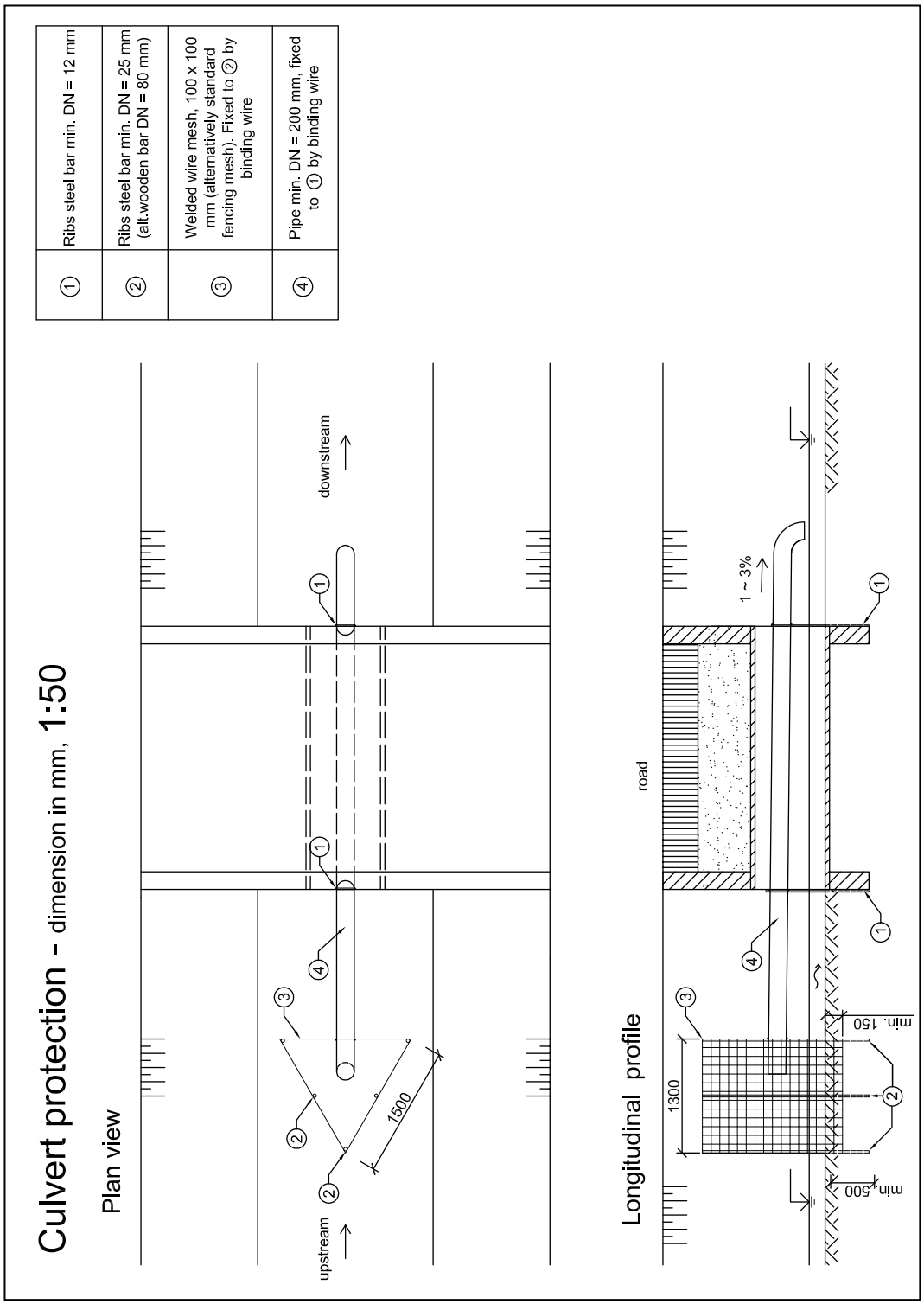
Annex 7


Filling opened channels with coarse rockfill
dimensions in mm, 1:50
road
Drainage ditch
(ephemeral water course)
Rockfill
graine size 125 - 250 mm
water level
Increasing of land surface
dimensions in mm, 1:50
min. 1 %
humus layer
embankment
Humus strippin
1:1 (1:1,5)
water level

Annex 8

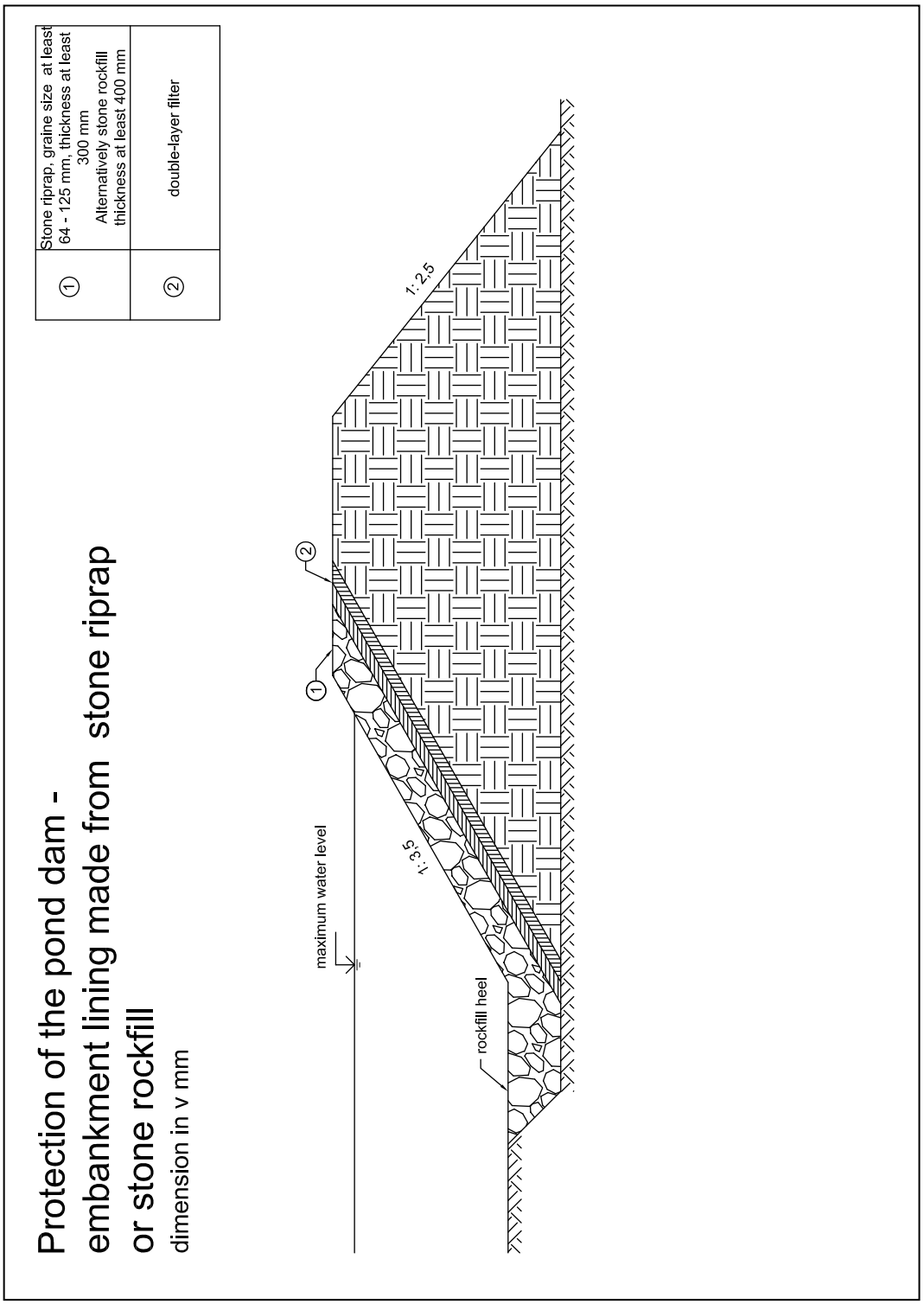

Culvert protection - dimension in mm, 1:50
Plan view
upstream
downstream
1
Longitudinal profile
road
1
1
Weldment from the welded wire mesh, mesh size max 100x100 mm, frame is made from steel L profiles (50x50 or 70x70 mm)
Dimensions deped on the culvert size

Annex 9

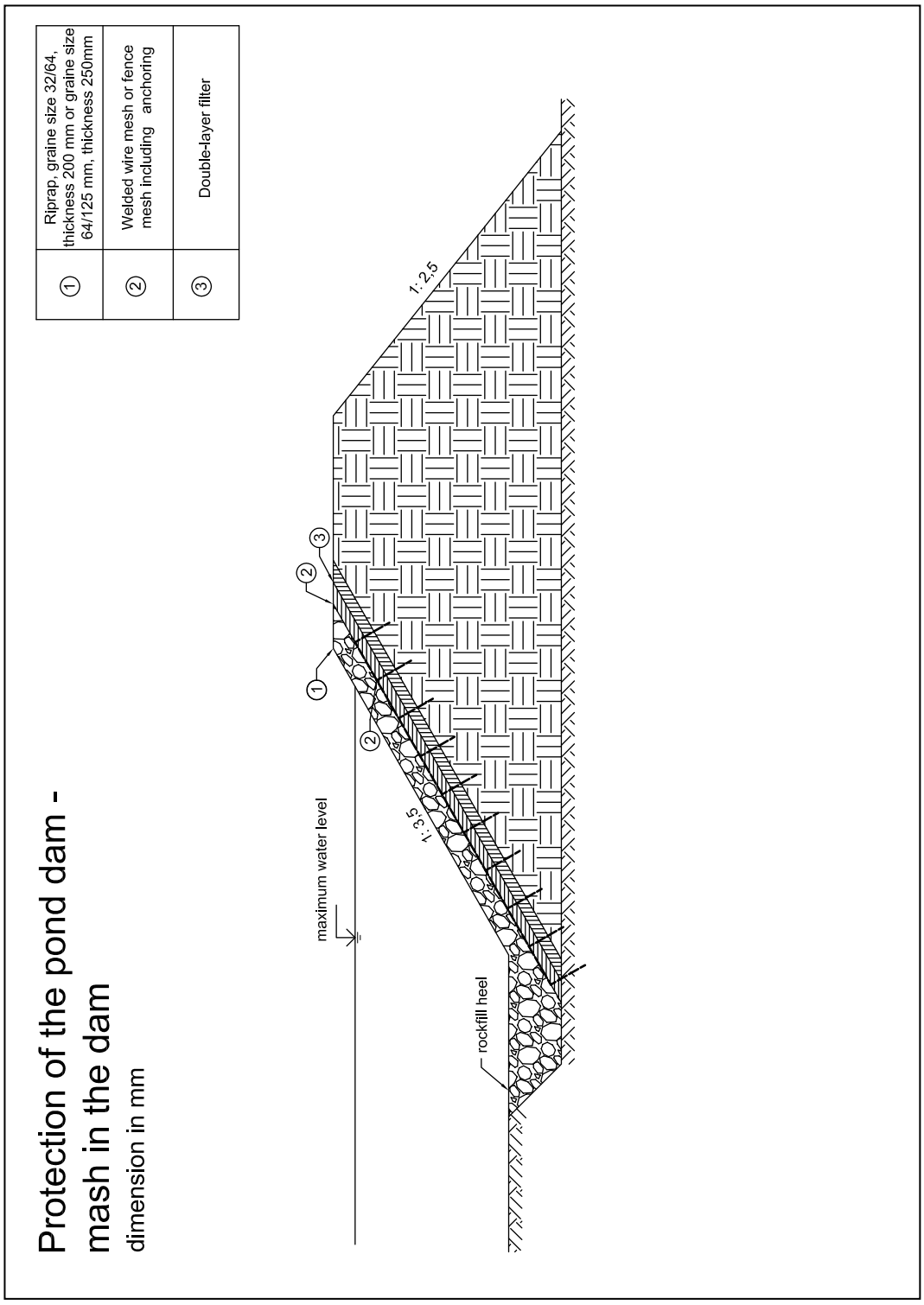


①	Ribs steel bar min. DN = 12 mm
②	Ribs steel bar min. DN = 25 mm (alt.wooden bar DN = 80 mm)
③	Welded wire mesh, 100 x 100 mm (alternatively standard fencing mesh). Fixed to ② by binding wire
④	Pipe min. DN = 200 mm, fixed to ① by binding wire

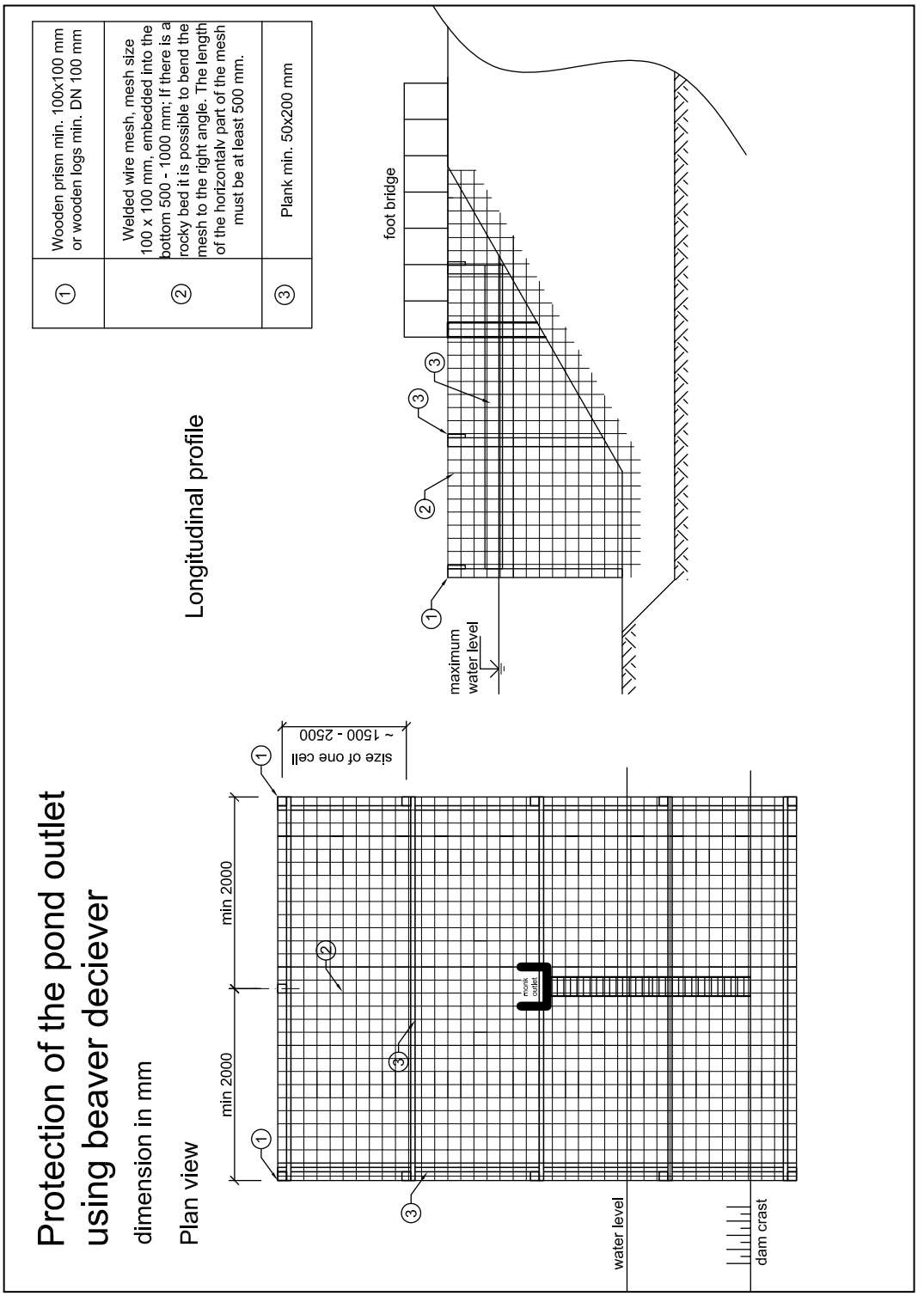
Annex 10


Protection of the pond dam - embankment lining made from stone riprap or stone rockfill
dimension in v mm
① Stone riprap, graine size at least 64 - 125 mm, thickness at least 300 mm
Alternatively stone rockfill thickness at least 400 mm
② double-layer filter
1:2,5
1:3,5
maximum water level
rockfill heel

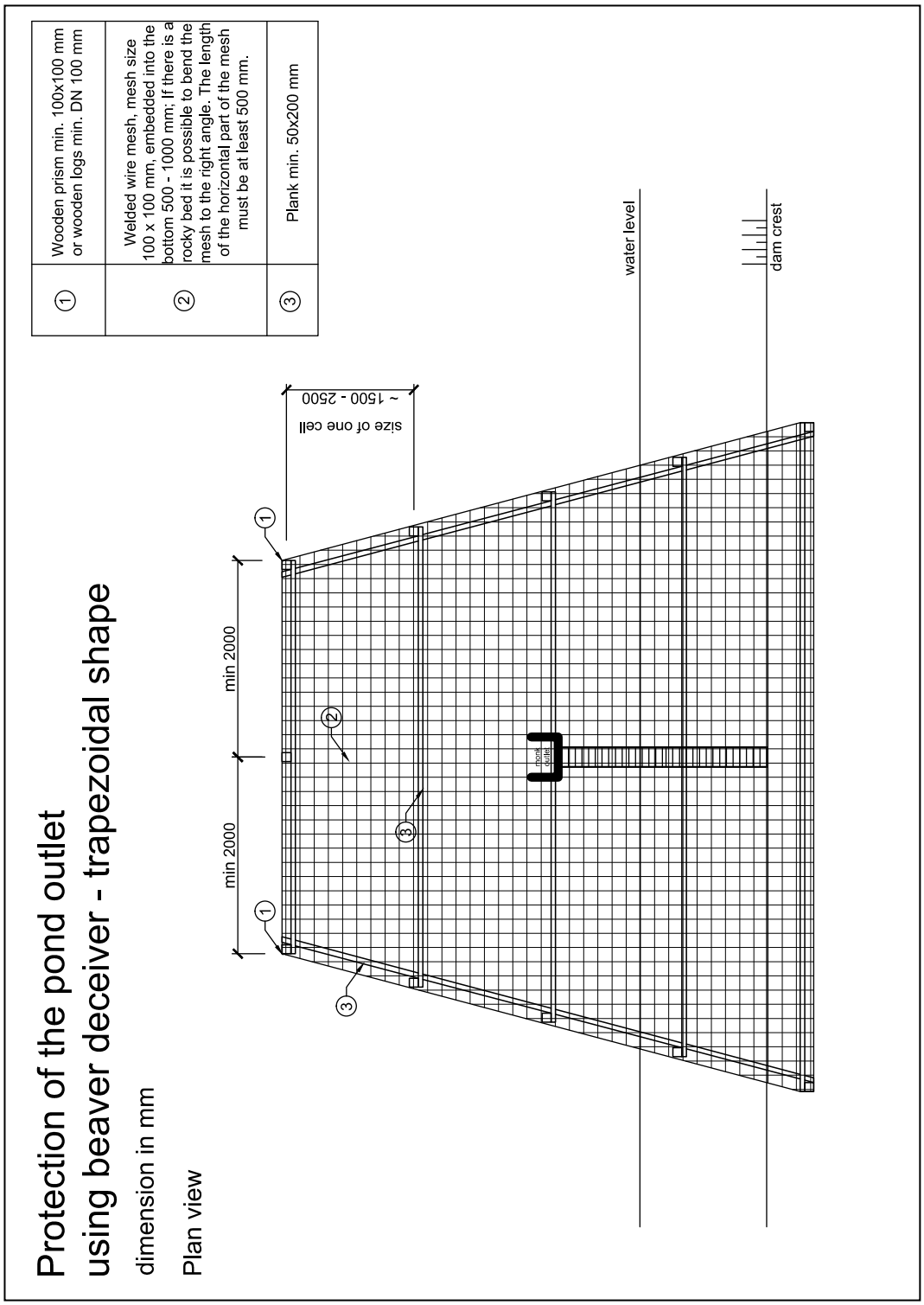
Annex 11


Protection of the pond dam - mash in the dam
dimension in mm
① Riprap, graine size 32/64, thickness 200 mm or graine size 64/125 mm, thickness 250mm
② Welded wire mesh or fence mesh including anchoring
③ Double-layer filter
1:2,5
1:3,5
maximum water level
rockfill heel

Annex 12


Protection of the pond outlet using beaver deciever
dimension in mm
Plan view
min 2000
min 2000
size of one cell ~ 1500 - 2500
monk outlet
water level
dam crast
Longitudinal profile
foot bridge
maximum water level
① Wooden prism min. 100x100 mm or wooden logs min. DN 100 mm
② Welded wire mesh, mesh size 100 x 100 mm, embedded into the bottom 500 - 1000 mm; If there is a rocky bed it is possible to bend the mesh to the right angle. The length of the horizontalv part of the mesh must be at least 500 mm.
③ Plank min. 50x200 mm

Annex 13

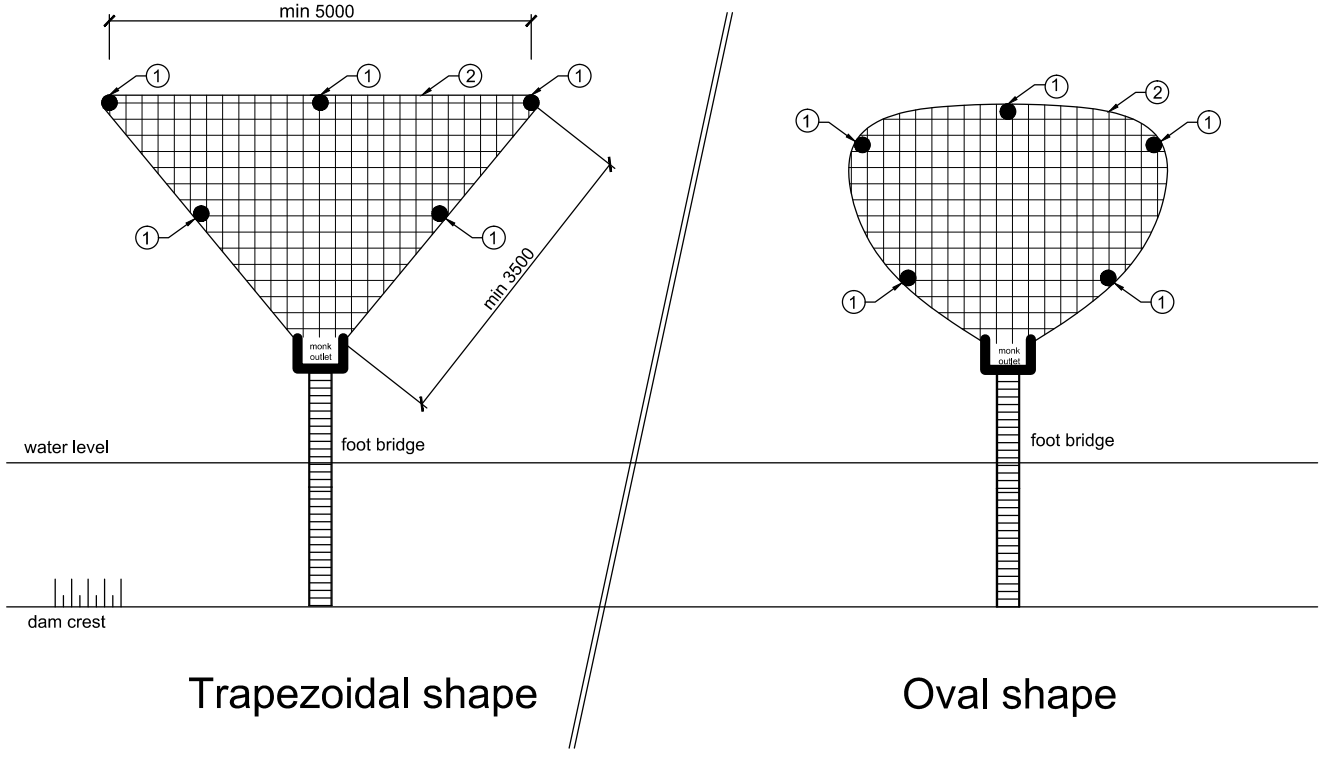

Protection of the pond outlet
using beaver deceiver - trapezoidal shape
dimension in mm
Plan view
① Wooden prism min. 100x100 mm or wooden logs min. DN 100 mm
② Welded wire mesh, mesh size 100 x 100 mm, embedded into the bottom 500 - 1000 mm; If there is a rocky bed it is possible to bend the mesh to the right angle. The length of the horizontal part of the mesh must be at least 500 mm.
③ Plank min. 50x200 mm
min 2000
min 2000
~ 1500 - 2500
size of one cell
water level
dam crest
flow direction

Protection of the pond outlet using beaver deceiver - variation of the shape

dimension in mm

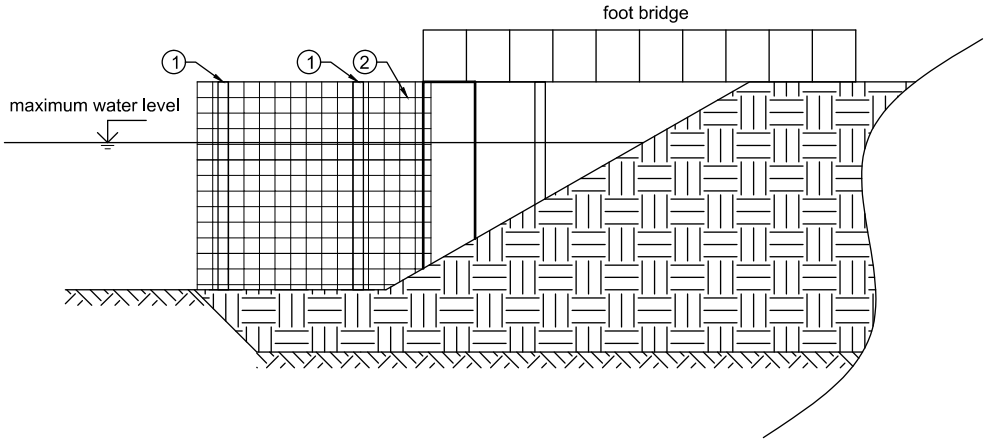
①	Wooden prism min. 100x100 mm or wooden logs min. DN 100 mm
②	Welded wire mesh, mesh size 100 x 100 mm

Plan view



Protection of the pond outlet
Variant - open monk outlet
longitudinal profile

①	Wooden prism min. 100x100 mm or wooden logs min. DN 100 mm
②	Welded wire mesh, mesh size 100 x 100 mm



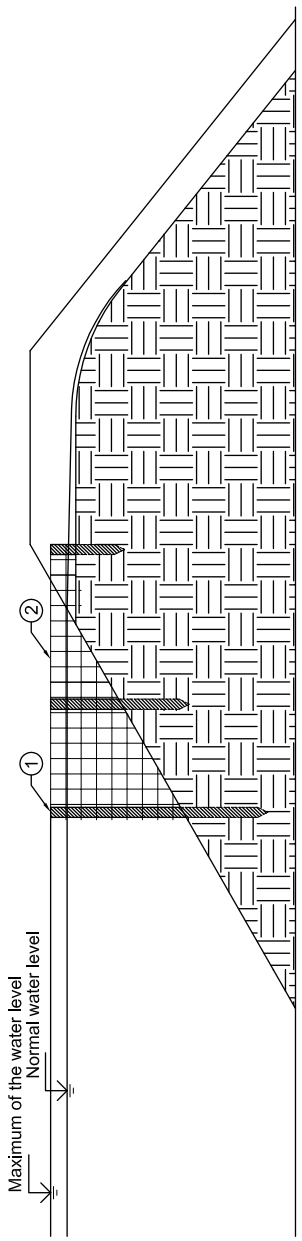
Annex 16

Protection of the safety spillway

dimensions in mm

①	Pilots: option 1 - steel option 2 - steel foot + wooden prism option 3 - wooden prism
②	trash rack (alternatively welded wire mesh, mesh size 100 x 100 mm)

Cross sectional view

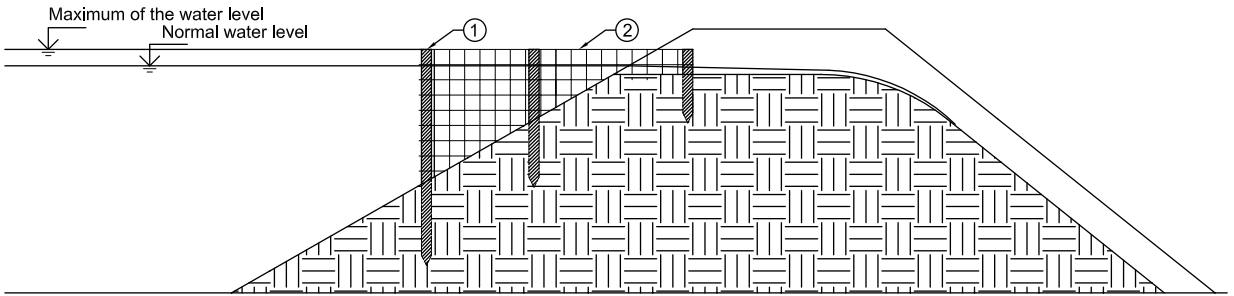


Protection of the safety spillway

dimensions in mm

①	Pilots: option 1 - steel option 2 - steel foot + wooden prism option 3 - wooden prism
②	trash rack (alternatively welded wire mesh, mesh size 100 x 100 mm)

Cross sectional view



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