Assessment of the impact of the modernization of railway lines on the Natura 2000 network – the Polish experience

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Abstract. This work presents the most important conclusions from the assessment of a modernized railways impact on the Nature 2000 areas in Poland. The studies were conducted in 2005, in 8 sectors with a total length of ca 850 km, in several regions of the country. As a result, 10 direct impact effects of modernized railway lines on natural environment and a number of distant, indirect and accumulative influences were identified. At least some of the negative environmental effects could be minimized by employing the mitigating means proposed in the work.

Key words: railway lines, modernization, Natura 2000 network, accumulated influence, mitigation measures

1. Introduction

In 2005, we conducted for PKP Polskie Linie Kolejowe S.A. an evaluation of the impact of the modernization of the railway lines E-65 from Warszawa to Gdynia, E-59 from Wrocław to Poznań, the Warszawa-Łódź line, E-20 from Siedlce to Terespol, E-20 Poznański Junction, E-30 from Węgliniec to Zgorzelec, from Węgliniec to Bielawa Dolna, and E-30 from Węgliniec to Legnica on Nature 2000 territory (Fig. 1). The analysis covered altogether about 850 km of the modernized railway lines. This article presents experience from the conducted evaluation.

2. Aspects of the impact of railway line modernisation requiring consideration in the context of their impact on the objects protected by Nature 2000

Analysing the potential impact of the planned undertaking on the condition of the components of the natural environment, considering the possible kinds of impact on the protection targets (species and natural habitats) in Nature 2000 areas, involves analysing all the possible interactions between the undertaking and the Nature 2000 network's protection targets. Such interactions may arise at the stage of construction, exploitation, or liquidation.

Below, there is a characteristic of most important, recognized influences.

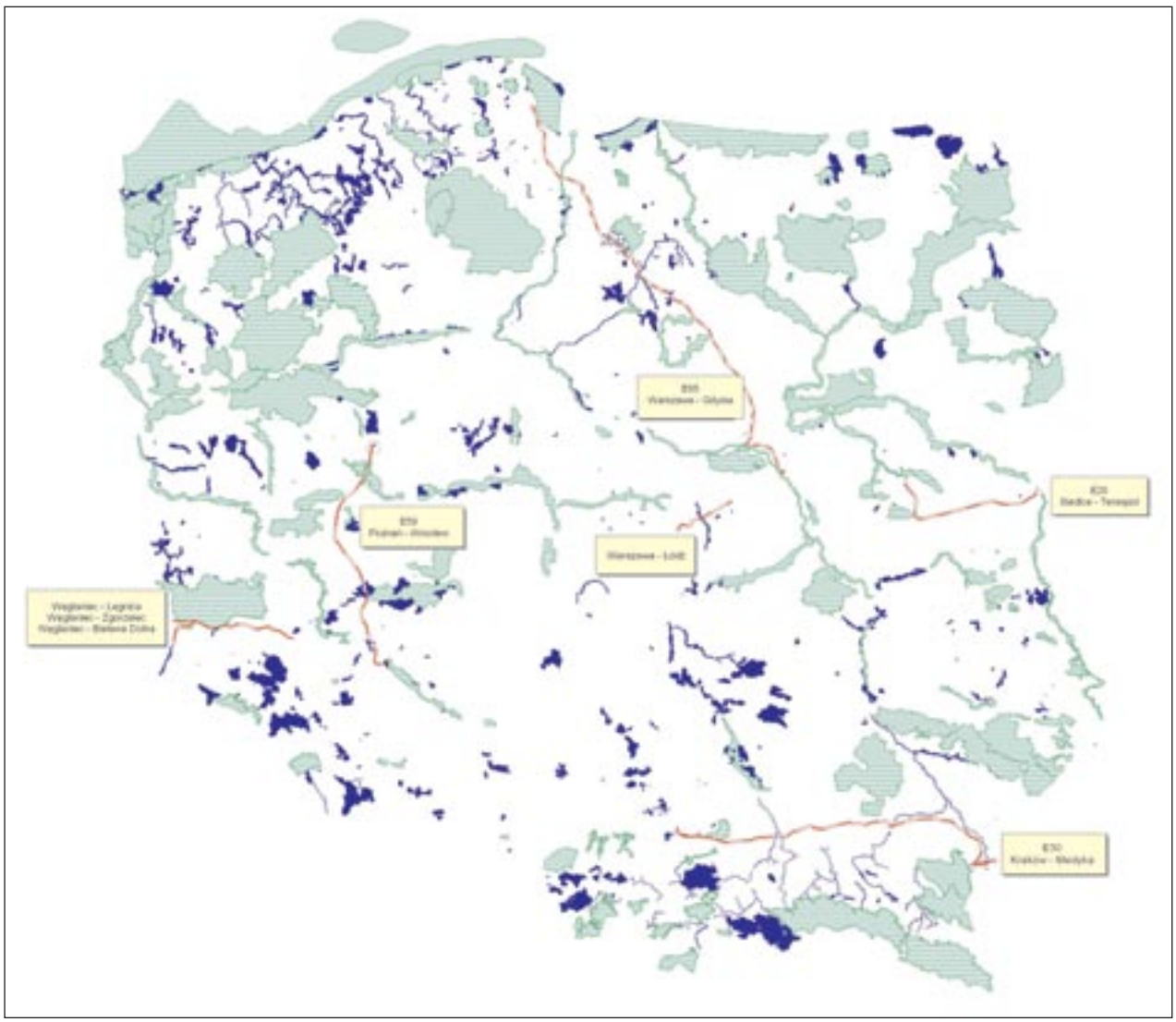

Fig. 1. Modernised railway lines in the context of the Nature 2000 network

2.1. Land occupation

The permament occupation of land is connected with local adjustments of the geometry of railway tracks, particularly the correction of curves, and with building of access roads due to the planned closing-down of the railway crossings as well as organisation of a construction site, including a storage area. Temporary occupation of land is connected with the excavation for fibre optic cable construction. If land occupation concerned natural habitats or habitats of species listed in the Appendices to the Habitats Directive or the Bird Directive, it would cause irreversible devastation of the relevant fragment of the habitat, which requires evaluating whether this impact is important at the scale of the Nature 2000 area.

In the case of modernisation of existing railway lines, the scale of permanent occupation of land was usually insignificant; however, it may be a significant problem if the line is adjacent to small but very valuable patches of natural habitats or if the sites of the protected species are present on the existing embankment or in the close vicinity of the line (on the embankment one might find, for example, Pasque flower (*Pulsatilla patens*); in the immediate vicinity of the line there were small water reservoirs important for the Great Crested Newt (*Triturus cristatus*) and the Fire-bellied toad (*Bombina bombina*).

A major problem was the temporary occupation of land due to construction works; e.g. for storing materials, stock of machines, etc. Most often they are located in "unusable" areas which in

fact can be precious natural habitats (sandy swards, valuable meadows). In the current tradition of evaluating impact on the environment, such impact was treated as temporary; however, from the point of view of Natura 2000, a habitat once destroyed cannot be quickly restored. Despite the temporary character of the impact, its effects are long term.

The problem of this effect usually can be solved by designing the line appropriately and first of all by planning the construction works appropriately (saving patches of precious habitats and species).

2.2. Cutting trees or shrubs

Such logging may have an impact on Natura 2000 protection targets if it involves trees which are habitats for insects listed in Appendix II to the Habitat Directive (e.g. oaks being habitat to the Longicorn Beetle (*Cerambyx cerdo*) or the Hermit Beetle (*Osmoderma eremita*) as well as trees or shrubs which are essential elements of the structure of birds biotop, e.g. blackthorn thickets in places of occurrence of a Red-backed Shrike (*Lanius collurio*) and the like.

In the case of modernization of the existing railway lines, the impact scale was usually relatively insignificant, but major conflict situations were encountered locally, e.g. blackthorn shrubs on the slope of an embankment destined for modernization, being an important biotope for birds; and clusters of maple (*Acer campestre*) near the line, species from a regional Red List. Usually cutting down bushes and trees could not be avoided, but this particular kind of impact can be compensated for relatively easily by planting new shrubs of appropriate species.

2.3. Noise and disturbance connected with construction works and exploitation of the line

Noise resulting from the construction of the line as well as the disturbance introduced by the permanent presence of human beings may impact the behaviour of animals listed in the Appendices to the Habitat Directive or the Bird Directive, especially of mammals and birds. In the case of some birds, this may cause relocation of breeding places and avoidance of the close neighbourhood of the line. When it comes to mammals, the line might function more strongly as an ecological barrier during construction. The impact is proportional to the intensity and duration of the construction works.

Although difficult to measure, the noise-impact was one of the most significant and important problems. What is more, it is very difficult to mitigate it effectively. This is because the stress factor for animals is not the measurable noise level (which can be reduced) but rather the very presence of human beings and the frequency of disturbing stimuli (which cannot be excluded if construction works are to be carried out). A particularly important problem arose when the modernized line cuts across refuge sites of strongly antropophobous species (wood grouse, black grouse, black stork).

The noise connected with train traffic is surprisingly a far lesser problem for functioning of natural systems than one might think. It is a repeated factor that animals are able to get used to. Moreover, modernization of a line usually results in its ‘silencing’, although increase of train traffic frequency is assumed.

2.4. Impact on surface and ground waters at the stage of construction

The danger of change to water relations is caused by works connected with drainage of the track-way, excavations, pile-driving during construction, and reconstruction of viaducts, bridges, culverts, etc. The risk of negative impact arising is especially high in places where the line crosses hydrogenic habitats, e.g. boggy forests. The existing conflict is in such a case irresolvable, because due to technological reasons, the substructure of the track has to be well drained, whilst the adjacent ecosystems, in order to maintain a proper state of protection, need to maintain their marshy character.

Moreover, we need to bear in mind that some technical solutions serving to drain the line (e.g. so-called 'Krakowskie open channels') can be a major ecological barrier and the cause of mortality of small animals (see below).

In places of intersection of the railway line with water courses, there is the danger that mo ernisation works (e.g. repair or redevelopment of bridges or culverts) could change the ecological character of the water course. Works carried out in a river stream, e.g. near bridge piers, as well as all works transforming a river bed near bridge structures (including local reinforcement of banks and local restoration of river control) sometimes cause damage to local but important fauna biotopes and aquatic plants, including in particular direct damage to water-crowfoots (habitat 3260) and fish biotopes, including their spawning-grounds. The problem is easy to resolve by designing the works in a way that eliminates technical intrusion in the water course bed.

Works conducted at the 'intersections' of the railway line with water courses that are biotopes of protected fish, carried out during the spawning period or fish migration period, can locally disturb the functioning of their populations. This requires planning such works in non-conflict periods according to the needs of fish.

The danger of pollution permeating to waters pertains in particular to works carried out near bridge objects and culverts, but also remote surface flow from the area of earthworks. In most cases, the danger of pollution with chemicals and crude oil derivatives is noticed, but the danger of temporary disturbance of water is disregarded (polluting with suspended matter). In the case of earthworks, temporary clouding of water in small water-courses nearby the building site is particularly dangerous. Despite the temporary character of this phenomenon and the fact that it does not cause major and lasting deterioration of water quality as understood in the regulations in force, it can exert considerable impact on the populations of some species of fish from Appendix II of the Habitats Directive and on vegetation. Even the temporary presence of larger amounts of suspended matter in water can destroy water-crowfoot vegetation in the water course stream and lead to fish leaving the biotope. This problem can usually be solved using technical means.

2.5. Impact of pollution generated at the exploitation stage

Exploitation of a railway line is connected with creation of various pollutions, among which predominate: (*i*) bulk and liquid materials dispersed/spilled in transport (e.g. crude oil derivatives, chemicals, fertilizers, crops, etc); (*ii*) crude oil derivatives from rolling stock (if using the older rolling stock type); and (*iii*) utility sewerage dumped from railway rolling stock. Exploitation of a railway line is also connected with the risk of occurrence of considerable pollution as a result of breakdowns or accident. These pollutions can have a serious effect on natural habitats protected as part of Natura 2000 sites and on populations of fish and amphibians and as a consequence on populations of birds and mammals that feed on fish and amphibians (e.g. otter, kingfisher). The risk becomes serious at points where the line intersects with environmentally valuable water courses. Technical solutions need to be applied, making the flow of water from the railway line to such a water course impossible.

The use of herbicides as part of maintenance of the railway line has a major effect on the railway line vegetation. They have (as assumed) a considerable impact first of all on the vegetation of the track-way which may modify the occurrence and the distribution of 'railway neophytes' but also through damaging their habitats and opening ecological niches for specialised and more durable species. Moreover, the use of herbicides poses a danger to amphibians. Herbicides are very dangerous for their sensitive skin and can cause deformation of animals, especially the young. They have also negative impact on the biology of a species, e.g. on breeding. The problem becomes even more serious when the railway line crosses local migration routes of amphibians or nears important amphibian refuge sites. The use of herbicides in such sections has to be discontinued.

2.6. Accidental killing of animals

On a building site or access roads to a building site, the fauna mortality rate can increase, in particular for amphibians – including species listed in Appendix II to the Habitat Directive – related to their accidental killing by building equipment. The impact is proportional to the intensity and length of the construction works. The problem can be usually alleviated or avoided through proper spatial and time organisation of work.

2.7. Bringing and spreading of alien species

The breaking of ground surface, as well as redevelopment of track-way, can create ecological niches susceptible to inhabitance by expansive species of plants of geographically foreign origin. This will, however, result in the destruction of their populations that currently exists on the track-way. Therefore, either stimulating or limiting effect of the works on the populations of 'railway neophytes' is possible. The construction work related to breaking ground surface can also create niches which make it easier for foreign expansive species to spread along the railway line, entering natural habitats. Publications include descriptions of such phenomenon in relation to *Impatiens parviflora*. This phenomenon is, however, very difficult to model and forecast; moreover, there are no practical ways to limit the related risks.

2.8. Barrier effect for wildlife

This is one of the most serious effects of railway lines on the nature. A railway line is for various species of wildlife a barrier of various degrees of 'permeability' (Fig.2). The barrier effect of a railway line, related to a larger extent to its physical features (scarps of embankments and excavations, scarps of drainage facilities, sometimes concrete 'Krakow-type open channels', a wide strip of foreign environment, ecologically alien substrate on the track-way) than to the movement of trains along the line (even the maximum density of train traffic corresponds to a low-density local vehicle road).

For large mammals (lynx, wolf, as well as ungulates which are their food) a railway line which has existed for a long time is a foreign element, but it has to considerable extent 'melted into' the landscape and for fauna crossing it is not very stressful – so long as nobody tries to fence the line along longer sections, trying to avoid another danger – the collision of animals with trains. A serious barrier can occur in places in which a road also runs along the railway line.

For animals linked to aquatic environment (otter and beaver), the places of crossing the railway line are first of all culverts on water courses. Therefore, the barrier effect of a line depends on the design of culverts, and here in particular on their diameter and size. Pipe culverts that are generally used, as well as all kinds of culverts whose bottom is fully filled with water, often regarded as 'fauna passages', in fact do not function this way at all.

For amphibians, most existing railway lines are now serious barriers. Modernisation often assumes construction of drainage ditches along certain sections of a line, so-called Krakow-type open channels, which are completely impassable for amphibians and, in addition, they become traps in which amphibians and other small fauna die. The barrier effect of a railway line causes the fragmentation and isolation of populations and makes the migration of fauna impossible or difficult. Moreover, the track itself – rails and a strip of stony, dry, and in many cases polluted ground (herbicides) – is an impassable barrier for amphibians. The problem occurs locally, in places where the railway line cuts off e.g. habitats or areas of winter stay and breeding of a local population. Such places may become the sites of mass mortality of amphibians during local seasonal migrations. This can even lead to the extinction of the population. In such places, appropriate passages for amphibians need to be constructed.

The barrier effect of the line itself can be augmented by the barrier effect of roads running parallel to the railway line. The permeability of the linear element of fauna infrastructure depends,

among other things, on the width of the strip of the foreign environment and the number of structures foreign to animals in this strip. Therefore, planned modifications of the road system, including the construction of access roads to crossings parallel to railway line (due to the liquidation of some of single-level crossings) need to be considered in this respect too.

Important for the functioning of the Natura 2000 network is the barrier effect of not only the sections of the line that cross Natura 2000 sites, but also those sections which dissect ecological corridors connecting the sites or create edge barriers that make dispersal of animals from the sites or their migration to the sites more difficult.

Despite the possibility of using technical mitigation solutions (various systems of fauna passages), the barrier effect of the line cannot be reduced to zero.

Fig. 2. The line E65 fragments the ecological corridor of the River Mławka and after modernisation could be a major ecological barrier. In its present form, it already poses a threat of isolation

2.9. Wildlife mortality as a result of collision with trains

Train traffic on the line causes collisions with animals and their death (Figs.3,4). This risk pertains to practically all the species of animals crossing the railway line; however, the most frequently registered are collisions of wild boar and roe deer with trains. The increased risk of collision pertains to all birds (e.g. ravens and kites) that feed on carcasses (e.g. a roe deer killed by a train). The cases of collision of species protected as part of the Natura 2000 network with trains are relatively rare, but due to low numbers of their population, even the slightest risk might be regarded as considerable. Predator birds and owls (also Venus Flytrap and shrikes) use the traction poles as lookouts in many places, because nearby are the most attractive hunting places for these species. They eat carcasses found on the track-way. Such behaviour elevates the risk of their collision with trains. Besides mortality on the track-way, mortality as a result of collision on roads parallel to the railway line can also be important. Therefore, the planned modifications of the road system, including the construction of access roads to crossings parallel to the railway line (due to the liquidation of some of single-level crossings) need to be considered in this respect too.

The fencing of long sections of a railway line, sometimes done in order to make passage of fauna impossible, is not a good solution – although it can reduce mortality, it increases the barrier effect of the line, which in most cases is much more dangerous. A promising method of mitigating the death risk without a corresponding increase of the ecological barrier effect are acoustic deterring devices, currently at the stage of tests in practice. However, there is no way this effect could be reduced to zero.

Fig. 3. Amphibians are often killed in collisions with trains. The track-way is an impassable barrier for them

Fig. 4. So-called Krakow-type open channels, serving to drain the railway line embankment, are a barrier for amphibians and other animals

2.10. Birds crashing into railway line infrastructure

Flying birds can crash into barriers, e.g. elements of bridge structures or the traction network. This risk is considerable in the case of bridge structures in river valleys which are migration routes for birds. A considerable number of birds migrate at night, which increases the risk of collision with structures which are not lit. Lighting the structure of a bridge can reduce the risk, although it does not reduce it entirely.

3. Remote and indirect impacts

Remote and indirect impacts are of equal importance, and sometimes even more important than the direct ones. Although their inclusion in EIAs is not simple, they must not be disregarded!

3.1. Change of impact of alternative communication channels

The condition of the railway line and its exploitation parameters (throughput, train speed and the resultant time of run) obviously have an effect on the attractiveness of the railway line as compared to alternative transport channels (road and air). Because infrastructure elements exist related to these alternative channels and the resultant environmental impacts (including the effect on the Natura 2000 network), the subject matter undertaking needs to be considered in this context, too.

3.2. The effect on urbanisation processes

In many countries, including in Poland, one can observe the relation of urbanisation processes with communication routes. Such a relationship can also theoretically pertain to railway lines. Good availability of passenger transport can stimulate housing developments, and the availability of cargo transport, industrial developments. In Poland, however, this effect seems to be disregarded, as compared to the urbanisation effect of the road network. It is not observed that the availability of passenger railway transport and the quality of this communication (time of travel) has currently had any influence on the prices of real property or the decisions related to spatial development. In the same way, industrial, service (including sales and logistics) investments localisation decisions are these days made rather on the basis of the quality of communication services on roads and not railway lines. However, such an effect can take place in the longer term. Similarly, in the longer term there could be the pressure to locate industrial investments where there is good communication services provided by railway transport ensured.

3.3. Changes in the model of area penetration in connection with changes in road system

Modification of the layout of roads, as well as the network of forest roads, related to the liquidation of some railway crossings, as well as the construction of temporary access roads to building sites, can result in a change in the way the area is penetrated, including 'opening and making available' places so far hard to penetrate or in which to carry out economic activity. We have observed this phenomenon in particular in Bory Dolnośląskie, where minor modernisations of forest roads made in order to improve access to a building site improved the accessibility to the area for forest management (they won positive opinions of forest managers), but this meant 'opening' the so far inaccessible area and a very negative effect on refuges of anthropophobic birds.

3.4. Difficulties in the protection of Natura 2000 sites

The liquidation of crossings at the track-way level, related to the modernisation of the railway line, can to a certain degree impact the accessibility of farming land, thus exerting an effect on their use. Because meadow habitats (e.g. 6150, 7230) are material objects of protection as part of Natura 2000 sites, whose protection consists in their mowing in the proper rhythm and at the proper time, limiting access to individual patches of habitats can make the performance of protection tasks more difficult. Such an effect should also be included in the assessment.

4. Accumulated effects – a major problem in impact assessment

The instances of potential possibilities of the effects of modernisation of railway line accumulating with the effects of other undertakings are related first of all to the case of a railway line and a road running parallel, in particular to bridge crossings that are parallel and located close to one another (Fig. 5). In such a case, integrated solutions need to be applied (jointly designed), but the procedures provided for in Polish law make it very difficult.

Fig. 5. Accumulated impacts – a railway line and a road (E 65 near Zakole Rzeki Wel Natura 2000 site)

5. Examples of mitigation measures

5.1. Systems of amphibian passages

A well-designed system of passages for amphibians should be preceded by a reliable field stock-taking, specifying the directions and the types of migration of amphibians and a preliminary assessment of the degree to which the system of passages can reduce mortality of amphibians and preserve the functionality of the local migration corridor. In typical conditions, migration activity of amphibians has several stages:

- Breeding migrations – adult individuals migrate from hibernation places to breeding places and then, after mating, to feeding grounds (spring);
- Trophic migrations – 1-year old or older individuals that are not yet old enough to mate migrate from winter stay places to feeding grounds (spring); adult animals and 1-year olds or older individuals that are not yet old enough to mate migrate from one feeding habitat to another (summer); juvenile animals (after metamorphosis) migrate from their lair to feeding habitats (summer, early autumn);
- Migrations to winter places – adults and juvenile animals migrate in search of proper places of hibernation (autumn).

Optimum amphibian passages should consist of a system of tunnels and guiding fences. A fence is an indispensable element placed along the embankment, which leads the amphibians to the tunnel and which prevents the animals from entering the track-way. This element has to be installed between the tunnels. The shape of fences should be designed so as to eliminate the possibility of the amphibians' climbing, as well as to protect the fence from dumping and overgrowth.

The dimensions and shape of tunnels should be in line with ecological requirements for wildlife, providing contact with natural ground during migration. The best and the most durable are concrete elements. Their dimensions should be appropriate (minimum width 100 cm and minimum height 60 cm), which should guarantee that the animals enter the tunnel. ZIEGER prefabricates are a good example of tunnels that meet wildlife ecological requirements (Figs. 6,7).

Fig. 6. Tunnels and ZIEGER type guiding fences for amphibians. Maintaining the natural soil and placing a guiding board in the tunnel is significant.

Such tunnels fulfil the function of a safe passage not only for amphibians. Experience shows that not only amphibians use the passages, but also small shrew-type mammals, arvicolinae, muridae, and sometimes mustelidae, as well as badgers.

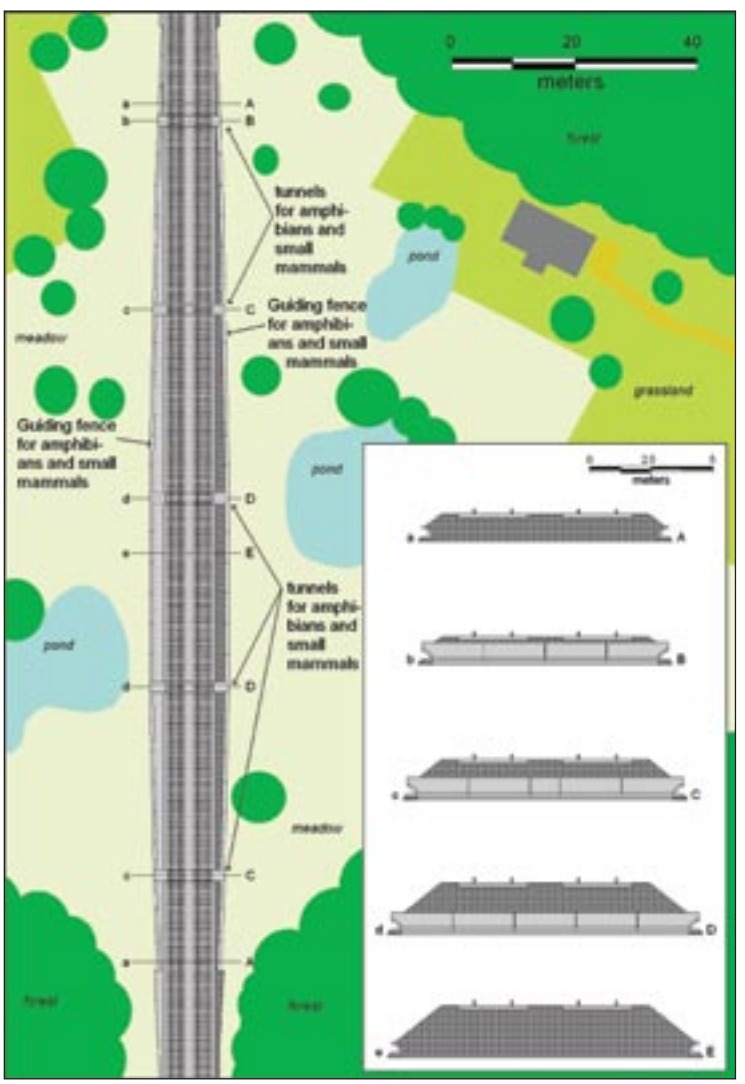

Fig. 7. Scheme of the designed system of underpasses for amphibians under the railway

5.2. Minimizing the barrier effect of the railway line on animals – UOZ 1 disperser and reconstruction of bridges

In order to maintain the patency of ecological corridors, solutions are pursued that would enable fauna to freely cross the railway line at places where they migrate or live. On railway sections which cross ecological corridors, we proposed the experimental use of acoustic dispersers, UOZ-1 devices, prepared by the Forestry Research Institute – Department of Natural Forestry, which are sign stimuli dummies, triggering an instinctive flight reaction in wild mammals (Fig. 8). This promising solution might prove effective and much less expensive than other risk minimisation measures.

Fig. 8. UOZ-1 acoustic dispersers

A properly modernised railway bridge can become the most valuable facilitation of migration of animals, as the main passage for otters, beavers, wolves, lynx and other forest animals (deer, wild boar, small predators), species which in their migrations and penetration of home range are willing to use the semi-natural river banks. In order to keep the river course clear throughout the year, we recommended building additional spans on dry land along the river bed, if land relief allows it. Such a solution was proposed, among others, at the crossing of the E65 railway line with the River Drwęca Valley Natura 2000 site.

6. Recapitulation

Taking into account the effect of the railway investment on Natura 2000 sites and the integrity of the Natura 2000 network results from the current regulations of EU and national law. In line with the same regulations, not the place of origin but the place of effect is decisive in starting the procedure of assessment of impact on Natura 2000 sites. Therefore, the procedures should consider not only the areas crossing with railway investments, but also remote areas, in which there is the risk of effect. The most important effects of modernisation of the railway line on Natura 2000 sites which we identified are: (1) cutting trees or bushes, (2) noise and disturbance related to the exploitation of the line, (3) the effect on surface and underground waters during construction, (4) fauna mortality as a result of collision with trains, (5) the barrier effect of the railway line on animals, (6) the spreading and distribution of alien species and other, described in the present study. In order to minimise the negative effects, we proposed the use of various mitigation measures, such as: (1) appropriate passages for wildlife, (2) preservation of valuable habitat patches, (3) redevelopment of bridges and (4) installation of experimental acoustic dispersers.