

LANDSCAPE ECOLOGICAL CONSEQUENCES OF THE CITY OF PRAGUE SUBURBAN-SPRAWL DEVELOPMENT DEMONSTRATED ON THE SEWAGE CONDUIT CONSTRUCTION

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Abstract

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Prague suburban landscape development was demonstrated on one of the sewage conduit extensions. The impacts of the construction were assessed using the original method of environmental vulnerability and development feasibility. Specific problems of historical heritage, geological, hydrological and biotic aspects of the problem are assessed in detail using multidisciplinary evaluation of the critical factors. The feasibility of the project is estimated from the possible risks of the impact, that the construction might have, both during the implementation phase and upon its completion. These risks are satisfactorily solved by conditions stipulated in the study of biota, air and noise pollution and historical values, which make part of the EIA procedure. The most sensitive area will be protected by using tunnel construction of the sewage conduit.

Key words: Prague, suburban development, waste water drainage system, landscape ecological vulnerability, project feasibility

Introduction

Ever increasing use of suburbia is typical for the development of the Czech capital city of Prague. Both the current inhabitants and the newcomers tend to look for a place for living that would be situated in greenery areas with an easy access to both the city centre and the broader inner city. The value of the farming land belt surrounding Prague is incomparably lower than that of the newly emerging building land in the city. The objective of this paper

will not discuss the pros and cons of this process or to compare the benefits of suburbia colonisation with the losses caused by urban-sprawl, but to discuss the context of city spreading demonstrated on a case study describing a process initiated by expansion of urban area, the extension of a trunk sewer to Prague's borders, an investment that is necessary instrumental for the city to survive.

Prague's sewer system is based on a network of about ten trunk sewers branching into secondary networks, which conduct wastewater to the central wastewater treatment plant and other minor plants. The H sewer is one of the trunk sewers, conducting waste water from one of the eastern parts of Prague and it was necessary for the H sewer to be extended to meet the city's development in that district.

That extension was in conflict with the historically valuable centre of Dolní Počernice and preserved natural monument of Počernický rybník (Počernice Pond).

Research sites and methods

Historical consequences of the plan for the affected area

The wavy countryside in the basin of the Rokytka stream, where the current village of Dolní Počernice is situated has been inhabited since prehistory, particularly at the upper bench up the northern side of the current Počernice pond. This was the place where a settlement of the Rivnac culture people was founded in the late Stone Age – Eneolite about 4.000 years BC, protected with a pointed-pale fencing. In later periods, the inhabitants came down nearer to Rokytka, leaving marks of their existence by the bank of the pond and particularly by the north-western edge of the village in the location of the former sand quarry on a slightly high-ground lip between the confluent of Rokytka and Chvalský stream.

Between 1800 and 1700 BC, a large settlement of the Bronze Age people of the Unetice culture on this location developed here, with a burial ground of a uniquely large area and distinctive folded position of dead bodies. After some time a settlement dating back to the "Roman times" originated on the former Unetice settlement in the 2nd century AD, with residential huts trenched in sand.

The first Slavic settlers of the future Dolní Počernice chose to live near old transit routes leading to the ford crossing Rokytka. We should expect that that was the centre of the oldest settlement, in the location of the current old village situated over the ford crossing the neck of the marshy valley of Rokytka. The settlement disintegration in the early Middle Ages accompanied by the inclusion of additional farmsteads seems to have formed a cluster-type village, the layout of which has been preserved since the 12th century.

At present, the preserved cultural monuments under the state protection include the old and new castles, church, and a pub.

Environmental consequences of the construction project in the affected area

The area is classified as belonging to the province of central European deciduous forests, the Hercynian sub-province. It is part of the bioregion No. 1.5 "Českobrodský". The prevailing biota is slightly thermophilic of the 3rd oak-beech altitudinal vegetation zone (Culek et al., 1996).

The pond is located at the Rokytka stream, in the western part of Dolní Počernice. There is an old park downstream of the pond in the floodplain of the Rokytka stream. The pond's basin upstream is formed by the Rokytka, Říčanský, Běchovický and Blatovský streams. The area of this basin is 83 km². It has been a natural monument since 1988. It is protected for its significant plant and animal communities.

The floodplain of the Rokytka stream is formed by quaternary deposits, mainly clay-sand alluvia. The subsoil consists of the Upper Ordovician sediments – stages Beroun to Dvůr Králové. They were deposited in a cold sea that gradually shallowed. Beroun is represented here by its upper part – the Vinice, Zahořany and Bohdalec groups. The Vinice group is formed by monotonous black and grey mica schist with a low content of mica. The time of its sedimentation was characterised by a deep mud bank and lack of oxygen. This is also reflected by the fauna found here – small Brachiopoda with prevailing species *Aegiromena anquilina*; trilobites are represented here by *Marrolithus*, *Dalmanitina*, *Selenopeltis* and other genera; we can also find bivalves, ostracods and hyolitha. The Zahořany group is characterised by monotonous grey or grey and green siltstone with high content of mica. They occasionally contain originally calcareous concretions (transformed by weathering even to limonitic residue). Rich benthic fauna was found both in the siltstone and especially in the concretions (the close well-known location “Štěřboholý brickyard”). Brachiopoda form a much varied community, characterised by *Drabovia* and *Aegiromena*, over 30 species of trilobites (*Dalmanitina proeva*, *Marrolithus ornatus*, *Stenoparia panderi*, *Selenopeltis inermis* and others, gastropods, bivalves, Conularia, Bryozoa, and common echinoderms. The Bohdalec group covers the largest area around the Počernice pond. It is mostly found here in its shallow-water – polyteichus facies. The slates contain locations of clay limestone, calcareous siltstone, and sandstone with calcareous or secondarily limonitized concretions. It is rich in Bryozoa such as *Batostoma*, *Trochopora*, *Monotrypa*; there are numerous Brachiopoda and small trilobites. The Dvůr Králové stage is formed by a single group – the Dvůr Králové group. It consists mainly of green and grey clay slate, with only sparse fossil finds. The above-mentioned brief overview indicates the possibility of fossil finds in the area of the Počernice pond natural monument. There are basically no outcrops. Fossil finds can be expected if artificial exposures uncover basement rocks. Considering the nature of rocks, i.e. occurrence of concretions and solid calcareous locations, there are likely occurrences of weathered rock not deep under the current surface. Many fossils were found here during the construction of a motorway circuit.

Along the western banks of the pond, there are vast floodplain forests of the *Alno-Ulmion* type (turning into the *Carpinion* type at higher altitude), and reed beds (*Phragmition*). Southern banks are already affected by landfills. The eastern part is fully overgrown with reeds and shrubby willows. Limited areas of free water surface are characterised by vegetation of the *Hydrocharition* type. There are sporadic impenetrable patches of shrubs and climbing plants of the *Senecion fluviatilis* type. The eastern-most part of the Počernice pond natural monument is threatened by a waste dump near the Běchovice railway station.

The shallow tributary part of the pond has prevailing high sedge vegetation dominated by *Carex disticha*, *Carex acuta* and *Carex acutiformis*. The following species have been found in the pond's littoral: *Phragmites australis*, *Typha angustifolia* and *Phalaris arundinacea*. Water vegetation in the pond itself is very poor, with only three species of vascular plants found: *Zannichellia palustris*, *Potamogeton pectinatus* and *Potamogeton pusillus*.

Wetland alder vegetation with *Alnus glutinosa* is found in the eastern part where it forms a narrow border along the pond and the reeds. The banks are mainly overgrown with narrow strips of floodplain tree species with prevailing *Fraxinus excelsior*. The eastern part of the right bank has vast areas of willows (*Salix cinerea*, *Salix viminalis*, *Salix triandra*, *Salix caprea*). Transitions to *talus forest* and the *Carpinion type forest* are developed in the western part. The vegetation of natural species is sporadically replaced by acacia trees.

With regard to potential natural vegetation, the key phytocoenoses in the given area are *Pruno – Fraxinetum Carpinion*, *Molinio arundinaceae-Quercetum*, and *Genisto germanicae-Quercion*.

Pruno – Fraxinetum is a frequent association of flatland floodplain locations of the Czech Cretaceous Basin and Prague Plateau. It is also found in the Czech-Moravian highlands, the foothills of the Orlické mountains, and border zones of the Chřiby mountains. Before the intensive deforestation of the wide floodplains, this association was probably rather common in the downs of the whole Czech highlands. The *Pruno – Fraxinetum* association in the area of Prague is found particularly in the flat eastern part. It is common in the wide floodplains of the Botič, Rokytka, Říčanský and many other streams, and it was also found in the flat depressions e.g. around Dolní Počernice.

In the 2005 field research, 135 species of vascular plants (trees excepted) were found in the given area. This list can be limited due to the absence of a research of the spring aspect of the herb layer, where some spring ephemera have surely not been recorded.

In the field research, no endangered species of plants have been found in the part of the Počernice pond natural monument potentially affected by the construction project, except for *Cyperus fuscus*, newly found in

this natural monument, which is however strictly limited to uncovered pond bottom, and its occurrence in the location is conditioned by lowering the water level in connection with the reconstruction of the dam. The nearest known location of this species is the so-called Hrněčské meadows by Průhonice u Prahy.

The plants considered endangered in the research were those listed in the addenda of the Regulation No. 395/1992 Coll., and in according to Art. 3 of the Act No. 114/1992 Coll., on the protection of nature and landscape. The plants considered significant in the research were those species listed in the Red Book of the Czech Republic, with special attention being deserved among other things by the first discovery of *Cyperus fuscus* L., limited to uncovered bottom, which was found in the affected location in connection with the reconstruction of the pond dam and radical lowering of the water level. With adequate pond management after its filling, the population of this species in the pond's basin can be preserved. This location is however outside the area affected by the construction project.

Besides artificial anthropic systems such as fields (areas used in agriculture as well as areas currently lying fallow; horticulture), gardens (detached houses with gardens, cemeteries, allotments), parks (intensely cultivated compact plantations of woody ornamentals in combination with regularly mown lawns), lawns (mown several times in the season, in high-density development, rich in dicotyledonous plants, without significant occurrence of planted trees or shrubs), and urban greenery (greenery typical of open areas in urban development consisting of loose plantations of trees either in the areas of lawns or in open unsown areas), there are seven syntaxonomic units identified in the area (Moravec et al., 1991):

1. *Phragmition communis* K o c h 1926 – freshwater associations of still water reeds
2. *Arrhenatherion* K o c h 1926 – mesophilic meadows of lowlands to submontane level
3. *Salicion triandrae* T h. M ü l l e r e t G ö r s 1958 – willow shrubs on the frequently flooded banks of fast flowing streams
4. *Alno-Ulmion* B r. B l. e t T ü x e n e x T c h o u 1948 em. T h. M ü l l e r e t G ö r s – floodplain forests representing the primary vegetation of flooded and waterlogged areas
5. *Carpinion Issler* 1931 em. M a y e r 1937 – floriferous mesophilic, occasionally even slightly hygrophilous oak-hornbeam and oak-linden groves representing the primary, mostly climax vegetation of lowland and highland level
6. *Senecion fluviatilis* T ü x e n 1950 – natural as well as anthropic fringe associations of the flooded areas of rivers and streams, rarely of still water areas, often in contact with reeds
7. *Arction lappae* T ü x e n em. G u t t e 1972 – ruderal associations of biennial to perennial nitrophilous plants on anthropogenic soils of ruderal locations (dumping grounds, waste dumps).

The Počernice pond is one of the most significant pond locations in Prague. The environmental research of the affected area together with studying corresponding literary sources suggests the presence of the specially protected animal species mentioned below. The additional ornithological research discovered 53 nesting or migrating bird species, with two critically endangered species *Pandion haliaetus* and *Rallus aquaticus*, and three very endangered species – *Alcedo atthis*, *Podiceps griseigena*, *Acrocephalus arundinaceus* (according to the Regulation of the Ministry of Environment of the Czech Republic No. 395/1992 Coll.). There are several species of amphibians (*Rana esculenta*, *R. temporaria*, *R. ridibunda* and *Bufo bufo*), classified according to the above-mentioned Regulation No. 395/1992 mainly as critically, very or generally endangered species. The following species of mammals have been found in the affected area – *Lepus europaeus*, *Capreolus capreolus*, *Sus scrofa*, *Vulpes vulpes*, *Martes foina*, *Mustela nivalis*, *M. nigripes*, *Microtus arvalis*, *Mus musculus* and *Talpa europaea*. Molluscs are represented by *Anodonta cygnea*, gastropods are represented by *Anisus vortex* and *Viviparus contextus*. The beetles found here among others are the ground beetles *Stenolophus mixtus*, *Bembidion fumigatum*, *Europhilus gracilis*; small weevils are represented by the interesting and rare species *Eubrychius velutus*, living under water on whorled water milfoil (*Myriophyllum verticillatum*).

Aim characteristics and substantiation

Construction of the extension of the interceptor, which enables gravitational draining of sewage from the area of Dolní Počernice and adjacent suburban parts of Prague into the central waste water treatment plant has long been postponed and solved by means of alternative methods that required pumping stations as well as using local waste water treatment plants, often nearing the end of their lifetime.

The designed extension of this interceptor shall continue the already constructed section of the interceptor H in the periphery of Dolní Počernice towards Prague. The track of the sewer, 1.987 m long and of a DN 800 profile, shall lead through the historical centre of Dolní Počernice via a tunnel, it will continue through the protective zone of the nature sanctuary of the Počernice lake, out of the full-grown greenery along the Rokytka stream, and it will end at the existing waste water treatment plant in the cadastre of Běchovice (its lifetime ends in the next few years).

The need of the implementation of this aim is substantiated by significant development of residential area being prepared in Prague's suburban parts of Dolní Počernice, Běchovice and Újezd nad Lesy, including the vast technological park of Běchovice.

The designed solution enables to close down four pumping stations and three local waste water treatment plants in this part of Prague. This will bring less operating costs of the whole sewage draining system in this area.

Sewage will be definitively drained out of the area of the Počernice lake, which will contribute to the revitalisation of this nature sanctuary.

In the historically and scientifically sensitive area the extension of the interceptor H shall be realised by means of a tunnel (1650 m) with technical and safety shafts, and also via a 337 m ditch.

Classification of landscape vulnerability and feasibility of the project objectives

The methods used were our own well-established methods of classifying the vulnerability of landscape and objective feasibility, as adapted to the specific parameters of the subject area and character of the considered objective (Martiš, 2001). These methods enable to classify and evaluate all the relevant data, regarding the area in relation to the aim being considered, and to supply grounds for the evaluation of the influence it might have on key items of the environment. Based on analysis and classification of the data they yield a synthesis of the total vulnerability rate of the landscape, and feasibility of the objective, using a seven-point colour scale.

In this particular case, the evaluation was performed using expert conclusion from the spheres of geology, hydrology, pedology, detailed biological research (including dendrological aspects), and landscape ecology. An important input within the evaluation was also the assessment of the history of the subject area. The above mentioned seven-point scale of vulnerability and feasibility was applied in each of the 54 shafts of the sewer (Fig. 1). The final classification was processed taking the individual expert opinions' relevance into account, as well as based on the general knowledge of the problem being solved and the subject area. Prevailing highest rate of vulnerability (red, or even better to say, scarlet) in partial evaluations determined the classification of the final opinion as that of generally extraordinary vulnerability of the nature, and, to a certain extent, also not easy feasibility of the aim in reality. If yellow and green prevailed in partial expert evaluations, there was no reason to classify the final opinion in any other way. Prevailing blue colour that determined the feasibility of the aim was reflected mainly in verbal conditions of implementing the aim.

Results and discussion

In this particular case, i.e. the construction of the extension of the interceptor H in the area of Dolní Počernice (or, partly also in Běchovice), the evaluation of environmental vulnerability of the landscape and the feasibility of the aim shows that the greatest attention should be paid to construction activities in the historical centre of Dolní Počernice (shafts 1–9). In this area some problems may be caused by the subsoil (shafts 1, or 3–9), as the construction passes quaternary sediments that are sandy or gravel-like by their grain size, which may bring problems from the point of hydrology. As far as hydrobiology is concerned, the most sensitive section appears to be the one between shafts 23 and 26 (valuable littoral); regarding fauna, the section between shafts 30 and 36 may be vulnerable (mainly in relation to birds' nesting places).

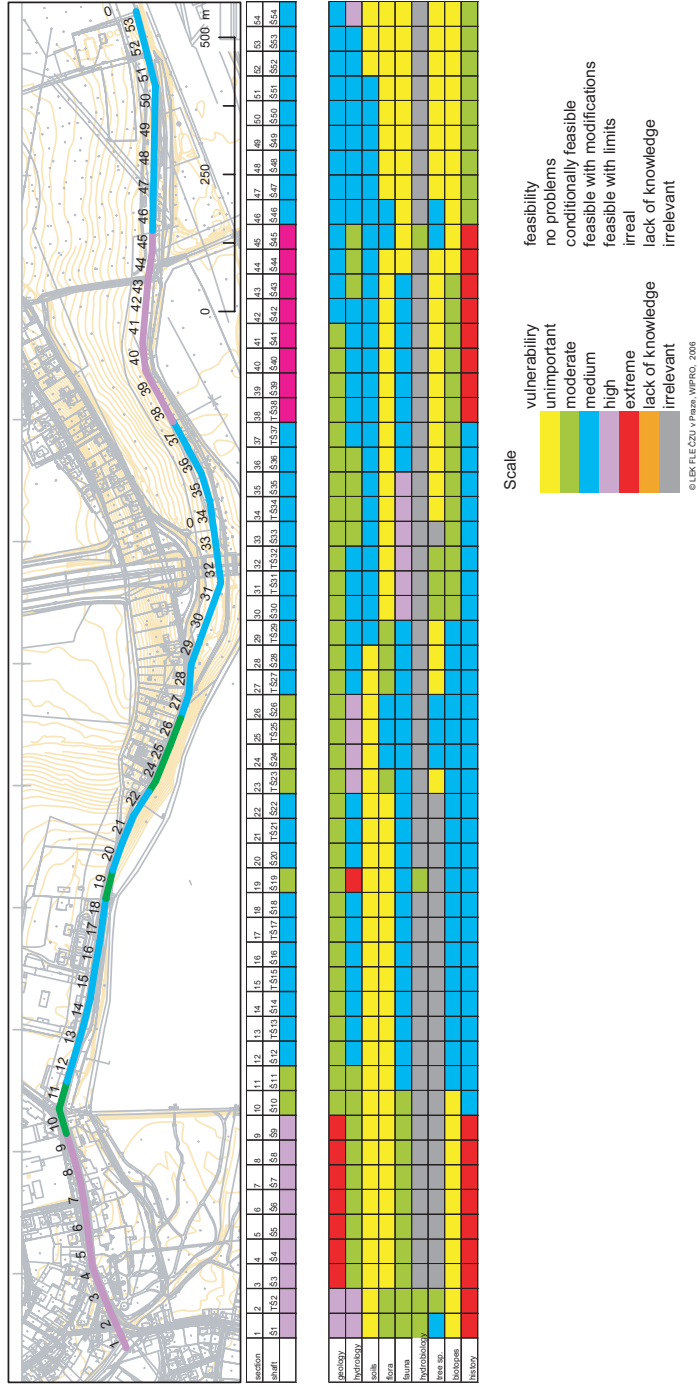


Fig. 1. Classification of ecological vulnerability and project feasibility of the of H sewage conduit construction in Dolní Počernice with the assessment of the 54 shafts sections.

As proven by multidisciplinary evaluation of critical factors using methods of classifying vulnerability of landscape and aim feasibility based on the assessment of the relevance of the individual expert opinions (ranging from geology, hydrology, soils, flora, fauna, hydrobiology, dendrology, landscape ecology, and history of the subject area), as well as based on general knowledge of the problem being solved and the subject area, the implementation of the aim to extend the interceptor H in the cadastre of Dolní Počernice, or Běchovice, shall not cause any intrusion to historical, cultural or scientific merits, or any disturbance of ecological stability of the interest area. The terms of implementing the aim and its operation are clearly defined. Upon the completion of the construction, improved comfort of living in the historical residential area of Dolní Počernice, as well as better composition and functioning of the vegetative cover within the protective zone, and also of other values worth protection, of the nature sight of the Počernice lake should presumably improve.

Conclusion

From the geological and hydrogeological point of view the environmental vulnerability is evaluated as generally mild in Ordovician stabilized sediments, medium in non-stabilized quaternary sediments of variable grain composition, and high in non-stabilized quaternary sediments of sandy and gravel-like grain composition (Rokytká terraces) - here it is mainly the high porosity and permeability of the rocks that is taken into account.

The feasibility of the project is estimated from the possible risks of the influence the construction might have (both during the implementation and upon its completion) with regard to rock environment. This influence has much to do with the technology used for the implementation. Whereas in using an open ditch the feasibility should be more or less free of any bigger problems, digging a shaft may bring unexpected situations, which rather makes the feasibility conditionally realistic.

According to us, the main discrepancy between feasibility and vulnerability dwells in the following explanation: Between designed shafts, TS2 and S9, the construction runs via quaternary sediments that are sandy or gravel-like by their grain composition (Rokytká terraces). In this area, though, there is the old residential area of Dolní Počernice present, and it can be assumed that the local aquifer bound to the Rokytká terrace can be used as the source of drinking water within the objects of the old residential area. The geological environment is none too complicated, thus the feasibility is conditionally realistic. We see the risk (i.e. high vulnerability) in theoretically potential failure of sticking to a suitable technology, and subsequent affection of the level – or quality – of the subterranean water, both during the implementation of the construction and upon its completion.

In the subject area there is low-class farmland prevailing in the open landscape, i.e. land showing average production power and mean level of protection (can possibly be used for building), or land with production power below average and limited protection, utilizable also for building.

The construction of the extension of the interceptor H may be associated with negative effects of construction (pollution of the surrounding area with noise, dust and traffic caused by the operation of building machines, and supplying building materials), and thus possibly disturb the factors determining the wellness of inhabitants, as the construction site is situated in a residential area. These risks are satisfactorily solved by conditions stipulated in the study of emissions, immissions and noise, which makes part of the notice for EIA procedure (Martiš, 2006).

The construction needs to be implemented out of the period sensitive for the avian (nesting, etc.), i.e. the time between the beginning of spring and full summer must be excluded. The relevant service of the Institute of Archaeology, Academy of Science of the Czech Republic, in Prague must be noticed of the construction at least 10 days prior to its commencement. When stripping the top layer of the soil, it is necessary to store topsoil and the layers beneath it separately so that they can subsequently be utilized for reclamation. If the construction comes into contact with valuable trees, adequate protection of the root system, trunk and crown must be provided for. When building open ditches, it is necessary to inspect these every morning, and to remove animals (amphibians, reptiles, small mammals) that may have fallen into them. If necessary, the river water shall be transferred via a steel pipe (DN 1000, 15 m long), the ends of which shall be embanked; when building the tunneled section of the sewer along the Počernice pond it will be necessary to lower the level of water, or even to drain the lake completely.

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References

- Culek, M. et al., 1996: Biogeographic Division of Czech Republic (in Czech). ENIGMA, Praha.
Martiš, M., 2001: Ecological vulnerability of landscape – how to categorize it? Proceedings from the 21th Annual Meeting of the International Association for Impact Assessment, May 25–June 3, 2001, Cartagena, 5 pp.
Martiš, M., 2006: Classification of Landscape Ecological Vulnerability and Feasibility of Development Projects and Concepts. Inaugural dissertation. ZF JU České Budějovice.
Moravec, J., Neuhäusl, R. et al., 1991: Natural Vegetation of the City of Prague and its Reconstruction Map. Academia, Praha, 200 pp.

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Martiš M., Pecharová E., Kašparová I.: **Krajině ekologické souvislosti rozvoje předměstí Prahy na případu stavby prodloužení kmenové kanalizační stoky.**

Rozvoj předměstí Prahy si vyžaduje rozšiřování sítí technické infrastruktury. Jednou z takových staveb se stalo prodloužení kmenové stoky H v prostoru Dolních Počernic. Vzhledem k mimořádným přírodním a kulturně historickým hodnotám dotčeného území (přírodní památka Počernický rybník, historické osídlení území od neolitu, historie obce Dolní Počernice od 12. století) byla tato stavba posouzena s využitím metody klasifikace ekologické zranitelnosti krajiny a proveditelnosti tohoto záměru. Nejcitlivější jsou úseky v oblasti osídlení v neolitu a historické části Dolních Počernic. Přírodní hodnoty, které jsou důvodem ochrany Počernického rybníka, nejsou z hlediska stavby zásadní. Ve volné krajině bude vedena stoka v terénním zářezu s kontrolními šachtami, v osídlené části v tunelu s kontrolními šachtami. Posouzení prokázalo reálnou proveditelnost uvedené stavby.