1 Danube Delta Biosphere Reserve **2** Srebarna Nature Reserve **3** Kalimok-Brushlen Protected Site **4** Rusenski Lom Nature Park
5 Persina Nature Park **6** Djerdap National Park **7** Gornje Podunavlje Special Nature Reserve **8** Kopački rit Nature Park
9 Lonjsko Polje Nature Park **10** Duna-Dráva National Park **11** Duna-Ipoly National Park **12** Dunajské luhy Protected Landscape Area
13 Záhorie Protected Landscape Area **14** Donau-Auen National Park **15** Donauauwald Neuburg Ingolstadt

MANUAL OF BEAVER MANAGEMENT WITHIN THE DANUBE RIVER BASIN

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1. INTRODUCTION

For millions of years, beaver has been an integral part of the Danube basin fauna. Consequently of the development of intolerant predatory civilization, beaver was completely exterminated from the Danube basin in XIX. century. Only in 1966, beaver was reintroduced in the Danube river basin. Thereafter, its population experienced unprecedented increase; nowadays this trend is pan european. At the beginning of the 20th century, only 1200 specimens persisted in eight Eurasian refugia. Following the hunting prohibition and rehabilitation programs in 15 countries, beaver population currently stands at approximately 1 000,000 individuals in Europe and Asia (Halley, 2011). The most abundant are populations of Scandinavia, Russia and Baltic States. Overall, 23 countries joined the restoration of beaver until 2009 (Norway, Sweden, Finland, Russia, Estonia, Lithuania, Latvia, Switzerland, Poland, Austria, Czech Republic, Slovakia, Croatia, Hungary, Denmark, Netherlands, Germany, Spain, Belgium, Serbia, Bosnia-Hercegowina, Romania and Scotland). They are motivated by the attempt to utilize beaver activity to stop degradation processes of watercourses, restore natural ties, and increase biodiversity, as well as tourist attractiveness of areas.
Basic idea of the Manual of beaver management in the Danube river basin is to make accessible all important informations about the beaver population, to ensure its protection and to minimize the damages resulting from beaver activities, ever since their initial appearance on the territory of the Danube River Basin countries.
Objectives of preparation of the manual take into account beaver´s unique biology, its impact on the environment, as well as the requirements of current nature conservation:

- Beavers adapt populated environment to their needs and change it more than any other wildlife. Building activity of beaver is fundamental to the functioning of many ecosystems. It also has an impact on the management (economy) of man.
- Beaver population will continue to grow numerically, but also expand its distribution area. Scale of conflicts will gradually expand, while some of them will remain unpredictable.
- In every conflict situation, it is needed to balance the benefits and losses to the environment and man management.
- Given the long-range migratory tendency of beavers, management plan must be established for a large area.
- Methods of conflict resolution must take into account representation of stakeholders (aggrieved person, state nature protection, public), as representative as possible.
- The management of beaver population must take into account the function of riparian zones (beaver environment and niche), which has an important role in maintaining ecological stability, water quality and cleanliness, species diversity, erosion limiting, flood wave flattening and moisture retention in the territory.

Beaver gradually returns to the area, from which he was thoroughly eliminated away by people's selfishness. His return is accompanied by several complications, from which humans wean away in his absence.
Beaver has brought many positive changes in the man disturbed land, gaining thus sympathy of many people. Its protection is ensured in all Eurasian countries, where it occurs. Again, people have to get used to beaver activity, same as they got used to other animals.
This manual should help to make this happen as soon as possible, and in favor of beaver and man.

2. HISTORY

Having the greatest flexibility and adaptability of all recent mammals, order *Rodentia* has overcome all other mammal orders by its genera and species richness. First rodents appear in the fossil records at the end of paleocene (65.5-58.7 milion of years ago). Their origin, however, remains relatively unknown (compared to other mammal orders). As the transitional fossil records are absent, paleontologists only slowly reconstruct the phylogenetical sequence (evolutionary continuity) of their respective forms (records).
Species of superorder *Castoroidea* formed during Early Tertiary directly from the most primitive stages of family *Paramyidae*, inhabiting the palearctic region during Paleocene (ŠPINAR, 1984). Evolving by several lines, they adapted the life history related to water environment, although primarily adapted to the burrowing (terrestrial) way of life. During their whole history, their distribution remained holarctic, like those of north american genera *Palaeocastor, Agnotocastor* (early oligocene), *Castoroides*, and european genera *Trogontherium* and *Steneofiber*.

Palaeocastor: fossils and burrow castings (corkscrew shaped) were found in miocene layers. Terrestrial way of life.

Castoroides: Extinct genus of giant beavers from pliocene. Two species known: *Castoroides leiseyorum* and *Castoroides ohioensis* reaching size of 2.5 m, representatives of tertiary megafauna.

Trogontherium: monotypic extinct genus of giant beavers. Fossil remnants were found in middle pleistocene formations (0.6 – 0.5 milion of years ago), located in the prehistorical riverbed. Species weighed up to 8 times more than recent beavers. Its skeleton resembles that of recent beavers.

Steneofiber: extinct genus of 30 cm sized beavers, inhabiting probably large freshwater lakes, similarly to recent beavers. Semi-aquatic environment may be indicated by a double claw. This double claw is used to comb through the beavers hair to maintain its resistance against the water environment.

Beavers possibly survived Cenozoic era solely within the Europe, recolonising the North America again, through Asia and Alaska. This hypothesis, however, is not consensualy accepted by all scientists, as the eldest fossil records on both of continents date from the sediments of similar era.
Genus *Castor* appears first in the upper oligocene (HINZE 1950). Recent european beaver (*Castor fiber* L., 1758) evolved approximately 15 milion years ago in the middle pliocene, and inhabited whole Eurasia. WARD *et al.* (1991) allege genus *Stenofiber* as the direct ancestor or close relative to the ancestor; both recent species (*Castor fiber* and *Castor canadensis* KUHL, 1820) evolved by its alopatric speciation[1] . Common origin of both species is witnessed by shared ectoparasites, acarid *Castoris histiophorus*, and a beetle *Platypsillus castoris*.
Since the beginning of Quarternary period, in correlation with cooling and warming, beavers distribution area moved northerly and southerly several times.

At the beginning of holocene epoch, beaver was typical member of middle European fauna consisting of deer, roe deer, wild boar, aurochs, brown bear, wild cat, wolf and european hare. Permanent settlement of man-hunter in this epoch, and subsequent adaptation of the landscape to its own requirements led to a steady disruption of relationships in the environment (nature).

[1]alopatric speciation – formation of new species, when geographical barier divides distribution area of original species. Population on both sides evolves separately and by accumulation of small changes two species diverge (appear).

Direct ancestors of beaver with similar lifestyle and body shape lived more than 30 milion of years ago.

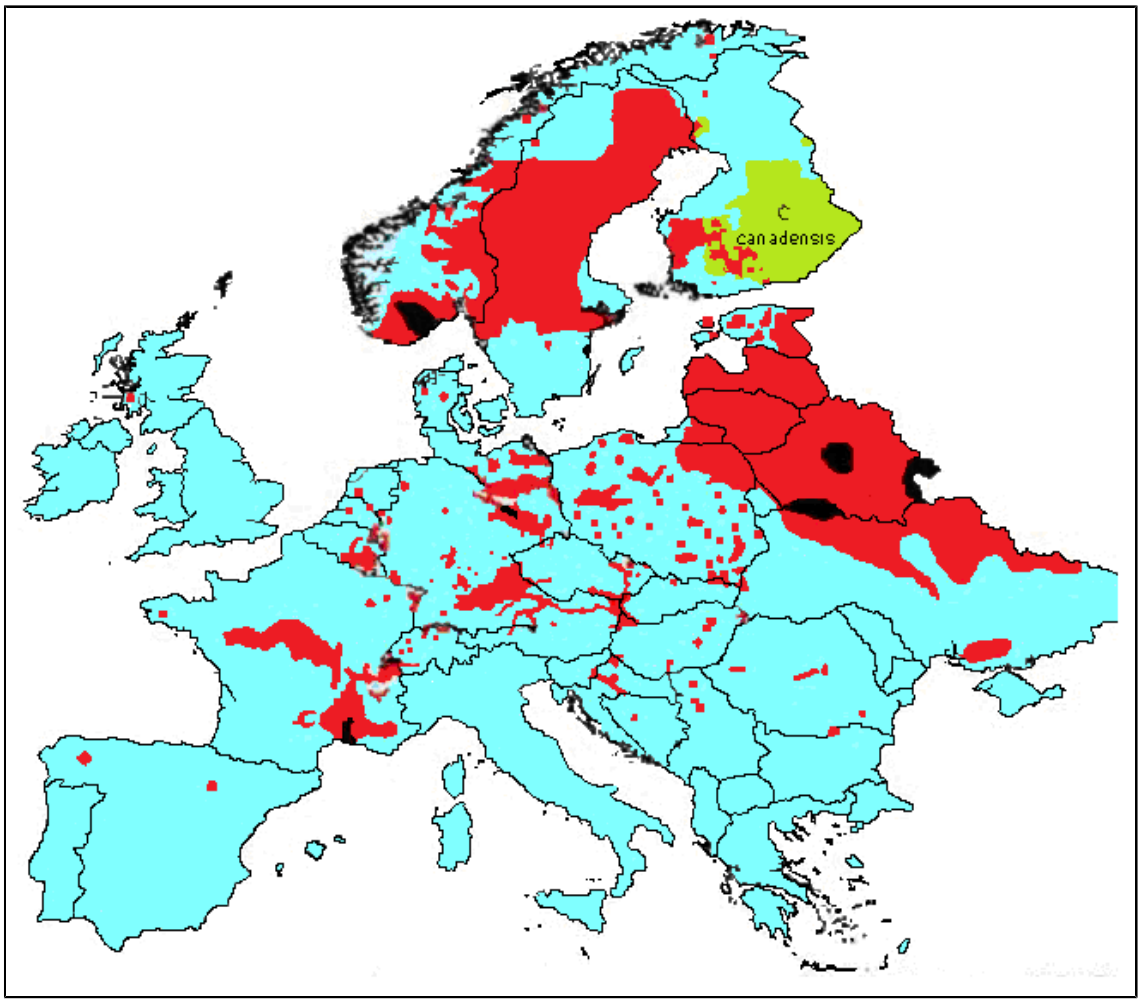
Tab. No.1.: Chronological sequence of superorder *Castoridae* members of Eurasia

Milion of years ago	Epoch	Genera (Species)
Tertiary		
33,7 – 23,9	Oligocene	*Steneofiber fossor*
23,9 – 5,3	Miocene	*Castor sp., Paleomys sp., Steneofiber eseri*
5,3 – 1,9	Pliocene	*Trogontherium, Steneofiber, Castor sp.*
Quarternary		
1,9 – 0,008	Pleistocene	*Trogontherium, Castor fiber*

Eurasian beaver *C. fiber* colonised whole forest areas and partly steppe areas of Eurasia, and its occurence was influenced by glacial periods of middle and upper pleistocene. During glacial periods, beaver found refuge in the Pontic area and South Europe. From currently known fossil records it is impossible to determine which of forms inhabited the Danube region (HINZE, 1950). In Europe, autochtonous beaver survived the omnicide by humans in 4 isolated regions:

- *C. f. galliae* Geoffroy, 1803 – lower section of Rhône River in France
- *C. f. albicus* Matschie, 1907 – middle section of Labe in Saxony-Anhalt
- *C. f. fiber* Linnaeus 1758 – South Norway
- *C. f. vistulanus* Matschie, 1907 (synonyms *belarusicus* Lavrov 1974, *belorussicus* Lavrov 1981, *orientoeuropaeus* Lavrov 1974 and *osteuropaeus* Lavrov 1974) - Belarus – Poland – Rusia.

As a source of food, fur, drug (in folk medicine) and currency, beaver was an integral part of evolving human civilization. Beaver thus enjoyed popularity of the top of the power oligarchy. Demonstrable evidence of their interest in beavers is the history of enforcement (establishing) of the so-called german law on protection of agricultural crops. The right to protect the crop from the adverse activity of game animals was enforced for the beaver as for the last of all game species.



Map No. 1.: Current distribution area of beaver in Europe. Red: occurence of *C. fiber* at the beginning of XXI. century, black: preserved recent localities at the beginning of XX. century (numbers: 1. *C. f. fiber*; 2. *C. f. albicus C. f. galliae*; 4. *C. f. vistulanus*), green: occurence of *C. canadensis*. Source: Halley & Rosell (2002). http://www.bibermanagement.de/

Depleted as the firsts were beaver populations in the areas with advanced civilisation i.e. in Mediterranean region (Greece, Spain, and Italy later) as well as British Isles. In most othes countries, beaver disappeared during the XIX. century. Last records from the countries of Danube river basin can be found in Tab. No. 2

Tab. No. 2.: Extremity dates of beaver population progression in respective countries within the Danube River basin (Parz – Gollner & Vogl 2006, Vorel *in verb.*, Grubešic *et al.* 2006, Cirovič 2012, Ionescu *et al.* 2006).

Country	Last record of occurence	First reoccurence		Current pop. size
		spontaneous	introduced	
Württemberg	1842	?	?	?
Bavaria	1867		1966	More than 6 000
Austria	1869	1970	1976	2 800 – 3 000 (2006)
Czech Republic *	1885	1982	1991	1 500 – 2 000 (2010)
Slovak Republic *	1856	1976		1 000 (2010)
Hungary	1865	1980		500
Slovenia	?	1999		6
Croatia	1857	1996	1996	350 – 400 (2006)
Serbia	1887	1999	2004	140-150 (2010)
Bulgaria	?	Planned	Planned	
Romania	1824		1998	270 (2006)

* Population within the Danube River basin.

After the eradication of beavers, several attempts on their return to the nature were recorded in different parts of Europe, motivated by economic benefits. For example, in Bohemia, during the second half of XIX. century, beavers were initially reared on farms, then discharged into the fish-pond area Třeboň. Subsequent problems with the protection of ponds against beaver activities and absence of species protection has led to their re-eradication.

A major change of attitude towards beaver occurs after pushing out the last few population residues beyond the human reach; Norway in 1824 (from 1814 to 1905 Norway formed part of union with Sweden), Germany in 1910.

Following the succesful restitution of beaver in North America, Russia, the Baltic States and Scandinavia, first restitution into the Danube basin in 1966 was motivated mainly by environmental benefits. Beaver was released into the main stream of Danube and its tributaries Inn and Isar. Released individuals originated from Russia and Poland (Weinzierl 1973), France and Scandinavia (Schwab 2012, personal communication). Because Germany was divided by the iron curtain at that time, relict population of *C. fiber albicus*[2] from Elbe river was not accessible to become a source of genetic material (other reason was low population size).

120 individuals were released until 1982. Newly established population showed very viable. In 2011, estimated size of population was 14 000 individuals and it was also used as a source for the renewal of beaver population in other countries on the lower stretches of the Danube. In 70th years, beaver naturally extended further into the river system of Austria (Salzach and Inn), Czech republic and Baden-Württemberg.

Beaver restitution continued in 1976, when in Austria, easterly from Vienna a total of 42 individuals were released until 1988, including 15 specimen of *C. canadensis* (Kollar 1992).

Released beavers expanded naturally by the river network. In the same year (1976), first beaver was recorded in Slovak territory, within the Morava river basin (tributary Malina (III. order tributary), pouring into the Morava river), 60 km from the release site in Eckertsau. In the eighties, they reached the Danube delta at Szigetköz, and since 1981 they expand northerly to the Czech republic territory (Šafář 2002). Between 1991 and 1996, in Litovelské Pomoraví (middle Moravia), 22 beavers were released, originating from Poland and Lithuania (Kostkan 1998).

In the early nineties, beavers originating from the East German population of *C.f. albicus*, migrated from Hessia into northern Bavaria.

Tab. No.3.: Overview of beavers introductions in Hungary (WWF Hungary)

Locality	Date of release	Individuals released
Gemenc és Karapancsa	1996-1998, 2004	53
Hanság	2000, 2002	24
Felsô-Tisza	2001, 2002	10
Tiszaladány-Tiszadob	2003	20
Kesznyéteni TK	2002	15
Közép-Tiszai TK	2004, 2005	64
Mátra, Domoszló	2005	3
Mártélyi TK	2006	8

[2] Around 200 specimens of *C. f. albicus* persisted 200 persisted in1950 (Heideke & Horig 1986).

During the three-year program (1996 – 1998), 29 beavers were released at the confluence of the Drava and Mura rivers in Croatia, near the common border with Slovenia and Hungary. Another 56 individuals were released on two sections of the Sava River and its tributary Cesme near Zagreb (Grubešić *et al*., 2006). At the same time, beavers originating from the release on the Croatian part of the river Drava, penetrate to the river Kerk in southwestern Hungary near Lake Balaton.
From the autumn 1998 to the autumn 2001, 164 beavers in total were released in Romania, in wider central section of the river Olt. In 2002, a new population was established in western Romania on Mures river, by introduction of 57 specimens. In the autumn of 2003, another population was initiated on Ialomita river in eastern Romania, by introducing 34 specimens from Bavaria (Ionescu *et al.*, 2006).
In Vojvodina, northern Serbia, beaver originating from the group released in Gemencs, Hungary was shot, in march 1999. In 2004, beavers were released in two sites at the old Sava river system, in Serbia. 35 beavers settled in Zasavica (released on 31th april 2004, 2nd march 2005 and 2nd april 2005) Two groups, each of 20 individuals were released from december 2004 to april 2005 in the second locality, Obedska Bara (Cirovič 2012, personal communication).
Currently, beavers are experiencing a renaissance. Originating from the first 120 Bavarian individuals (and the ones released in Austria), the beaver population now reaches at least 100 times the number released. But the estimated aggregate amount of 15 000 beavers is still to be regarded only as the initial number, taking into the account the size of the Danube River Basin (801,500 km^2)
As a result of restitutions mentioned, populations of very different origin were established within the Danube river basin. Populations of subspecies thus can be hardly determined.
Population established in Bavaria originated from Russian, Polish and French genetic material.
Beavers released in Austria, easterly from Vienna, between 1976 and 1988, had the following origin (Lutschinger 1988):

Tab. No. 4.: Beavers released in Austria, easterly from Vienna (Lutschinger 1988)

Taxon	Number
Private breeding*	7
Castor fiber fiber	8
Castor fiber vistulanus	4
Polish *Castor fiber vistulanus*	13
Castor Canadensis	7
Total	39

* probably originating from Switzerland (prof. Pilleri) – Canadian beavers

In 1991-1992, 20 individuals from Suwalki region, nortern Poland, and in 1996, one adult pair from Lithuania were introduced to Litovelské Pomoraví (Czech republic) (Kostkan 1998). Beavers originating from Poland penetrate gradually towards the main channels of the rivers of East and Northern Slovakia (Orava, Váh, Ondava, Laborec, Topľa).Due to the inconsistency of restitutions, allochthonous Canadian beaver was also introduced into the Danube river basin (Until now, none of the animals trapped for

relocation, nor found dead in Austria has been canadian beaver, however; Schwab, personal communication).

Climatic oscilations during glacial periods were not as detrimental as subsequent omnicide of beavers by man.

3. BIOLOGY AND ECOLOGY OF BEAVER

3.1. Description

Beaver is an unmistakable animal species, characterized by:

- flattened tail covered with leathery scales,
- stout body, weighing up to 30 kg as adult,
- the smallest silhouette protruding above the water surface among mammals,
- significant imprint of the tail leaving a trail,
- highly skilled and flexible forelimbs,
- powerful and massive hind limbs with webbed toes.
- beavers are the largest rodents of European fauna

3.1.1. Anatomy and appearance

3.1.1.1. Body description

Beaver organism is well adapted to the life in water.

Beaver has harmonious, muscular and compact body. The most striking feature of the body is scaly, flattened tail, up to 35 cm long. Beaver compact body structure enables survival in cold regions. Ensures the lowest possible heat loss, by low ratio of body surface to its volume.

Beavers have very good submerging capabilities. While normally they remain 2-5 minutes under water, in case of emergency they are able to remain submerged up to 15 minutes. During extreme submersion they slow down heart rate, nitrogen and oxygen is stored in muscles, which are capable of short-term anaerobic work.

3.1.1.2. Sexual dimorphism

External sexual characters for distinguishing beavers sex are not known, except for breastfeeding period. At that time, lactating nipples are evident in females. Female is as large as or larger than males (without practical use in sex determination, but rather an unusual phenomenon among mammals).

3.1.1.3. Extremities

Limbs are short and very strong. In water, beavers move especially with the help of web-footed hind legs, which have strong web between toes. Both front and rear legs have strong claws. Second toe of hind leg has a double claw that is used to maintain fur. With his front leg, beaver is able to grasp different objects (for example, thin twigs to nibble), thanks to the partly opposable fifth toe.

3.1.1.4. Dentition

Consists of 20 teeth: four strong permanently growing incisors (*incisivus*), which have vivid orange color on front surface and sixteenth molars (*molaris*).

Dental formula 1013/1013 = 20

Teeth are controlled by the powerful jaw muscles. Mouth may be closed behind the incisors, so those may also be used underwater.

3.1.1.5. Fur

Densest fur in the animal kingdom. Air cushion created between the dense hair provides good thermal protection and buoyancy support for swimming.

3.1.1.6. Senses

Beaver senses and their placement developed in that way, that the most important ones can be effectively used when almost entire body is submerged.
Smelling. Very well developed sense of smell. With an excellent sense of smell, beavers usually can recognize what is happening around them.
Hearing. Water is excellent conductor of sound compared to air (6 x faster = 1440 ms^{-1}). Predecessors of today's beavers used this physical property to develop very good hearing, by which beaver clearly distinguishes acceptable sounds from the dangerous ones. Ears are small, and while submerged, folding flap prevents water penetration to the auditory canal. Beavers rely heavily on the orientation with hearing aid.

Vision does not count for a reliable sense of priority. Beavers have no color-vision and do see mainly movement on short distance.

3.2. Distribution and abundance of beaver in the Danube River Basin

Today, the area of European beaver in the Danube basin is disjoint (see map No. 2). Most important population by its area and abundance settles across southern Bavaria, along the Danube, through Austria to Slovakia and to Hungary. In Austrian – Slovak border a projection of distribution area along the Morava River reaches relatively high in the north to the Czech Republic. In the eastern part of basin, smaller subpopulations were iniciated, which will link together gradually.

In the years 2009 – 2010, an interesting summer occurrence of beaver on the Zelené Kačacie pleso tarn in the High Tatras mountains was recorded, at an altitude of 1551 m.

Source: http://www.spravatanap.org/documents/archiv.html#Bobor_na_Zelenom_plese

Map No. 2.: actual beaver occurence within the Danube river basin (violet line: Danube river basin border, yellow dots: occurence/releases within SCIs, hashed area: estimated occurence

3.3. Demands on the environment and food

Beavers are very flexible in choice of their semi-aquatic habitat. Waterbody may have a different shape and size. They colonize both running and standing waters of all categories. Hovever, they prefer standing or slow flowing waters. Quality of the environment is primarily determined by the supply of vegetation. If sufficient food supply exists, they ascend to the mountain streams and do not avoid built-up areas.
Their dependence on water is determined by their food niche, where water is the transport medium for varied offer of food, optimal habitat for preferred plants, as well as safe shelter from predators, and marginally a cooling medium. Less critical is the type of water body and its depth. Beaver can regulate desired depth of waterbody by its construction activity. As factors, more important are higher and solid banks and relative calm. It may even settle streams with only intermittent flow, as well as small swamps with the absence of open water.

Beaver consume only fresh plant tissues. Given that beavers do not hibernate, they consume in winter the only accessible fresh plant mass – sprigs of trees.

Primary habitats for beavers are coastal osiers (*Salix* spp.). On the contrary, exclusive alder shore vegetation does not allow long-term settlement. Alder bark is uneatable as it contains tannin alkaloid, which affects proteins.

Beavers are relatively resistant to biological contamination, and even capable of living in a tank of waste water. If the reservoirs dry up, beaver are able to migrate and leave the territory; they return following the rise of water level. Large river is often extreme habitat on which they are unable to regulate the water level; in specific conditions, juveniles can drown or freeze in burrows.

In large and medium-sized running waters beaver family "requires" (territory length is) about one kilometer long stretch. In small streams, it extends to 3-5 km depending on the available food and population density. Standing waters (regardless of size) are usually occupied by one single family. Multiple families can live only in large waterbodies with sufficiently secluded bays.

3.4. Reproduction and mortality

Mating takes place in winter (January to March), and always in water. After 105 to 107 days (May to early June), furred and sighted pups are born, mostly two to three, maximum seven. Nursing time is 6-8 weeks, youngs getting care of parents, but also of a year older siblings. Cubs do not leave the lair the first two months. After 11 days, youngs begin to consume plant food, and they change diet completely after 3 weeks. In that time, gurgle and squeal of juveniles can be heard few steps away from the lair.
Mortality of cubs is high (bacterial infection, the summer floods). Only about a quarter to half of beavers reaches the age of two years.
Beavers differ from other rodents by size and reproductive strategy, that is based on the low reproduction speed, increased parental care, long term care for the offspring, long periods of adolescence and length of weaning. Reproductive strategy is similar to other animals, living in a family where the family has more reproductions - eg. marmots, badgers and wolves. Similarly to these animals, beavers reach sexual

maturity at about 2/3 of the maximum weight of adults, at minimum age of 1.5 years, after the winter in the second year of life (second winter).
Beaver population dynamics is mostly autoregulative, without significant impact of predators. Beavers live relatively hidden and are active mainly at dusk and at night. Range of beaver parasites is not very different from other rodents linked to water. Diseases: Tularaemia (so-called Hare plague) caused by bacteria *Francisella tularensis*, pneumonia and tuberculosis.
Parasites: flukes (*Trematoda*): *Stichorchis subtriquetrus* (Rudolphi, 1814) in the cecum and rectum (penetration of 80 to 90% of the population). Nematodes (*Nematoda*): *Capillaria hepatica* Bancroft, 1893 in liver tissue, penetration of the population up to 20%. Mites (*Acarina*): *Schizocarpus mingaudi* (Trouessart, 1896). Beetles (*Coleoptera*): *Platypsyllus castoris*, Ritz; *(Staphylinoidea),* feeding on beaver fur and skin.

Most important of abiotic factors are floods from May to late August, when the young beavers are immobile and unable to cope with the enormous water flow.
For beavers of all ages, various technical "traps", like uncovered deep water pits, channels and probes, from which they are unable to climb, are dangerous.
In the wild, they can live up to 15 years.

3.5. Way of life

Beavers are highly territorial and mark their area with the caudal gland secretions (castoreum). Musk smell very accurately informs potential intruders about the composition of families or condition of individuals. Within their territory, beavers usually look for food up to 20 m distance from shore. Occasionally, however, they may move away to a few hundred meters. Throughout the year, beavers often do visit the vicinity of their territory, at night they are able to swim up to 20 km. The longest are, however, transfers of young beavers seeking a location for settling and mate.
Beavers feed exclusively on vegetation. During the growing season (vegetation period) they are searching for succulent herbs growing in lighted locations, affected by increased water levels. In the winter, they eat live plant tissues. They prefer juicy young bark.

3.6. The annual cycle

Beavers are active throughout the year, do not fall into hibernation. In winter, they dive under the ice or stay in their burrows. They are less active.
In the spring their activity launches by scent re-marking of territory. Simultaneously with re-marking of territory, dispersion migration of sub adults to new territories begins. Impetus to the increase of construction activity is the offspring expectation. In May and early June, there is a litter of pups. Reproductive burrow is fitted to the safest place in the territory of a beaver family. The presence of pups stimulates parental couple to build more burrows/lodges at a distance of 30 to 200 meters as a shelter for the yearlings who are, after a couple of days, involved in rearing.
Peak of activity falls on spring time, when they are rearing youngs or on autumn time, when they prepare for winter.
Beavers dissipate into the surroundings, during the vegetation season. At the end of July (August), beavers activate near the burrows. At the beginning of autumn they

increase consumption and in the middle of autumn they begin to gnaw big trees and gather supplies for the winter.

Family overcomes winter together and thoroughly prepare for it. In late autumn, they repair weirs and dams, improve channels and accumulate stocks of food. They fell more than 90% of the trees in autumn, until the arrival of frost. Branches of deciduous plants contain the largest amount of nutrients until defoliation. Coniferous trees do not alter much the amount of nutrients in the branches throughout year.

3.7. Social structure

Beavers are substantially monogamous, and live in permanent families. A typical beaver family consists of parent breeding pair, this year's pups and pups from the previous year (yearlings) - it is thus 4 to 6 (10) individuals.
At the beginning of the third year of life, in the spring, young beavers usually leave the family nest and search both partner and territory to settle down. Composition and size of families also depend on quality of environment. In the case of poor food base or under severe stress, reduction of the number of young occurs or reproduction is completely omitted.
Between the members of beaver family, strong social ties exist. They are reinforced by mutual games and rearing of their offspring.

3.8. Regulation of population size

Beavers are very capable fighters. In their current area within the Danube basin, beavers do not have large predators that would hunt them. Population size limits its self by self-regulation. Territoriality is one of the main mechanisms of autoregulation of beaver population.
Size of beaver territory depends on quality of aquatic habitat and food supply. In case of strong population growth, beavers are forced to move borders of territory closer together, thereby narrowing their district area. Population pressure is also reflected in the reproduction and individual growth. Stress of a dense population affects growth of juveniles, increases morbidity and mortality, weight loss and decreases body size of animals. In case of high population density, migratory beavers have little hope to find a free territory. They are aggressively banished from the occupied territories and mortality is, also due to infections in wounds, significantly higher.

4. ENGINEERING ACTIVITIES

4.1. Gnawing of trees

Clearest signs of beaver presence in a locality are the trunks of trees characteristically gnawed to hourglass shape. Beavers gnaw trees to:
- bring food closer
- obtain building materials for construction and repair of weirs, lodges, burrows and dams.

Beaver uses very sophisticated security system for felling. When felling trees, no injury happens (or almost never happens) to any family member. On principle, beaver gnaws thick trunks circumferentially, so that he does not shift the focus. It allows it to retain the slimmest ungnawed core, and the felling of trees is not limited by their size. Beaver leaves the core part of trunk ungnawed and lets the stronger winds to topple down the tree. Besides this, it responds quickly to each crackle (sound) by fleeing into hiding. Beaver is unable to perform directed felling. Direction of treefall is determined by the focus of the crown. Logically it's the side with greater intensity of solar radiation, i.e. from the outer edge of the forest stand.

4.2. Building activity

Beavers' need for security and safety of each family member is extremely strong and unusual in comparison to other animals. They spend much time and energy thereby. They engage the whole family by particularly extensive building activity to secure themselves. Range of beaver structures include:
- burrows and burrow systems,
- weirs and weir systems,
- reservoirs and reservoir systems,
- lodges,
- channels,
- dams and dam systems.

The aim of the building effort is to slow down the flow, increase water levels and increase the water surface. This ensures concealment of the entrances to the burrows, possibilities of escape in case of the attack, facilitated transport of building materials and food supplies, and, not least, changes habitat conditions to accommodate more plants preferred by beaver.

4.2.1. Digging activity

4.2.1.1. Resting haunt

Place to beaver daily stay in summer. It is located in close proximity of water, so that in case of danger the animal can escape to water in few jumps. Beavers build them mostly in a tangle of roots of alder or willow trees growing on the flooded low banks. For this purpose, they dig a depression at the foot of the tree, remove tangled roots, and strew it with bark chips and gnawed twigs

4.2.1.2. Burrows and burrow systems

Most common type of dwelling. In cases where the banks of streams or dams are high enough, beavers dig burrows. They are often very complicated and multi-level with lots of corridors leading into the water (usually 3 to 5) and blind corridors with nest (chambers). The length of corridors may reach several tens of meters. Burrows are wide and high of more than 25 cm. Beavers dig burrows just below the surface. Often burrows slump by weight of man or larger animal. Entrances are under water, vents can be found on the banks. Only if the water freezes, beavers create entrance on dry soil. Because burrows often collapse, beavers repair holes by putting branches and soil into the ceiling hole. Later, they add material from the outside and build something in-between the burrow and the lodge.

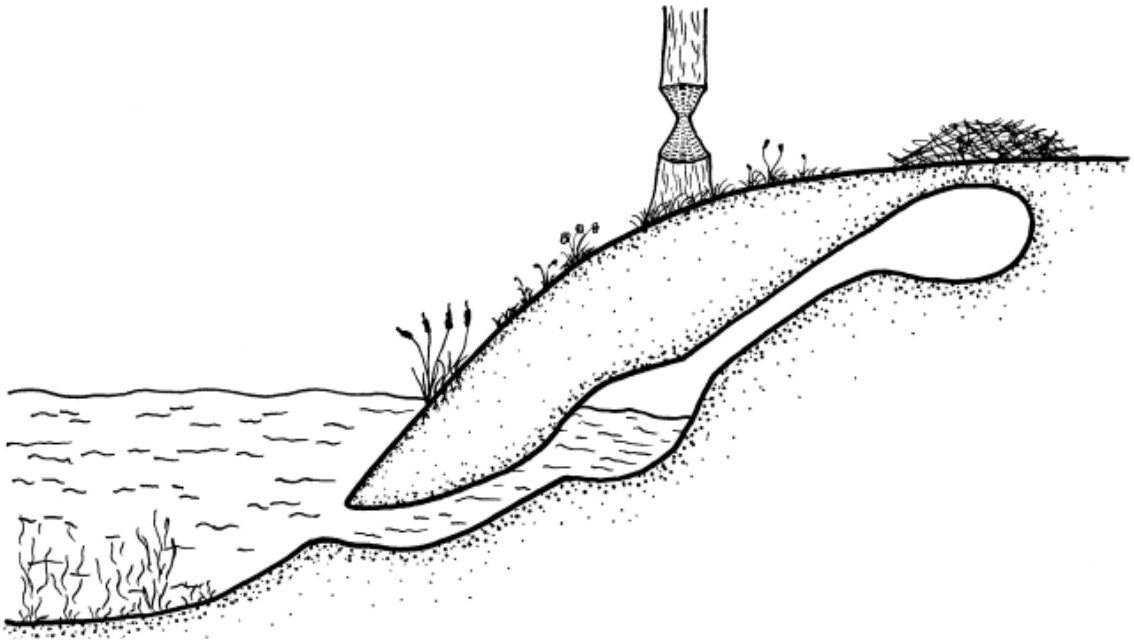


Fig. No. 1.: Beaver burrow

4.2.1.3. Channels

To increase the safety standard of the family, beavers dig up channels.
On the banks, they dig long narrow flooded walkways - a corridor that will provide safer access to distant sites. Beaver deepens the channel by digging in soil, and gnawing in peat and reed. Shallow sections with insufficient depth are inclosed. Beaver channels characteristically converge to the lodge. Channels are built mostly in the second half of the summer at lower water levels.

Beavers can completely change the appearance of inhabited shores by their digging activity.

It is not rare that beavers adapt to the offer of the locality and, for example, occupy a variety of technical works. A particular example is the settlement of beavers in a storm sewer of urbanized district of the city. They accommodate this unusual underground system to their needs by building a small weir, which serves as a feeding stool at a same time.

4.2.2. Building activity

4.2.2.1. Beaver dams (weirs) and systems of weirs

Beavers build dams (weirs) - transverse buildings - mostly on smaller shallow streams, from locally available materials: branches, mud, sod, stones and gravel. Beavers thus stabilize water levels in small streams with low water level, on a level from 80 to 100 cm, necessary for the security of the family. Weir can reach several hundred meters of length and height of several meters. Weirs of this size are relatively durable and easily support an adult man. By adjusting the size of the apertures they control the water level in the reservoir. During floods, they dig up the side channels, which conduct water torrents. Beavers are superb engineers and planners – they choose very deliberately (with "knack") the place for damming the flow, so that given the current situation, with the least investment of labor and material, they maximize the effect - slowing down the water flow, increasing its level and enlarging the water surface. Any damage to weir, even intentionally caused by man, is rapidly removed, otherwise it could lead to detection of buried underwater entrances to burrows.
Beavers often build entire levels of weirs, which weaken the water pressure and allow flooding of larger areas. One of them, the main dam, protects the lodges or entrances to burrows. Other weirs serve to secure the main weir or to raise the water level in the beaver reservoir.
In addition to permanent weirs, beavers built so called temporary weirs to bridge a temporary decline in water flow during the summer months. Temporary weirs are simplier buildings. At first glance, it is apparent they lack solid foundation.

4.2.2.2. Reservoirs and ponds

As a result of dam building, increased and stable water level hides entrances to the lodge and burrows, allows flooding of food stored for the winter, reduces escape distance and facilitate the transport of timber. Beaver reservoir maintain a stable level of water compared to stream water levels. Beaver achieve this by letting the inflowing water pass through the edge of weir or dam and immediately corrects any damage. Surfaces of beaver reservoirs in the lowlands reach as much as several tens of hectares. Reservoirs accumulate different amounts of water – from 100 to 200,000 cubic meters.

4.2.2.3. Lodges and semi-lodges

In low relief terrain, which does not allow to build dry chamber in a system of burrows, beavers build lodges from similar material as weirs. In the middle, above the water, there is usually a chamber lined with plant material and shavings. From the chambers, passages come out in the shape of the siphon with the outlet under water. Lodges are built also in high relief terrain where loose or rocky substrate does not allow digging of long and complex burrows.

4.2.2.4. Dikes

Beaver dikes - lengthwise structures along the water body – are the rarest type of beaver “engineering” activities. They serve to increase the water level in reservoirs, basins and channels over the surrounding terrain.Unlike the weir, apertures are absent and significantly less water leaks through. They are well sealed, it is not easy to find a crack with clear evidence of a water leak. The length of such structures may reach several hundred meters and a height ranging from 0.15 to 0.50 meters (more than 1 m at short distances).

Beavers anchor the foundations of their buildings by sticking branches to the bottom. In a similar way, they store food supply for winter. The difference is that the branches as the foundations of buildings are built more densely, and are directed upstream, to utilize the pressure of water current to stabilize the structure.

Beavers use a wide range of "engineering" approach in their activities. They impress by the adaptability to the landscape giveness, that they, if necessary, very effectively adapt for their own use.

5. INFLUENCE OF BEAVERS ON THE ENVIRONMENT

It is difficult to find such species among the other animals, that has a comparable influence on the landscape, as a beaver. To some extent, it can be compared only with the influence of large herbivores, sustaining extensive grass area against the succession of plants.

5.1. Hydrology of region

Prior to colonization of historic land by man, beaver weirs were common in small streams in most parts of the northern hemisphere. With the extirpation of beaver, man destroyed a huge retention capacity of the land, which in turn affected the hydrology and sediment dynamics in the whole river basins. All implications of this significant transformation of land hydrology are not fully known. But in the arid and semi-arid areas, with a high probability, loss of such water resource in the land deteriorated possibilities of land use by loss of pasture, rapid drainage along the river basins and ephemerisation of streams (Pollock et al., 2003).

On a regional scale beavers have an interesting impact on hydrological conditions, both on the quantitative and the qualitative indicators. Results of research conducted in the USA and Canada show that beavers modify in some areas up to 40% of the total length of streams, and, during the summer, their reservoirs accumulate even 30% of water of the entire water basin. Obviously, this effect can be reached only in the areas with saturated beaver population.

Each beaver reservoir accumulates large amount of sediments. Based on the decline of flow rate in the reservoir, drag and carrying energy of flow decrease, and carried particles fall to the bottom. Water, with a significantly reduced amount of suspended solids and sediments overflows through the edge of the weir. Plants, growing on the bottom and shores, filter captured suspension. Over time, the communities of anaerobic organisms formed on the bottom mineralize organic matter. Beaver reservoirs also capture parts of stems, branches, foliage, as well as anthropogenic waste.

The literature states that every adult beaver is involved in removing sediment from water, in an amount up to 700 kg per year. Therefore, beaver reservoirs are like water cleaning plants; without greater interest of water managers, however. Chemical composition of water accumulated in a beaver reservoir changes, increasing the nitrogen content, whereas nitrogen, phosphorus and carbon compounds are accumulated in anaerobic sediments. Thanks to the activities of microorganisms, heavy metals are removed and pollution of inflowing acids and bases is neutralized and stored in the bottom. Beaver with his activity causes constant mixing of water and speeds up chemical processes.

Water, accumulated in the reservoir, locally rises the level of groundwater on surrounding land. It changes chemical composition and moisture of soil, as well as species composition of soil fauna.

5.2. Landscape structure

Digging of beaver burrows and channels, as well as flooding of large areas significantly change the character and the appearance of the shoreline or of the waterbody itself. Part of the watercourse transforms into a water reservoir with shallows, while in another sections it initiates recess of the riverbed. Disturbed shores stabilize by succession and overgrow by willows, which often grow from branches stuck by beaver. Meanders create gradually, and shoals separate from stream. These fluvial processes are best seen in technically modified watercourses. They are the prime example of renaturation of the river environment. Beaver starts it by distorting a simple line by felling of trees across the watercourse. The next step is to breach the reinforced bank by digging of an extensive system of burrows. Following this, the banks of the stream recover to the natural meandering state.
In the localities colonized for longer time, harmful effects of amelioration of the land often extinguish, following the activity of beavers. Beavers are more sensitive to perceive the logic of the functioning of the land as human implementers of amelioration. Slowing the flow by its dam will accelerate complete clogging of ameliorated channel.

Of course, beavers alter the landscape even in natural, unaltered ecosystems. In terms of food and safety they prefer open landscape with a high proportion of water surface. To achieve this, they build large reservoirs using systems of weirs, to flood the wooded floodplain of watercourse, without that they would immediately settle there on a permanent basis. They move permanently into the area only when the water reservoir forms and attractive herbs overgrow it. Abandoned beaver reservoirs gradually cease to exist without permanent maintenance of weir system.
Drained areas overgrow by grasslands and only later by a tree formation. This way, beavers create conditions for maintaining grassland ecosystems under natural conditions, where continuous forest is the potential vegetation. In doing so, speed of succession is subject to many factors. As a rule, these are factors that determine not only the dynamics of beaver activity, but also the dynamics of ecosystems. It is for example the turbidity of watercourse or the vegetation zone. The first factor affects the rate of sedimentation of reservoirs, the second affects the speed of woody plants recovery.

Beavers have the abilities, which greatly affect the landscape. Apart from beavers, only humans can do this. However, the results of human and beaver activity differ contrastly, even if both pursue it in order to meet their needs. Beaver activity is more sensitive towards the land; beaver handle much smaller volumes of material and uses only natural, unprocessed material. As a part of natural processes in the land, it can be qualified as permanently reversible process.

5.3. Biodiversity

Beaver activity is driven by the instinct to constantly improve the living conditions of members of its family, while it also significantly affects the welfare of other animals and plants.
Beavers fell trees and shrubs to get to the bark and thin shoots, which are their main winter diet. Moreover, branches are used as material for its constructions.

Generally, they prefer soft woods. In several regions of its distribution area, beaver residence is conditional on the occurrence of willow and poplar. In our region, such a tight bond was not observed. Beaver gnaws even coniferous trees, although it sticks his teeth with resin. On the other hand, gnawing of (invasive species) ashleaf maple (*Negundo aceroides*) and black locust (*Robinia pseudoacacia*) is very limited.

Beavers gnaw especially younger and juicier trees. Woody plants with a trunk of diameter <10 cm represent 80 to 90% of the total volume of beaver diet. This is explained by higher content of parenchyma, lesser consuption of time and energy. Beavers gnaw plants mainly in the winter months. In regions with stronger frosts, 90% of woody plants are felled in the autumn and early winter, before the onset of severe frost. During summer, in the vast majority of sites, beaver do not gnaw woody plants at all. Thus, they do not usually affect reproduction of hollow and tree nesting birds. Only in the absence of adequate supply of herbal plants, beavers may gnaw trees during the summer.

Beaver is able to remove trees and even entire stands, through long-term flooding of areas.

By rising of water level in the reservoirs and by gnawing of trees, beavers cause changes in structure and species composition of plant communities. The process of reconstruction of overgrown natural willow and alder stands is thus initiated and bushes gradually become dominant layer. Areas of light demanding species of grasses and herbs also enlarge. Broad ecotone arises between the water and dense vegetation. Illuminated and warmed shallow water in the reservoir creates fertile conditions for the development of wetland communities with reed. In the reservoir itself, aquatic vegetation evolves.
Increasing of water temperature and of nitrogen and phosphorus compounds content causes the development of phyto-and zooplankton. Wealth of organic matter and slow flow create conditions for many aquatic invertebrates (mayflies, stoneflies, caddisflies, dragonflies, crustaceans, etc.), characteristic of stagnant water. Increased incidence of several fish species reflects improved food supply. They are attracted by deeper water and juvenile fish by sheltering possibilities in abandoned burrows. Presence of fish and water that does not freeze down to the bottom of a beaver reservoir have a positive impact on the recovery of otter populations. Environment changed by beaver is also used by muskrats, deer and wild boar. Around the reservoirs, incidence of reptiles, amphibians and small mammals is demonstrably greater.

Public opinion on the influence of beaver buildings on the autochtonous ichthyofauna is ambiguous. We meet frequently with the opinion of fishermen exploiting smaller streams, complaining of water flow slowing down by beaver weir construction. “Standing water and increased accumulation of sediments does not benefit trouts, on the other hand, contributes chubs”. Several authors such as Avery (2004) argue that removing the beaver weir improve conditions for increasing the representation and better growth of trout. In doing so, he did not examine other non-salmonid fish or other environmental factors. His results suggest that removal of beaver weirs may be useful for a narrow set of species. Roni *et al.* (2005) considered the use of beaver revitalisation capabilities as successful strategy, profitable by quantity of native species of fish and other animals.Kukula & Bylak (2010) mentioned in the study of the upper stretch of San river in Bieszczady[3] the impact of renewed and rapidly growing

[3] Bieszczady, mountains on the southern border of Poland, forming distribution board between the Danube and Wisła

beaver population on the ecosystem of the mountain stream, with a characteristic fish assemblage dominated by trout *Salmo trutta* morpha *fario* as positive for the whole fish stock. In particular, they highlight the increased supply of wood, increasing the shelter and food opportunities for invertebrates and the whole food chain, including trout. Beaver was brought into the basin of the upper San River in the Bieszczady to restore the ecosystem disrupted by conveying wood by bed of mountain streams which were used as road. In the beds of streams all shelter options and retention capacity have been destroyed (KUKULA 2003). After the release of beavers, status of ichthyofauna improved significantly (Negrylów stream). It was confirmed that environmental changes initiated by beavers had a positive impact on ichthyofauna of studied stream. The study also showed that the beaver is clearly important for the restoration of degraded aquatic ecosystems and accelerates their revitalization. Data did not confirm the negative impact of beaver on fish. In fact, by building weirs, beaver creates habitats to overcome periods of low water level, where even larger fish can survive. KUKULA & BYLAK (2010) indicate that trouts of TL> 20 cm were found exclusively in deeper water of beaver reservoirs, where numerous shelters were located in tree roots and stems submerged by beaver.
Transverse structures fragment fish habitats on streams of each size. The same should apply to beaver weirs. When comparing the transverse structures of man and beaver, the difference in fish abundance is interesting. Beaver weirs unlike human structures are an important element enrichiching sheltering and feeding opportunities of aquatic animals. Beaver dam is partially water permeable with number of apertures used by the fish. KUKULA & BYLAK (2010) proved overcoming of beaver weirs by fish in increased spring flows without difficulty. Durability of beaver weirs is altered by large water flow, beavers themselves partialy discharging accumulated water at high flow rate, as well as by longevity of beaver families.

Reduction of water flow above and below the dam leads to increased sedimentation, decreased dispersion of organic matter and increase in water temperature. In terms of water chemistry, it is usually accompanied by a decrease in oxygen saturation and disappearance of sensitive species. In beaver ponds KUKULA & BYLAK (2010) measured the average oxygen content (10.3 mg/l) significantly higher than the minimum requirement of salmonid fish. Beaver weirs changed the basic characteristics of a mountain stream, creating a new habitat with deep, but well oxygenated standing water.

Photo No. 1.: Beaver lodge is a good model indicating the importance of dead wood in the stream. Tangle of dead wood of beaver lodge provides excellent shelter and living space particularly for fish. Densities of fish higher than the average of comparable stream (sometimes more than eighty times), are often detected in immediate surroundings of the beaver lodge. Beaver lodge is ideal as nesting pad. On slide: nesting wild goose. Author: Rudolf Jureček

By systematic felling of trees beaver creates a niche for faster reproducing species of soft woods, such as willows and poplars. Construction of the beaver reservoir turns man unified ladscape with simple geometric lines into the real natural oasis. Beaver settlements are very illustrative demonstration of natural processes. They are suitable not only for education of biology, but also of hydrology and geomorphology. Beaver localities are also attractive to admire and photograph. Hunters welcome beaver activity in particular for increasing the supply of waterfowl for hunting. It is not unusual, that a beaver reservoir creates an attractive hunting site on the monotonous plowed ground.

Beaver is a vector of landscape recovery and increase of ecological stability of the land, restorer of biodiversity, a catalyst for self-cleaning ability of rivers and their banks.

6. BEAVER OCCURENCE MAPPING (EXTENSIVE MONITORING)

Within the framework of the beaver preservation program, as well as for determining its favorable status, is extremely important to monitor its population dynamics in space and time - “Hold regular surveys of beaver distribution in the territory of the Member States of the European Union every 5-7 years with closer monitoring of sensitive areas and territories, where changes are expected in the status of population”.
Choice of correct and effective methods is important to detect the distribution of beaver, abundance and density of its population at national and regional level.

Monitoring of beaver is a binding obligation of EU Member State.

At the current range of distribution and expansion of beavers in the Danube river basin, it seems to be practical to use differentiated methods of mapping and monitoring populations:

I. areas where the beaver is in the initial stage of extension (Hungary, Croatia, Serbia, Bulgaria, Romania, Slovakia partially)
II. areas where beaver already stabilized in different stages (Germany, Austria, Slovakia partially)

6.4. Methods of mapping of beaver occurence

Beavers, after several tens or hundreds of years return to their territory.

Re-colonization phases

Re-colonization of the territory of beavers takes place in two distinct phases. The first phase - rapid growth of the distribution area by colonization of new territories up to the next barrier (mountain slopes, large water works (constructions, buildings). During this first phase beavers occupy all optimum location. Second stage - population growth, during this stage beavers increase their density within territory by inhabiting of less optimal sites. At this stage, exponential growth occurs in populations. Finally, reaching the carrying capacity, exponential growth turns into a sigmoid growth, due to self-regulation of beaver populations.

6.4.1. Direct methods of occurence detection

They are based mostly on visual observation. An observer may monitor the animals at selected days, particularly while obtaining and consuming food, active adapting of populated territory area, and so on. Monitoring can be carried out mainly from the ground, eventually using camera sets or telemetry. Among the direct methods, we count handling (catching) methods. When obtaining data on the abundance, standard conditions must be met. It is not possible to collect the data in different seasons. A

prerequisite for obtaining accurate results is the knowledge of biology and ecology of species, as well as the experience of observers.

6.4.1.1. Visual observation

Passive, quietly sitting observer can count the animals in the evening without disturbing them. Because of the strict territorial behavior of beavers, longer observations more likely provide more accurate data on the abundance. In active monitoring, observers must move through dense stretches of the counting area with nuisance (disturbing effect on animals). Night observation from boat using a spotlight can be more advantageous, as it provides good results without significantly disturbing beavers in their activity (Cirovič 2012, personal communication).

6.4.1.2. Video surveillance sets

Video surveillance systems (VSS) can be used for monitoring of beaver while moving on the surface and shore, surveillance of beaver buildings in repair of intentionally disturbed beaver weir, gnawing localities and so on. Advantage over visual monitoring is greater credibility of the digital recording technology.
Phototraps can also prove useful, especially when installed on beaver paths, while being significantly cheaper than an VSS.

6.4.1.3. Direct observation

Obervation of activity mainly on the water surface.
Beaver is an unmistakable animal species, characterized by:

- flattened tail covered with leathery scales,
- stockier body weighing up to 30 kg as adult,
- the smallest silhouette protruding above the water surface among mammals,
- significant imprint of the tail leaving a trail,
- highly skilled and flexible forelimbs,
- powerful and massive hind limbs with webbed toes
- predominantly crepuscular or nocturnal activity
- holding its head above water and the tail submerged on long stretches while swimming
- submerges for a longer time
- when startled, he strikes the tail over the water surface, and then remains submerged for a longer time
- on dry land, he moves like other quadrupeds
- may stand up on its hind legs

Photo No. 2.: Age (weight) class can be distinguished according to the draft (percentage of body submersion)

At the night time, silhouette against the illuminated water surface allows to reliably determine the age categories of adult, subadult (2 years old), 1 year old juvenile, and this year's juvenile (yearling; Vorel (2011 personal communication), Cirovič (2012, personal communication).

Younger individuals are lighter, have higher buyoancy and a larger proportion of the body can be seen compared to adults. This year's juveniles can be identified by protruding head and whole back while swimming. In subadults swimming, it is possible to see head, most of the neck, and rear of the back above the surface. In the adults, only the top of the head can be seen.

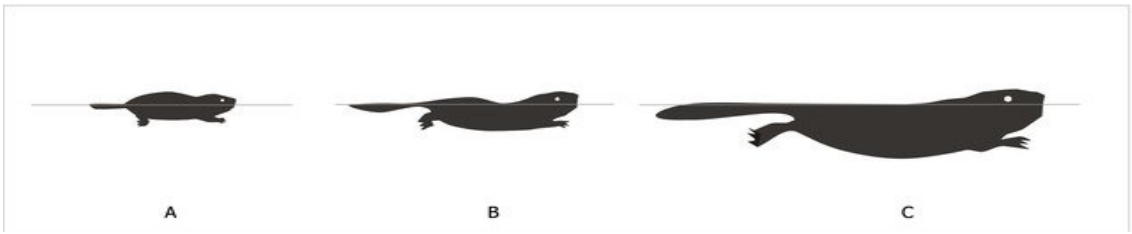


Fig. No. 2.: According the experiences, it is possible to distinguish the age by characteristic way of swimming. (By A. Vorel)

Beavers´ stay on the shore can be observed from the water surface at night when it is frozen, or from a boat.
Monitoring of the acoustic expression can be used only as supplementary information

a) identification of the beaver presence at night, when disturbed, in the form of noisy slap of tail over the water surface. The sound is like breaking of a strong branch.
b) in reproducing families, youngs permanently echo sounds – “mewl"

In visual observation and video surveillance it is very difficult to ensure avoidance of duplicated (multiple) counting.

6.4.1.4. Telemetry

This method can specify the size of the territory of one family, interactions with the territories of neighboring families, or migration, if the telemetry transmitter is fit to a juvenile prior dispersing.

6.4.1.5. Cadaver

Records of incidental findings of dead individuals may be an important additional source of information not only on the occurrence of individual species, but may also contribute to a better understanding of some threatening factors, especially in case that populations are already in the initial stage and not yet stabilized.

6.4.2. Indirect survey methods

6.4.2.1. Questionnaire survey

Sending of special questionnaires to organizations operating within the territory with the potential beaver occurrence (stakeholders of hunting areas, conservation departments, etc.) at certain intervals. Given the need of distribution of a large number of questionnaires (for example, there are now 1795 hunting grounds in Slovakia, more than 5,400 hunting grounds in Czech republic, 11 757 Jagdgebiete in Austria), it is appropriate to associate the questionnaires also with the obtaining of additional information on the conservation of important vertebrate species (eg. otter etc.).

6.4.2.2. Terrain mapping of areas – signs of presence

Indirect methods of detection are based on the signs of presence of beavers, which can be used to estimate the abundance of populations as well. The occurence of beavers established in the country manifests itself clearly in many ways, and particularly in the form of signs of presence - many of them cannot be overlooked. For survey purposes signs of presence fall into five categories:
Feeding activities – gnaw marks, droppings, feeding stools, teeth imprints, stocks
Territorial activities - scent marks
Motion activities – paths, tail or paws prints, slides
Sheltering activities - Resting haunts, burrows, lodges, semi-lodges
Construction activities – dams, weirs, canals, water reservoirs, water ponds

Signs of presence are found in lines on the banks of waterbodies, as well as on transversal barriers of rivers. Width of line is usually up to 20 meters from the stream, very rarely up to 60 m. Most densely concentrated signs of presence occur within a distance of 10 m from shore, greater width may occur in particular due to fluctuations in water levels or an attractive food source.
Signs of presence tend to be interconnected.

6.4.2.2.1. Foraging activities

6.4.2.2.1.1.Gnaw marks

They are most common signs of presence. Wide traces of large gnawing teeth occur on gnawed surfaces, best visible on trees. Less noticeable on herbs, where confusion with gnaw marks of hare, muskrat, nutria, or large herbivores is possible.

Photo No. 3.: Reed gnawed by beaver

Depending on the degree of gnawing of woody plants, there are three basic types:

1) Completed gnawing – the tree is felled or the gnaw marks are around the entire perimeter with typical shape of an hourglass. For safety reasons beavers do not gnaw entirely trees of larger dimension, and lets the stronger winds to topple down the tree.

Photo No. 4.: Completed gnaw

2) Uncompleted gnawing – the tree is gnawed from one side, or, in larger diameters, shallow gnaw around the entire diameter.

Photo No. 5.: Uncompleted gnaw

3) A mirror – gnawed bark on small area, as if „tasting“ the tree or marking locality

Photo No. 6.: „Mirror“ of gnawed bark

Gnaw marks are counted and identified according to the diameter of trees in multiple categories and tree species. Recorded are active, unoxidised, unblackened, undarkened (unfaded) gnaw marks, not older than 3-4 months.
Note: Twigs gnawed by beaver, deposited by water flow at the edge of the shore provide information on the presence of beaver on the upper section of the stream or its tributaries. It was proven useful to check small piles of deposited twigs.

6.4.2.2.1.2. Droppings (Faeces)

Debris containing undigested plant residues in the form of sawdust, scales and bast fibers. Longitudinal or oval droppings, deposited singly, cylindrical 2.5 to 4 cm long and 2 cm thick, or spherical with a diameter of 2 cm, contain only undigested plant parts, especially the crust. Beaver defecates most frequently in water, rarely on dry land. Very rare sign of presence. Decomposes relatively quickly. Usage of faeces as a non-invasively obtained DNA material for the polymerase chain reaction - PCR, must meet strict conditions:
- It must be very fresh - from the previous night,
- It must be stored in ASL buffer or 96% ethanol right in the field.
Due to their relatively rare occurrence, and lack of the literature on the use of this molecular - genetic methods, it seems it is not used too much today. (According to Cirovič (2012, personal communication) more advantageous material to use for DNA analysis is hair taken from beaver passing by “hair trap”).

Photo No. 7.: Beaver droppings

Note: Brown-reddish traces of urine can be seen only on the snow.

6.4.2.2.1.3. Feeding Stool

particularly woody plants are concentrated by beavers to a safe place where they are consumed. Feeding remnants are lying freely, twigs peeled of bark, bark free of bast. Feeding stool is being located close to the edge of the waterbody on the islands or shelfs, in the bushes.

Photo No. 8.: Photo: beaver feeding stool

6.4.2.2.1.4. Impressions of teeth

Beaver gnaw marks character is unique and confusion with the gnaw marks of other animals is excluded. Beaver gnaws thick trees around the entire perimeter with typical shape of an hourglass, or sharpened pencil. When the tree is growing on the slope, beavers gnaw it from one side (in the form of a pit). Thin trunks of 5-6 cm thickness can be cut by diagonal bite in one pressing of jaws. Traces of incisors are well discernible on the cut.

Upper incisors (*incisivus*) provide support. Lower incisors (incisivi), leaving traces with two grooves, determine the direction and strength. Twigs of about 1 cm thickness are cut through by single pressing of jaws. Such a cut is usually smooth and sloped, depending on beaver head skew. Beaver incisors width increases with age (see attached Table No. 5). Knowing this, we can roughly determine the age of animals gnawing the wood. However, it should be borne in mind, that the width of the trace on the tree is slightly different from the actual width of the teeth, due to the flexibility of wood. Even greater differences can be observed on lateral gnawing of bark, when gnawing through to the cambium. Widest traces (imprints) should be taken into consideration as first. As the first gnaw overlaps with the subsequent one, it is better to deal with transversal gnaws in the toughest wood. This method can not only determine the age of the animal, but also the number of animals involved in tree gnawing, which is sometimes a matter of all active members of the beaver family.

Tab. No 5. Width of incissors

	unit	Older than 1 year	2 – 12 months old cub	1,5 month old cub
Lower incisors	mm	8 – 9	Up to 7,5	2,6
Upper incisors	mm	7,5 – 8,5	Up to 7,2	2,5
Type of gnaw		Completed		Attempts

Photo No. 9.: Detail of beaver gnaw marks

6.4.2.2.1.5. Food cache

To store fresh cut branches as a winter food supply, beavers stick them into the bottom of the waterbody - similarly to the foundations of their buildings, only considerably sparsely.

Photo No. 10.: Food cache

6.4.2.2.2. Defensive activities

6.4.2.2.2.1. Scent marks

Beavers are higly territorial and actively defend their territory. They mark the boundaries of the territory of family by scent marks - mounds located on the shore (diameter around 20 to 35 cm) consisting of mud, sand, gravel or vegetation marked by excreta of anal glands. A strong odor is felt at a great distance. Scent marks bear lot of information on individuals who made it. They are regularly visited and maintained by active members of the family.

The highest intensity of scent-marking lasts from March to late summer (when migration of 2 year old beavers occurs, and it is important to show the occupancy of site). During the main period of monitoring (November-March), scent marks occur only exceptionally.

When monitoring, we distinguish:

active scent marks (identifiable by human smell)

inactive scent marks (old and washed, but still visually recognizable)

Photo No. 11.: Scent marks on a mound of sand

6.4.2.2.3. Motion activities

6.4.2.2.3.1. Paths

Almost everywhere, where beaver exists for longer time, there is a well-trodden, smoothly cleaned path, with lying branches, often with brought mud, vegetation that grows on the sides of the trail is muddy and beaten. These paths reach the length of

several tens of meters, leading to the gnawing places within forest stands. Beaver trails lead around perpendicularly to the shore. Paths along the shore are absent in beavers.

Photo No. 12.: Beaver path in winter

6.4.2.2.3.2 Imprints of paws and tail

Imprints of beaver limbs are rarer to find than a beaver building. It is possible on a very wet soil or snow. Frequently beaver remove all traces with the tail, pulled on the ground, or from side to side on the snow, leaving wavy impression.

Unlike the otter traces, which track has the shape of the dashed line, the beaver´s are in two lines, i.e. right and left limbs. The front paws imprint slightly in front and laterally from the hind limbs. The hind imprints can slightly overlap the front ones, not in a straight line but rather a little diagonally, which is associated with so-called duck swing. Beaver walks slowly, in small steps, sometimes may run jumping for short distance, but it usually represents a certain risk. The best footprints are visible in clay or mud in places where it leaves water. The front limbs are slightly pushed away from the front and from the side away from the hind limbs, the hind ones slightly overlap the front ones and are not in a straight line but a little diagonally, which is associated with so-called duck swing.
Having the shortest lifespan of all marks of presence, they confirm the current incidence of beaver in the area. By measuring the length of footprints, the age of the animal can be approximated.

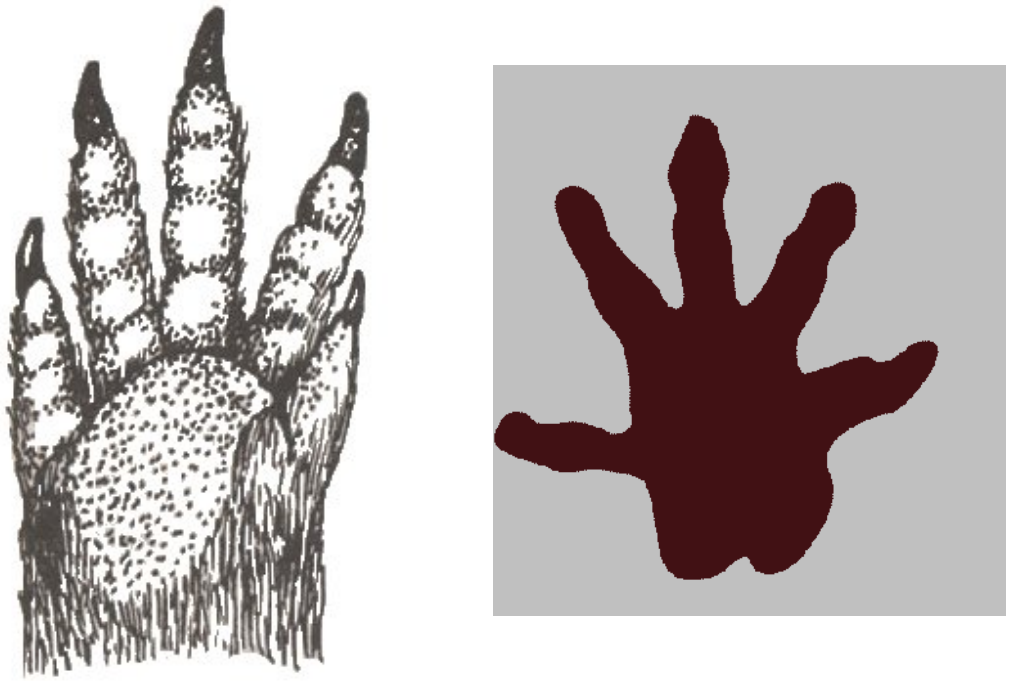


Fig. No. 3.: Impressions of front legs are star-shaped with distinct ridges from claws at the ends of fingers (like otter footprint).

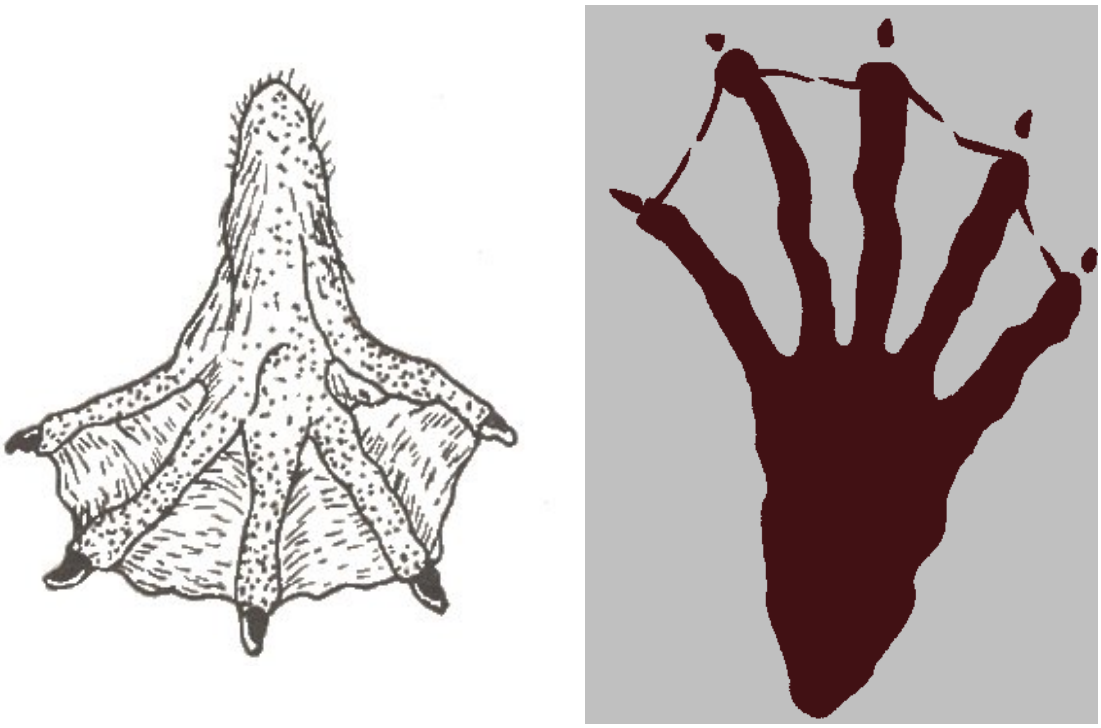


Fig. No. 4.: Hind limbs have fan-shaped imprint, elongated more than fore limbs, with apparent deepening of the heel, and outstretched fingers with claws. Interdigital webbing is not usually visible in a footprint, only rarely on muddy ground.

Photo No. 13.: Imprint of beaver paws

6.4.2.2.3.3. Slides, chutes

These are characteristic sloping paths, by which beavers come ashore. They are muddy and smoothed by beaver body and woody plants, pulled by beaver into the water.
On lodges and weirs are paths by which beaver brings out a building material.

Photo No. 14.: Beaver lodge with slide

6.4.2.2.4. Sheltering activities

6.4.2.2.4.1. Resting haunt

Place to beaver daily stay in summer. Usually chooses a place hidden behind the uneven terrain, and lines it with the dry vegetation, leaves and twigs. It is located in close proximity to water, so that in case of danger the animal could escape to water in few jumps. Beavers build them mostly in a tangle of roots of alder or willow trees growing on the flooded low banks. Resting place blends very well with its surroundings and it mostly can be unveiled by remnants of food - gnawed twigs and woodchips. This type of beaver shelter can be found as the first sign of a residence on the newly colonized sites..

6.4.2.2.4.2. Burrows

Since they are hidden underground and underwater, their determination is hampered. Entry to burrows disclose at the temporary decline of water levels.

Simplest beaver burrow is a straight tunnel, which begins under water and ends deep in the bank by the expanded chamber, where the animal creates a nest. The entrance to the burrow is located at a depth of up to 2 m, usually under the drooping branches of trees above the water, or under the roots of coastal woody plants. If the water level in the tank substantially reduces, beavers build a new entrance below the original one, but definitely in the water. Sometimes, when water levels fall quickly, and beaver cannot dig new entrance so quickly, he uses the old one, although it remains above the water surface.
Burrows have several entrances mostly underwater. Further from the shore, a ventilation shaft leads to the surface, which beavers use at night, and in case of danger, when they need quickly and quietly retreat from the feeding place on dry land.

Photo No. 15.: Unmasked entrance to beaver burrow after decrease of water level

All entrances and exits on the surface are carefully camouflaged by dense vegetation. Suitable period for mapping is thus beyond vegetation season, when the dark burrows are contrasty against the withered vegetation or snow. Current use of burrows documents:

1. A pile of substrate on the bottom in front of burrow - remnant of beaver activity. Beaver regularly cleans the den of accumulated food residues: gnawed branches, pieces of wood together with the substrate that were dug out into the water.
2. In the case of muddy bottom, the bottom in front of burrow is lighter from the surrounding. Mud is washed away by swimming animals.
3. Warm air rises from the ventilation shaft of burrow in the winter
4. If an inhabited burrow is damaged, beaver repairs it, by bringing piles of branches on the surface. Vaults of shallow burrows often slump by weight of man.

Photo No. 16.: Beaver burrow is repaired by putting branches and soil into the ceiling hole. Later, they add material from the outside and build something between the burrow and the lodge.

Old abandoned burrows slump over time just below the surface, and form traces or holes on the surface

6.4.2.2.4.3. Lodges

Lodge is an impressive and unmistakable building up to 3 m high; diameter of base is up to 20 m. Beaver origin of the construction can be confirmed by characteristically gnawed shafts and ends of branches. Gaps between the thick woods are filled with fine twigs, dry reed and mud. Seeming chaos in the placement of building materials creates, in fact, remarkable durability of the whole constuction. From the outside, lodges have no visible entrances. All entrances and exits are hidden below the water surface.
The newly built lodge has a conical shape. If the vault of a lodge is slumped (mostly its top part), it is abandoned. Actual occupancy of the lodge is confirmed by a fresh wet

pavement, which leads to its top. Through this trail, beaver pushes building material on a construction. Depending on the region, lodges are usually built or repaired since October to early December. In winter, during cold days, actual occupancy can be confirmed by observing the gas exchange with the external environment.

Photo No. 17.: Beaver lodge in floodplain forest. Entrance to the lodge is obvious on the bank.

6.4.2.2.4.4. Semi-lodges

Another type of dwelling. The base is a classic burrow, which is further improved by superstructure of another floor, by bringing branches and mud. Upper floor is used at higher water levels. This type of construction is used on sites with similar conditions as where lodges are build.

Photo No. 18.: Semi-lodges

6.4.2.2.5. Construction activities

6.4.2.2.5.1. Dams (weirs)

Transverse building - mostly on smaller shallow streams from locally available materials: branches, mud, sod, stones and gravel, in submontane areas even from heavy stones. The main evidence determining beaver dam are clear impressions of beaver teeth on used branches. The height of dam is in the range of 20 - 120 (250) cm, length is up to several hundred meters. Weirs of such dimensions are relatively permanent and easily support the weight of an adult. Unlike the dikes, weir is equiped with apertures to transfer part of the water flow. Beaver sometimes builds a trail of mud on the crest of the weir, which is, by several experts, considered as a sign of completion of building (the final height accomplished).

Photo No. 19.: Beaver weir

For mapping purposes, it is recommended to measure the length and height of weir. In case of advanced monitoring, depending on the presence of foundations under construction, classify constructions by durability. Temporary summer dams does not have foundations anchored into the bottom, unlike permanent weirs.

6.4.2.2.5.2. Beaver dikes

Lengthwise structures along the water body - the rarest type of beaver “engineering” activities. The length of such structures may reach several hundred meters and a height ranging from 0.15 to 0.50 meters (more than 1 m at short distances). Beaver builds dikes just like transverse dams (weirs), by heaping up the soil mixed with gnawed wood and reed to mounds. However, beaver dikes, unlike the weirs are well sealed; it is not easy to find a crack with clear evidence of a water leak. Dikes are built on stagnant and slowly flowing waters.

For mapping purposes, it is recommended to measure the length and height of dam.

Photo No. 20.: Beaver dike

6.4.2.2.5.3. Channels

Using channels, beavers interconnect waterbodies, make available food supplies and building materials. Channels are usually flooded with water and their length can reach several hundred meters, width 0.5 m (max. 3 m) and have a depth ranging from 40 to 70 cm (max 140 cm). Depth over 1 m is dug up only for short distances, and serves as a shelter. In the reed and peat are evident traces of gnawing teeth. Shallow sections with insufficient depth are enclosed by impermeable embankment of 30 to 40 cm height. Channel width is about 0.5 meters, tens of meters in length, depth greater than 0.7 m. Beaver channels characteristically converge to the lodge. Sometimes, beavers mask sections of channels near the burrow by laid branches. Channels are built mostly in the second half of the summer at lower water levels.
For mapping purposes, it is recommended to measure the length and depth of the channel and detailed description of the construction techniques such as gnawing, enclosing by embankment and so on. Noteworthy are the intersections of beaver channel and reservoir on a beaver dam.

Photo No. 21.: Beaver channel dug in the soil and gnawed in reed.

6.4.2.2.5.4. Reservoirs and ponds

Increased and stable water level hides entrances to the lodge and burrows, allows flooding of food stored for the winter, reduces escape distance and facilitate the transport of timber. Beaver reservoir maintain a stable level of water compared to stream water levels. Beaver achieve this by letting the inflowing water pass through the edge of weir or dam and immediately corrects any damage. Surfaces of beaver reservoirs in the lowlands reach as much as several tens of hectares. Reservoirs accumulate different amounts of water – from 100 to 200,000 cubic meters.

Beaver reservoirs and ponds are striking features of the landscape, mainly used for aerial monitoring. They are also useful for land based survey.

7. BEAVER PROTECTION

7. 1. Threats

In time and space, beaver was able to adapt well to temperature changes in its environment. This is confirmed by its current distribution area extending from central Sweden to Southern France. Temperature oscillation of the climate at the end of the Tertiary, which in many ways changed species composition in Europe, was unable to threaten the existence of beavers to such extent, as subsequent chase by man. This has happened on the whole Eurasian continent. In the past, there were several reasons for hunt on beaver, but the most serious were: hunting for quality fur, meat and castoreum for medical use. Later, with the intensification of agriculture and the industrial period (industrial revolution), another reason became protection against the beaver activities, such as extirpation of beaver from pond farming areas due to damage to embankments and dams of ponds (HOŠEK 1978).
Causes of rapid decline of beavers from the fairly large original area are currently difficult to understand. For example, in the western part of the beaver´s distribution area, causes include especially the significant intervention to the environment, such as loss and economic conversion of natural habitats like floodplain forests, wetlands, and river banks (shoreline). But surprisingly, beaver now returns with unprecedented swiftness into such altered habitats. Contrarywise, in the eastern Poland, the beaver was extinct in the period, when the landscape was still coated with primeval forests, and despite the fact, that already Boleslav the Brave (967 - 1025) established a permanent office for management – Bobrovník (Beaver man), and his successors limited the right to hunt on beaver just for the top of oligarchy.

Causes of the historical beaver decline within the whole distribution area and, on the contrary, its current vigorous return bears certain ambiguities. Partly, this could be explained by beaver synanthropy.

7.1.2. Threatening factors:

Historically confirmed

Until present, several confirmed causes of beaver extinction persist, which may continue to threaten their population:
1. hunting (especially illegal), beavers are vulnerable in particular because of their striking marks of presence in landscape and permanent territories tied to waterbodies.
2. intensive land use, transport and reduction of landscape connectivity, habitat destruction

Contemporary threatening factors

Besides the historically documented threats, a large number of civilization impacts emerge, such as:
3. Competition with penetrating North American Canadian beaver (*Castor canadensis*). (So far, only in Finland and adjacent areas)
4. Water pollution (impact on food sources in the form of increased accumulation of contaminants in the tissues of beavers).

Especially risky is the beaver foraging specialization in fast-growing soft wood and aquatic vegetation, which are hyperaccumulators of (especially) heavy metals. High ability of aquatic plants to accumulate metals (for example *Typha angustifolia*) in hundred times higher levels than normally acceptable levels in plants, without serious damage to their metabolism is used in bioremediation methods (treatment of contaminated water or soil). But, unfortunately, in nature, accumulated compounds penetrate through primary consumers further into the food chain.
Reduced quality and purity of water, however, did not yet manifest limiting for beaver survival. They are able to live in tanks of waste water in sewage treatment facilities, or storm sewer outlets, and use them as residence burrows. This proves quite high resistance of beavers against biological (as well as urban) pollution.

5. Defensive reaction of man, protecting its security and economic interests against the influence of beaver on the landscape.

6. Traffic collisions - the intensification of transport (shipping, road and rail), intensification of the use of watercourses, construction of barriers on water flows, and so on.

7. Habitat destruction (deforestation, regulation and maintenance of river beds and banks of already regulated streams and rivers, occupation of landscape for building, intensification of transport - shipping, road and rail transport, the intensification of the use of watercourses, construction of barriers on rivers, etc.).

8. Uncovered technical equipments in water and its proximity acting as traps.

Beaver species protection requires certain species-specific features compared to other mammals. European beaver, despite the current population size in the upper part of the Danube river basin requires continued protection. Its historically acknowledged vulnerability confirms the concerns about its further occurrence. In the current stage of (omnipresent) exploitation of environment by man, beaver is threatened by human response to its rapid reproduction and active intervention in the environment, by which beaver varies hydrology even in locations heavily exploited by man.
In intensively used land, beaver is threatened by induced conflicts with human security and economic interests, caused particularly by their construction activities.

Beaver, due to its very significant impact on the environment, requires introducing active management, in particular to encourage prevention of the extensive damages caused by beaver activities. Prevention of problems with beavers is often the only solution, as many times the remediation is not possible. In countries with a longer experience of coexistence with beavers, complex measures are used.
Well-proven is the consultancy of specialists, who apply a wide range of technical (nets, drains, grids, fences, etc. ..), hydrotechnical and biological measures to control water levels in beaver reservoirs, protect dikes against undermining, to protect significant trees, and carry out rescue catches and transfers. On sensitive sites, they prevent beaver's settlement.

Administrators of facilities associated with surface waters must continually check the status and endangerment of equipment (road culverts, flood dikes, pond dikes)

Given the wide range of beaver impact, awareness and public education is necessary to protect beaver. Man should learn again to coexist with beaver, as he already accustomed to coexist with other animals. And same as he adopted procedures for the protection of agricultural and forest plants from other major herbivores, hares and wild boar.

7.2. Species protection

7.2.1. Legal protection of beaver

On the territory of states of the Danube river basin, beaver is protected by:
a) National legislation,
b) International conventions.

7.2.1.1. Protection on national level

Tab. No. 6.: Protection on national level

State	Method of protection
Germany	Prohibition of hunting since 1910 (Heidecke, 1984). Strictily protected by German Nature Conservation Law as implementation of FFH-Directive
Niederösterreich	Nature Conservation Act of 2000. Water Act (WRG 1959)
Czech republic	Decree of Ministry of Environment of Czech Republic No. 395/1992 Coll., Annex No. III,
Slovakia	Act of NC SR No. 543/2002 Coll., on Nature and Landscape Protection, § 35 article 1. Decree of Ministry of Environment of the Slovak Republic No. 24/2003 Coll., implementing Act of NC SR No.543/2002 Coll. Act of NC SR No. 184/2002 (Water Act)
Hungary	Decree of Ministry of Environment of Hungary No.13/2001, Annex No. 2.
Slovenia	
Croatia	Act on Hunting of 17 November 2005 (Broj: 01-081-05-3423 / 2) Accoring to Article 3, paragraph (1), beaver is classified as a hunting game. (Official Gazette No. 140/05),
Serbia	Beaver is strictly protected species listed in Appendix 1 - strictly protected species (Official Gazette of the Republic of Serbia, no. 05/10)
Bulgaria	
Romania	Parliament Act 407 of 2006, in the Annex. 2 lists wild animals for which hunting is prohibited, with the amount of compensation in case of violation of the Act. (Castorul 6000 Lei)

7.2.1.2. Protection on the international level

On the territory of Slovak Republic, European beaver is protected also by international conventions and directives:

- Bern Convention (Convention on the Conservation of Wildlife and Natural Habitats)
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (The Habitats Directive)

Beaver protection within NATURA 2000

Within the Danube river basin, on territory of EU member states, beaver is protected in 159 SACs (Special Areas of Conservation) (source: http://eunis.eea.europa.eu)

Tab. No. 7.: Number of NATURA 2000 sites in the EU member countries within the Danube River Basin

State	Total number of SACs	Within the Danube basin, by biospherical region			
		Total	Pannonian	Alpine	Continental
Germany	416	79	-	-	79
Austria	19	19	-	2	17
Czech republic	7	5	3	-	2
Slovakia	47	42	37	5	-
Hungary	14	14	14	-	-
Slovenia	3	3	-	-	3
	506	162	54	7	101

7.2.2. Active protection

7.2.2.1. Methods of active protection

Beaver, due to its unique ability to influence the landscape deserves a special treatment. So far, 22 countries in Europe actively restore beaver population on their territory.

Beaver restitution

Restitutions (reintroductions, translocations) played an important role in restoring of beaver population in Europe and Asia. In the not too distant future, beaver will extend again over a large part of the continent, due to its population growth. If conservationists want to accelerate the processes of ecological restoration using beaver capabilities in currently unpopulated areas, it is necessary to responsibly choose the nearest geographical form of beaver. The best strategy for beaver restitution is to create a network of interconnected subpopulations within the river basin (Zurowski & Kasperzcyk, 1988; Nolet & Baveco 1996). Supposed autochtonous danubian beaver subspecies (race) was completely exterminated. The nearest recent population, naturally spreading over the Slovak territory is *Castor fiber vistulanus* Matschie, 1907.
Releasing beavers to the new locations is a very sensitive issue. Prior the release of beavers, new region should be well mapped and considered whether it would not cause a big conflict in the future. In Great Britain (Wales, Scotland), referenda about the recovery of the beaver population were implemented.

Beaver transfer is implemented by release of beaver pairs on the pre-selected area. Prior to beaver's release, it is desirable to improve the quality of the environment, for example:

- Creating a buffer zone of 20-50 m along streams and reservoirs, in which no economic activity should be carried out
- planting of trees preferred by beaver, building of artificial burrows and creating conditions for burrows digging in the technically modified banks.

Choice of a new locality for the restitution of beaver population must be done very sensitively, especially given the potential for subsequent conflicts of interest due to restriction of human activities.

Prior the transfer of beavers to a new location, artificial burrows can be build (see Fig. No. 11), in which animals are placed for acclimatization and reduction of the shock of transfer. After few days spent in the artificial secured burrows, they can be released into the environment.

Experiences with beaver reintroductions (Croatia, Hungary, Bavaria) however show, that building of an artificial lodge is not necessary, but rather sufficient number of released animals in the area (40-60), different families released in different sites to prevent territorial fights (Schwab 2012, personal communication).

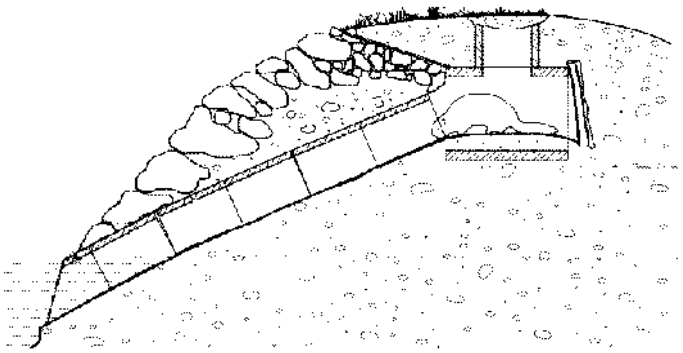


Fig. No. 5.: Artificial beaver burrow

Care of habitats

Coastal osiers (*Salix* spp.) are the primary habitats of beavers. Under these conditions, beavers reach higher fertility than elsewhere (Heidecke, 1991), while causing relatively little conflict with man. Intact softwood lowland forest is crucial for maintaining a healthy population of beavers. However, Floodplain Rivers are under increasing anthropogenic pressure from the beginning of human colonization. During this period, major part of floodplain forests in Central Europe was already cut off. At present, the last residues of floodplain forests remain in European countries, listed as prioritary protected habitats (Code 91E0, 91F0)

Besides the adequate food supply, natural water regime is also important. Water regime, strongly altered by human activity, such as damming of the flow, can have serious consequences for beavers. Especially in the areas, where beavers prepare winter food supplies, water regime with high levels in summer and low water levels in winter may cause flushing of stocks (by sudden discharge) or their drying in case of water level decrease (Wilsson, 1971; Nault & Courcelles, 1984, Smith & Peterson, 1991).

7.2.3. Education

Given the wide range of beaver impact, public education and awareness is necessary to protect it. Unfortunately, beaver is often abused by media and political marketing, by one-sided pointing to its negative impact on the economic and security interests of man. Education should aim to balance these one-sided informations, by showing its unprecedented positive contribution to the recovery of the damaged landscape. In doing so, beaver localities are very suitable for general public education and understanding of natural processes, especially of fluvial processes and ecological relationship of plants and animals.

Education should be addressed to:

a) people professionally concerned with beaver activities

- to develop for each country, region a practical manual aimed on local conditions, indicating the possibility of protection against beaver activities - technical designs, models, technical drawings with dates and schedules of materials as well as the indicative budget.

Manual should be addressed to :

- governmental water, road, forestry, land and nature conservation management,
- communes, cities, municipalities,
- managers of watercourses and water bodies,
- forestry and agricultural subjects,
- environmentally-oriented NGOs.

b) the general public.

In this respect, it is necessary to:

- prepare concise and engaging information on beaver life, cohesion and cooperation within beaver families,
- build specialized nature trails.

Long time populated beaver localities are with vogue incorporated into educational paths. Beaver with its activities, has the unprecedented ability to catch one´s eye by attractive experience of nature. This can be used with success to learn to understand beaver activities and favorable treatment, even though beaver often gets into conflicts with humans due to its revitalization activities. Beaver sites offer in relatively small area and at frequent intervals a dynamic, constantly changing environment.
Visitor will like to return:

a) to see how beaver had enriched the environment with a new building block,
b) to experience again the contact with nature, enhanced by the attractive offer of beaver engineering, which excels by a high flexibility to hydrological changes, topography and geographical conditions.

It would be very irresponsible to commit the re-disappearance of beaver from the Danube river basin.

8. CONFLICTS BETWEEN BEAVER AND MAN

(by G. Schwab & S. Geißler)

Beaver activities can generally be seen very positive from a nature conservation and water management point of view (see chapter 5.). In a cultural landscape, however, beavers restructuring landscape used by man, can result in a number of conflicts between beaver and man.

These conflicts between beavers and human in cultivated landscapes can be summarised in the following categories:

- Feeding activities on crops
- Cutting trees and shrubs
- Digging activities
- Dam-building activities
- Other conflicts

8.1 Feeding activities on crops

In areas, where farmland extends to the edge of water, beavers have quickly accustomed themselves to the new food sources. Preferred crops are sugar beets, maize, grain and rape, but beavers have also been feeding on a variety of vegetables (from asparagus to zucchini) on crop land and in private gardens.

The economic damage from feeding is normally rather low, unless beavers have learned to store crops for winter food: the number of beavers feeding in a field is limited to a few by their territorial system, they normally harvest only what they consume (without damaging much more, as e.g. wild boar), and crop prices are normally rather low.

More severe than feeding are the side-effects. Beavers harvest crops on land and feed close to water. Going back and forth for harvesting and transporting the crops can damage the banks at the exit points. In case of light soils, long canals into crop fields can develop.

Damage to banks enables water to work on the banks, and wash off parts of it. Canals in fields can make harvesting edge parts more difficult or even impossible, as machines can not cross over the canals.

When beavers use crop fields with adjacent drainage ditches or small creeks, they tend to build dams or easier access. This may cause fields to be flooded or ground to be soaked to an extent which prevents harvesting machines from using the areas.

Photo No. 22.: Beaver feeding site in a sugar beet field. Typical are the “harvested” patch and the path from the water to the patch at the bottom of the picture.

Photo No. 23.: Beaver feeding paths in a rapeseed field.

8.2 Felling of trees and shrubs

The felling of trees, either for food or for construction material, can lead to a range of conflicts in the cultivated landscape.

Beavers do not only cut “worthless” willow trees and poplars, but also economically valuable species and specimen (e.g. oaks with 60cm DBH[4]). Conflicts also can arise

[4] DBH - Tree diameter at breast height

form the extensive cutting of newly planted trees, the more or less complete removal of narrow forest strips along riverbanks and the chopping of single, large trees characterising a landscape.

Especially in settlements, conflicts can arise by cutting fruit trees and ornamental shrubs in private gardens.

In areas with few trees left, the thinning of riverside woods can lead to reduced shadowing of the water, which can turn problematic in smaller creeks.

Problems also often arise as entailing damage from trees cut or debarked trees turning into dead wood. Trees gnawed by beavers can fall on fences, power lines, buildings, roads, rails or cars and cause further damages. The chopped down trees can cause further conflicts. In smaller water courses they can obstruct water run-off, back up water and cause flooding or divert water towards the banks, causing breaking away of banks.

As floatsam, the trees or their parts can cause damage to (or at least increase maintenance costs of) hydropower facilities; small twigs can be sucked into turbines and cause increased maintenance. In single cases, anglers have been complaining about logs impeding their fishing activities.

The removal of chopped down trees to ensure flood discharge and water flow, removing trees from agricultural areas, and cutting of gnawed trees in the framework of public security cost extra maintenance time and money.

Beavers colonising commercially used forests can cause problems and damage by cutting and/or debarking trees or by flooding complete forest stands.

Further conflict aspects are of rather psychological nature; so for example the envy that beavers are allowed to do what is prohibited for the farmer (like cutting trees without permission), or when the influence on the landscape characteristics caused by cut trees and shrubs is not appreciated by local people.

Sometimes this can even lead to the spontaneous revaluation of former unregarded shrubs as valuable woodland. In such cases, it is important to carefully distinguish between effective impairment and sheer disfavour.

Photo No. 24.: Beaver damage to spruce.

Photo No. 25.: Beaver damage in a plantation.

Photo No. 26.: Not much commercial damage, but the landscape looks untidy.

Photo No. 27.: Removing of trees gnawed by beavers along roads cause increased maintenance costs.

Photo No. 28.: Chopped down trees can cause problems with water flow in small creeks.

8.3 Digging activities

Beavers do dig a number of tunnels into the banks along the water bodies in their territories. These structures can be entrances to burrows and lodges, they can be tunnels for hiding for a short term, and they can be under water connections between two bodies of water or just a “little hole” dug by young beavers.

Sometimes beavers dig open channels above ground as waterways to food sources; these channels can in light soil also develop simply by beavers going and forth while harvesting food.

Beaver tunnels and burrows are a problem, when they are under areas used by people (roads, farmed areas, settlements). The burrows can collapse, vehicles and people can cave in and be damaged or hurt.

Beaver burrow in flood protection dams close to rivers (dikes with the absence of berms are most threatened), in dams along raised canals or in dams of fishponds can degrade the stability of the dams. The dams can break and cause flooding, fish ponds can be completely drained.

In smaller creeks and ditches beaver paths can damage banks and allow running water to do further damage. In small drainage there can be extra costs for maintenance for removing earth from beaver burrows and repairing banks or bank fortifications.

Photo No. 29.: Caved in beaver burrow under a field.

Photo No. 30.: Broken dam of a sewage plant.

Photo No. 31.: Beaver tunnel under an unpaved access road to fields.

Photo No. 32.: Well trodden beaver path into a pasture.

8.4 Dam building activities

Beavers build dams whenever the water level in their habitat is too low or if the fluctuations are too much to keep the entry to their den continuously below the water surface. They also build dams for easier access food sources farther away from water or to transport food easier on the water. In a cultural landscape, beavers very often do not have to build “real” dams. It might be enough to block man-made “bottlenecks” as culverts or pipes.

In the cultivated landscape, areas flooded by beaver ponds become inoperable to agricultural use and forestry, and even the use of non-flooded areas can be indirectly affected, e.g. when access routs are flooded.

Impacts of beaver dams can reach way beyond the areas flooded due to associated rise in ground tables. Even in areas farther away, land use can be impacted, crop growth can be impeded, or commercially valuable tree species might die off.

Water-soaked river banks are more likely to break down, and paths, roads and railways along damed areas can be threatened. Beaver dams can also lead to backflow into drainage pipes and sewage treatment plants, thus influencing their function.

In fish hatcheries beaver dams can block of fresh water inflow. Blocked outflows in fish hatcheries and sewage plants can yield to water running over the dams and washing them off. Blocking of outflow structures in fish hatcheries can impede harvesting.

Only in very intensively man-changed creeks and ditches beaver dams can impede fish migration, as in this cases by-pass channels can not form.

Photo No. 33.: Beaver flooding caused by a dam in a private forest

Photo No. 34.: Flooded meadow due to a beaver dam in an elevated mill creek.

Photo No. 35.: Flooded beaver path into a corn field

Photo No. 36.: The flooded access road to a meadow valley

8.6. Other

(by D. Valachovič)

- felling of trees through telephone and electric air line
- damage to the historic parks and memorable trees
- damage of buildings, especially holiday homes built in the vicinity of the watercourse area.

Soaking of buildings can occur due to the flooding of its surroundings, that may have disastrous consequences combined with the frost. Beavers can damage small buildings on the banks by felling the tree over building.

- Degradation of some ecosystems and their elements protected as specially protected parts of nature (protected areas, protected species)
- *flooding of protected ecosystems*
- *clogging of revitalisation channels*

9. SOLUTIONS FOR BEAVER CONFLICTS

(by G. Schwab & S. Geißler)

An analysis of the various conflicts with beavers in the cultivated landscape reveals that the majority of conflicts occur in a relatively narrow strip along the water bodies settled by beavers (90% within 10m, 95% within 20m distance), Fig 6.

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Conflicts farther way from the water occur only in exceptional cases, e.g. in places with highly attractive crops like sugar beets, if beaver flood areas or as secondary effects from breaking dikes.

This result is the basis for solutions concerning conflicts with beavers.
The most sustainable solutions are unused areas along the river banks; areas which are - independent from the beaver topic – also necessary for water and flooding protection. Where these areas can not be created, or only partially and / or mid and long-term, there are many smaller locally usable measure to solve and mitigate conflicts.

In justified single cases, it can also be necessary to dislodge beavers from an area.

A substantial part of conflict solution is always public relations and communication to provide information about beavers, typical conflicts and solution measures to landowners and stakeholders.

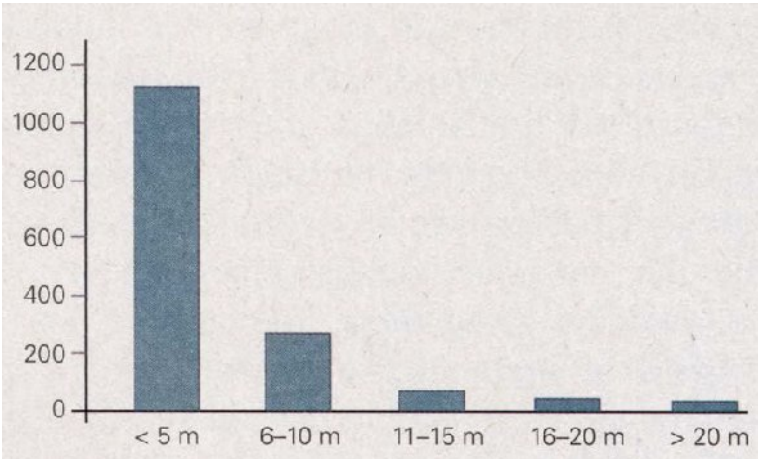

Fig. No. 6.: Conflicts with beavers occur mostly within a 20 m broad strip along the riverside (x-axis distance to the water, y-axis number of beaver traces, from LfU 2009).

9.1 Establishing unused river banks

Establishing unused riverbanks does not only sustainably solve problems with beavers, but is also necessary from the viewpoints of water conservation, flood water retention and the cross linkage of habitats. The width of such areas should be aligned with the topographic character of the landscape, while for the sake of beaver conflict solutions should never fall short of a range of at least 10m.

These unexploited areas should be state or public (e.g. communities, nature conservation organisations) owned and can be created either by purchase, leasing or exchange of land. One possibility is for example to use legally required compensation areas for new build streets, housing or industrial sites.

Photo No. 37.: With 10-20 m broad riverbanks

9.2 Local individual measures

Local individual measures include a range of measures that serve the purpose of prevention and mitigation of possible damages. Whenever measures are started, potentially relevant legal requirements (e.g. concerning the removal of beaver dams) have to be considered.

Individual measures for the sake of habitat improvement for beavers (like tree and shrub planting) are necessary only in few special cases, while apart from that, habitat

development should be left to the natural processes initiated by the beavers (if there are no other contrary indications)

Typical measures for the prevention and mitigation of damages are (details in the appendices and literature cited):

Selection of crops and crop rotation for agricultural parcels

By the selection of crops that are less attractive for beavers or of lower economical value, feeding damage or at least its financial significance can be reduced.

Electric fences

Electric fences can be installed in a variety of cases for the prevention of beaver damages. They stop the beavers from accessing riverside parcels and thereby protect crops and trees from being fed on. Furthermore, after the removal or lowering of a beaver dam, an electric fence can prevent the rebuilding.

Beaver proof fencing

Not only electric but also simple fences that are trenched into the ground can prevent beavers from entering cultivated area. The costs for such a fence meanwhile do in most cases only pay off if valuable trees or private gardens are to be protected.

Fencing out keep horses and cattle from riverbank strips

Cattle and horses can be stopped from entering the riverside area by electric or standard fences, preventing them from breaking into beaver tunnels.

Photo No. 38.: After the lowering of a beaver dam, an electric fence hinders reconstruction.

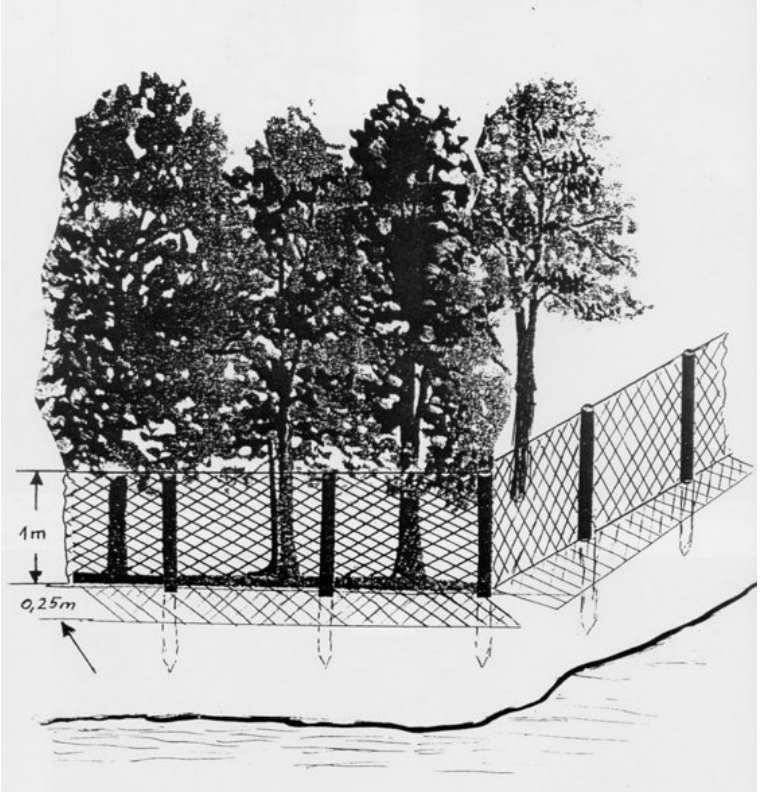

Fig. No. 7.: Scheme of a beaver proof fencing with trenched fence (Nitsche 2003).

Protection of individual tees

Valuable trees can be protected with wire meshes of at least 1 m height or by sand based substances (e.g. WÖBRA) that keep beavers from gnawing. For straight shafted trees, screed grids have proven their usefulness, especially because of their optical advantages. As an alternative, 2 to 3 layers of 4-edge-meshes can be used. Thinner material ("chicken wire") is often ripped by beavers and not recommended.

Supplemental feeding

Supplemental food (e.g. cut shrubs) can reduce beaver chopping activity. This measure should only be used in special cases (e.g. beavers in settlements) as the additional feeding eventually influences the natural regulation mechanisms.

Planting of woody food

The planting of shrubby willows can provide alternative food for the beaver near the water and thereby lower damage to more distant valuable trees.

Photo No. 39.: Single tree protection with screed grid.

When planting new forest, 10 m wide strip along the water should be planted with unused softwood, and only subsequently should be planted woods for lumber.

Leaving cut down trees

If chopped trees are removed, beavers have to cut new trees to compensate this „loss“of food. Chopped trees should therefore be left until spring to allow full use by beavers. If safety reasons require, the trees can be fixed with steel cables to prevent being washed of during flooding and causing problems downstream.

Frightening away (short-term)

Indicator lights from construction sites or ultrasonic noise systems can be used to frighten away beavers, however mostly only short-term (e.g. in fish hatcheries during harvesting). In private gardens in villages, a free roaming dog can keep beaver out.

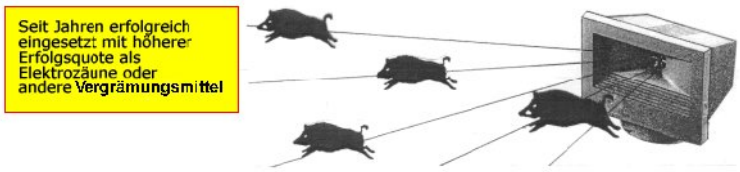

Fig. No. 8.: An ultra-sonic noise device works not only against wild boar, but often also against beavers

Lowering and removing beaver dams

Negative effects of beaver dams can be mitigated by lowering the dams to a level acceptable by adjacent land user, if necessary, a full removal is possible (with permits)

Rebuilding of the dam can often be prevented or delayed with an electric fence or an ultrasonic noise device.

Photo No. 40.: Smaller beaver dams can often be taken out easier and faster by hand than with a digger.

Draining beaver dams

The water level behind beaver dams can sometimes be regulated by a flow device build into the beaver dam. The goal is a water level deep enough for the beaver and low enough for adjacent land users.

For a flow device to work, it is necessary to leave a minimum water level of > 80 cm and to protect the inflow from being plugged by beavers. Regular control for function is necessary.

Chain of cans

In some cases, a chain of plastic canisters, stringed together with a rope was enough to keep beavers from rebuilding removed dams.

Putting sheet metal on boards of weirs and game feeders

Gnawing on the boards of weirs or of game feeders can be prevented by enforcing them with sheet metal

Photo No. 41.: A flow device (here with a 40 cm pipe) creates a compromise between water level required by beavers and acceptable by land users

Photo No. 42.: Not an optic beauty, but simple and cheap: some plastic canisters above the creek prevent rebuilding of a beaver dam

Protection of culverts and pipes

Culverts and pipes prone to be blocked by beavers can be protected with wire grating. This makes it more difficult for the beavers to block, and easier for man to remove material.

Photo No. 43.: Protection of an outflow pipe from a fish pond with wire grating.

Filling in burrows

Beaver burrows on used areas, especially roads should be filled in short-term to prevent follow-up damages

Removing material from creeks and deepening creeks

By deepening creeks the water level can be established in a way that beavers do not have to build dams or only shallower dams. As this measure is rather expensive and influences creek hydrology, it should be restricted to parts of the creek, especially in the surrounding of lodges.

Selection of tree species for newly planted forests

When establishing new forest plantations, shrubby willows should be planted on the river banks, commercial species farther away. Thereby, regenerating winter food is provided for beavers, and feeding pressure on commercial trees is lower

Plantations along roads next to water should be restricted to shrubby species; so there are not trees that can be copped by beaver and fall on the road.

Photo No. 44.: Protection of a culvert with wire grating. On the right the material, that had to be removed from the culvert before blocking

Location and design of possible hibernating ponds

By selecting the location (separate, apart from running waters) and/or design (shallow banks, no trees / shrubs) ponds can be made unattractive for beavers as hibernating ponds, thereby hindering beaver settlement.

Bank revetment

Banks can be protected from being undermined by installation of wire grids or meshes, by piled walls or by stone placement. Due to the high costs, such measures do only take place on short stages of waters or partial sections with severe damage potential (e.g. flooding of populated areas).

Bank revetments however do offer protection not only from beavers but also from various other digging animals like muskrats and nutrias, and for that, should be standard content of dam restorations and bank revetments.

Photo No. 45.: Bank revetment with a wire grid

Relocation of dams, dikes and pathways

The relocation of infrastructures will normally only be possible in special cases and in combination with other measures

9.3 Dislodgement of beavers

There are no known measures to keep beavers out of larger zones. So far, any of the various trials to force beavers to leave a specified area did fail. To create a “beaver hostile“ habitat, all trees and shrubs would have to be removed and all riverbanks would have to be covered in stone to prevent the establishment of dens – which would be an altogether inacceptable measure.

In cases, where other solutions for beaver caused conflicts are not possible or too expensive, beavers can be trapped and dislodged. Legal requirements in most countries along the Danube are based on derogative option in the FFH directive

The displacement of the beaver is effectively realized by life catch traps that are placed ashore on beaver passages. (Other possibility would be to catch animal from boat using a lightspot to find it and a landing net to catch it (Cirovič, 2012, personal communication)). The further treatment of the beaver is subject to the decision of the local authorities.

A range of reasons stands against the direct shooting of beavers for reasons of removal, exemplary, that the hunting must be complex because of the need to completely remove each and any of the night active beavers from the area; Also, it is impossible to find an injured beaver, which indicates problems with animal welfare, and in many areas (e.g. settlements) hunting is not possible at all, while anyway, the hunting and killing of a protected species that enjoys broad sympathy is hard to communicate after all.

9.4 Public relations

One of the most important parts of beaver management is public relations.
Beavers were extinct in the Danube basin in most areas for nearly 200 years, and the knowledge about the species, its actions and effects has been lost. Public relations shall not only be used to promote the beaver, but also inform about biology and behaviour of the species and about possible conflicts and solutions.

If timely considered in the process of all water and utilization planning, most conflicts can be avoided from beginning on. To allow that, participants of all user groups and decision makers should be part of the public relation management. To reach all the different beaver stakeholders, differentiated communication practices are necessary.

Beaver flyer

A short 20-30 pages brochure is one of the main information sources for beaver management. With this size, all aspects of the beaver and its management for the most different stakeholder groups can be addressed. The brochure can be laid at all important locations in the community like banks and town halls and also made available via the internet.

Beaver educational trail

An attractive educational trail can help a lot for the understanding and acceptance of the beaver in the local society. The educational trail should be placed as central as possible in the area to attract as much public interest and visitors as possible. For the setting up of such a trail, suitable beaver habitats should be easy to reach and close to existing recreation areas. Thereby, the existing infrastructure can be used and costs are minimized.

The selected beaver habitat should be in a way that beaver dams and trails can be seen all over the year (and for example are not covered by greens in the summer).
Beaver learning path should be used for actions in public relations (e.g. beaver in school classes).

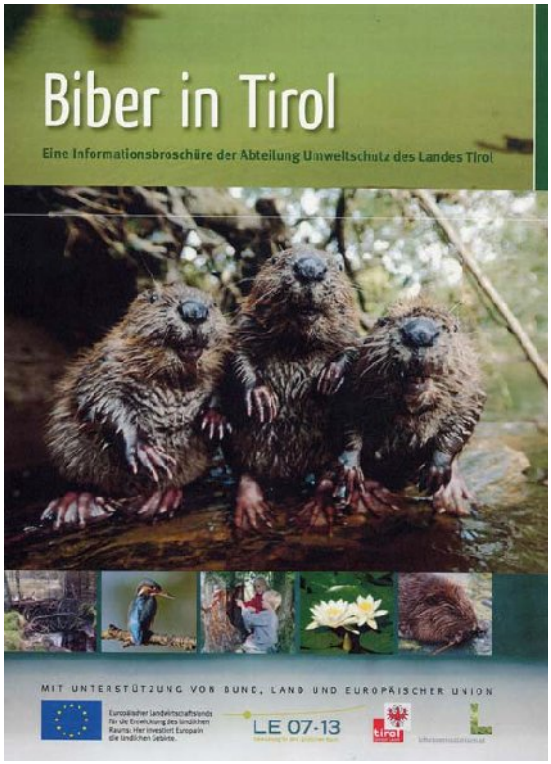

Photo No. 46.: Example of a beaver flyer from Tyrol, Austria

Information boards „beaver“

Besides „full“ trails, single boards next to existing hiking and biking trails can inform about beaver signs and beavers. The give short information and create interest. For uninformed people, a chopped tree is a „damage“, for informed people a dead tree is habitat for many rare insects and a cover for fishes.

Photo No. 47.: A small plate informs about the beaver „wilderness“in the background.

Beaver presentations and field trips

Presentations and field trips to beaver sites can be made for different interest groups and age classes. To establish and maintain a minimum standard, examples of presentations and field trips can be provided for qualified trained guides. These examples can then be adapted to local requirements.

Photo No. 48.: Page on beaver biology from an presentation provided for beaver guides in Bavaria

Beaver-website

A website allows time independent access to information around the beavers. Besides background information on beaver and beaver management, actual and local information (e.g. whom to call) can be provided, as well as e.g. instructions for protecting trees

Training courses for special interest groups

Many conflicts with beavers can be prevented, if the beaver is part of all plans along water bodies.

Besides specialists (e.g. Landscape architects, water management personnel) other groups involved in decision and opinion making (e.g. majors) should be trained too in order to create the consciousness for early thinking about beavers in planning

It is not necessary for these groups to have detailed knowledge about all aspects of conflict solutions, but to have the knowledge to involve beaver specialists in planning processes from the beginning..

Press materials

For working with media, it is useful to have information on beavers ready for use for them. This can be e.g. short texts, based on the beaver flyers provided for journalists on field trips or for downloading form the beaver-website.

Beaver in school classes

Beavers, their activities and influences are perfectly applicable to explain ecological interactions and cross links between nature and human land use to pupils and show them how important it is to respect the needs of animals while cultivating areas. Materials for the most different age groups are already developed and available, exemplary at the Bavarian academy for environmental protection in Laufen (Beavers in the manual “animal’s life”) and at the Rheinland Pfalz Beaver centre.
As long as propriety is respected, these can be adapted to local needs with low effort.
There are also a lot of educational games for different age groups to help learning about the beaver by playing.

Photo No. 49.: Getting to know about the beaver playfully: A group of children

Beaver materials for public relation purposes

The understanding of beavers is a highly important part of the communication strategy, especially regarding youth and children. Such understandable materials can among others be preparations, skulls, paw imprints and beaver gnawed tree limbs. Of such materials, collections should be built to be available at lectures, tours and classes.
Examples for such collections, including also other stuff like beaver games, are the beaver bag by the initiative “Hallo Biber!” or the Bavarian beaver rucksack by the Bund Naturschutz in Bayern e.V.

Photo No. 50.: Collection of beaver materials for lectures and excursions in the Bavarian beaver rucksack.

9.5 Beaver Management: Tasks and organisation

Beaver management, like wildlife management all in all, is still a relatively young discipline of environmental protection. The main difference between wildlife management in general and classic protection of the environment lies within the fact that instead of solely caring for animals, habitats and law, sustainable wildlife management also takes into account the needs and interests of the local population.
Still, this different aspects and their expectations often collide: While the conservationist is happy about the beaver, the farmer is annoyed by flooded plains and wants to get rid of the species; While the European otter finds a new feeding ground in the beaver reservoir, orchid lovers are sad that some of their rare plants have drowned in the same pond. The EU delegate has enacted the strict juridical protection of the beaver, while his local fellow party member wants to win the votes of beaver-frustrated farmers; a house owner uses the press to put the blame for his wet cellar which has been wet for decades, now finally on the beaver, and local politicians fall in by attacking the environmentalists – and in midst that all, without knowing it, there swims the unsuspecting beaver.
And this is the point, where beaver management takes into action to arrange a balance between all the different human expectations and the necessities of beaver habitats.
In the end, beaver management is not so much about the management of beavers, but people.

9.5.1 Tasks of beaver Management

Between this conflicting priorities there form a lot of tasks for the beaver management.

Advice in conflicts

One major topic is to help and assist affected people in cases of beaver conflicts to find solutions and compromises. This can only work locally and in cooperation with all affected stakeholder groups and specialists.

Preventive advice

Even better than to find solutions for conflicts, it is to prevent conflicts from happening from the beginning on. For that, adequate communication with landlords, residents close to the water, politicians, authorities and different federations is important.

Inclusion of the beaver in existing planning processes

Many preventive measures can be carved out at low costs if they are included into existing processes for planning and construction allowances. For example, the installation of wire grids in the construction phase of rainwater retention basins costs only a fraction of the later upgrade. Today, the beaver should be taken into account in each and any planning and measure alongside waters, even if not present at the moment.

Assistance in the implementation of solutions

The employees of the beaver management should also assist affected people with the implementation of found solutions like the setting up of an electrified fence or the installation of a wire protection for trees.

Mapping and controlling of Beaver presence

Knowledge of the presence and habitat size of the beavers and local beaver population are preliminary for effective beaver management. Which measure is to be utilized in cases of conflict can often only be decided after gaining detailed knowledge of the full habitat. For example, beaver dams that guard the den are of far higher importance to the beaver than such that only serve the temporary access to a certain feeding ground. The frequent and recurring inspection of beaver habitats is also important to allow the near-term reaction on possible problems like gnawed trees and floods in anticipation of arising damages.

Public Relations

As pointed out in section 7, the information of the local society about the beaver, especially as a lot of knowledge has been lost over the last decades, is a major part of beaver management.

Investigation and acquisition of funds

Beaver management is expensive. Costs arise not only from the needed staff but also from necessary measures. Anyhow, in many cases it is not needed to find additional financial sources, as existing financing solutions can be sufficient. Therefore it is important to properly investigate all possible sources of financial funding. For example, measures of public relations can be funded within the scope of “Förderung der Umweltbildung and Public Relations” of the Tyrol environmental funding program.

Design of plans for individual beaver habitats

To allow the effective use of preventive measures it is sometimes helpful to develop an individual management plan for single beaver habitats. In this plan, possible conflicts as well as solutions, measures, cost and funding probabilities in accordance to their expected project time and possible expectations of the local authorities are defined and logged.

Mediator role

One more important task is to help locally in conflicts as mediator between all the different stakeholder groups. In many cases, not the beaver itself is the real problem, but it is used as a catalyst to reprocess long existing problems. In the end, the tasks of beaver management can be summed up in only one sentence: To bring back the beaver into the hearts and minds of the population.

9.5.2 Organization of a beaver management

Beaver management is management of people. The connected tasks are mostly time consuming, and especially the local assistance in conflict situations does exceed the capacities state environmental protection authorities.

In countries areas, where beavers have now established for some decades and conflicts have to be solved, beaver management has now being working for a while. From there, the following suggestions for the organisation of working beaver management can be made. Of course, the structure has to be adapted to legislation, responsibilities, administrative and other structures in the different countries along the Danube.

A. State authorities

State authorities have the final "responsibility" for beavers. This includes e.g. implementation of law and derogation, funding of measures and beaver management and organising training of local beaver consultants

Beaver round table
In Bavaria, the Ministry of Environment organises a round table on beaver topics 1-2 times a year. Members are delegates form the authorities involved, from land user and nature conservation organizations and beaver specialist. The round table discusses recent developments and makes recommendations to authorities for permanent improvement of beaver management

B. Beaver specialists

Beaver specialists (e.g. biologists, foresters, natural resource managers) are responsible for bigger areas. They have a whole variety of tasks. They support local and state authorities in decision making about derogations, train the local consultants, organise surveys and develop materials for public relations

C. Local beaver consultants

Beaver management is people management, and people having problems with or questions about beavers need quick help. This can only be done, if there is sufficient number of qualified people to do this. In several countries, a system of local "beaver delegates" has been developed to help the environmental protection authorities with these important aspects of beaver management. The beaver delegates are normally working as volunteers with compensation for their expenses and support, after prior training, local authorities in the process of protecting and managing beavers on a community / several communities' level. They consult farmers, help implementing protective measures (e.g. electric fences) but do also monitoring and public relations work.

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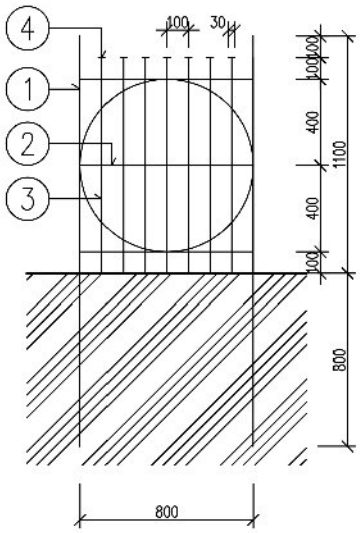
APPENDIX: TECHNICAL DRAWINGS

LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm)	PCS.	TOTAL LENGTH (m, m2)	UNIT WEIGHT (kg/m, kg/m2)	TOTAL WEIGHT (kg)
1	STEEL ROD 50x10mm	1900	2	3,80	3,93	14,95
2	STEEL ROD 50x5mm	800	3	2,40	1,96	4,70
3	ROUND STEEL BAR ø6mm	1000	6	6,0	0,222	1,35
4	ROUND STEEL BAR ø6mm	30	6	0.18	0,222	0.04
TOTAL WEIGHT						21,04

SCHEME FOR THE CULVERT ø 800mm



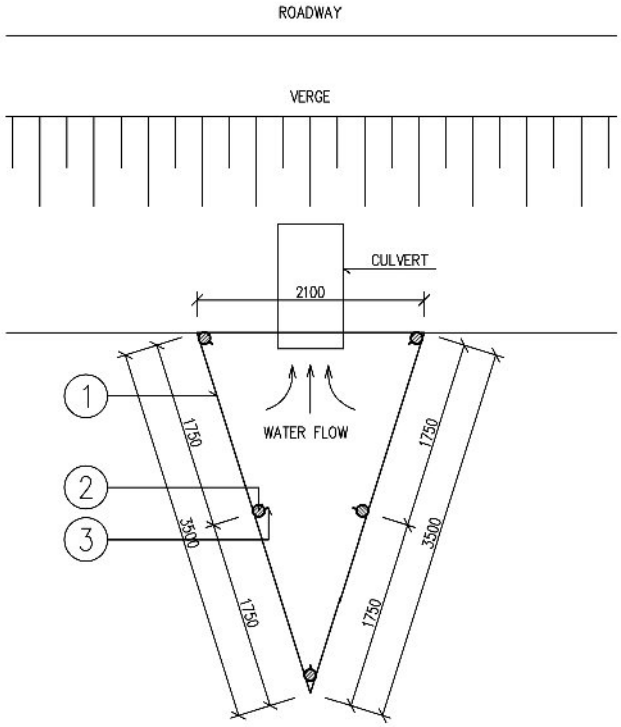
– HAMMERITE PAINT (1 X) IS RECOMMENDED (GLOSSY SMOOTH SURFACE)
COLOR DARK GREEN

TASK NAME **MANAGEMENT OF BEAVER**	DATE	05 / 2011
	FORMAT	1 x A4
CONTENT: **GRID PROTECTING THE CULVERT**	NO. OF TECHNICAL DRAWING	1

LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm2)	PCS.	TOTAL LENGTH (m, m2,m3)	UNIT WEIGHT (kg/m, m2, m3)	TOTAL WEIGHT (kg)
1	WELDED STEEL MESH MESH SIZE 100mm, WIRE ø2.5mm	240000 mm2	1	24 m2	0,77	18,50
2	WOODEN ROD (BLACK LOCUST) ø100mm ROT-PROOF IMPREGNATED TIMBER	3500 mm	5	0,136 m3	1800	245
3	DRAWN STEEL WIRE ø 2mm	400 mm	20	8 m	0,022	0,18

SCHEME FOR THE CULVERT ø 800mm



– HEIGHT OF FENCE ABOVE THE MAX. WATER LEVEL IS 1500 MM, TOTAL HEIGHT OF FENCING DEPENDS ON LOCAL CONDITIONS OF MAX. WATER LEVEL, IN THIS CASE 2500 MM

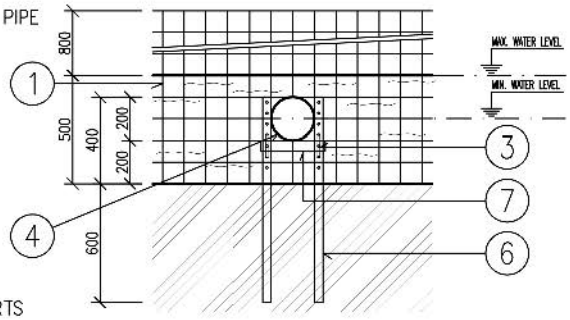
TASK NAME: **MANAGEMENT OF BEAVER**	DATE	05 / 2011
	FORMAT	1 x A4
CONTENT: **TRIANGULAR–SHAPED FENCING**	NO. OF TECHNICAL DRAWING	2

LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm2)	PCS.	TOTAL LENGTH (m, m2,m3)	UNIT WEIGHT (kg/m, m2, m3)	TOTAL WEIGHT (kg)
1	WELDED STEEL MESH MESH SIZE 100mm, WIRE ø2.5mm	14500000 mm2	1	14,5 m2	0,77	11,17
2	WOODEN ROD (BLACK LOCUST)ø100mm ROT-PROOF IMPREGNATED TIMBER	2000 mm	7	0,11 m3	1800	198
3	DRAWN STEEL WIRE ø 2mm	400 mm	37	14,80 m	0,022	0,33
4	PVC PIPE ø200mm	2000 mm	2	4 m	2,20	8,80
5	PVC PIPE ø200mm PERFORATION ø20mm, a=50mm	2000 mm	2	4 m	1,70	6,80
6	FLAT BAR 40/4mm, 1/2 WITH HOLES OF LENGTH ø5mm, a=50mm	1000 mm	16	16 m	1,256	20,10
7	SQUARED TIMBER (BLACK LOCUST) 50/50mm ROT-PROOF IMPREGNATED TIMBER	300 mm	8	0,006 m3	1800	11

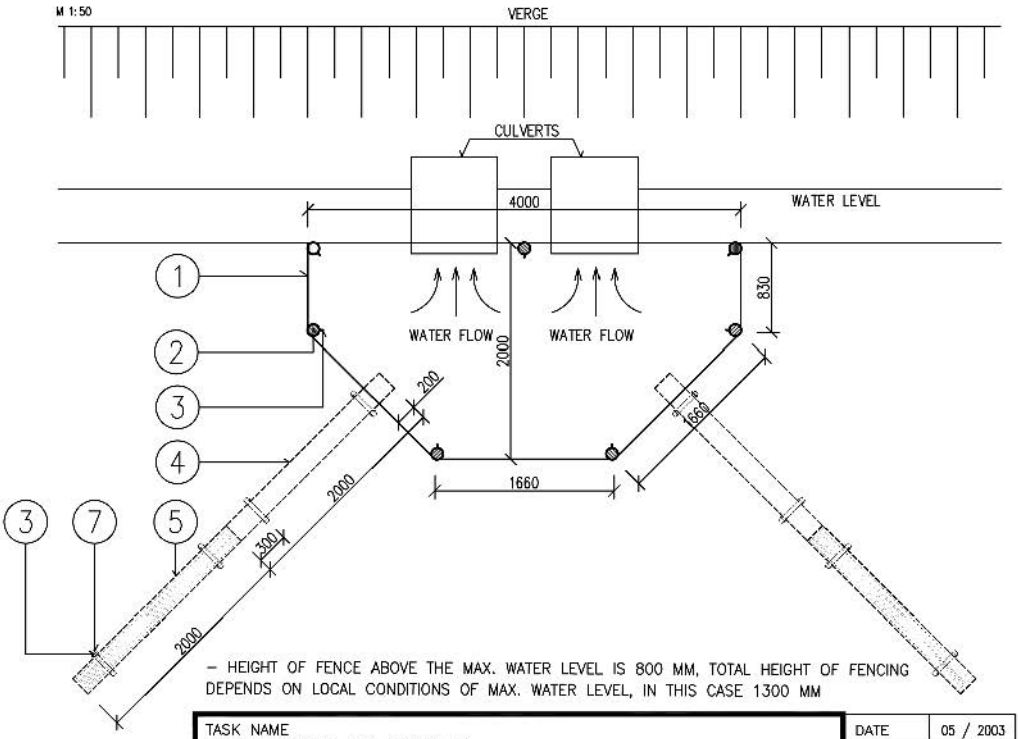
ANCHORING OF PVC PIPE

M 1:25



SCHEME FOR TWO CONCRETE CULVERTS

M 1:50



– HEIGHT OF FENCE ABOVE THE MAX. WATER LEVEL IS 800 MM, TOTAL HEIGHT OF FENCING DEPENDS ON LOCAL CONDITIONS OF MAX. WATER LEVEL, IN THIS CASE 1300 MM

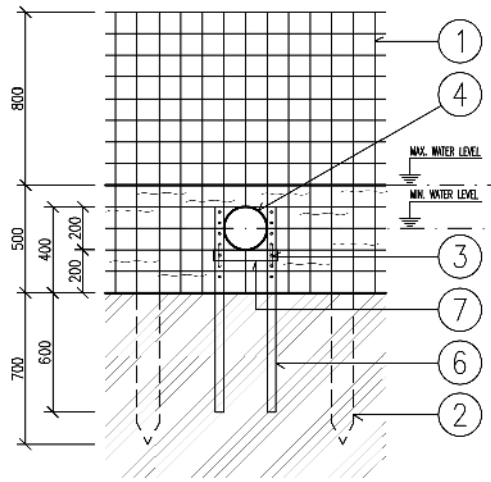
TASK NAME **MANAGEMENT OF BEAVER**	DATE 05 / 2003
	FORMAT 1 x A4
CONTENT: **FENCING – VERSION WITH TWO PIPES**	NO. OF TECHNICAL DRAW 3

LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm2)	PCS.	TOTAL LENGTH (m, m2,m3)	UNIT WEIGHT (kg/m, m2, m3)	TOTAL WEIGHT (kg)
1	WELDED STEEL MESH MESH SIZE 100mm, WIRE ø2.5mm	16000000 mm2	1	16,0 m2	0,77	12,35
2	WOODEN ROD (BLACK LOCUST) ø100mm ROT-PROOF IMPREGNATED TIMBER	2000 mm	12	0,187 m3	1800	336
3	DRAWN STEEL WIRE ø 2mm	400 mm	50	20,0 m	0,022	0,44
4	PVC PIPE ø200mm	2000 mm	1	2 m	2,20	4,40
5	PVC PIPE ø200mm PERFORATION ø20mm, a=50mm	2000 mm	1	2 m	1,70	3,40
6	FLAT BAR 40/4mm, 1/2 FLAT BAR WITH HOLES OF LENGTH ø5mm, a=50mm	1000 mm	8	8 m	1,256	10,05
7	SQUARED TIMBER (BLACK LOCUST) 50/50mm ROT-PROOF IMPREGNATED TIMBER	300 mm	4	0,003 m3	1800	5,50

CROSS-SECTION A-A

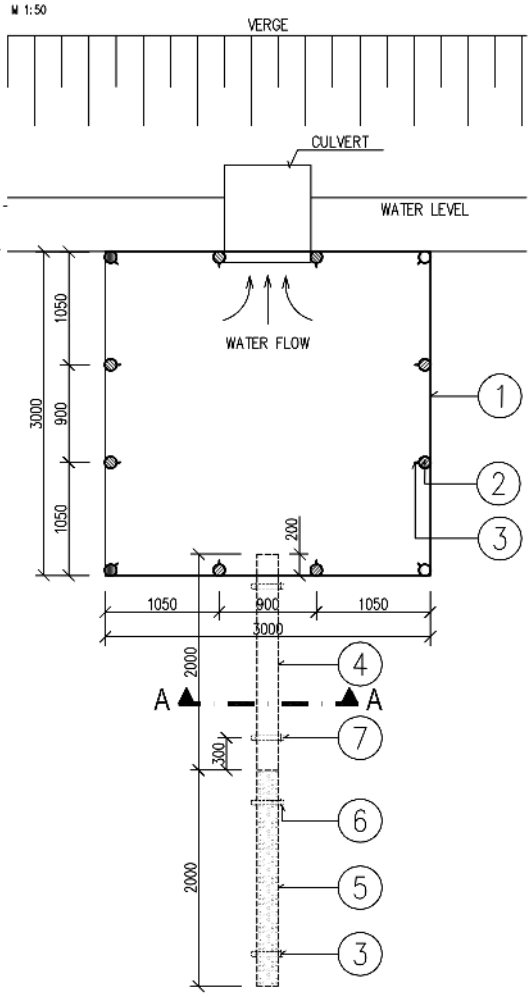
M 1:25



- HEIGHT OF FENCE ABOVE THE MAX. WATER LEVEL IS 800 MM, TOTAL HEIGHT OF FENCING DEPENDS ON LOCAL CONDITIONS OF MAX. WATER LEVEL, IN THIS CASE 1300 MM

SCHEME FOR ONE CONCRETE CULVERT

M 1:50



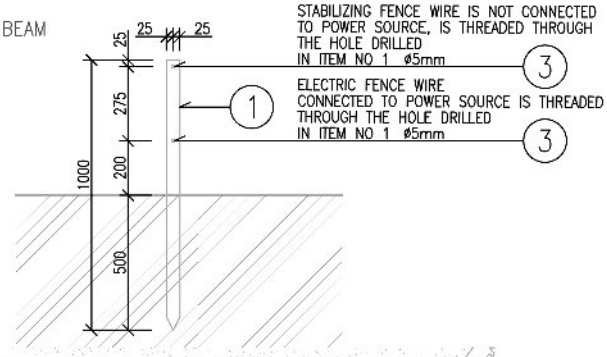
TASK NAME: **MANAGEMENT OF BEAVER**	DATE	05 / 2003
	FORMAT	1 x A4
CONTENT: **FENCING – VERSION WITH SQUARE FENCING AND SINGLE PIPE**	NO. OF TECHNICAL DRAWING	**4**

LIST OF MATERIAL

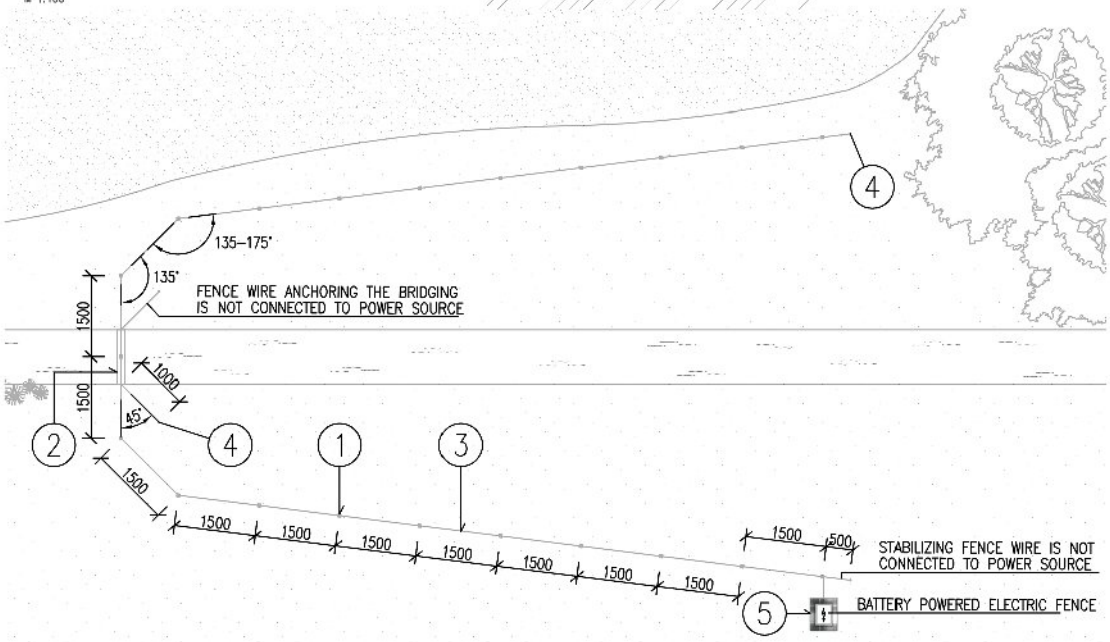
ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm2)	PCS.	TOTAL LENGTH (m, m2,m3)	UNIT WEIGHT (kg/m, m2, m3)	TOTAL WEIGHT (kg)
1	SQUARED TIMBER (BLACK LOCUST) WITH TAPERED END	1000 mm	21	0,0525 m3	1800	94,50
2*	BRIDGING OF SQUARED TIMBER (BLACK LOCUST) 250x250mm	1000 mm	1	0,0625 m3	1800	112,50
3	ELECTRIC FENCE WIRE ø3 mm STARLIGHT PE MONOFILAMENT	–	–	65 m	–	–
4	WOODEN STAKE (BLACK LOCUST) ø25mm WITH TAPERED END	500 mm	4	0,001 m3	1800	1,80
5	GEOTEXTILE PAD	0,3 m2	1	0,3 m2	–	–

* LENGTH OF BRIDGING DEPENDS ON THE WIDTH OF WATERCOURSE
– ROT–PROOF IMPREGNATED TIMBER PADS

SUPPORTING BEAM
M 1:20



SCHEME OF ELECTRIC FENCE
M 1:100



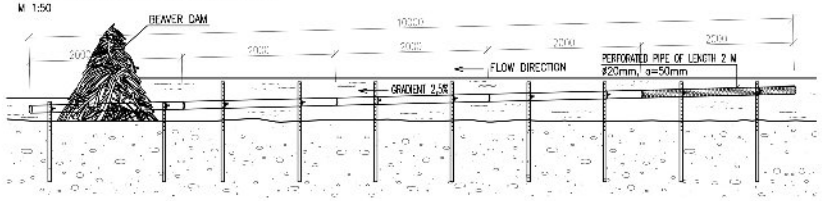
– ELECTRIC FENCE WIRE MUST FOLLOW THE TERRAIN IN HEIGHT OF MAX. 200 MM
– TO OVERCOME WIDER WATERCOURSES IT IS RECOMMENDED TO USE MULTIPLE INTERCONNECTED SEGMENTS (ITEM NO.2)

TASK NAME:

MANAGEMENT OF BEAVER	DATE	05 / 2003
	FORMAT	1 x A4
CONTENT: **ELECTRIC FENCE**	NO. OF TECHNICAL	**DRAWING 5**

DIAGRAM OF PIPE PLACEMENT

M 1:50



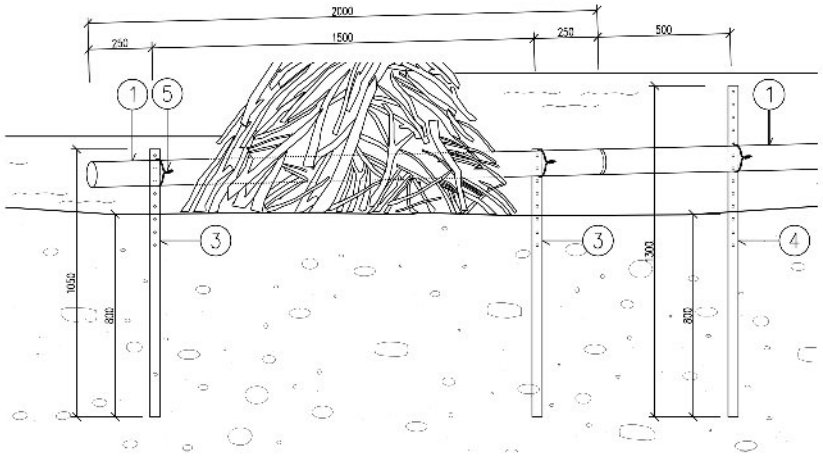
LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS (mm)	PCS.	TOTAL LENGTH (m, m2)	UNIT WEIGHT (kg/m, kg/m2)	TOTAL WEIGHT (kg)
1	PIPE ø 100mm WELDED OF STEEL SHEET X MM THICK. /0,7mm	2050	4	8,20	5,50	45,10
2	PIPE WELDED ø 100mm OF PERFORATED METAL SHEET, 0,7mm THICK.	2000	1	2,00	3,50	7,00
3	FLAT BAR 40/4mm, 1/2 WITH HOLES OF LENGTH 35mm, a=50mm	1050	2	2,10	1,256	2,64
4	FLAT BAR 40/4mm, 1/2 WITH HOLES OF LENGHT 45mm, a=50mm	1300	8	10,4	1,256	13,06
5	DRAWN STEEL WIRE ø 4mm	750	10	7,5	0,0887	0,66
TOTAL WEIGHT						68,45

– ALL DIMENSIONS MUST BE ADJUSTED ACCORDING TO THE ACTUAL STATE.
– ITEM NO. 1 AND 2 MAY ALTERNATIVELY BE MADE OF PVC PIPE.

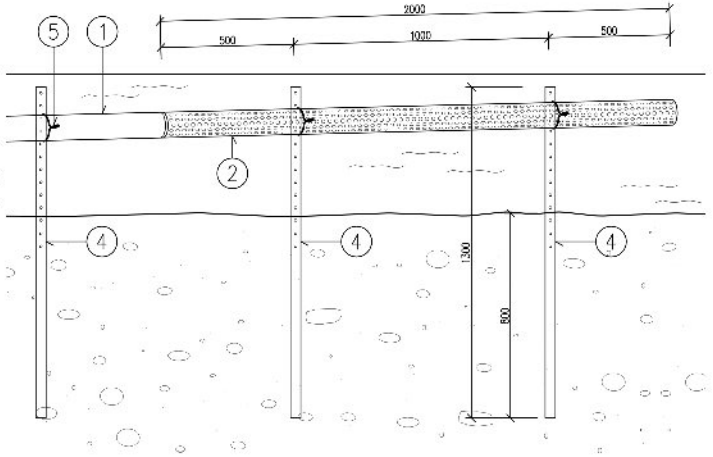
DETAILED VIEW ON THE PIPE TRANSITION THROUGH DAM

M 1:15

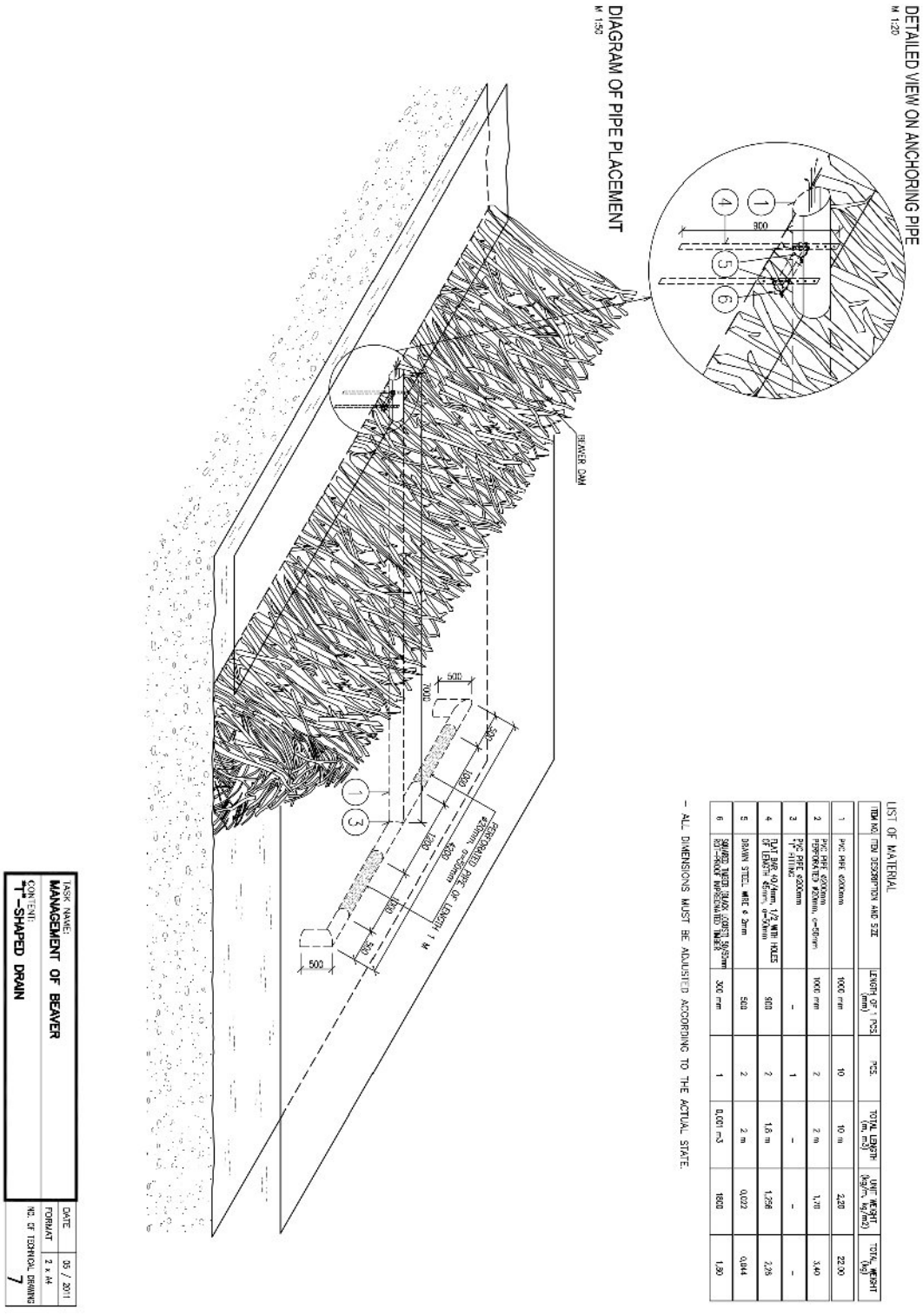


DETAIL VIEW ON PERFORATED PIPE

M 1:15



TASK NAME: **MANAGEMENT OF BEAVER**	DATE	05 / 2011
	FORMAT	2 x A4
CONTENT: **BASIC DRAIN**	NO. OF TECHNICAL DRAWING	**6**

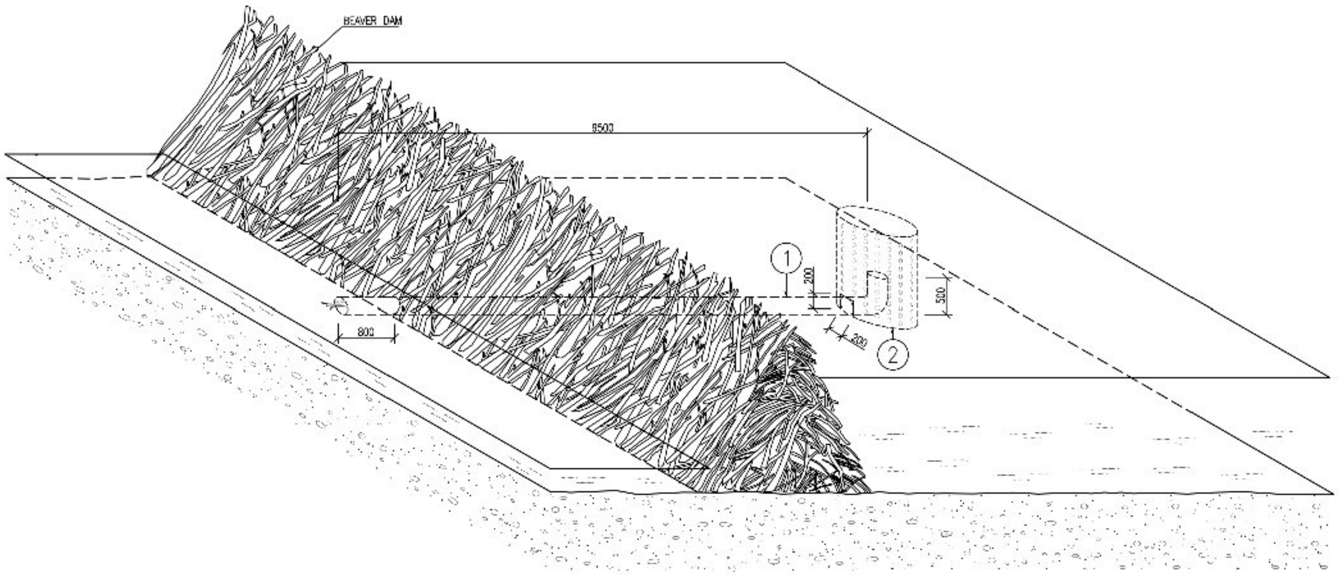

DETAILED VIEW ON ANCHORING PIPE
M 1:20
DIAGRAM OF PIPE PLACEMENT
M 1:50
BEAVER DAM
LIST OF MATERIAL
ITEM NO.
ITEM DESCRIPTION AND SIZE
LENGTH OF 1 PCS. (mm)
PCS.
TOTAL LENGTH (m, m2)
UNIT WEIGHT (kg/m, kg/m2)
TOTAL WEIGHT (kg)
1 PVC PIPE Ø200mm 1000 mm 10 10 m 2,20 22,00
2 PVC PIPE Ø90mm PERFORATED Ø20mm, n=15pcs 1000 mm 2 2 m 1,70 3,40
3 PVC PIPE Ø200mm - 1 - - -
4 FLAT BAR 40/4mm, 1/2 WITH HOLES OF Ø13mm, e=54mm 900 2 1,8 m 1,250 2,25
5 DRAWN STEEL WIRE Ø 2mm 500 2 2 m 0,022 0,044
6 SHAPED TWISTED BLACK CONSTRUCTION REINFORCEMENT MESH 50x50mm 300 mm 1 0,001 m3 1800 1,80
- ALL DIMENSIONS MUST BE ADJUSTED ACCORDING TO THE ACTUAL STATE.
TASK NAME:
MANAGEMENT OF BEAVER
CONTENT:
"T"-SHAPED DRAIN
DATE
05 / 2011
FORMAT
2 x A4
NO. OF TECHNICAL DRAWING
7

LIST OF MATERIAL

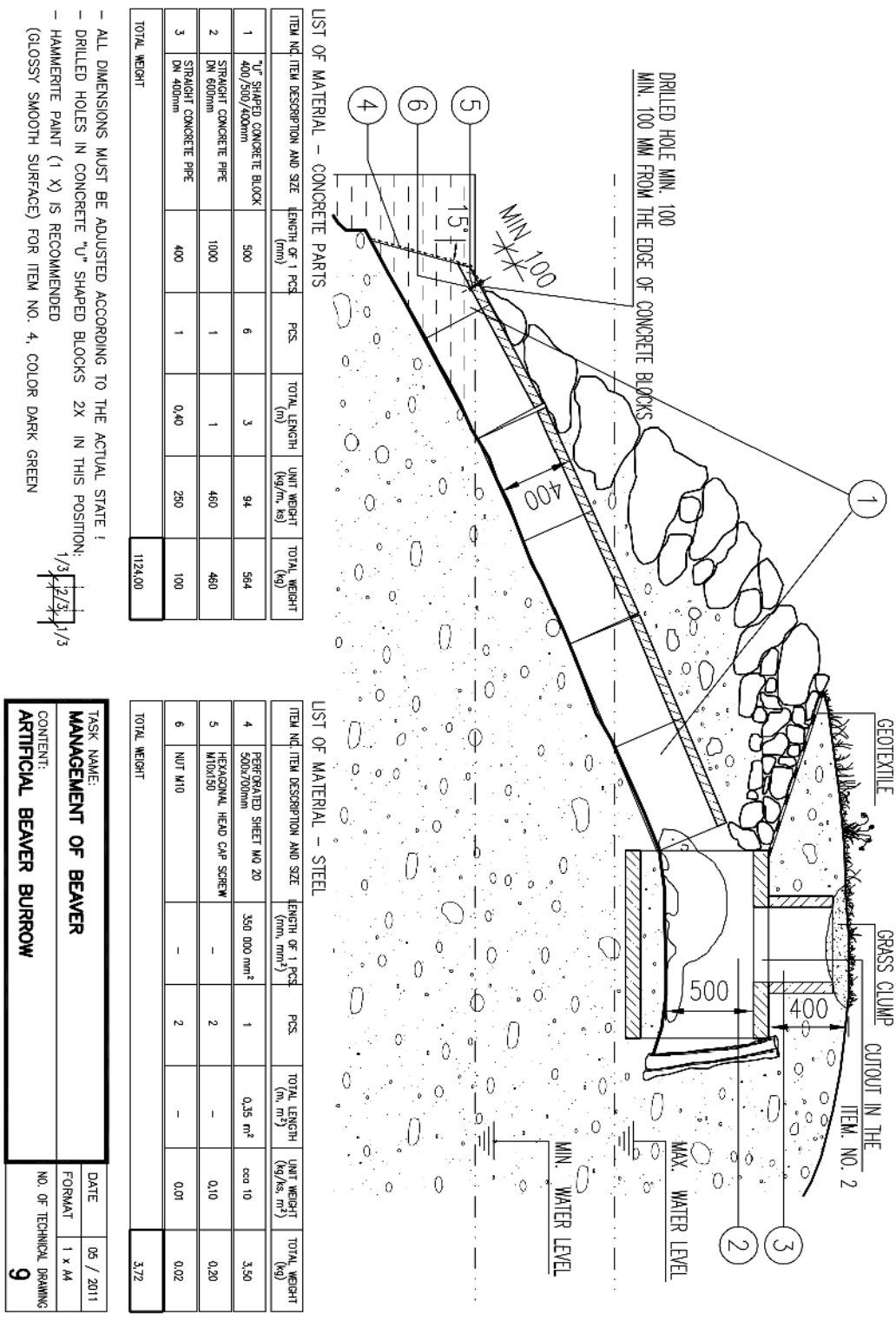
ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS (mm)	PCS.	TOTAL LENGTH (m)	UNIT WEIGHT (kg/m)	TOTAL WEIGHT (kg)
1	PVC PIPE ø200mm, PLACED ON THE BOTTOM, ONE PIECE HEAT BENT BY 90° IN ITS HALF LENGTH'	1000 mm	10	10 m	2,20	22.00
2	METAL BARREL (APPROX.ø800mm, V=1200mm), PLACED UPSIDE DOWN, WITH A CUTOUT FOR PVC PIPE, PERFORATED ø50mm, a=200mm	–	1	–	–	–

– ALL DIMENSIONS MUST BE ADJUSTED ACCORDING TO THE ACTUAL STATE

– HAMMERITE PAINT (1 X) IS RECOMMENDED (GLOSSY SMOOTH SURFACE) FOR ITEM NO. 2, COLOR DARK GREEN



TASK NAME: **MANAGEMENT OF BEAVER**		DATE	05 / 2011
		FORMAT	2 x A4
CONTENT: **DRAIN WITH THE METAL BARREL**		NO. OF TECHNICAL DRAWING	8



LIST OF MATERIAL – CONCRETE PARTS

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm)	PCS.	TOTAL LENGTH (m)	UNIT WEIGHT (kg/m, ks)	TOTAL WEIGHT (kg)
1	"U" SHAPED CONCRETE BLOCK 400/500/400mm	500	6	3	94	564
2	STRAIGHT CONCRETE PIPE DN 600mm	1000	1	1	460	460
3	STRAIGHT CONCRETE PIPE DN 400mm	400	1	0,40	250	100
TOTAL WEIGHT						1124,00

LIST OF MATERIAL – STEEL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm²)	PCS.	TOTAL LENGTH (m, m²)	UNIT WEIGHT (kg/ks, m²)	TOTAL WEIGHT (kg)
4	PERFORATED SHEET M0 20 500x700mm	350 000 mm²	1	0,35 m²	cca 10	3,50
5	HEXAGONAL HEAD CAP SCREW M10x150	-	2	-	0,10	0,20
6	NUT M10	-	2	-	0,01	0,02
TOTAL WEIGHT						3,72

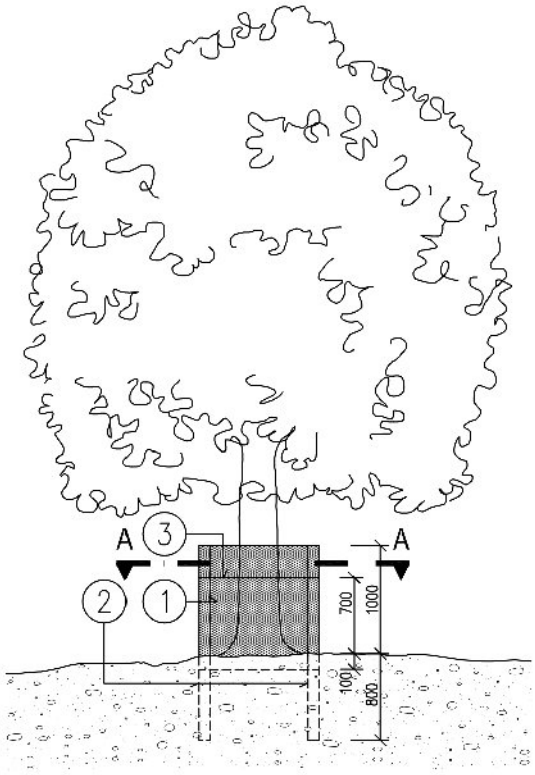
- ALL DIMENSIONS MUST BE ADJUSTED ACCORDING TO THE ACTUAL STATE !
- DRILLED HOLES IN CONCRETE "U" SHAPED BLOCKS 2X IN THIS POSITION:
- HAMMERITE PAINT (1 X) IS RECOMMENDED (GLOSSY SMOOTH SURFACE) FOR ITEM NO. 4, COLOR DARK GREEN

1/3 2/3 1/3

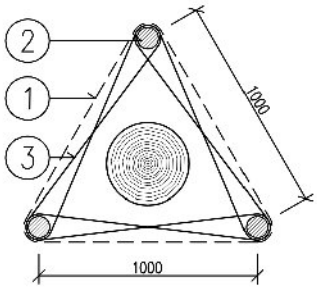
TASK NAME:	**MANAGEMENT OF BEAVER**
CONTENT:	**ARTIFICIAL BEAVER BURROW**

DATE	05 / 2011
FORMAT	1 x A4
NO. OF TECHNICAL DRAWING	**9**

SCHEME FOR A TREE WITH TRUNK OF 500 MM DIAMETER



SECTION A–A
M 1:25



LIST OF MATERIAL

ITEM NO.	ITEM DESCRIPTION AND SIZE	LENGTH OF 1 PCS. (mm, mm2)	PCS.	total volume, surface (m2, m3)	UNIT WEIGHT (kg/m2, kg/m3)	TOTAL WEIGHT (kg)
1	PERFORATED SHEET MQ 20 (BLACK STEEL) 3500x1100mm	3850000 mm2	1	3,85 m2	cca10	38,50
2	SQUARED TIMBER (BLACK LOCUST) # 100mm ROT–PROOF IMPREGNATED TIMBER	1800 mm	3	0,042 m3	1800	75,80
3	HEMP ROPE ø10mm	7500 mm	1	7.5 m	–	–

– PERFORATED SHEET MUST REACH MIN. 100 MM BELOW GROUND (BARRIER AGAINST BURROWING)

TASK NAME: **MANAGEMENT OF BEAVER**	DATE	05 / 2011
	FORMAT	1 x A4
CONTENT: **TREE PROTECTION**	NO. OF TECHNICAL DRAWING	10