COST-SUBURBAN WG1

- NOVI SAD - City Case report

City development and its subsurface

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1. Historical development of the city

The Novi Sad territory has been inhabited by humans since the Stone Age (about 4500 BC). A settlement was located on the right bank of the river Danube in the territory of present-day *Petrovaradin*. In antiquity, the region was inhabited by Illyrian, Thracian and Celtic tribes, especially by the Scordisci. Celts were present in the area already in the 4th century BC and founded the first fortress on the right bank of the Danube. Later, in the 1st century BC, the region was conquered by the Romans. During Roman rule, a larger fortress was built in the 1st century (Cusum) and was included in the Roman province of Pannonia.

In the 5th century, Cusum was devastated by the invasion of the Huns. By the end of the 5th century, Byzantines had reconstructed the town and called it by the names *Petrikon* or *Petrikov,* after St. Peter. In the Middle Ages, the area was subsequently controlled by the Ostrogoths, Gepids, Avars, Franks, Great Moravia, Bulgaria, again by Byzantines, and finally by the Hungarians. It was included into the medieval Kingdom of Hungary between the 11th and 12th century. Hungarians then began to settle in the area, which was previously populated mostly by Slavs, and the place was mentioned for the first time under the Hungarian variant Peturwarad or Pétervárad (Serbian: Petrovaradin), which derived from the Byzantine variant, in documents from 1237. In the same year, the existence of several other settlements were mentioned to exist in the territory of modern urban area of Novi Sad.

From 13th to 16th century, the following settlements existed in the territory of modern urban area of Novi Sad:

- on the right bank of the Danube: Pétervárad (Serbian: Petrovaradin) and Kamanc (Serbian: Kamenica);
- on the left bank of the Danube: Baksa or Baksafalva (Serbian: Bakša, Bakšić), Kűszentmárton (Serbian: Sent Marton), Bivalyos or Bivalo (Serbian: Bivaljoš, Bivalo), Vásárosvárad or Várad (Serbian: Vašaroš, Varad, Varadinci), Zajol I (Serbian: Sajlovo I, Gornje Sajlovo, Gornje Isailovo), Zajol II (Serbian: Sajlovo II, Donje Sajlovo, Donje Isailovo), Bistritz (Serbian: Bistrica);
- Some other settlements existed in the suburban area of Novi Sad: Mortályos (Serbian: Mrtvaljoš), Csenei (Serbian: Čenej), Keménd (Serbian: Kamendin), Rév (Serbian: Rivica).

Novi Sad, as we know it today, is one of the younger cities although there are traces of life even from the Neolithic period, the occurrence of tundra and steppes of Pannonia, after the formation of ice and the withdrawal of the Pannonian Sea. Mostobran, the first municipality in place of today's city was founded in 1694, when Serb merchants formed a colony across the Danube from the Petrovaradin Fortress (Figure 1). This small settlement was known by the name: *Račko Selo*, then *Rački grad* and *Petrovaradin Šanac*, and the current name of the city, Novi Sad, dated from February 1, 1748th.

Figure 1. Novi Sad 1745

(Source: Petrović et al., 1987)

During the bombing of the city from the fortress on June 12th in 1849, by the Hungarian army, when the city was devastated, its centre almost completely destroyed, and development halted. This caused massive damage to the economy and life in Novi Sad.

However, the city was quickly rebuilt in the second half of the 19th century. From the World War I, Novi Sad was left intact thanks to its distance from fronts. In the period between the two world wars, Novi Sad grew into an important economic centre for the time, and before the World War II, the city had 70,000 inhabitants. In 1941, Novi Sad fell into the hands of the Hungarian fascist soldiery. On October 23th in 1944 it was liberated, but it was ruined, with only 40,000 inhabitants, without any factories, and with no electricity. After the liberation, the city has grown into one of the most important economic, industrial, financial, cultural and educational centre in former Yugoslavia.

2. City description

2.1 City location and key data

Novi Sad is the second largest city in Serbia. It is the cultural, educational, scientific, economic and administrative center of the Autonomous Province of Vojvodina – nothern province of Serbia.

It is located at 19°20' east longitude and 45°46' north latitude, at the 1255 km point of the Danube River, and it covers a territory of two regions: Bačka region on the left bank of the Danube and Srem region on the right bank of Danube river (Figure 2). Elevation of Bačka side ranges from 72 to 80 meters, while the Srem side elevation goes up to about 250 m.

Novi Sad lies in the intersection of the main European Road Corridors, the Danube river banks and Danube-Tisa-Danube (DTD) Canal facing the northern slopes of *Fruška Gora* Mountain.

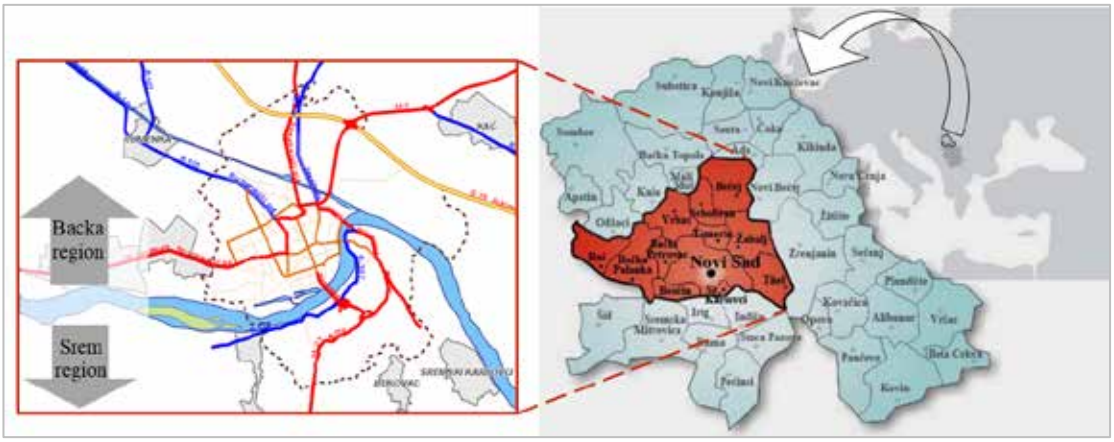


Figure 2. Geographical location of Novi Sad (Source: adapted from PE Urbanizam, 2004)

The population of the city of Novi Sad is relatively large. According to the last census in 2011, the city of Novi Sad had 341,625 inhabitants, while 277,522 inhabitants live in urban area (Statistical Office of the Republic of Serbia, 2012). The urban area covers an area of 106.2 km^2 and the total city area covers 699 km^2. The former has an average population density of 2,183 people per km^2 and the latter has 526 inhabitants per km^2. The total number of dwellings is 72,513 with an average number of 2.63 persons.

The city of Novi Sad consists of two urban municipalities: The Municipality of Novi Sad (in Bačka region on the left river side) and the Municipality of Petrovaradin (in Srem region on the right river side). There are 16 settlements located on its territory: *Begeč*, *Budisava*, *Bukovac*, *Čenej*, *Futog*, *Kać*, *Kisač*, *Kovilj, Ledinci*, *Novi Sad*, *Petrovaradin*, *Rumenka*, *Sremska Kamenica*, *Stepanovićevo*, *Veternik*, *Stari Ledinci*.

For transport, people use automobiles (44.7%), public transport (29.1%), walking (21.9%), bicycles (3.0%) and motorcycles (1.2%). The mobility is 2.65 trips/day/capita or 744,750 trips/day in total (PE Urbanizam, 2009a).

2.2 Petrovaradin Fortress

The Petrovaradin Fortress is a symbol of Novi Sad. It is an outstanding achievement of fortification construction of the 18th century, and one of the most complex, biggest and best preserved artillery bastion fortifications in Europe. The area of the Petrovaradin Fortress is completely located at the territory of the Petrovaradin municipality that geographically belongs to Srem. According to a legend, the name Petrovaradin is derived from words of numerous languages – "*Petra*" is Latin for rock, "*var*" is Hungarian for town, and "*din*" is Turkish for faith. Following that, Petrovaradin means "*the town on a rock strong as faith*". Another name of the Petrovaradin Fortress is "*the Gibraltar on the Danube"* due to its strategic position and the significance the fortress had for the Habsburg monarchy, but also reflects its stance high on the steady rocks overlooking the Danube.

The Petrovaradin Fortress was built in the period from 1692 to 1780, with great efforts of the whole Habsburg Empire involving huge financial resources and the great loss of life due to hard work during its construction. It is built on a vast area of 112 acres, and it has seven levels, of which four are underground. Underground levels were constructed between 1768 and 1776. There is an extensive array of underground tunnels with cumulative length of approximately 16 km.

The area of the Petrovaradin Fortress including the Lower Town, is defined as the principal area, i.e. the primary centre for tourism in the greater Novi Sad area. Status of the Petrovaradin Fortress is regulated and guaranteed by the Law on Cultural Heritage, adopted in 1994 by the National Assembly of the Republic of Serbia. In that sense, it is the immovable cultural heritage of great importance ("Official Gazette of the Republic of Serbia", 1994). It was decided in the previous act of the Executive Council of Vojvodina, that the Upper and Middle fortress and the Lower Town (Figure

3) were an immovable cultural property and historical complex of great importance (Garača *et al*, 2012).

Figure 3. Plan of the Petrovaradin Fortress (Source: Garača et al., 2012)

The fortress is managed by several public companies at the same time, whereby the managers of these public enterprises represent the committee in charge of monitoring.

3. Area characteristics

3.1 Geology

Basic urban characteristics of Novi Sad were shaped by the natural environment (geography, climate impacts and location), cultural and historical traditions, economic, political and other conditions of development.

The topography and relief of Novi Sad is characterized by a variety of configurations and the geological structures of the region. The overall development of the city was mostly influenced by the natural suitability of crossing the Danube, and thus all the roads are acquired in Novi Sad and Petrovaradin to easily and safely cross the Danube. Maximum levels of groundwater, planning and construction of a canal system for wastewater and atmospheric waters management and the level of the Danube River had the most significant impact in determining the levelling of the area on the left bank of the Danube (Figure 4).

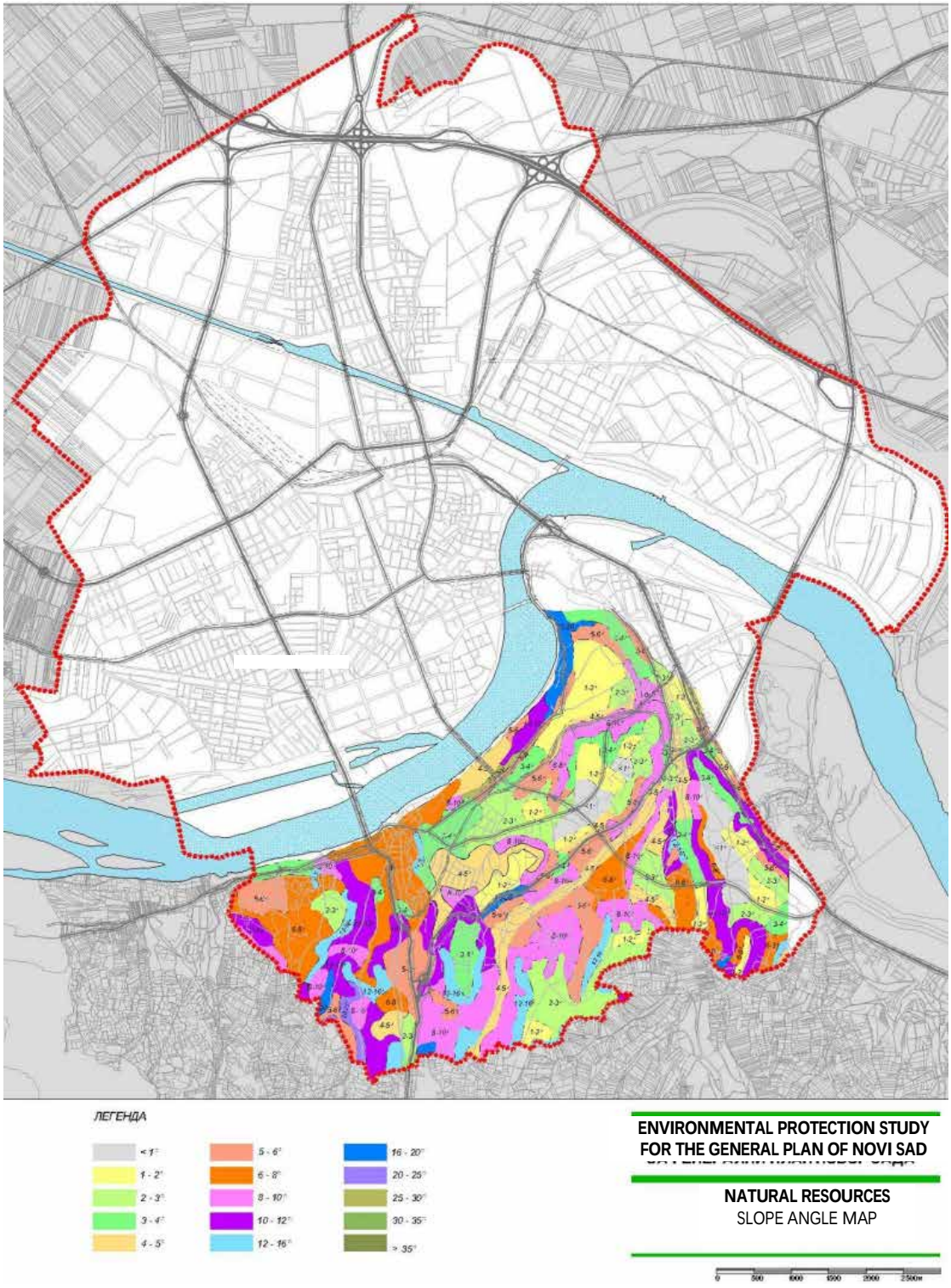


Figure 4. Angle of inclination of Novi Sad area (Source: PE Urbanizam, 2009b)

The construction of a large complex of the fortress and its needs for various civil services was another important factor for the development of the municipality of Novi Sad. Commercial, economic, cultural and political significance of Novi Sad surpassed the importance of Petrovaradin and became an important factor in the development of the region. However, the most important visual impression

associated with Novi Sad is the geographical position with agricultural hinterland of the Pannonia Plain, the position on the Danube River, and very near Fruška Gora Mountain.

3.2 Pedology

The soil of the area is heterogeneous and consists of automorphic, hydromorphic, halomorphic and subaqual types of soil (Faculty of Technical Sciences, 2011). The most widespread soil belongs to the automorphic order which is characterized by a soil profile which moisture is exclusively provided through atmospheric precipitation and there is no excess water retained in the soil profile because of water trickling through the soil. Significant land areas are covered by hydromorphic order soil which is characterized by additional moisture provided from diffuse water sources in terrain of higher elevation i.e. either flood or ground waters of different origin. Excessive soil moistening within the profile may be caused by the presence of an impermeable layer within the solum that causes a hydromorphism with all the consequences that are derived from it. Smaller areas are also covered by halomorphic order soils. These were also influenced by supplemental groundwater or surface water, and differ from the hydromorphic soils by being saline or alkalized. Subaqual soil formed under a shallow water cover of standing water represent the smallest land in the Novi Sad area based on a soil type division.

With different possibilities for using land with different soil types as a natural resource, most of the surface area of Novi Sad, north of the Danube has a great potential for primarily crop and vegetable production (PE Urbanizam, 2009b). The area south of the Danube, which includes the slopes of Fruška Gora Mountain is mainly eutric soil (eutric cambisol), chernozem on loess and loess sediments and rendzina the loess and loess sediments, while the lower parts of the coast are alluvial (fluvisol) and diluvial (colluvium) soil.

Fruška Gora slopes are predetermined for fruit and grape production. Areas where the climatic and topographic conditions prevent planting of vineyards and orchards, can be used as a meadow, pasture or forest land.

Land productivity largely determines the degree of utilization of other natural resources. A distribution of individual soil types (Figure 5) determinates the land use when considering numerous problems related to planning of all economic sectors (area urbanization, road network, industrial facilities, etc.)

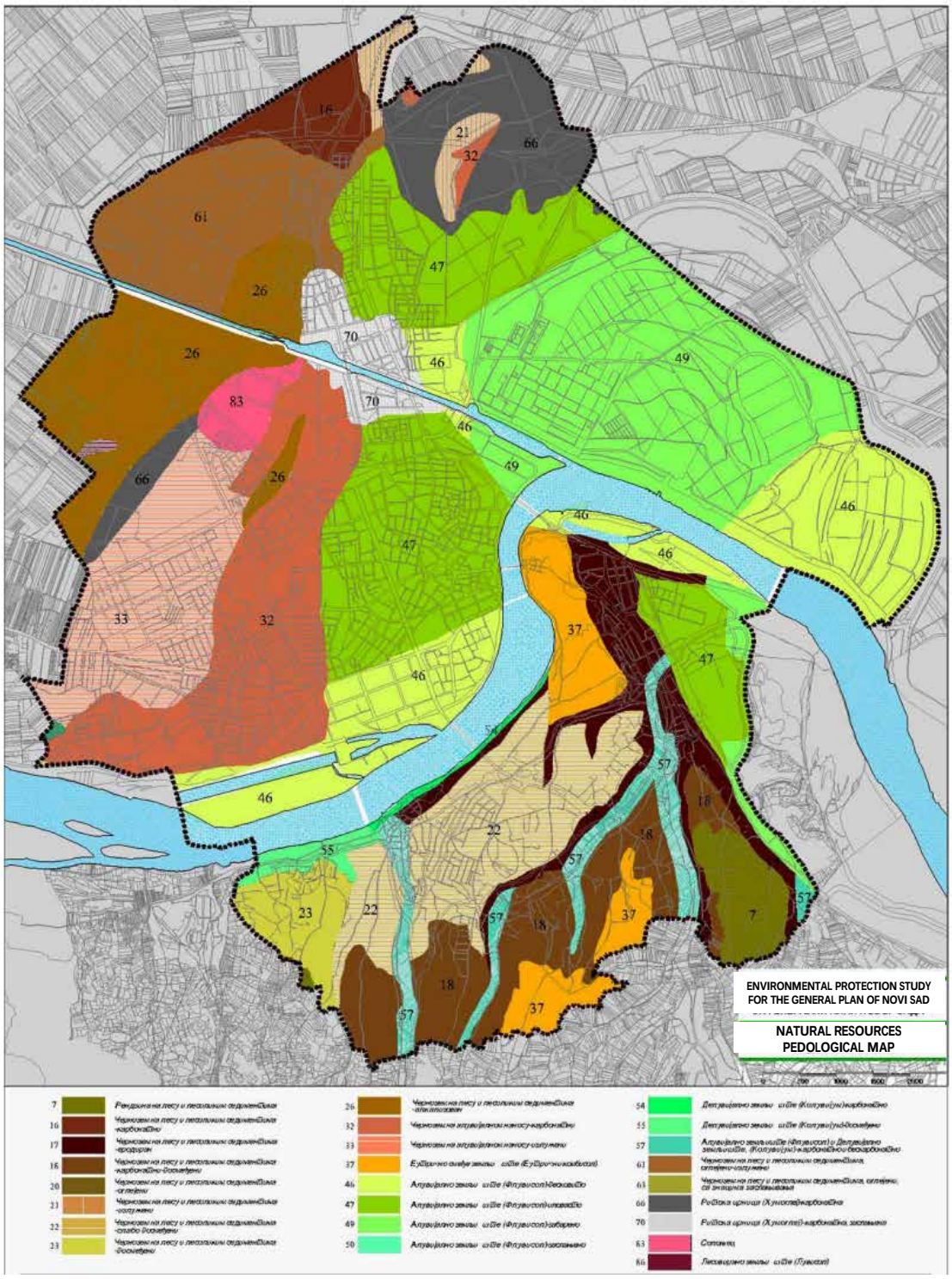


Figure 5. Pedological map of Novi Sad (Source: PE Urbanizam, 2009b)

3.3 Geomorphology

The city area is characterized by two distinct geomorphological units: Fruška Gora Mountain and the plain bottom of the Pannonian Basin. Due to its characteristics and long and rich geomorphological history, Fruška Gora Mountain is potential geotouristic destination of Serbia and also applied for UNESCO geopark recognition (Petrović et al., 2013).

Novi Sad city lies on the most southern part of the Pannonian Basin, which has a uniform geological structure and is fairly flat (Figure 6). Fluvial erosion is and has been limited to the interference of meanders in the Danube riverbed, and aeolian and fluvial reservoirs dominated as terrain building factors. The alluvial plain of the Danube is much more developed on the left side of the Danube riverbed, and in some parts it goes up to 10 km into the loess terrace. On the right side of the Danube riverbed, the alluvial plain occurs only sporadically in limited space. The alluvial plain of the Danube in Novi Sad area is asymmetric because it was created by river moving towards the south and breaking through the Fruška Gora Mountain. The largest part of Novi Sad is located on an alluvial terrace. The remains of the old Danube riverbed and ridges between them form the relief of todays geomorphological form. On the side of the Bačka region, there is a continuous plain which follows the entire length of the Danube. Smaller geomorphological forms of inundation plane are similar to the forms in loess and river terrace. Danube riverbed is carved in the inundation plain. Actively eroding the inundation flat, loess plain and the slope of the mountain, then causing a potential for landslide processes in the loess plain and transfer and deposition of the eroded materials, construction of islands and sandbars are among the most intensive geomorphological processes. The average width of the main channel of the Danube in Novi Sad area is approximately 600 m (Faculty of Technical Sciences, 2011).

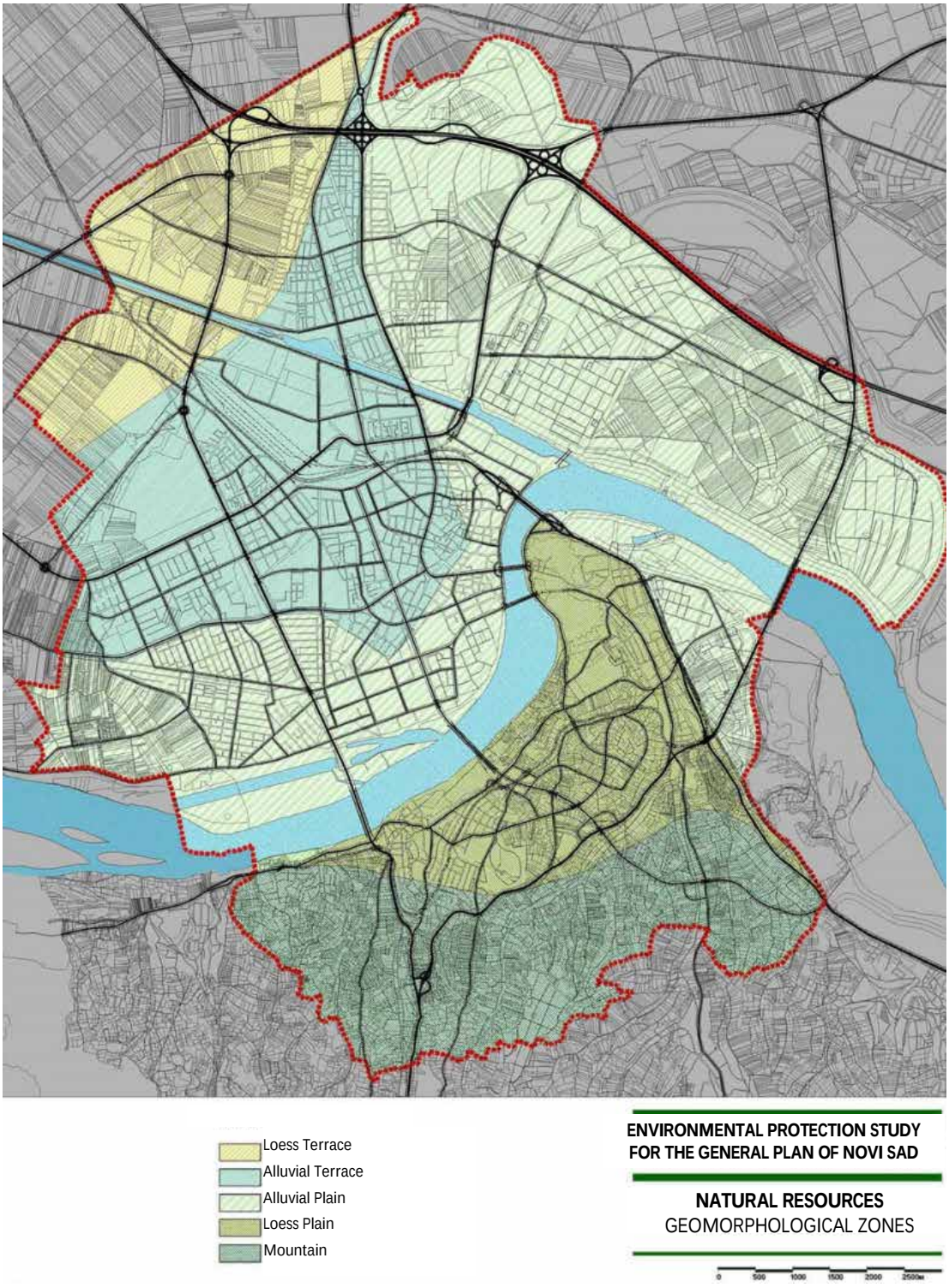


Figure 6. Geomorphological units of Novi Sad (Source: PE Urbanizam, 2009b)

3.4 Groundwater

A high level of groundwater is a problem that the city planners has had to deal with. The first and basic measures to protect the field from the adverse impacts of groundwater was uplifting the ground level by terrain filling. Before protection was made, ground level ranged from 74.50 to 75.50 m asl, and after terrain filling, the ground level elevation increased to range from 77.00 to 78.50 m asl. However, elevation of the terrain disrupted the natural topography of the field, which led to basements and cellars flooding in periods of unfavorable hydrological conditions. For these reasons, observation of groundwater levels started in 1953.

The depth of the phreatic aquifer is different in each geomorphic unit. In the alluvial plain of the Danube aquifer depth is 0 – 2.5 m, and in the alluvial plains of the streams 0 – 3 m. In the alluvial terrace its depth ranges from 0 – 4 m, and in the loess terrace goes to 8 m, but may be shallower. In the alluvial plain, the water regime of the phreatic aquifer depends on the regime of the Danube. High groundwater occurring in wetlands show considerable changes, as opposed to the deep groundwater that exhibit greater stability. In the lower parts of the alluvial plain groundwater reach the surface and flood such areas. Some parts of these areas are under water most of the year. Moving away from the river banks the impact of water level weakens, changes are slower and stability is greater (Faculty of Technical Sciences, 2011).

4. Urban infrastructure

4.1 Transport

Novi Sad is located at the crossing of European and national roads, among which the most important are: the Danube river, railway Vienna - Budapest - Belgrade - Asia, E-75 highway from Northern Europe - Central Europe - Balkan - Asia and the main national road, rail and waterways.

Road

Road traffic is a dominant transport mode with regard to the amount of both transported goods and passengers driven. Novi Sad has good road transport conditions, both in urban and rural areas. Four main national roads and five secondary national roads are connected with the primary urban transportation network (Figure 7).

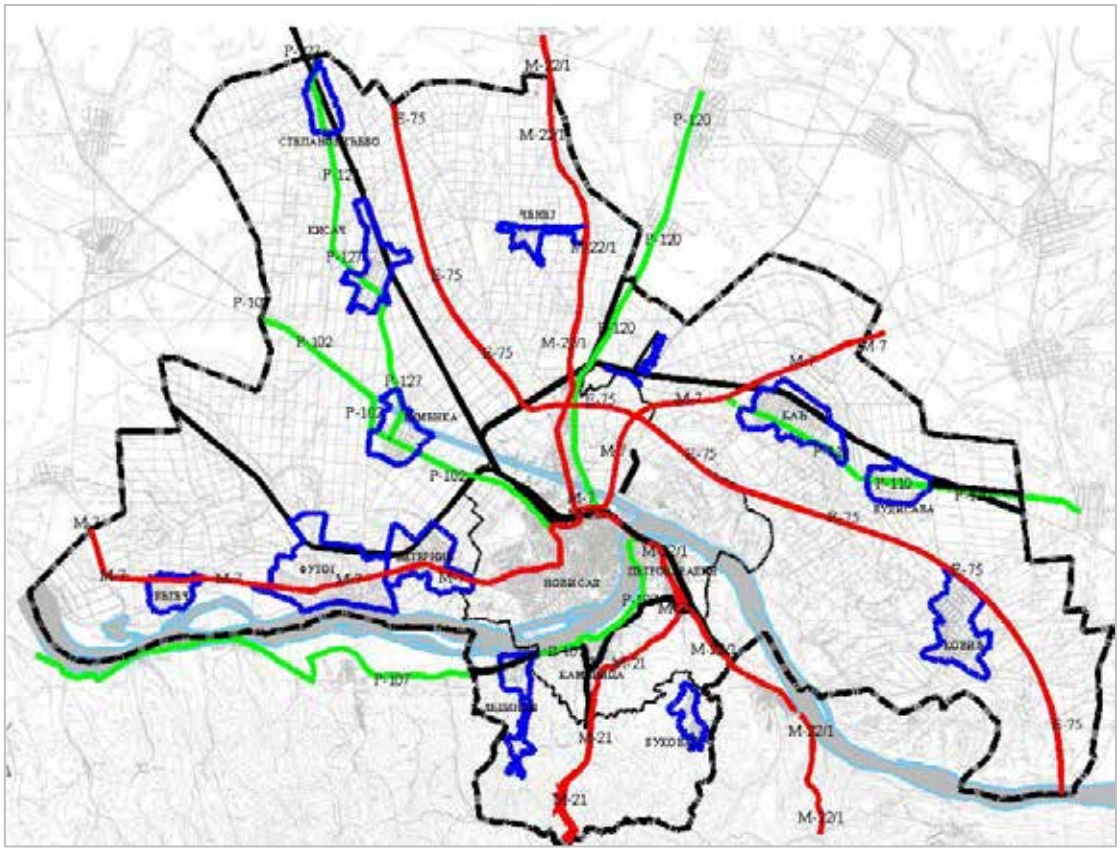


Figure 7. Road network in the area of the city of Novi Sad (Source: PE Urbanizam, 2004)

Urban transportation is performed mostly by cars (around 42% of total trips), public transport (around 32%, only by busses as there are no trams or underground transportation systems) and walking (around 22%). Bicycle culture is almost lost (only 4% of total trips are performed by bicycle), despite its convenient location and topography. Traffic planners are trying to implement measures for revival of bicycle culture in Novi Sad.

Rail

The rail transport system in the Novi Sad region is characterized by uniform spatial disposition and density of the railway network, which greatly influenced the development of many settlements along the railway. A new *Novi Sad Railway Junction* is one of the most advanced systems in the country, and its construction is in the final stages. The railway lines from the direction of Belgrade, Subotica, Bečej, Zrenjanin, Sombor and Beočin intersects here, so the city is well connected by rail with the rest of the province. Development of *Novi Sad Railway Junction* is harmonized with the development of the city. Therefore, the required area for the construction of this node is included in the current General Plan of the city.

Waterways

It is a general view that Novi Sad has not utilized its suitable geographic position to its greatest potential, especially with respect to waterway transport. The Danube River is an international waterway on which navigation must be carried out by the Convention of 1948. The Novi Sad gravitating area is characterized by a system of the Danube and Tisa waterways, canal Novi Sad - *Savino Selo* and large canal (King Alexander Canal) connecting the Danube with the river Tisa. The Danube waterway allows navigation of all vessel and barge types, and canals allows navigation of barge convoys in linear formation. There is a lock on the canal whose bandwidth meet the needs of navigation.

The Port of Novi Sad is the one of the most important inland ports in Serbia. It is located at 1254 km, on left bank of the Danube, in the Novi Sad – Savino selo Canal (part of the Danube – Tisa – Danube - DTD Canal network) at its 0.4 – 1.2 km (Figure 8). Port lies on the surface of 50 ha of sandy area, with height 5 m. All Serbian ports have been privatized currently, except the Port of Novi Sad, which is a public state owned port.

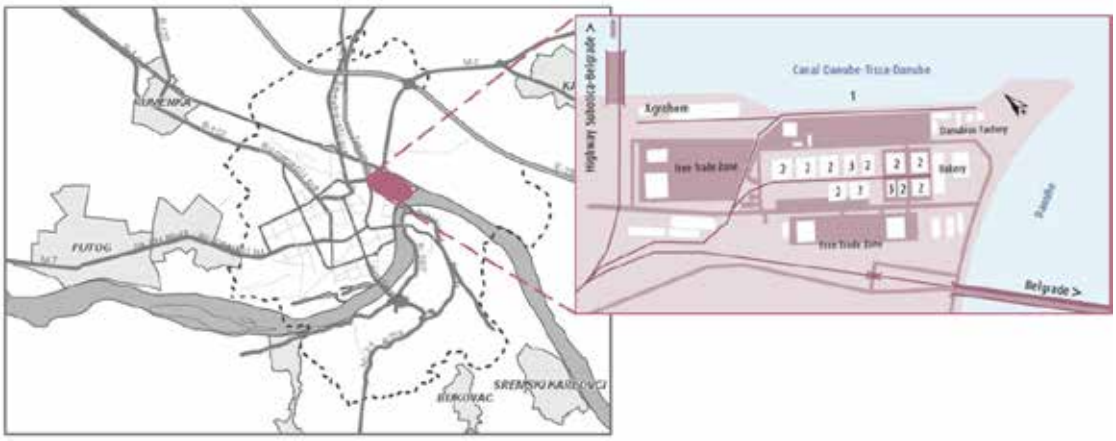


Figure 8. Location of the Port of Novi Sad (Source: adapted from Madin et al., 2014)

From the very beginning of its existence, Novi Sad is also known as the city of bridges and barracks. The first permanent pontoon bridge was built in 1788 and destroyed in bombing in 1849. Two more bridges are built - a railway bridge in 1883 and Prince Tomislav bridge in early 1928. During World War II both bridges were destroyed, and in the place of the former Prince Tomislav Bridge a permanent steel bridge was built, formerly named Marshal Tito Bridge, a later named Varadin Bridge with length of 344 m. A new railway bridge (Žeželjev most) was built in 1961, downstream of the Varadin Bridge. This was a steel-concrete bridge with two arches, and for a long time the only railway bridge in Novi Sad. On the occasion of forty years of liberation Novi Sad received another iron bridge to Sremska Kamenica - Most slobode (Freedom Bridge). During the NATO campaign against the Federal Republic of Yugoslavia in 1999, Novi Sad has been bombed 78 days and the bridges was completely destroyed. Today, Novi Sad has three bridges - a new combined bridge for railway and heavy vehicles, and two renewed - the bridge Duga (Rainbow) on the place of Varadin and the renewed Most slobode. Additionally, one more bridge, which is replicated Žeželjev most, is under construction.

Air

Čenej Airport is located ten kilometres north of Novi Sad, near the main road M-22/1. The airport has an agri-sporting character. Its technical characteristics does not meet the requirements for commercial use. According to the Spatial Plan of the Republic of Serbia (2010) and the Master Plan of Novi Sad (2006), it is planned construction of a modern airport that will allow the use of air transport for passengers and goods at the current location of the Čenej Airport.

4.2 Housing

Due to the strong mechanical growth, houses in many parts of the city have been quickly replaced with lower buildings, without appropriate allocation of parking places. Housing covers most of the urban area. The number of households is 72,513 and the average household has 2.63 members.

Recognizable design of almost identical objects was developed in the absence of constraints, regardless of the area specific characteristics and environmental conditions.

In areas that are threatened by groundwater, the ground floor of the building is limited to be above the maximum elevation of the observed groundwater level and the specific conditions of construction methods are required (PE Urbanizam, 2010).

4.3 Water management and treatment

Historical records show that the inhabitants of *Petrovaradin Šanac*, were using drinking water from the Danube River as they fought with the river and the wetlands in order to turn it into a fertile ground for the development of settlements. However, even then there were problems with the Danube water quality. The Administration of *Petrovaradin Šanac* called in experts to dig wells and teach the locals to dig themselves. Public wells were usually dug at intersections and were around 30 feet deep. Number of wells has increased, but citizens did not stop to drink the water of the Danube. Although they had already noted epidemics of various diseases caused by drinking water from the Danube, only cholera epidemic of 1892nd forced the Magistrate to seriously think through how to supply the city with good drinking water. Drilling of the artesian wells then began, and it continued for the next few decades. Simultaneously with the construction of artesian wells, testing of water sources was started. Although a large project was planned, World War 1 stopped the construction of the water supply network. After World War 1, projects were planned and then rejected, and so it continued on until the outbreak of the World War 2. This conflict ended with Novi Sad having no municipal water supply system, but an agglomerate of 1,000 private and 106 public wells. In the early 1950s, preparations were made for the construction of a distribution network and a water treatment plant that started in 1953, but still there has been debate about which water use. Finally the decision was made to go on groundwater. In 1965, the city finally abandoned the concept of supplying water from the river and fully implemented a groundwater supply system.

The water management system is using groundwater from shallow aquifers (about 20 m in depth) accessed from wells along the riversides. The water supply network length is around 1,150 km. The existing water supply network (primary and secondary) covers a city area (first altitude zone of the water supply system). The second and third altitude zones are supplied with the application of additional reservoirs. Second altitude zone covers an area of *Sremska Kamenica* and *Sremski Karlovci*, and the third area *Bukovac*.

The existing sewerage system covers areas of Novi Sad, Petrovaradin and Sremska Kamenica, and collected sewerage water is conveyed and discharged directly into the Danube. The system is divided into two basins: the "northern" and "southern" city drainage basin. The size of the northern sewage facility is approximately 950 ha and southern around 800 ha.

The sewerage network which drain waste and storm water is very diverse in size, quality, material type and period of operation. There are old walled canals, ceramic, concrete, asbestos-cement and plastic pipes and reinforced concrete collectors of various shapes (rectangular, horseshoe, oval, etc.) from 116/60 cm to 240/400 cm size.

5. Urban planning and management

5.1 Groundwater level monitoring

Recently, the city municipality and urban planners from the from the Public Enterprise for City Construction and Development, Novi Sad has completed the IPA project CROSSWATER[1], financially supported by EU. As a result of the cooperation on the project, the city municipality has defined positions for piezometers for monitoring groundwater level in the city and implemented them (Figure 9). Thus, the groundwater level data are included into the comprehensive municipality GIS database. The collected data are presented regularly in public reports.

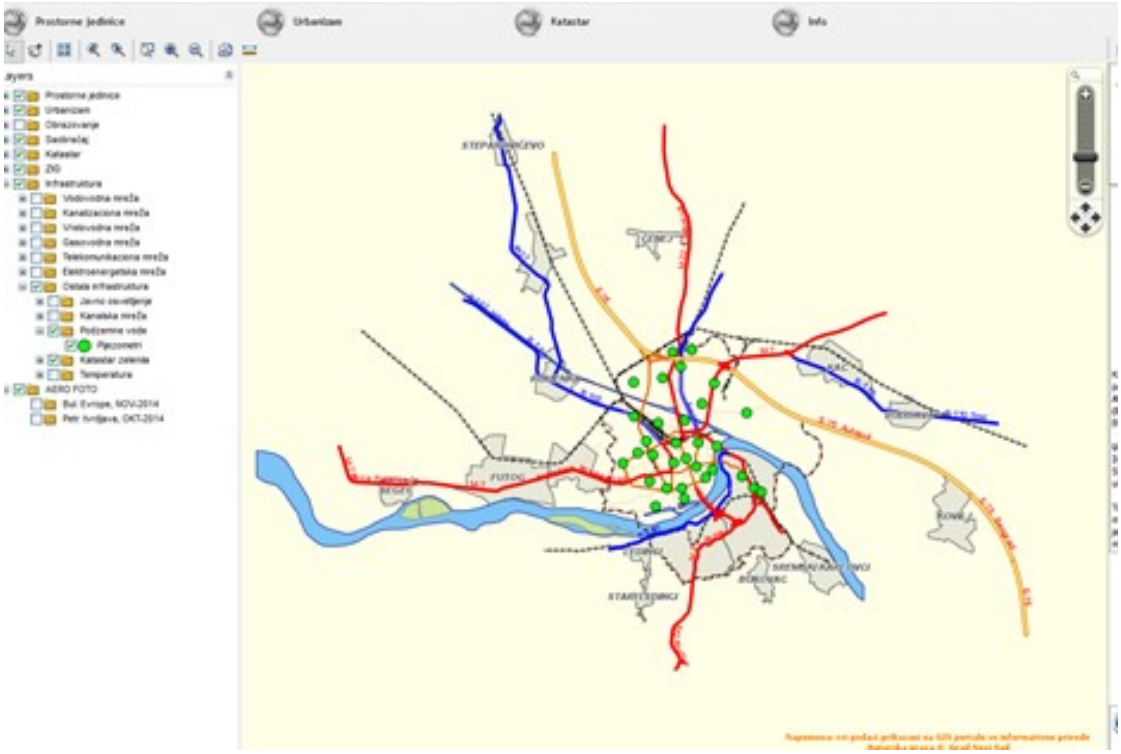


Figure 9. Locations of piezometers for groundwater level monitoring - the portal of the Public Enterprise for City Construction and Development, Novi Sad

[1] Project full title: Harmonized activities related to extreme water management events – especially flood, inland inundation and drought, ID: HUSRB/1203/121/145.

5.2 Traffic and transportation

Road

Transportation studies conducted in 2009 showed that the main strategic objectives of parking management include: increasing the available parking capacity (up to 85% of installed capacity), compliance with standards adopted by the traffic study and building new off-street parking facilities (parking garage). Due to limited space in the central city area and excessive demands, sustainable solution could involve the construction of public underground parking garage.

According to the Master Plan of the city of Novi Sad until 2021, the construction of a new bridge over the Danube should take place, due to increasing demands for connecting the two river banks. There are plans to construct a new bridge on the pillars of the former railway bridge (Bridge of Franz Joseph). Part of existing tunnel under the Petrovaradin Fortress will be used and enlarged for that purpose (Figure 10). Length of the planned road will be approximately 2.1 km. There are also plans for relocating traffic from the Lower Town. This would give an opportunity to restore some important historic buildings.

Figure 10. New bridge and tunnel through Petrovaradin Fortress (Source: Jevdjenic, 2013)

Rail

Detailed Regulation Plan of Novi Sad Railway Junction rules of development and construction were established in accordance with the land use, transportation network and other infrastructure, levelling solution, regulatory lines of the streets and public areas and construction lines with marking elements for geodetic surveying. The construction area covered by the plan is located in the northwest part of the city, and the size of area covered by the plan is 96.83 ha. The construction area is located at an altitude of 78.80 to 83.00 m. The relevant maximum groundwater level ranges from 77.80 to 80.10 m above sea level, a minimum level of groundwater from 75.00 to 76.30 m asl.

Another important project is the modernization of Petrovaradin-Beočin line, for which public and private companies analyse the possibility to implement the project using a public private partnership. The 17.2 km line has not been used since 2007 due to its poor condition. A restoration of this rail will take over cargo from cement manufacturer Lafarge, as well as part of the passenger transport in the Novi Sad area.

Waterway

The Port of Novi Sad plans to complete development of technological and transport subsystems in order to be able to provide container liner services. Also, it is planned to expand the transfering capacity for intermodal transport, as well as the establishment of regular navigational conditions on the DTD Canal (about 600 km) and Tisza River (Figure 11).

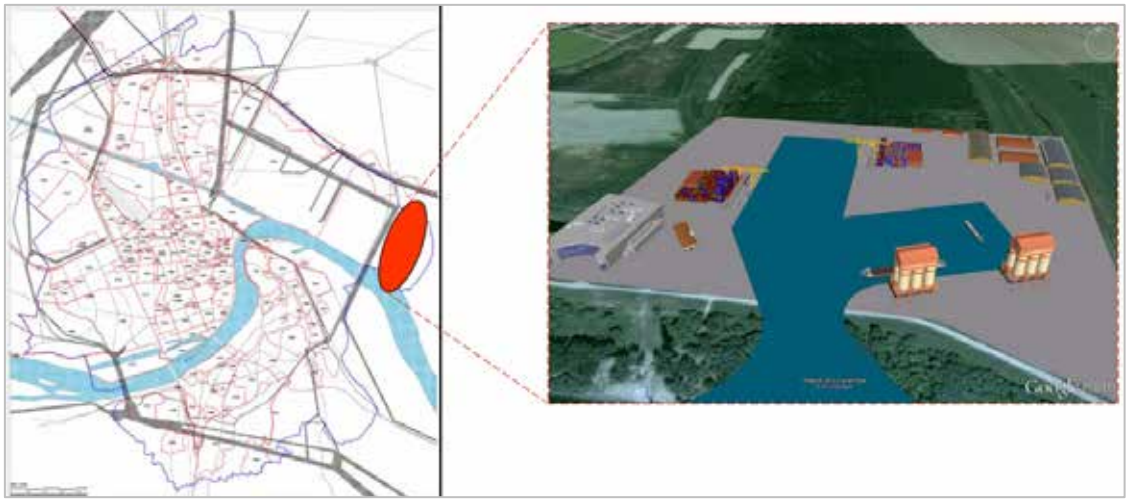


Figure 1. Planned location of the new port facilities (Source: adapted from Georgijević, 2012)

6. Underground usage

6.1 Waste management

The planned construction of a regional landfill could significantly affect the ecology of the city and it is important to take all measures to protect the environment in the urban area. The negative impact from landfill leachates on groundwater quality should be prevented, because the drinking water is supplied from the groundwater.

In order to perform full remediation of the landfill, a geotechnical and hydrogeological investigation must be performed, four monitoring wells on all four sides around the landfill should be set up, the status and quality of groundwater should be determined, mitigation measures and environmental protection should be planned, and implementation of a temporary waste transfer from the area to prepare the ground for the installation of impermeable HDPE film. The structure of the lower layer of the landfill is shown in Figure 12.

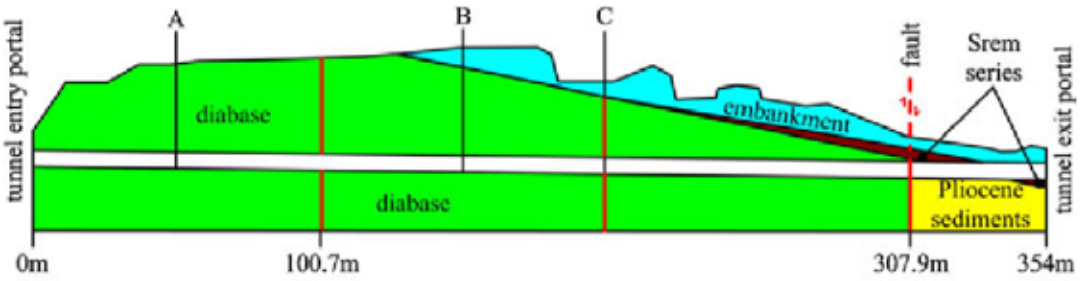
Figure 12. The structure of the ground layers under the planned regional landfill (Source: Faculty of Technical Sciences, 2011)

6.2 Traffic and transportation

Plans have been made to build a new bridge on the Danube and to enhance the existing tunnel through the Petrovaradin Fortress to be used for traffic. The length of the tunnel is 354 m. The new bridge should be constructed on the reinforced piers of the old (destroyed) Franz Josef railway bridge, which was 437.5 m long. Although one of the piers has been demolished to facilitate the safe flow of the traffic on the river, all the other piers still stand fully preserved.

Based on an investigation of the exposed surfaces, confirmed by the borehole logs and from the outcrops on the slopes and in the unsupported section of the old railway tunnel, the geology is diabase, which has been extensively jointed into blocks of various sizes. Diabase is a magmatic formation of Triassic–Jurassic age which occurs along the centreline of the road in the upper Fortress plateau and is known from boreholes to be present beneath the bed of the River Danube (Djogo et al., 2010). As seen from Figure 13, diabase was found from the entry portal of the tunnel, located on the Danube side, for a length of 307.9 m. The igneous rocks can be divided into two:

- From 0 to 100.7 m, the diabase is less jointed, less tectonised and has very good characteristics for tunnel construction (Vasić, 2007). In this area, further excavation is unlikely to affect the structures forming the Fortress;
- Between 100.7 and 307.9 m, the rocks are of similar petrology, but more fractured.



zone	E (GPa)	v	RMR	RBR	Q
A	40	0.19	72.60	93.81	15.98
B	25	0.23	54.45	80.94	5.26
C	0.1	0.26	19.93	33.20	0.74

Figure 13. Geotechnical cross-section of the planned tunnel (Source: Djogo et al., 2010)

6.3 Archeology

Recent archaeological findings in the northwestern part of Novi Sad, in the area of the settlement Sajlovo, was found when the works on new boulevard construction were carried out. This boulevard should link the city to the highway and allow faster development.

This archaeological site is beyond the scope of what is important for the city, the province and the republic. On the site, which is rated as extremely valuable, so far the remains of prehistoric settlements, copper and Roman periods, and evidence that this area in the last seven thousand years consistently had the residents.

The remains of the dugouts where former residents of Novi Sad lived, 19 prehistoric tombs, necropolis and settlements from the Copper Age and Roman coins which prove that in ancient times there existed trade between the Romans and Sarmatians.

6.4 Tourism

The aim of the Petrovaradin fortress was to protect the boundaries of the Empire. The fortress is among the biggest preserved fortress in Europe and many of its visible and less visible parts are unique in many ways.

As noticed, fortress consists of seven levels, of which the four ones are underground (Figure 14). Defenders of the Fortress, members of the Petrovaradin regiment, were operating on the defensive position known as the Battle Line, which architecturally continued into the system of underground mine galleries. Due to a great importance of this monumental defensive fortification and the constant threat of the Turks, the whole system of fortifications of the Petrovaradin Fortress, especially its underground part, was made up of a series of combat installations, which, among other things, are in the form of different obstacles, traps and barricades. The concept of defense installations of Petrovaradin Fortress is adapted to the terrain and the elevated hillside of the Petrovaradin Rock that gradually, in the form of fortification rings, reaches down to its base (The City Museum of Novi Sad, 2016).

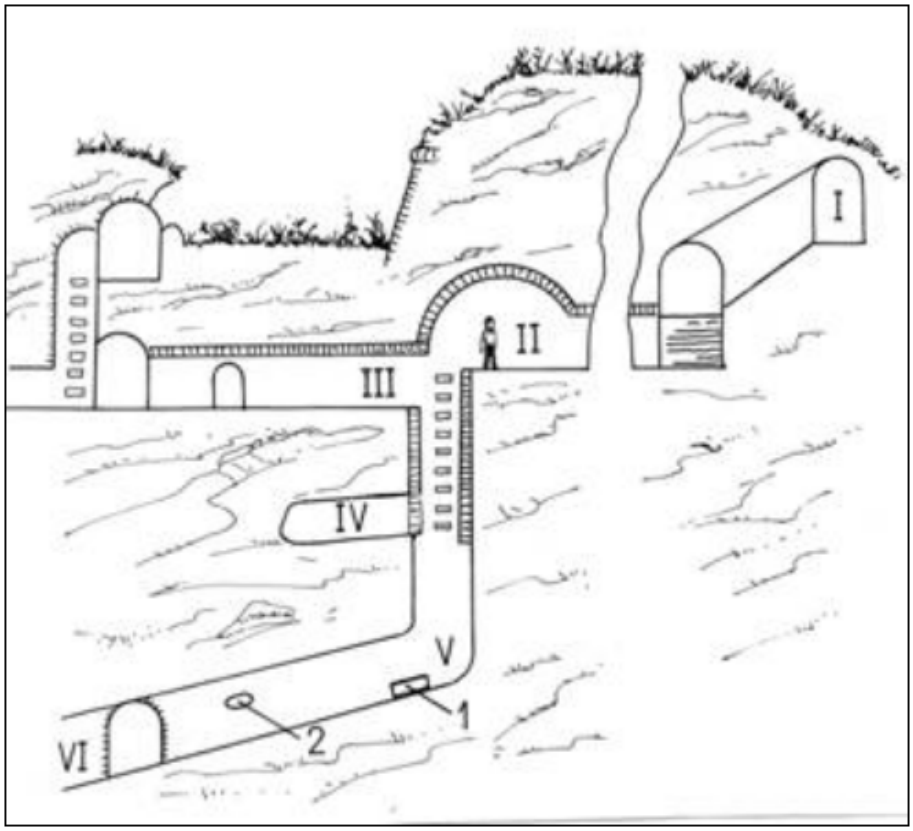


Figure 14. Cross-section under eastern part of the Petrovaradin Fortress (Source: retrieved from Milković, 2016)

Year 1780 is mentioned as the year when the Petrovaradin Fortress was finished, although certain underground works lasted for several more years. However, not everything that was planned was finished (unbricked corridors, 'earth tunnels', short 'dead-end' corridors etc.). Under the south part of the Petrovaradin fortress is the majority of underground galleries and tunnels (Figure 15).

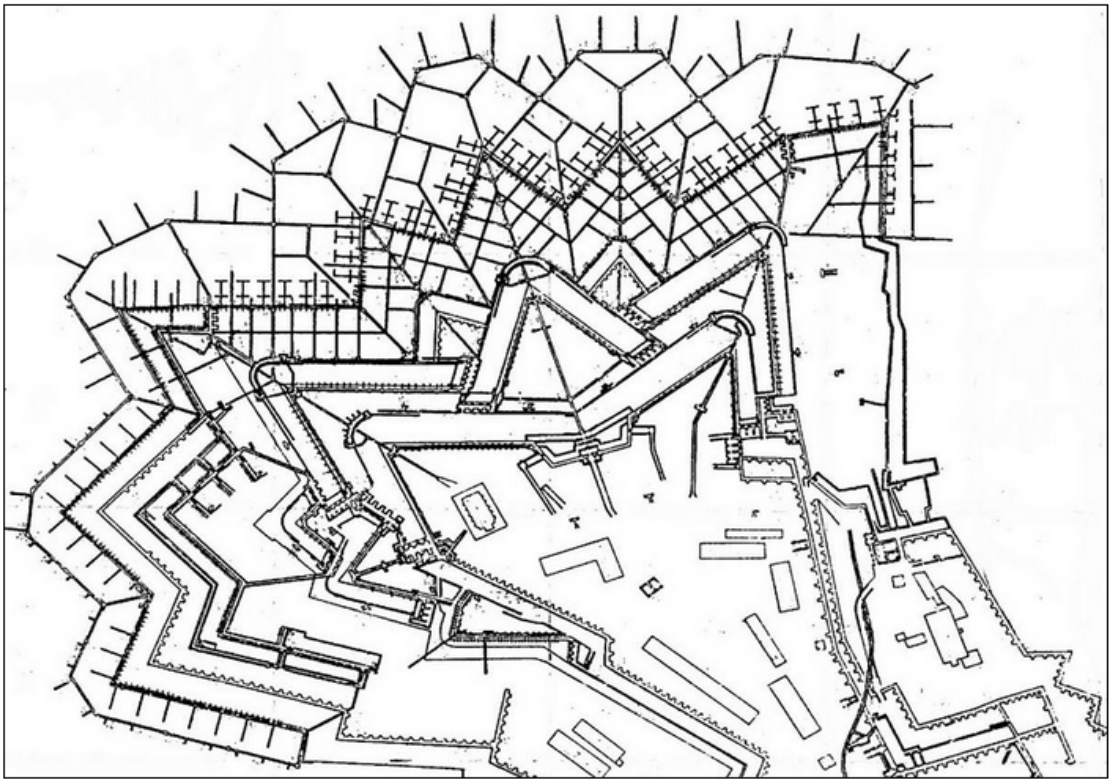


Figure 15. The plan of southern part of the Petrovaradin Fortress (Source: retrieved from Milković, 2016)

The fortress' underground military galleries are partly open for the public and also represent a valuable part of the tourist attractions of Novi Sad.

7. Conclusion

Problems related to groundwater, flooding, and shallow aquifer protection are traditionally important for urban planners. Beside long experience and good practice in groundwater monitoring, fast city development opened some new questions. Protection of recently discovered buried archaeological assets, as well as well-known historical places has an emerging significance. The increasing conflicting demands of the urban transport infrastructure, housing, environmental legislation and sustainable development are recognized and also need to be better addressed in the future.

There is though no subsurface database to link to the integrated and comprehensive above ground GIS/database available to planners. The subsurface has generally been seen as a constraint, and its use costly, in planning terms. There are intentions to use COST Sub-Urban ideas (e.g. the toolbox) to address these issues. Facilitated by an agreement between the Faculty of Technical Sciences and local municipalities, subsurface demands and opportunities should be explored more in depth, impacts on the subsurface considered, sources of data identified, and their integration improved.

8. References

Djogo, M., Vasić, M., Ćosić, M. (2010): Engineering geological evaluation of the conditions for constructing a bridge and a tunnel in the zone of the old Petrovaradin Fortress, Serbia. Bulletin of engineering geology and the environment, Vol. 70, No. 1, pp. 139-142.

Faculty of Technical Sciences (2011): Regional Waste Management Plan for the city of Novi Sad and the Municipalities of Bačka Palanka, Bački Petrovac, Beočin, Žabalj, Srbobran, Temerin and Vrbas (In Serbian). Department of Environmental Engineering and Occupational Safety and Health, Novi Sad.

Garača, V., Ćurčić, N., Vukosav, S., Curaković, D. (2012): Planning and equipping of the Petrovaradin Fortress lower town for touristic purposes. Journal of the Geographical Institute "Jovan Cvijić" SASA, Vol. 62, No.3, pp. 105-122.

Georgijević, M. (2012): Port of Novi Sad today and tomorrow. IWT Lab Novi Sad, 10 – 11 September 2012, Novi Sad.

Jevdjenic, A. (2013): With relocated railway towards a humane city. The fourth international conference "Towards a humane city", Transport in cities of Southeastern Europe, Novi Sad, 24th and 25th October 2013.

Madin, N., Ladanyi, R., Eles, B., Gardeva, N., Todorov, T., Kainzinger, K., . . . Sattler, M. (2014): Integrated Strategy for Functional Specialization of the Danube Ports in the Logistic Chain. DaHar WP4.2.

Master Plan of the City of Novi Sad until 2021 – revised text (2006). The Official Gazette of the City of Novi Sad, No. 39/2006.

Milković, V: Underground of the Petrovaradin Fortress. Veljko Milkovic Research & Development Center, website http://www.veljkomilkovic.com/PodzemljeEng.html (Last accessed: 9 May 2016).

Official Gazette of the City of Novi Sad (1993): Decision No. 8/93, Official Gazette of the City of Novi Sad.

Official Gazette of the Republic of Serbia (1994): Decision No. 71/94, Official Gazette of the Republic of Serbia.

PE Urbanizam (2004): Feasibility Study for Freight Logistic Centre in Novi Sad (In Serbian), Cost-Benefit Analysis, Novi Sad.

PE Urbanizam (2009a): Traffic study in the city of Novi Sad with traffic regulation dynamics (In Serbian). Department for city planning, Novi Sad.

PE Urbanizam (2009b): Environmental study in Novi Sad area (In Serbian). Department for city planning, Novi Sad.

PE Urbanizam (2010): City complexes design and architectural design of buildings in Novi Sad (In Serbian). Department for city planning, Novi Sad.

Petrović, B. Milisavac, Ž., Felbabov, V., Ševo, A., Stevanov, M., Bekić, T. (1987): Novi Sad (In Serbian). Monography, III edition, Matica srpska, Novi Sad.

Petrović, M.D., Vasiljević, Đ.A., Vujičić, M.D., Hose, T.A., Marković, S.B., Lukić, T. (2013) Global geopark and candidate – comparative analysis of Papuk mountain geopark (Croatia) and Fruška Gora mountain (Serbia) by using *GAM* model**,** Carpathian Journal of Earth and Environmental Sciences, February 2013, Vol. 8. No. 1, 105 – 116.

Spatial Plan of the Republic of Serbia (2010). Abridged version, 2010-2014-2020, Republic of Serbia, Ministry of Environment and Spatial Planning, Republic Agency for Spatial Planning, Belgrade.

Statistical Office of the Republic of Serbia (2012): Ethnicity. Census of Population, Households and Dwellings on the ethnicity of the population of the Republic of Serbia.

The City Museum of Novi Sad: Underground military galleries, official website, http://www.museumns.rs/en/node/94 (Last accessed: 9 May 2016).

Vasić, M. (2007): Geotechnical classifications for underground structures (In Serbian). Monograph, Faculty of Technical Sciences, Novi Sad.