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The Great Island of War in Belgrade. Development options and flood risk analysis

by

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In association with:



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The Great Island of War in Belgrade
Development options and flood risk analysis

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Summary

Belgrade is the capital and the largest city in Serbia. The city lies at the confluence of the Sava and Danube Rivers in north central Serbia, where the Pannonian Plain meets the Balkan Peninsula. The Great Island of War is the biggest of 16 river islands on the territory of Belgrade. It is situated on the very confluence of the two rivers, in the very centre of the city. It has large surface (1,579 km²) and, today, it is practically abandoned.

The Great Island of War emerged from the water in Middle Ages, due to centuries long period of material depositing material carried by the Danube. During history it changed its shape as well as purpose (mostly used as an army base while attempting to conquer the Belgrade fortress – thus the name) but regular floods washed all the remains and today it is in its natural form.

River banks overlooking The Great Island of War are the most attractive parts of river banks in Belgrade. Belgrade's oldest nucleus - the fortress of Kalemegdan (dating from Roman period) is constructed on the hill overlooking Island. Despite the huge potential and importance of the Island, according to official city land use plans its future is not defined.

Flood risks analysis of the Belgrade area today show that almost no vulnerable activities, nor areas are prone to flooding. In order to analyze development options of the Great Island of War, 3 development scenarios are selected and analyzed from the flood risk aspect and from the economy aspect.

Scenario of small changes is expected scenario if the future of the Island remains undefined. It assumes that natural environment will mostly stay preserved and that similar activities as at the moment, only with higher frequency will take place on the Island. With such development scenario no major changes are likely to happen not in the aspect of flood risk, nor in the economy growth of the area.

Scenario of uncontrolled development is not a likely scenario at the moment, but since it is unfavorable it requires risk analysis. It assumes unfavorable changes on the political and governmental level, leading to weakening of the public institutions, followed with general disrespect of country laws. Such economic and legal environment could lead to uncontrolled housing construction on the Great Island of War, which would cause significant changes in the hydrology of both rivers during flood. Flood risk analysis of this development scenario show that, especially in long term development process, major losses could occur (even endangering area of New Belgrade). Economic analysis show that profitability of this scenario is on a very low level.

Sustainable development approach starts with the cost-benefit analysis of the Island development and based on these results defines the frame and guidelines for further actions. It calculates investment that would be profitable both in case of undisturbed development and in case of a big hazardous event. Based on defined investment module, design process is performed, respecting guidelines of the city land use plans and resources of the area.

Flood risk analysis of the sustainable development scenario show that small losses could occur due to flood in the short term period and that there would be no losses in case of flood in the long term period.

Comparison of profitability and potential losses in short and long term period for the 3 analyzed scenarios show that major losses would occur with 100 year flood in the long period in uncontrolled development scenario and that only profitable scenario would be scenario of sustainable development, both in case flood occurrence and undisturbed development.

Background of the work

Short description of subject, objective of the dissertation, importance of the subject on town and national level, methodology of work

The theme of this dissertation will be the possibility to construct specific type of buildings on the Great Island of War and consequences of this action. The Great Island of War is a river island situated on the mouth of the river Sava in the river Danube, in the very center of Belgrade and it covers a surface of 1600 km². This subject – possibility of construction and appropriate type of buildings to be constructed on the island, has been an important topic in public discussions on the town and country level for at least few decades. Despite its excellent position, extraordinary environmental values and huge surface, island has not been used for urban development until today. The Great Island of War has a significant historical importance (thus the name), as it has always been used as army base while attempting to conquer the Belgrade fortress. The rivers Sava and Danube were borders between two big empires: Austro-Hungarian empire and Turkish empire.

The Great Island of War was formed of deposited material carried by the Danube. Velocity of flow of the Danube is reduced at the confluence with the Sava and this is the reason for deposition of river material and formation of island. It has large surface but it is very low and therefore prone to flooding. No dikes to prevent flooding were ever constructed on the island. In different periods of history it was also used for different kind of agricultural activities and western part of it was always used as a public beach.

Today, with fast growing of the city, the Great Island of War, has huge economic potential and this is the reason why lot of investors and decision makers are trying to deal with this subject. During past few years, new land use maps for the future development of Belgrade were produced. Despite significant efforts of different stakeholders invested in this task, future development of the Island remains undefined. The Island and few other locations are marked as “to be defined after further expert analysis

and public contests”. This illustrates complexity of the issue. Future development of the Great Island of War should be defined through multidisciplinary research in urban development, economic processes, hydrology, sociology, protection of the environment, architecture, geology etc. In this dissertation analysis will be focused on architectural concept of the development of the Great Island of War based on flood risk mitigation approach and economic analysis. Analysis will produce estimations of benefits and loses compared to investment for 3 possible development scenarios. Comparison of the results of 3 possible development scenarios will show short and long term impact on local and country level.

Methodology of work will include further analysis: potentials and resources of Belgrade and the Great Island of War; present flood risks in Belgrade; present development trend in Belgrade; new land use maps for Belgrade; 3 possible development scenarios (expected development scenario, uncontrolled development scenario and sustainable development scenario); design of the constructed structures on the Island planed within the sustainable development scenario; impacts of the 3 development scenarios on future flood risks; estimations of benefits and loses compared to investment for 3 possible development scenarios; short and long term impact on local and country level.

Research that has been done in this domain

Different architectural researches have been done about the possible construction on the Great Island of War, some as individual designs and researches, some as a part of specific public contests.

Most recent public contest organized to collect ideas and concepts on the subject of construction on the Island was held in 1997, and was titled “Vidikovac on the Great Island of War”. Within this public contest, analysis of construction of specific type of building on the island was performed.

Project Belgrade – research and design of the Island development presented on Venetian Architectural Biennale in 2006.

Individual diploma and thesis designs of different buildings for the Island.

Forests of the Great Island of War – environmentalists study, evaluation of protected forests on the Great Island of War.

ICPDR – International Commission for the Protection of the Danube River Secretariat - Action Programme for Sustainable Flood Protection in the Danube River Basin

Introduction – about the Belgrade, the Danube, the Sava, the Great Island of War

The Belgrade, brief data, location

Belgrade is the capital and the largest city in Serbia. It is one of the oldest cities in Europe, first emerging as prehistoric Vinča in 4800 BC, it was settled in the 3rd century BC by the Celts, before becoming the Roman settlement of Singidunum. The Slavic name Beligrad (a form of Beograd) was first recorded in 878 AD. It has been the capital of Serbia since 1403, and was the capital of various South Slav states from 1918 until 2003, as well as Serbia and Montenegro from 2003 until 2006. Today, it is a capital of Serbia.

The city lies at the confluence of the Sava and Danube Rivers in north central Serbia, where the Pannonian Plain meets the Balkan Peninsula. The population of Belgrade, according to the Serbian census of 2002, is 1,576,124. The Municipality in Belgrade with the highest population number is the New Belgrade with 217,773 inhabitants. New Belgrade was constructed during 1960-ties and 1970-ties on the previous swamp area, between rivers Danube and Sava.

The river Sava divides New Belgrade and Zemun in Western part of the town, from the older part of the city in the South-Eastern part. The Danube

divides old part of the city from some suburban settlements and agricultural area in the North. Zemun lies next to the Danube, on its right river bank and was independent town from Belgrade. Today it is included in Belgrade and represents one of its municipalities. Until one century ago Zemun was part of the Austrian empire, Belgrade was part of the Turkish empire, New Belgrade area was a swamp and the Great Island of War was divided between the empires.



Belgrade is today the largest city on the territory of the former Yugoslavia, and by population ranks fourth in the South Eastern Europe behind Istanbul, Athens and Bucharest.

The Danube, brief data, importance, hydrology

The Danube has been an important international waterway for centuries, as it remains today. Known to history as one of the long-standing frontiers of the Roman Empire, the river flows through—or forms a part of the borders of—ten countries: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Moldova, and Ukraine; in addition, the drainage basin includes parts of ten more countries: Poland, Switzerland, Czech Republic, Slovenia, Bosnia and Herzegovina, Montenegro, Republic of Macedonia, Moldova, and Albania.

The Danube (ancient Danuvius) originates in the Black Forest in Germany as two smaller rivers—the Brigach and the Breg—which join at Donaueschingen, and it is from here that it is known as the Danube, flowing generally eastwards for a distance of some 2850 km, passing through several Central and Eastern European capitals, before emptying into the Black Sea via the Danube Delta in Romania.

The Danube is navigable by ocean ships from the Black Sea to Brăila in Romania and by river ships to Kelheim; smaller craft can navigate further upstream to Ulm, in Germany. About 60 of its tributaries are also navigable.

Since the construction of the German Rhine-Main-Danube Canal in 1992, the river has been part of a trans-European waterway from Rotterdam on the North Sea to Sulina on the Black Sea (3500 km). In 1994 the Danube was declared one of ten Pan-European transport corridors, routes in Central and Eastern Europe that required major investment over the following ten to fifteen years. The amount of goods transported on the Danube increased to about 100 million tons in 1987. In 1999, transport on the river was made difficult by the NATO bombing of 3 bridges in Serbia.

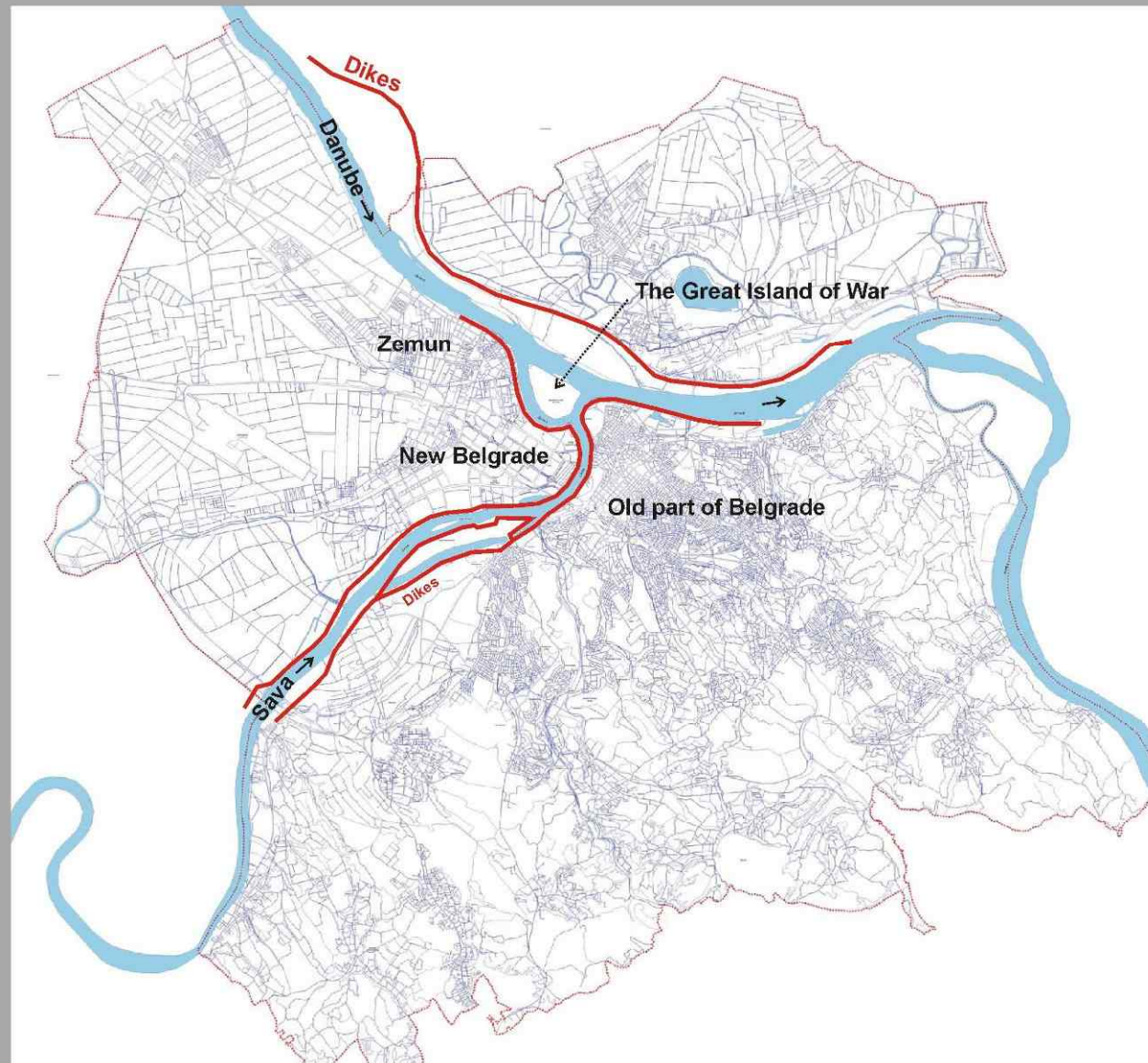
The clearance of the debris was finished in 2002. The temporary pontoon bridge that hampered navigation was finally removed in 2005.

At the Iron Gate, the Danube flows through a gorge that forms part of the boundary between Serbia and Romania; it contains the hydroelectric Iron Gate I dam, followed at about 60 km downstream (outside the gorge) by the Iron Gate II dam (Djerdap 1 and 2)

There are three artificial waterways built on the Danube: the Danube-Tisa-Danube Canal (DTD) in the Banat and Bačka regions (Vojvodina, northern province of Serbia); the 64 km Danube-Black Sea canal, between Cernavodă and Constanta (Romania) finished in 1984, shortens the distance to the Black Sea by 400 km; the Rhine-Main-Danube canal (about 700 km), finished in 1992, linking the North Sea to the Black Sea.



The Danube river bank in Belgrade during spring 2006 (100 year flood)



Map of Belgrade with position of dikes
Scale 1:230,000

The Sava, brief data, importance, hydrology

The Sava connects three European capitals: Ljubljana in Slovenia, Zagreb in Croatia and Belgrade in Serbia. In both Zagreb and Belgrade, it divides old and new parts of the cities (Zagreb-Noví Zagreb, Belgrade-Noví Beograd).

The Sava is created by two headwaters, Sava Dolinka (left) and Sava Bohinjka (right) which join between the Slovenian cities of Lesce and Radovljica. From there until it joins the Danube at Belgrade, Serbia, it's 945 km long (of which 206 km are in Serbia). From the source of its longer headwater, Sava Dolinka, in the north-western, Alpine region of Slovenia, it measures 990 km.

Through the Danube, it belongs to the Black Sea drainage basin, and represents the Danube's longest right tributary and second longest of all, after Tisa. It was once the longest river flowing completely within Yugoslavia proper, but after the breakup of the country in 1991, it now flows through four countries.

The Sava drains an area of 95.719 km², including 115 km² in northern Albania. Its average discharge at Zagreb, Croatia, is 255 m³/s, while in Belgrade it's amassed to 1,722 m³/s. It also gets very deep, up to 28-30 m near villages of Hrtkovci and Bosut, in Serbia. In Serbia it creates several big river islands (adas), including Podgorička ada near Provo and 2,7 km² Ada Ciganlija in Belgrade, the most popular Belgrade resort. The island has been connected to the right bank of the river with three causeways creating an artificial lake called "Lake Sava" with an area of 0,8 km². It is nicknamed "Belgrade Sea" and it is known to attract up to 350,000 visitors daily in the summer season.

The river bed is not regulated for the most of its length. That causes floods from time to time, which can affect as much as 5.000 km² of mostly very fertile land (Posavina, Sava Valley). In 1981 and April 2006, the Sava flooded lower parts of Belgrade. In 1977 & 1980 both federal and inter-republican agreements were signed about Sava's regulation, which were

supposed to regulate its waters to prevent flooding, build new power stations, establish full navigation to Zagreb and ecologically protect its waters, with the final deadline being the year 2000. However, not much was done and Yugoslavia itself broke up in 1991.

East of Ljubljana, the Sava flows through a 90 km long gorge and afterwards the Krško Field (Krško polje). As the Pannonian Sea receded, the Sava grew longer and longer, carving the Sava Trench (Savski rov) through which it flows to the east. Together with lower courses of Bosnian rivers which became its tributaries, it created huge floodplains. Becoming wide (at Šabac it's 680 m wide, while on its mouth only 280 m), the Sava begins to meander and in history changed course many times, being pushed by the gentle slope of the Pannonian bed to the south and by the force of its many right tributaries to the north. Old riverbeds turned into swamps and ponds known as mrtvaja (dead water) and starača (old water) in Serbian. The best known is one of the biggest ponds in Serbia and one of the biggest wild birds reservation areas in Europe, Obedska bara.

The Great Island of War, brief data, location, history, importance, resourcefulness

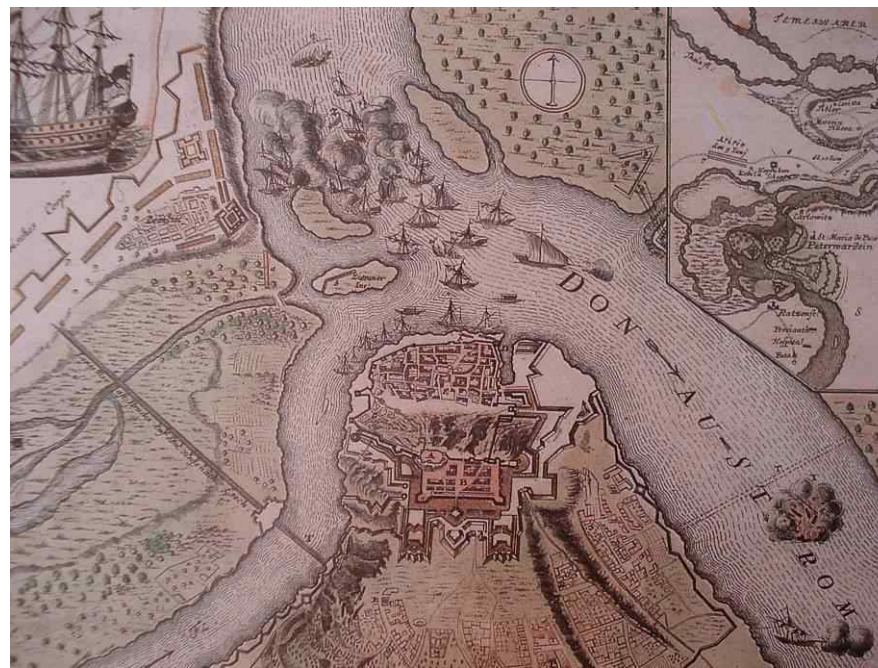
The Great Island of War is the biggest of 16 river islands on the territory of Belgrade. It covers a surface of 1,579 km². There are no flood protect measures on the Island and therefore the whole island surface is prone to flooding. Island is on a 69,5 – 73,5 m above sea level. No big structures exist on the island, only constructed buildings today are beach facilities (toilets, changing rooms) and some small private houses. Part of the island is used for some small agricultural activities. The only part of the island that is intensively used today is the beach part on the west end of the island with recreation area around. This part was especially intensively used during past few years as the access was made easier -army pontoon bridge connecting the beach and river bank was installed, but the natural flow of the Danube was affected.



the Great Island of War

River banks overlooking The Great Island of War are the most attractive parts of river banks in Belgrade. These areas are frequently used for recreation and lot of boats-restaurants are concentrated next to river banks overlooking the Island. Belgrade's oldest nucleus-the fortress of Kalemegdan (dating from Roman period) is constructed on the hill overlooking the mouth of the river Sava in the river Danube and The Great Island of War. The biggest river marinas in Belgrade are situated next to the river banks near the Island.

Importance for fresh water supply; the Great Island of War is important resource for fresh water supply for Belgrade area.



Belgrade and the Great Island of War around year 1500

Historical importance; the Great Island of War emerged from the water in Middle Ages, due to centuries long period of material depositing material carried by the Danube. Almost until the beginning of the 20th century Belgrade remained within the fortress walls (Kalemegdan fortress) and the rivers Danube and Sava were natural borders between two empires: Austrian and Turkish. On the South-Eastern part of the Great Island of War, Austrian fortress was situated with a purpose to defend the border and control the transport on the Danube. Today, there are no remains of this fortress. During history the Great Island of War changed its shape. After the 1st World War on the North-Western part of the Island natural beach was reconstructed and during the 1930-ties it was considered to be one of the most beautiful river beaches in Europe. During the construction

of New Belgrade, in 1950-ties, an attempt to change the shape of the Great Island of War was made, but due to material that was deposited by the Danube again and again, this process was finally abandoned. One of the theories why the Island still remains in its natural form is that Tito, president of former Yugoslavia, wanted to construct a mausoleum for himself on the Island. According to the Belgrade urban development plan developed in 1950. the Island was supposed to be connected on North-Western and South-Eastern parts with river banks, forming an artificial lake. The same type of action was performed on the other big river island in Belgrade – Ada Ciganlija, forming a big recreation area and artificial lake. The plan was never executed for the Great Island of War. Some other ideas discussed in public debates are construction of business city on the island , construction of Formula 1 autodrom, construction of new Zoo-park etc.



Belgrade and the Great Island of War around year 1700

Environmental importance; Vegetation on the island is forming rings following the banks and depending on the underground water level and height. Most frequent type of vegetation on the island are trees that grow in flooding areas and swamps (*Salicetum albae typicum*, *Salicetum albae amygdaletosum*, *Salicetum albae rubetosum* i *Salicetum albae populetosum nigrae*). The Great Island of War is habitat for about 196 bird species and about 500 plant species, and it includes a natural fish breeding ground. Importance of conservation of this natural oasis within the tissue of the city, as considered by environmentalists, is multifold for quality of environment and life of Belgrade citizens.



the Great Island of War

Urban life importance; the Great Island of War was used as an area for different music festivals, some of which were very big. There is no area such as Island, so wide with so easy accessibility, suitable for festival purposes in Belgrade.

Hydrology and flood risk mitigation importance; During floods, the whole island area functions as a natural retention area, with significant retention capacity and minimum flow velocity.



Kalemegdan (the Belgrade fortress) - opposite the Great Island of War

Recreation importance; Banks of the Island are frequent destination for sport fishermen in small boats and people looking for a place for relaxation. Beach on the North-Western part of the Island is intensively used during summer months.

Economic importance; With wide surface, excellent position and accessibility in the city and extraordinary environmental values, the Great Island of War has huge potential for a variety of economic activities.



Kalemegdan (the Belgrade fortress) - around year 1700

The Island is an important topic and a valuable resource for different social groups and individuals. Environmentalists would like to protect it and limit the existing beach and recreation area (with construction of few artificial hills to be used as shelter for wild animals during floods). Investors would like to set a profitable activity there and cover as wide area as possible. Urban planers would like to make it more active in city life. Hydrologists would like to leave it as it is, in it's natural shape. Architects see it as an excellent construction area etc.

Future planned development of Belgrade and the Great Island of War

In past few years new land use plans (covering period of next 20 years) were developed for the Belgrade and surrounding area. Due to fast growth of the city, some important changes were introduced in new plans, such as construction of major transportation routes and relocation of business center of the city from the old part to New Belgrade. Area analyzed in this work was, however, not covered with new plans although it is situated the very center of the city. Reasons for this are already mentioned and can be shortly defined as high resourcefulness of the area combined with opposed interests of the stakeholders.

The area of the Great Island of War and river banks opposite the island is in new land use plans marked as area that is to be still defined through future public debates and analysis. General opinion is that the complete area that is now prone to flooding (island and part of Danube banks not protected by dikes) should in some form remain as a green and recreational area. Already constructed dikes are protecting New Belgrade and lower part of the old part of the town and Kalemegdan (the Belgrade fortress) is constructed on the hill and can not be affected by floods. Up to now there is no official land use map for the Great Island of War, only protection measures to preserve nature and water resources, and this issue is still to be still defined.

Flood risks in Belgrade today

Flood hazards in Belgrade

Due to frequent war times in Belgrade history and fact that the rivers Danube and Sava were borders between Austrian and Turkish empire and therefore not a safe place to live at, the town did not developed widely along it's rivers. Only recent development (second part of 20th century) brought Belgrade closer to the rivers. Today, lower parts of Belgrade that are constructed are protected from flooding with different kind of dikes.

Old part of Belgrade is built on hills and therefore mostly safe from flooding. Zemun, former independent town and now municipality of Belgrade, is situated mostly on the hill in the western part of Belgrade and therefore also safe from flooding. New Belgrade is constructed on former swamp area next to the confluence of the Danube and Sava after construction of dikes and drying the area. New Belgrade soil is consisted mostly of sand material, and all of the construction in this area is done on deep foundation columns.

During Spring 2006, the Danube level in Belgrade reached a 100 year return period. This was a good opportunity to check on the spot effectiveness of all constructed flood protection measures. Fortunately, all

went well and some small leakages are just an illustration what could happen if the Danube level rose a little bit higher or the flood lasted longer.



The Danube river bank in Belgrade during spring 2006 (100 year flood)

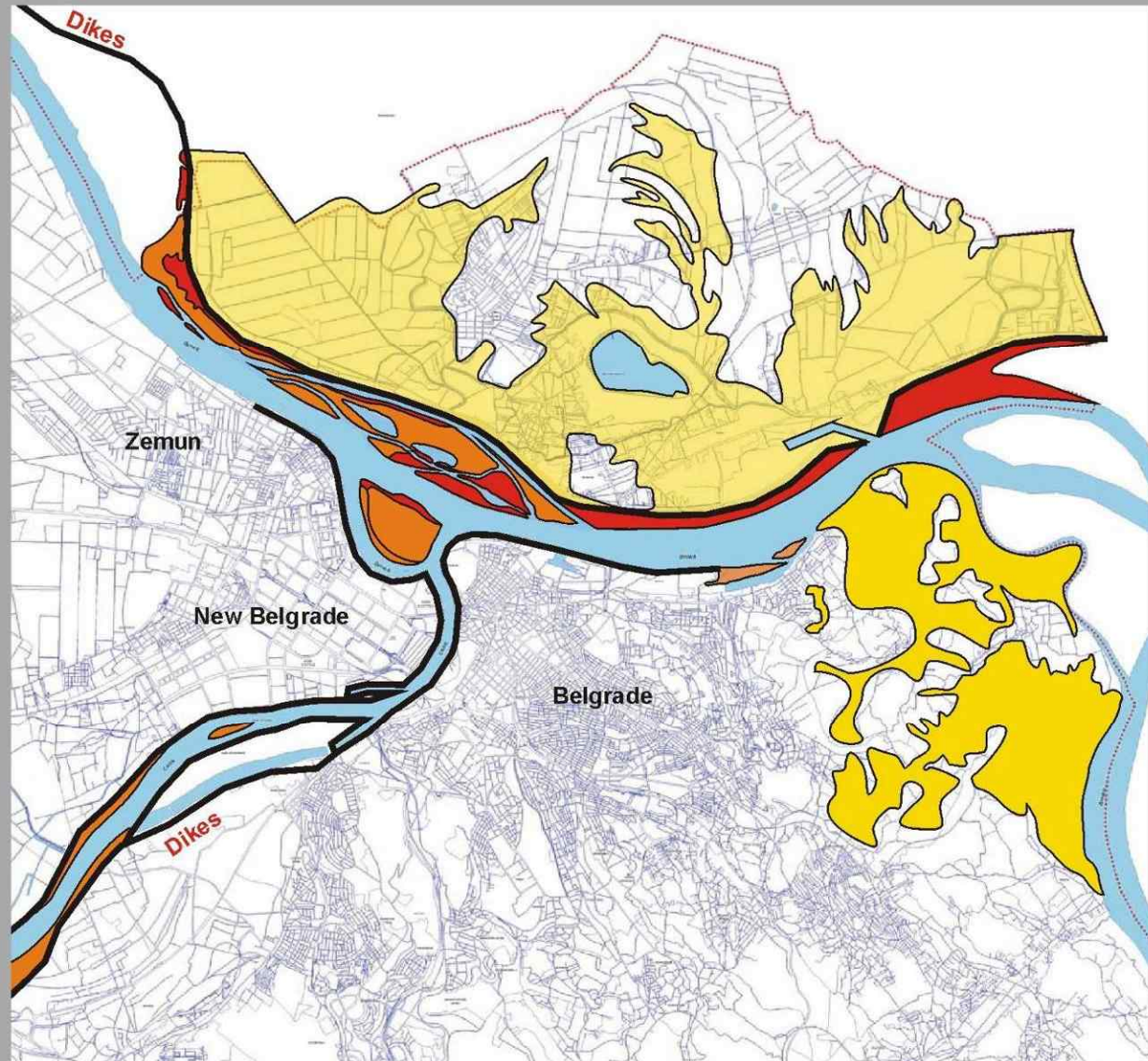
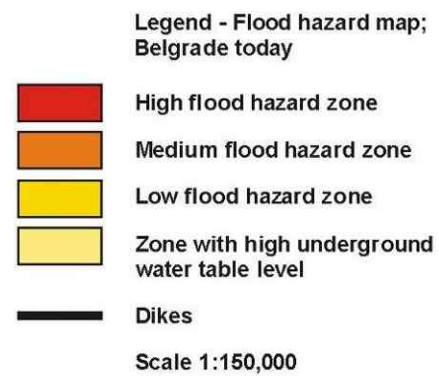
As hazard is defined by intensity and probability of occurrence of flood, areas in Belgrade prone to flooding, are marked as zones with different flood hazard:

High flood hazard zones - areas with expectancy of flooding within 10 years return period.

Medium flood hazard zones - areas with expectancy of flooding within 30 years return period.

Low flood hazard zones - areas with expectancy of flooding within 100 years return period.

Flood hazards in Belgrade today



Vulnerability of the hazardous area

Vulnerability of the areas in Belgrade prone to flooding can be analyzed through different aspects and in different methodology. In this work 3 aspects of vulnerability will be considered to determine an overall vulnerability level of analyzed areas: vulnerability of population, vulnerability of constructed environment and vulnerability of economic activity. Methodology of analysis will consist of 4 steps:

Step 1 - Defining land use map for the analyzed area

Step 2 - Vulnerability quantification through 3 vulnerability aspects

Step 3 - Vulnerability quantification for different land use zones

Step 4 - Overall vulnerability level and vulnerability map

Based on these 3 analyzed vulnerability aspects, for every identified zone in the hazardous area a specific vulnerability index will be defined. Following the 4 methodology steps, an overall vulnerability level will be determined and presented in the vulnerability map.

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Industry – area covered by big industry companies and infrastructure;

- 1. Defining land use map for the analyzed area** - complete area in hazard of flood is divided in zones that have similar land use and characteristics.

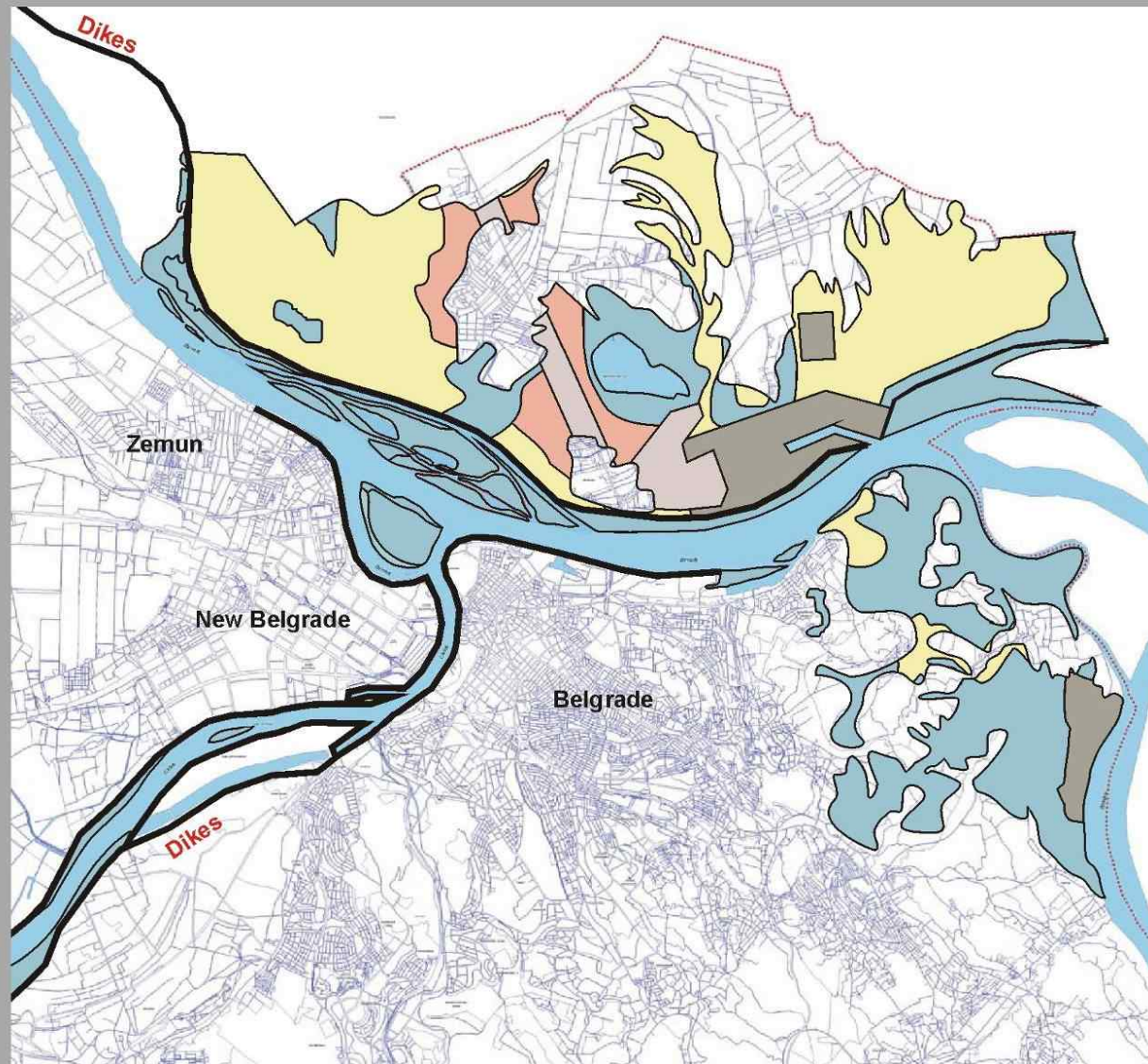
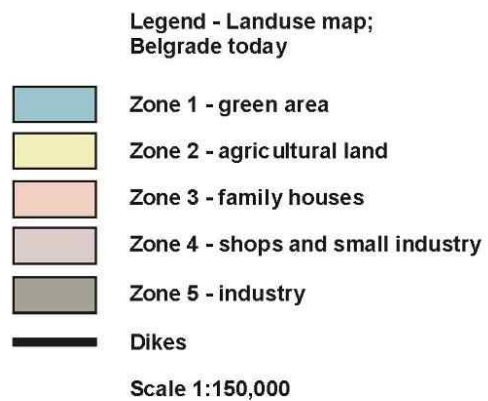
Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Agricultural land – area with predominant agricultural and farming activity;

Family houses – housing area covered with single family houses and some apartment buildings;

Land use map of Belgrade today

Area in hazard of flood divided in zones with similar land use and characteristics



2. **Vulnerability quantification through 3 vulnerability aspects** - set of criteria (*vulnerability quantification parameters*), defining level of vulnerability for the 3 analyzed aspects is defined. With this approach, quantification of vulnerability for different land use zones, through 3 vulnerability aspects is performed (vulnerability of population, vulnerability of constructed environment and vulnerability of economic activity).

Vulnerability quantification parameters:

- ***Vulnerability of Population***

High vulnerability of population in the area – **index 3**

More than 50 people per km² present in the area

Medium vulnerability of population in the area – **index 2**

5 - 50 people per km² present in the area

Low vulnerability of population in the area – **index 1**

Less than 5 people per km² present in the area

No vulnerability – **index 0**

No people present in the area

- ***Vulnerability of constructed environment***

High vulnerability of constructed environment – **index 3**

More than 20% of area surface covered with buildings and infrastructure or

Presence of at least one of the public or facility buildings or lifelines

Medium vulnerability of constructed environment – **index 2**

5% - 20% of area surface covered with buildings and infrastructure

Low vulnerability of constructed environment – **index 1**

Less than 5% of area surface covered with buildings and infrastructure or

No vulnerability – **index 0**

No constructed elements in the area

- ***Vulnerability of economic activity***

High vulnerability of economic activity in the area – **index 3**

High economic activity (more than 50 people professionally active per 1 km²) or

High dependence of economic activity on lifelines or roads or

High dependence of economic activity on atmospheric and soil conditions

Medium vulnerability of economic activity in the area – **index 2**

Medium economic activity (5 - 50 people professionally active per 1 km²)

Low vulnerability of economic activity in the area – **index 1**

Low economic activity (less than 5 people professionally active per 1 km²)

No vulnerability – **index 0**

No economic activity in the area

- 3. Vulnerability quantification for different land use zones** – for each land use zone, through all 3 vulnerability aspects, based on vulnerability quantification parameters, a vulnerability index is defined.

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Vulnerability of population – no people expected in the area during flood period – index 0

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – no economic activity – index 0

Agricultural land – area with predominant agricultural and farming activity;

Vulnerability of population – less than 5 people per km² present in the area – index 1

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Family houses – housing area covered with single family houses and some apartment buildings;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Industry – area covered by big industry companies and infrastructure;

Vulnerability of population – 5 - 50 people per km² present in the area – index 2

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

4. Overall vulnerability level – for every identified land use zone, a sum of vulnerability indexes is defined and based on following formulas, level of overall vulnerability is determined.

Sum of indexes of 3 vulnerability aspects = 0 → no vulnerability

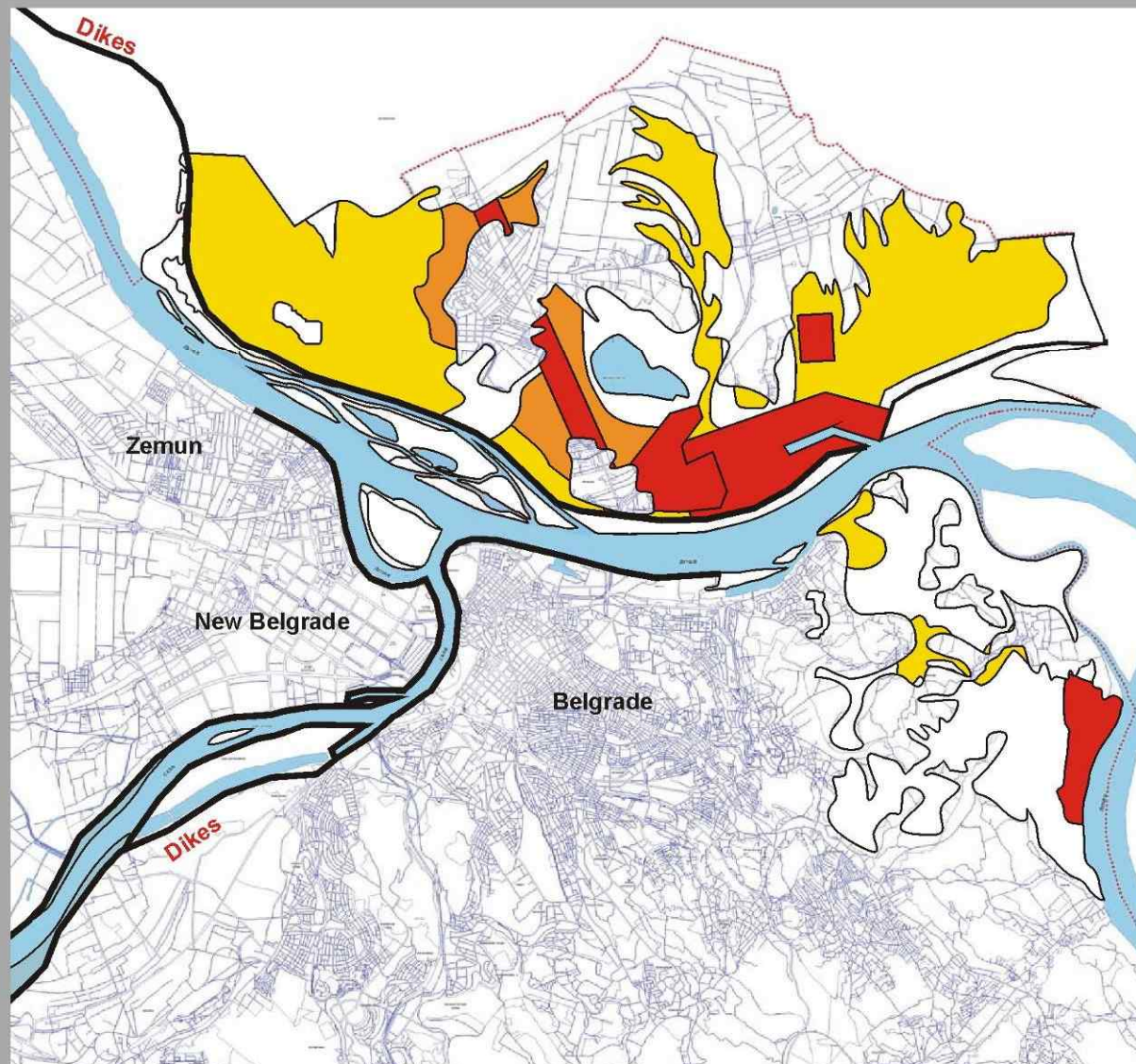
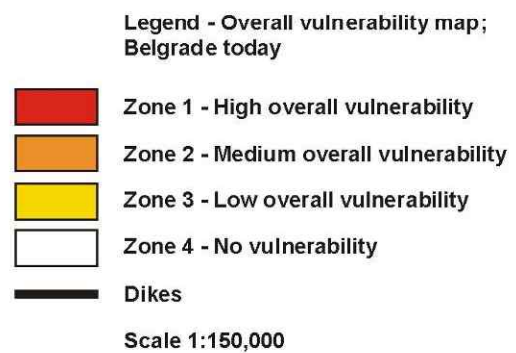
Sum of indexes of 3 vulnerability aspects between 1 and 3 → low vulnerability

Sum of indexes of 3 vulnerability aspects between 4 and 6 → medium vulnerability

Sum of indexes of 3 vulnerability aspects between 7 and 9 → high vulnerability

	Aspects of Vulnerability				
	vulnerability of population	vulnerability of constructed environment	vulnerability of economic activity	overall vulnerability	overall vulnerability
Zone No.					
1 - Green area	0	0	0	0	no vulnerability
2 - Agricultural land	1	0	1	2	low vulnerability
3 - Family houses	3	3	1	7	high vulnerability
4 - shops and small industry	3	3	3	9	high vulnerability
5 - industry	2	3	3	8	high vulnerability

**Overall vulnerability map of
Belgrade today**



Flood risks in Belgrade today

For flood risk calculation in Belgrade a following methodology was applied. To calculate flood risk in an analyzed area, quantification of flood hazards and quantification of overall vulnerability for the specific area was calculated. As risk is, by definition, result of level of hazard and level of vulnerability, a following formula was used for calculation of flood risk on the specific area:

Overall flood risk index = flood hazard x overall vulnerability (all analyzed for specific area)

Flood hazard level, defined by probability of occurrence and intensity of the phenomenon, was calculated as high, medium, low and no hazard and for each level of hazard a quantification value was assigned (or index number):

High flood hazard (probability of occurrence of flooding within 10 years) – index 3

Medium flood hazard (probability of occurrence of flooding within 30 years) – index 2

Low flood hazard (probability of occurrence of flooding within 100 years) – index 1

No flood hazard – index 0

Overall vulnerability level, as sum of 3 vulnerability aspects, was calculated as high, medium, low and no vulnerability, depending on quantification parameters. For overall level, a quantification value was assigned (or index number):

High overall vulnerability – index 3

Medium overall vulnerability – index 2

Low overall vulnerability – index 1

No vulnerability – index 0

After performing calculation of overall risk index, overall flood risk is described as high, medium, low or no risk based on the following criteria:

Overall risk index between 6 and 9 → high flood risk

Overall risk index between 3 and 5 → medium flood risk

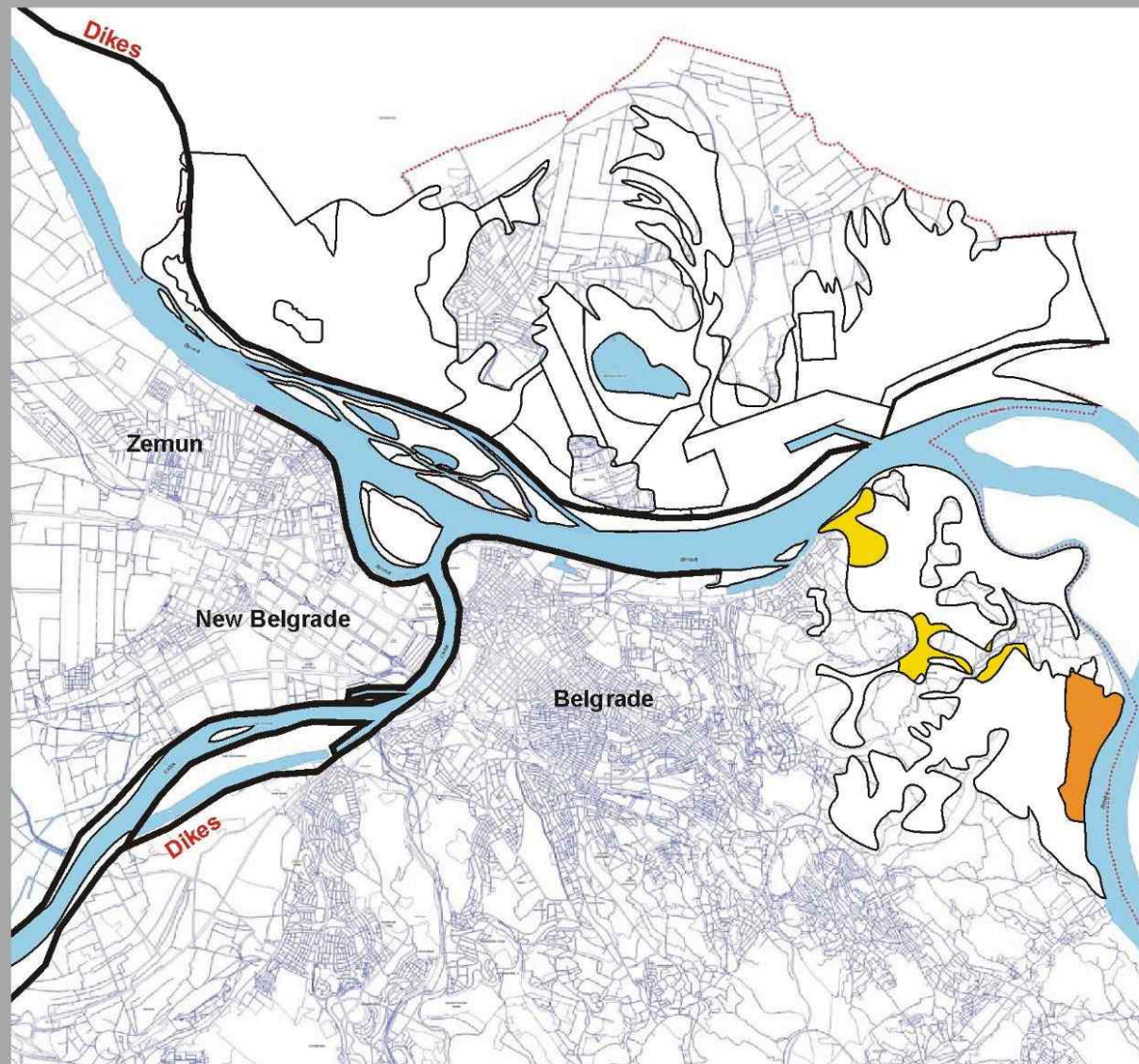
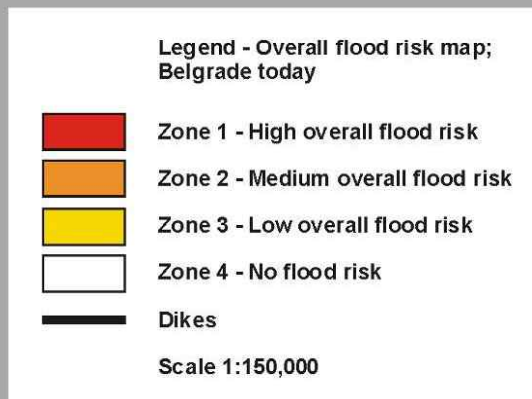
Overall risk index between 1 and 2 → low flood risk

Overall risk index = 0 → no flood risk

Calculated flood risk is presented in a table and on the map:

Zone No.	overall vulnerability	vulnerability index	hazard	hazard index	overall flood risk index	overall flood risk
1 - Green area	no	0	low	1	0	no
	no	0	medium	2	0	no
	no	0	high	3	0	no
2 - Agricultural land	low	1	low	1	1	low
	low	1	medium	2	2	low
	low	1	high	3	3	medium
3 - Family houses	medium	2	low	1	2	low
	medium	2	medium	2	4	medium
	medium	2	high	3	6	high
4 - shops and small industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
5 - industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high

Flood risks in Belgrade today



Since a 100 year flood occurred in Belgrade in spring 2006 (to be more specific, the level of water during this flood was the highest in past 107 years), we can know exactly what are the flood risks in Belgrade today. With existing flood protection measures, Belgrade can be considered safe for the medium duration of flood. Further development will change flood hazards and vulnerability level of different aspects and therefore level of flood risk will be changed. In further analysis 3 possible scenarios will be analyzed to examine future level of flood risk for each different development scenario for Belgrade.

Possible scenarios of development

Many different scenarios of development of the Great Island of War can be considered, taking into account huge interest for the Island from different sides. Only in past few decades many different scenarios were considered: construction of formula 1 autodrome, relocation of city business center to the Island, relocation of Zoo-park to the Island, cutting part of the Danube to form an artificial lake etc. All of these scenarios and many others are possible to happen, but the ones chosen to be considered in this work are: scenario of small changes (existing development trend which assumes no major investments will take place on the Island); scenario of uncontrolled development (unfavorable scenario which is, at the moment, unlikely to happen but should be considered since consequences of this scenario could be severe); scenario of sustainable development (proposed scenario, taking into account interests of majority of country and city inhabitants).

Scenario 1 - Scenario of small changes

(expected development scenario of the Great Island of War)

Scenario of small changes is expected scenario, as planned development for the Great Island of War requires significant investments which are not likely to happen soon. Reasons for this are several but most important ones are economic difficulties in the government and public sector and unwillingness of the authorities to allow private investments on such important location.

Small changes scenario assumes that natural environment will mostly stay preserved and that similar activities as at the moment, only with higher frequency will take place on the Island. Small, controlled investments are to be expected on the island within this scenario. For example, during summer months, a pontoon bridge is constructed connecting beach part of the island with river bank. This results in more intensive use of this area of the island and also on some small economic activity following this process. Removable facilities are installed during this period on this part of the island such as: removable toilets and showers, small café with terrace, some recreational facilities and storages etc. As these facilities are constructed and removed every season it can be assumed that such structures can be constructed as permanent facilities, since it is cheaper to construct it properly once than to remove it every year.

Small weekend houses exist today on the island, and despite the fact that they are constructed without a building permit and of poor building material, it can be assumed that this process will be intensified following growth of the living standard of the city population and city authorities not preventing illegal construction in this area. It can be assumed that in next 10 years number of weekend houses existing on the island will increase from presently existing 50 to approximately 200. These houses are mostly constructed as elevated structures (ground floor is raised on columns) but in the vicinity, different sheds are constructed and other material is usually stored. Some of these weekend houses are also used as permanent housing solutions, throughout all the year.

With increase of number of weekend houses some small economic activity can be expected to take place on the island, which will also lead to some more constructed facilities.

Flood hazards in Belgrade following the scenario of small changes

Hydrology of the Danube can be expected slightly to change following the development described in the scenario of small changes. As within the scenario of small changes a dispersed construction of individual housing units along the river banks on the island is to be expected, these constructions would present certain obstacles for natural water flow during flood. As these houses would be constructed of poor building material, they are expected to collapse during flood and together with the material carried by the river, form bigger obstacles for the natural flow. This would lead to a change in the flow process, causing flood hazard situation to change. As amount of construction within this scenario is small, changes in the flood hazard situation are expected to be small as well.

High flood hazard zones - areas with expectancy of flooding within 10 years return period.

Medium flood hazard zones - areas with expectancy of flooding within 30 years return period.

Low flood hazard zones - areas with expectancy of flooding within 100 years return period.

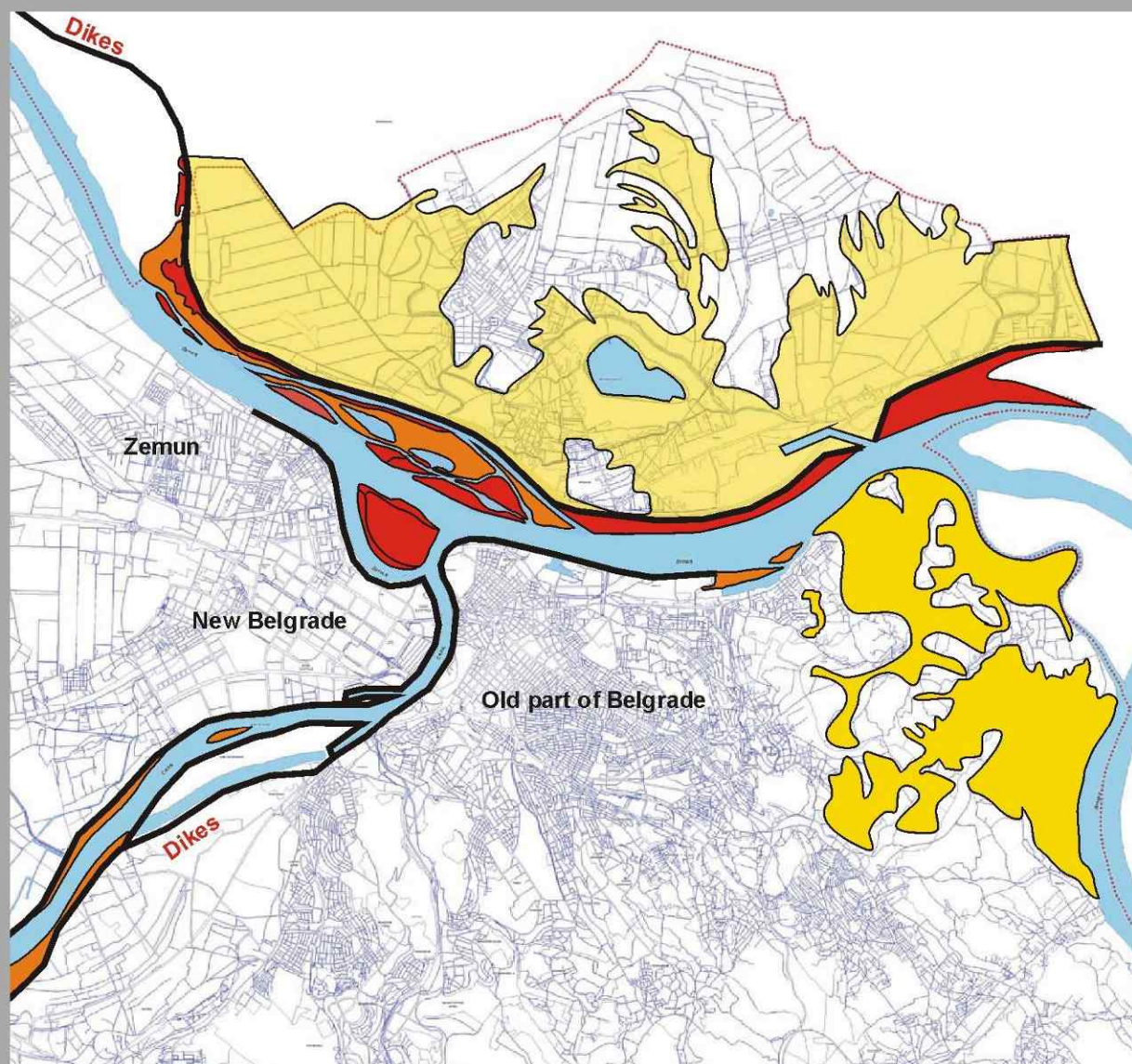
Flood hazards in Belgrade following the Scenario of small changes

(the Great Island of War and other river islands are in the high hazard zone)

Legend - Flood hazard map;
Scenario of small changes

- High flood hazard zone
- Medium flood hazard zone
- Low flood hazard zone
- Zone with high underground water table level
- Dikes

Scale 1:150,000



Vulnerability in Belgrade following the scenario of small changes

Vulnerability of the areas in Belgrade prone to flooding following the scenario of small changes is analyzed through the same vulnerability aspects and in the same methodology as for the vulnerability of Belgrade today. Three aspects of vulnerability are considered in determine an overall vulnerability level of analyzed areas: vulnerability of population, vulnerability of constructed environment and vulnerability of economic activity. Methodology of analysis consist of 4 steps:

Step 1 - Defining land use map for the analyzed area

Step 2 - Vulnerability quantification through 3 vulnerability aspects

Step 3 - Vulnerability quantification for different land use zones

Step 4 - Overall vulnerability level and vulnerability map

Based on these 3 analyzed vulnerability aspects, for every identified zone in the hazardous area a specific vulnerability index is defined. Following the 4 methodology steps, an overall vulnerability level is determined and presented in the vulnerability map.

- 1. Defining land use map for the analyzed area following the scenario of small changes** – slight changes of the land use are visible on the Great Island of War and on river islands located nearby, that are expected to develop in the same way.

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Agricultural land – area with predominant agricultural and farming activity;

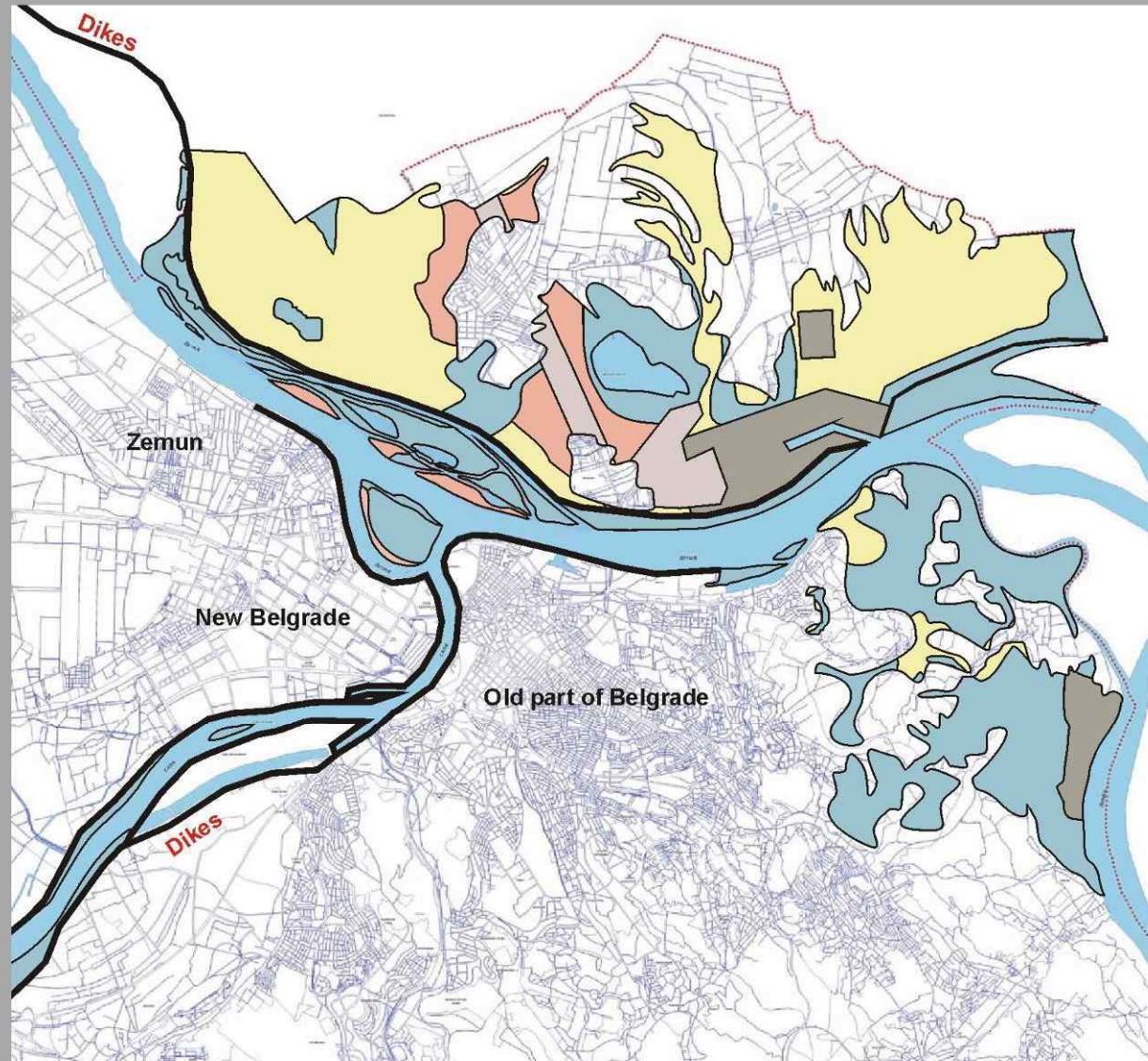
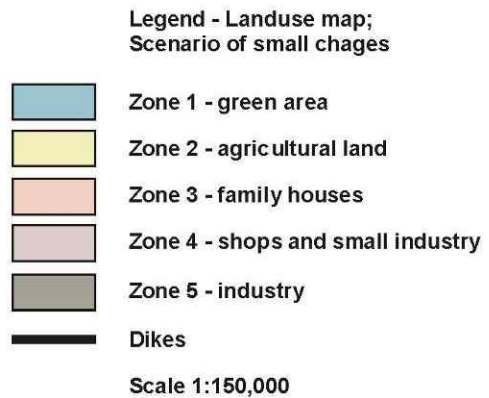
Family houses – housing area covered with single family houses and some apartment buildings;

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Industry – area covered by big industry companies and infrastructure;

Land use map of Belgrade following the scenario of small changes

(Areas on the Great Island of War are inhabited and have a different land use)



2. Vulnerability quantification through 3 vulnerability aspects – same *vulnerability quantification parameters* are used to calculate vulnerability indexes for 3 vulnerability aspects, as for the Vulnerability of Belgrade today.

3. Vulnerability quantification for different land use zones – for each land use zone, through all 3 vulnerability aspects, based on vulnerability quantification parameters, a vulnerability index is defined. Same formulas for calculating vulnerability indexes are used as for the Vulnerability of Belgrade today.

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Vulnerability of population – no people expected in the area during flood period – index 0

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – no economic activity – index 0

Agricultural land – area with predominant agricultural and farming activity;

Vulnerability of population – less than 5 people per km² present in the area – index 1

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Family houses – housing area covered with single family houses and some apartment buildings;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Industry – area covered by big industry companies and infrastructure;

Vulnerability of population – 5 - 50 people per km² present in the area – index 2

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

- 4. Overall vulnerability level** – for every identified land use zone, a sum of vulnerability indexes is defined and based on following formulas, level of overall vulnerability is determined.

Sum of indexes of 3 vulnerability aspects = 0 → no vulnerability

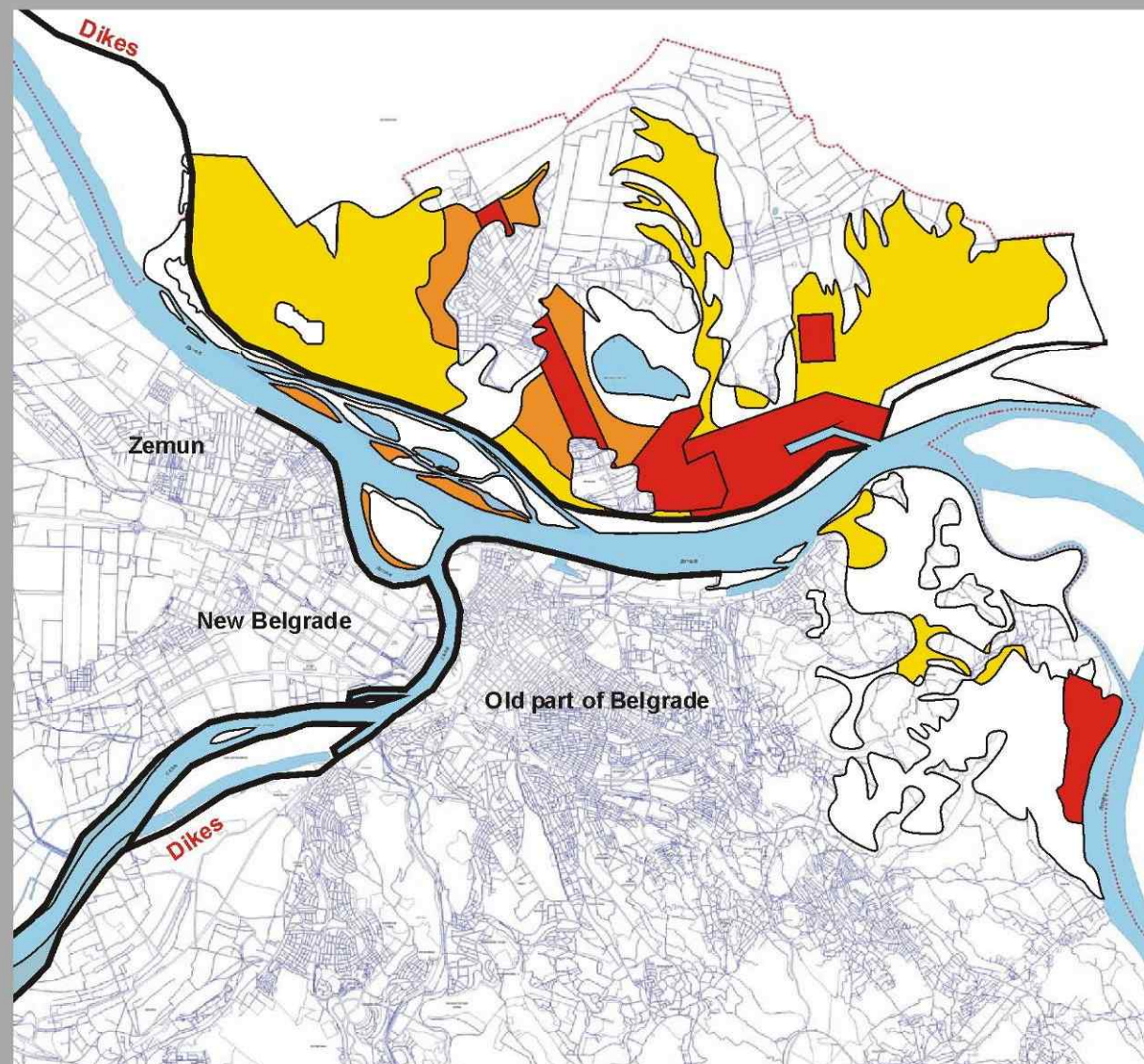
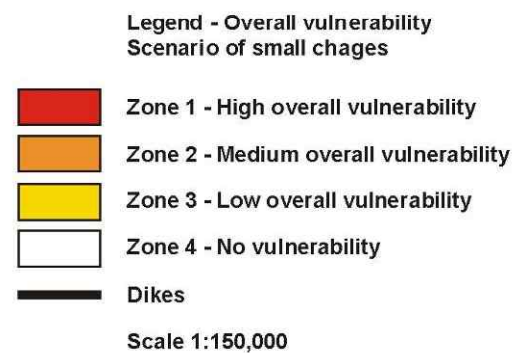
Sum of indexes of 3 vulnerability aspects between 1 and 3 → low vulnerability

Sum of indexes of 3 vulnerability aspects between 4 and 6 → medium vulnerability

Sum of indexes of 3 vulnerability aspects between 7 and 9 → high vulnerability

	Aspects of Vulnerability				
	vulnerability of population	vulnerability of constructed environment	vulnerability of economic activity	overall vulnerability	overall vulnerability
Zone No.					
1 - Green area	0	0	0	0	no vulnerability
2 - Agricultural land	1	0	1	2	low vulnerability
3 - Family houses	3	3	1	7	high vulnerability
4 - shops and small industry	3	3	3	9	high vulnerability
5 - industry	2	3	3	8	high vulnerability

**Overall vulnerability map of
Belgrade following the scenario
of small changes**



Flood risks in Belgrade following the scenario of small changes

For flood risk calculation in Belgrade a following methodology was applied. To calculate flood risk in an analyzed area, quantification of flood hazards and quantification of overall vulnerability for the specific area was calculated. As risk is, by definition, result of level of hazard and level of vulnerability, a following formula was used for calculation of flood risk on the specific area:

Overall flood risk index = flood hazard x overall vulnerability (all analyzed for specific area)

Flood hazard level, defined by probability of occurrence and intensity of the phenomenon, was calculated as high, medium, low and no hazard and for each level of hazard a quantification value was assigned (or index number):

High flood hazard (probability of occurrence of flooding within 10 years) – index 3

Medium flood hazard (probability of occurrence of flooding within 30 years) – index 2

Low flood hazard (probability of occurrence of flooding within 100 years) – index 1

No flood hazard – index 0

Overall vulnerability level, as sum of 3 vulnerability aspects, was calculated as high, medium, low and no vulnerability, depending on quantification parameters. For overall level, a quantification value was assigned (or index number):

High overall vulnerability – index 3

Medium overall vulnerability – index 2

Low overall vulnerability – index 1

No vulnerability – index 0

After performing calculation of overall risk index, overall flood risk is described as high, medium, low or no risk based on the following criteria:

Overall risk index between 6 and 9 → high flood risk

Overall risk index between 3 and 5 → medium flood risk

Overall risk index between 1 and 2 → low flood risk

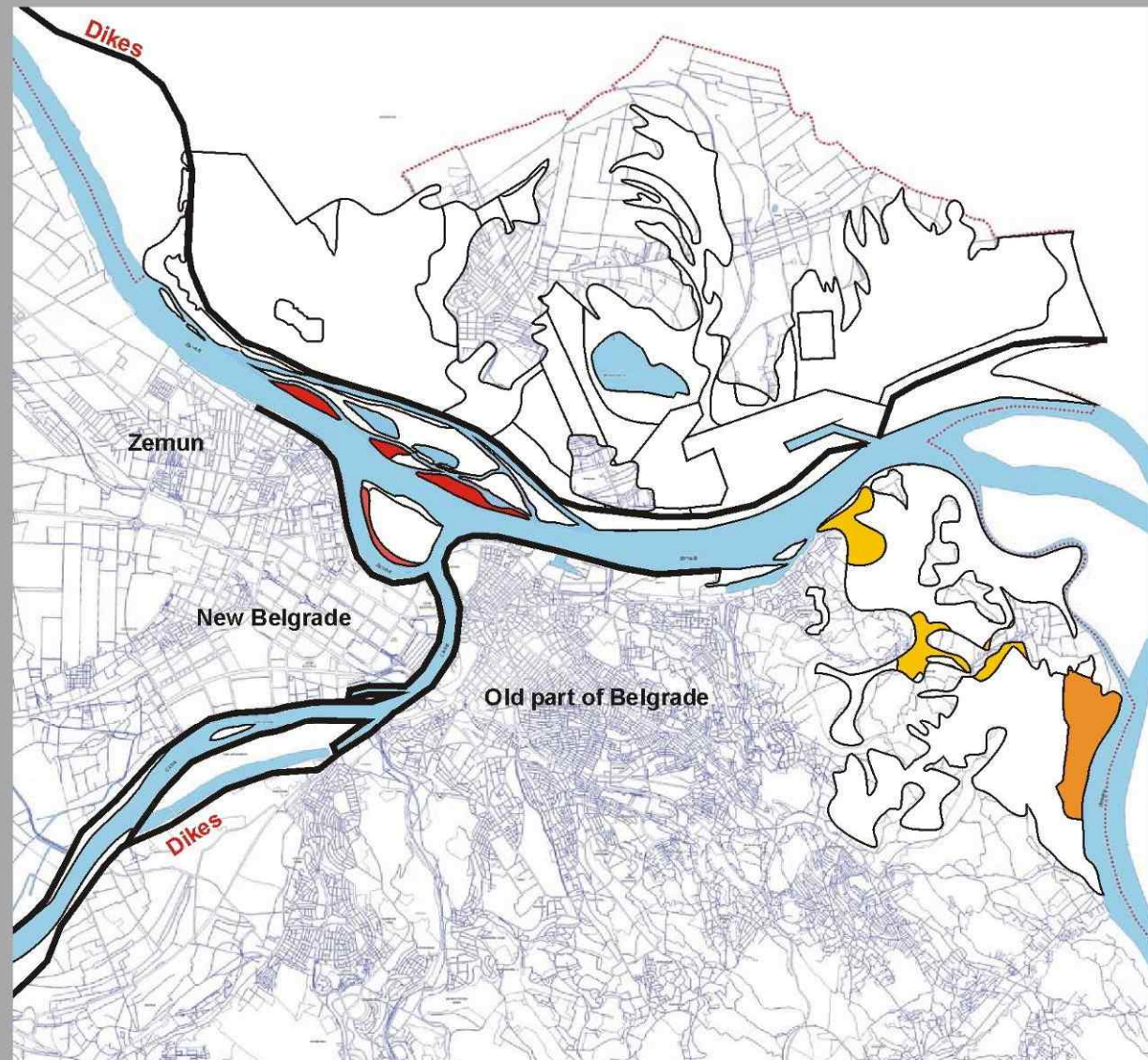
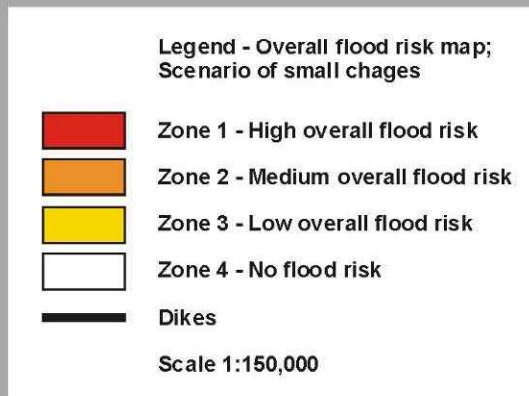
Overall risk index = 0 → no flood risk

Calculated flood risk is presented in a table and on the map:

Zone No.	overall vulnerability	vulnerability index	hazard	hazard index	overall flood risk index	overall flood risk
1 - Green area	no	0	low	1	0	no
	no	0	medium	2	0	no
	no	0	high	3	0	no
2 - Agricultural land	low	1	low	1	1	low
	low	1	medium	2	2	low
	low	1	high	3	3	medium
3 - Family houses	medium	2	low	1	2	low
	medium	2	medium	2	4	medium
	medium	2	high	3	6	high
4 - shops and small industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
5 - industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high

Flood risks in Belgrade following the scenario of small changes

Inhabited areas of the Great Island of War and other river islands are in the high risk zone



Short-term and long-term impact of the scenario of small changes

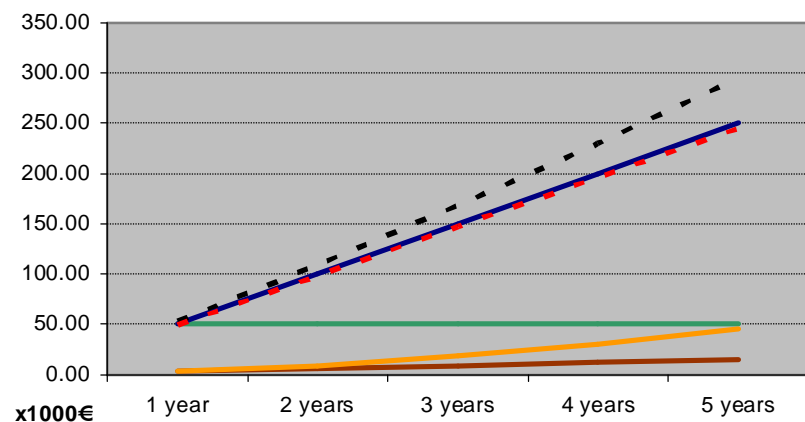
Cost-benefit analysis in case of hazardous event and in case of undisturbed development

Scenario of small changes assumes that no major investments would occur on the Great Island of War during the analyzed period of short-term development (next 5 years) and long-term development (next 25 years). All investments undertaken within this scenario are small private investments and can be calculated as 50,000 EUR of construction investment per year and 3,000 EUR income out of economic activities per 50,000 EUR construction investment.

Potential cumulative losses in case of hazardous event (100 year flood) can be calculated as destruction of 80% of the constructed environment and approx 3 years to recover economic activities. Constructed environment (temporary small family houses and facilities) built within this scenario of development is considered to be not resistant to big floods.

Scenario of small changes, short-term impact (5 years), undisturbed process:

scenario of small changes undisturbed development, short term impact					
	1 year	2 years	3 years	4 years	5 years
investment per year	50.00	50.00	50.00	50.00	50.00
investment cumulative value	50.00	100.00	150.00	200.00	250.00
income per year	3.00	6.00	9.00	12.00	15.00
income cumulative value	3.00	9.00	18.00	30.00	45.00
total value	53.00	109.00	168.00	230.00	295.00
potential cumulative losses	49.00	98.00	147.00	196.00	245.00



— investment per year — investment cumulative value
— income per year — income cumulative value
- - - total value - - - potential cumulative losses

This calculation results with 45,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 250,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 295,000 EUR

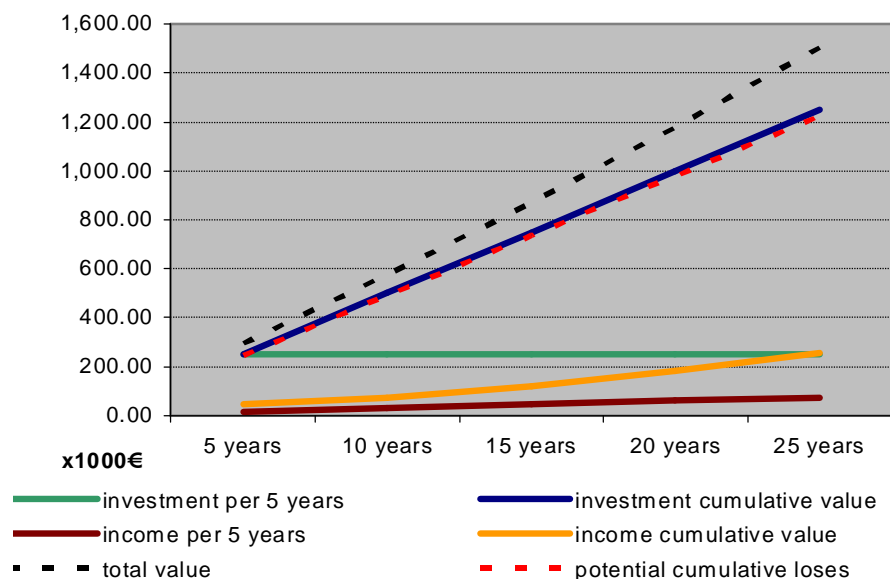
Potential cumulative losses in case of hazardous event (100 year flood) are calculated for each year as destruction of 80% of the constructed environment and approx 3 years to recover economic activities (income for the calculated year x 3).

scenario of small changes undisturbed development, short term impact					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	50.00	100.00	150.00	200.00	250.00
total cumulative income	3.00	9.00	18.00	30.00	45.00
PROFIT	-47.00	-91.00	-132.00	-170.00	-205.00

Financial analysis of the scenario of small changes in case of undisturbed development for the short-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of small changes, long-term impact (25 years), undisturbed process:

scenario of small changes undisturbed development, long term impact					
	5 years	10 years	15 years	20 years	25 years
investment per 5 years	250.00	250.00	250.00	250.00	250.00
investment cumulative value	250.00	500.00	750.00	1,000.00	1,250.00
income per 5 years	15.00	30.00	45.00	60.00	75.00
income cumulative value	45.00	75.00	120.00	180.00	255.00
total value	295.00	575.00	870.00	1,180.00	1,505.00
potential cumulative losses	245.00	490.00	735.00	980.00	1,225.00



This calculation results with 255,000 EUR cumulative income of the economic activities on the Island for the period of 25 years (long-term impact) and cumulative investment of 1,250,000 EUR in constructed facilities.

Total value in this scenario for the long-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 1,505,000 EUR

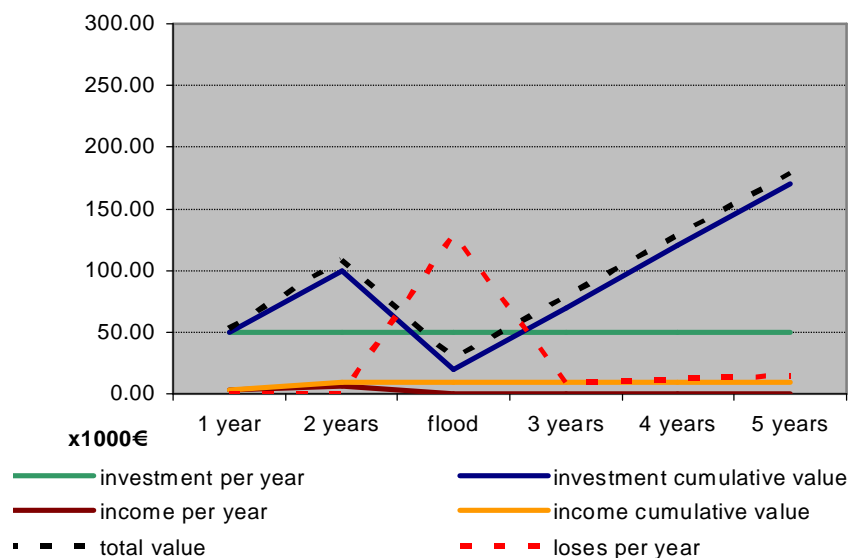
Potential cumulative losses in case of hazardous event (100 year flood) are calculated for each year as destruction of 80% of the constructed environment and approx 3 years to recover economic activities (income for the calculated year x 3).

scenario of small changes undisturbed development, long term impact					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	250.00	500.00	750.00	1,000.00	1,250.00
total cumulative income	45.00	75.00	120.00	180.00	255.00
PROFIT	-205.00	-425.00	-630.00	-820.00	-995.00

Financial analysis of the scenario of small changes in case of undisturbed development for the long-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of small changes, short-term impact (5 years) - case of 100 year flood in the 3rd year:

scenario of small changes case of 100 year flood in 3rd year						
	1 year	2 years	red flood	3 years	4 years	5 years
investment per year	50.00	50.00	50.00	50.00	50.00	50.00
investment cumulative value	50.00	100.00	20.00	70.00	120.00	170.00
income per year	3.00	6.00	0.00	0.00	0.00	0.00
income cumulative value	3.00	9.00	9.00	9.00	9.00	9.00
total value	53.00	109.00	29.00	79.00	129.00	179.00
loses per year	0.00	0.00	129.00	9.00	12.00	15.00



This calculation results with 9,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 250,000 EUR (50,000 EUR per year) in constructed facilities.

Total value in this scenario for the short-term period in case of 100 year flood in the 3rd year is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 179,000 EUR

In case of big hazardous event (100 year flood) within the short-term period loses can be calculated as 80% of the constructed environment and 3 years to recover economic activities:

Total loses for 100 year flood in short-term period (during the 3rd year):

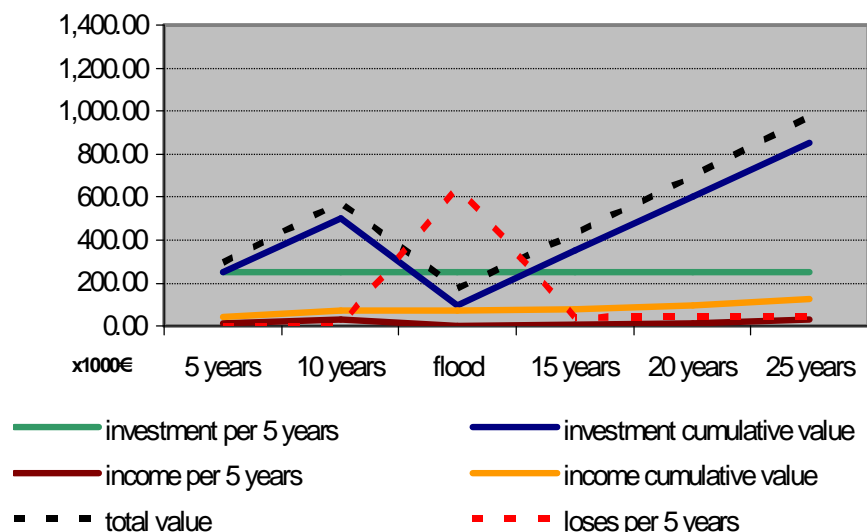
$$\begin{aligned}
 &0.8 \times 150,000 \text{ (constructed environment)} \\
 &+ 9,000 \text{ (income in the 3rd year)} \\
 &+ 12,000 \text{ (income in the 4th year)} \\
 &+ 15,000 \text{ (income in the 5th year)} \\
 &= 156,000 \text{ EUR}
 \end{aligned}$$

scenario of small changes - case of 100 year flood in 3rd year					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	50.00	100.00	150.00	200.00	250.00
total cumulative income	3.00	9.00	9.00	9.00	9.00
PROFIT	-47.00	-91.00	-141.00	-191.00	-241.00

Financial analysis of the scenario of small changes in case of 100 year flood for the short-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of small changes, long-term impact (25 years) - case of 100 year flood in the 15th year:

scenario of small changes case of 100 year flood in 15th year						
	5 years	10 years	flood	15 years	20 years	25 years
investment per 5 years	250.00	250.00	250.00	250.00	250.00	250.00
investment cumulative value	250.00	500.00	100.00	350.00	600.00	850.00
income per 5 years	15.00	30.00	0.00	5.00	15.00	30.00
income cumulative value	45.00	75.00	75.00	80.00	95.00	125.00
total value	295.00	575.00	175.00	430.00	695.00	975.00
loses per 5 years	0.00	0.00	645.00	40.00	45.00	45.00



This calculation results with 125,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 1,250,000 EUR in constructed facilities.

Total value in this scenario for the long-term period in case of 100 year flood in the 3rd year is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 975,000 EUR

In case of big hazardous event (100 year flood) within the long-term period losses can be calculated as 80% of the constructed environment and 6 years to recover economic activities:

Total losses for 100 year flood in long-term period (during the 15th year):

0.8 x 750,000 (constructed environment)
 + 45,000 (income in the 15th year)
 + 48,000 (income in the 16th year)
 + 51,000 (income in the 17th year)
 + 54,000 (income in the 18th year)
 + 57,000 (income in the 19th year)
 + 60,000 (income in the 20th year)
 = 915,000 EUR

scenario of small changes case of 100 year flood in 15th year					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	250.00	500.00	750.00	1,000.00	1,250.00
total cumulative income	45.00	75.00	80.00	95.00	125.00
PROFIT	-205.00	-425.00	-670.00	-905.00	-1,125.00

Financial analysis of the scenario of small changes in case of 100 year flood for the long-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Conclusion:

Financial analysis of impacts of the scenario of small changes shows that the result of the development in all 4 analyzed processes (undisturbed development for the short-term period; undisturbed development for the long-term period; 100 year flood in the short-term period; 100 year flood in the long-term period) is always far below the profitable level – cumulative income is always significantly lower than the cumulative investment.

**Scenario 2 – Scenario of uncontrolled development
(unfavorable development scenario of the Great Island of War)**

This scenario assumes unfavorable changes on the political and governmental level, which would lead to weakening of the public institutions, followed with disrespect of country laws and in general more chaotic public and economic environment. This is not a scenario that is likely to happen at this moment, but since it is unfavorable it requires risk analysis.

Such development occurred in Serbia during 1990-ties and throughout this period uncontrolled construction of housing units and different business premises was one of the major economic activity in the country.

(Municipality that lies close to the Great Island of War, Zemun, was during 1990-ties transformed with uncontrolled construction and urban development. Small family houses with business premises were constructed on former green and parking areas, significantly reducing quantity of parking and green space in the city and affecting urban activities and capacity of infrastructure and facilities. Large housing settlements were formed on agricultural land, lacking basic infrastructure such as paved roads, sewerage network, heating system and sometimes even regular water supply.)

Similar scenario can be, under mentioned circumstances, imagined to happen on the Great Island of War. If illegal family housing would start, very soon it would be followed with economic activity which would grow fast being positioned conveniently for all leisure and recreation activities.

In the first phase of this scenario it can be expected that construction of family houses would be the first type of construction to happen on the Island. Construction that is to be expected within this scenario should be of very poor quality and poorly and unprofessionally designed. Reason for this is that social categories that can not afford legal and decent housing solutions are the ones to be expected to start such constructions.

Construction performed in this phase of development should be considered as very potentially dangerous as it is expected that these buildings and infrastructure would easily be destroyed during flood.

(During 1990-ties in Serbia, after war conflicts on Balkan, social pressure for housing solutions was highly increased due to high influx of refugees and huge lack of public housing. This lead to construction of informal settlements mostly on agricultural land and mostly by socially and economically vulnerable groups. Similar profile of investors can be expected in the first phase of this scenario of development.)

In the second phase, this would result in intensive construction on the island, which would cause increase of economic activity required to service housing areas and development of basic infrastructure for these settlements and economic activity.

Following first two phases of development, bigger investors are to be expected. It can be assumed that in the third phase of development they would use surroundings of socially vulnerable groups as a form of protection for unofficial economic activity. Informal settlements are usually not easy to move once they are formed, but they can also “host” some of the very profitable economic activities.

Types of constructions (restraints, shops, cafés) that can be expected in this phase of development are more solid buildings than in the first and second phase. Considering the damage this constructions will suffer during floods, these buildings are in more favorable position than the ones constructed in the first and second phase. Considering the vulnerability of people and equipment in these buildings, they are also less vulnerable, but for the flow process during flood, these houses would present major obstacles.

Flood hazards in Belgrade following the scenario of uncontrolled development

Considering the flow process of the Danube and the Sava rivers during floods, both constructions, together with trees and deposited material on

the island have to be taken into account, as well as the material that rivers are carrying along during floods. Houses constructed during first and second phase of development can be expected to collapse during 100 years floods and heavily damaged during 50 year flood. Constructions raised during third phase of development can be expected to sustain 100 year flood, due to higher quality of construction material and therefore would function as obstacles for the natural flow. Trees in the area close to river banks on the island are more prone to collapsing during floods due to higher velocity of the flow in this zone and due to deposition of the material that is allways caught by the trees laying on the river banks. Collapsed trees and houses, together with the material that river is carrying from upstream are to be expected to deposit when coming across any obstacle such as remaining houses and strong trees. Deposited material in the river flow causes changes in the flow characteristics, making it faster in the gaps where the river is still running and rises the water level upstream of the obstacle. Rising of the river level endangers dikes and if they are constructed of natural material (which is the case in Belgrade – dykes protecting New Belgrade are made out of sand and soil) they will become less and less stable with the time they are in contact with water and erosion. Faster flow of the river in some zones causes stronger erosion of the river banks or dykes which leads to danger of dyke collapse.

High flood hazard zones - areas with expectancy of flooding within 10 years return period.

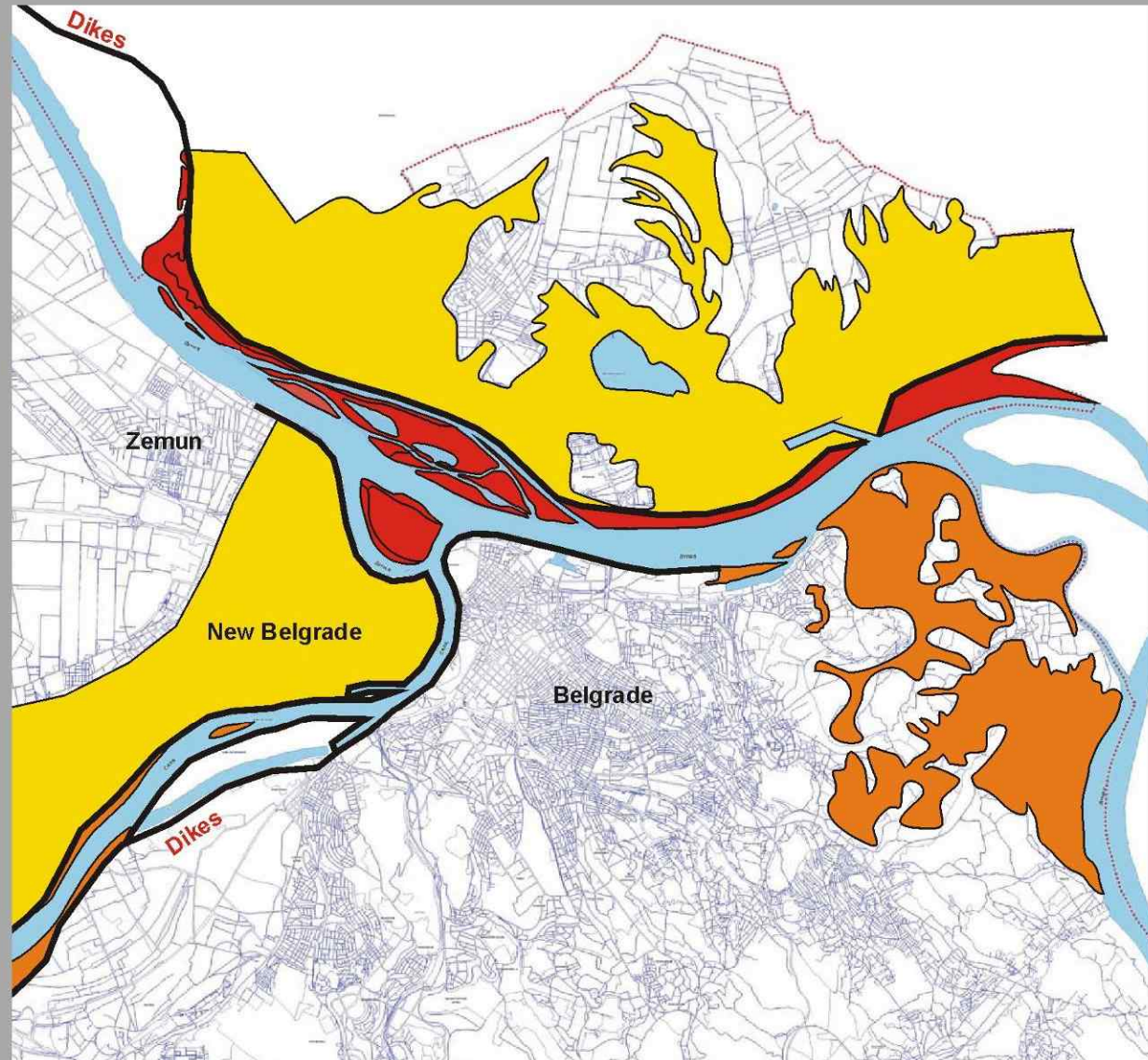
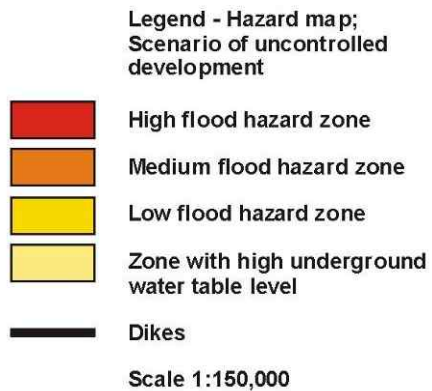
Medium flood hazard zones - areas with expectancy of flooding within 30 years return period.

Low flood hazard zones - areas with expectancy of flooding within 100 years return period.

Flood hazards in Belgrade following the Scenario of uncontrolled development

The Great Island of War and other river islands are in the high hazard zone and New Belgrade area is in the low hazard zone

Zone on the north of the Danube with high underground water table level is in the low flood hazard zone



Vulnerability in Belgrade following the scenario of uncontrolled development

Vulnerability of the areas in Belgrade prone to flooding following the scenario of uncontrolled development is analyzed through the same vulnerability aspects and in the same methodology as for the vulnerability of Belgrade today. Three aspects of vulnerability are considered in determine an overall vulnerability level of analyzed areas: vulnerability of population, vulnerability of constructed environment and vulnerability of economic activity. Methodology of analysis consist of 4 steps:

Step 1 - Defining land use map for the analyzed area

Step 2 - Vulnerability quantification through 3 vulnerability aspects

Step 3 - Vulnerability quantification for different land use zones

Step 4 - Overall vulnerability level and vulnerability map

Based on these 3 analyzed vulnerability aspects, for every identified zone in the hazardous area a specific vulnerability index is defined. Following the 4 methodology steps, an overall vulnerability level is determined and presented in the vulnerability map.

Defining land use map for the analyzed area following the scenario of uncontrolled development – changes of the land use are visible on the Great Island of War and on river islands located nearby, that are expected to develop in the same way

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Agricultural land – area with predominant agricultural and farming activity;

Family houses – housing area covered with single family houses and some apartment buildings;

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Industry – area covered by big industry companies and infrastructure;

Densely populated urban area – area covered with high rise apartment and office buildings, large market areas, vital roads and infrastructure, government administration and public buildings, with high economic activity;

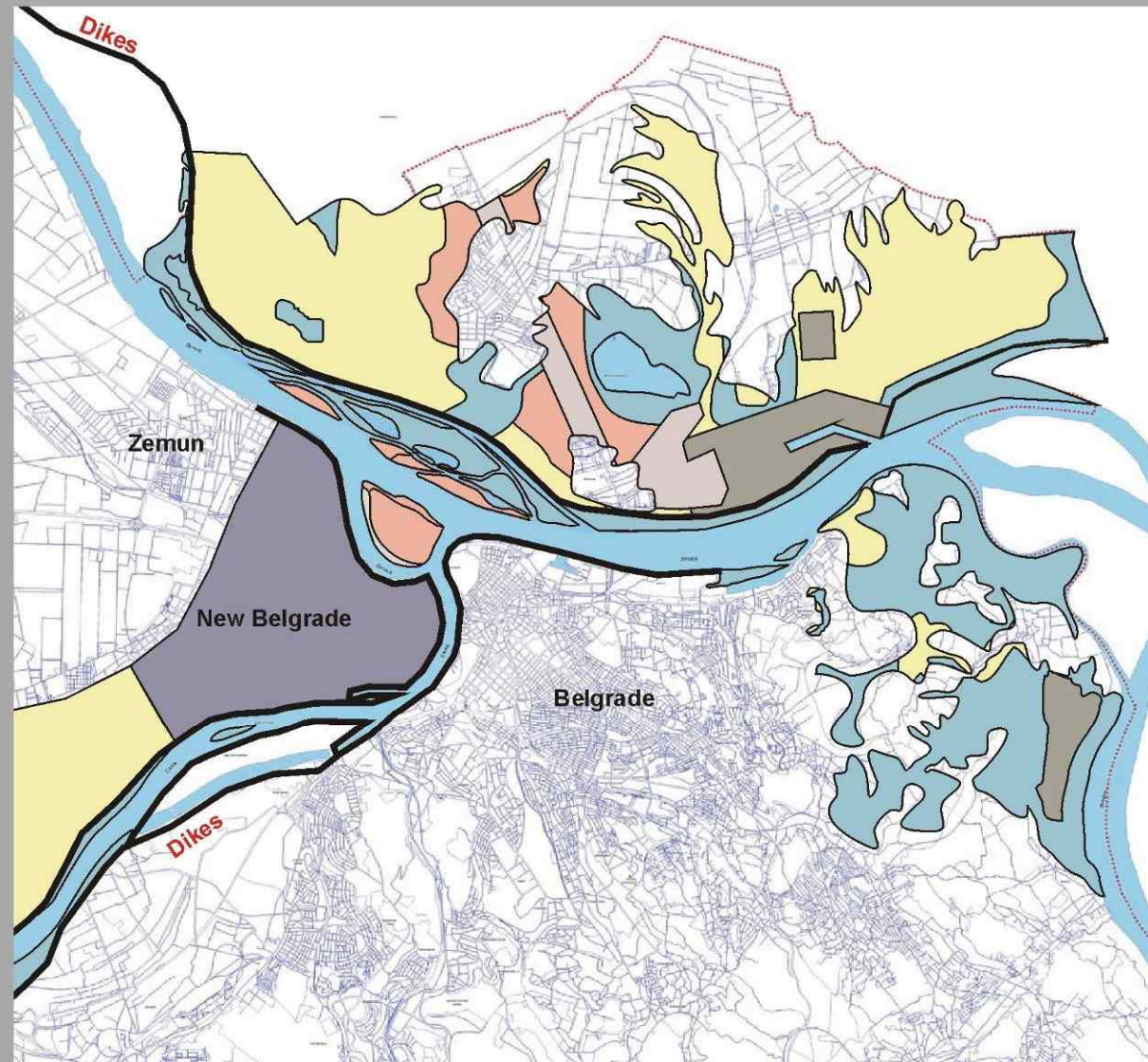
**Land use map of Belgrade
following the scenario of
uncontrolled development**

Changes of land use are visible on
the Great Island of War and other
river islands

Legend - Landuse map;
Scenario of uncontrolled development

-  Zone 1 - green area
-  Zone 2 - agricultural land
-  Zone 3 - family houses
-  Zone 4 - shops and small industry
-  Zone 5 - industry
-  Zone 6 - densely populated urban area
-  Dikes

Scale 1:150,000



Vulnerability quantification through 3 vulnerability aspects – same *vulnerability quantification parameters* are used to calculate vulnerability indexes for 3 vulnerability aspects, as for the Vulnerability of Belgrade today.

Vulnerability quantification for different land use zones – for each land use zone, through all 3 vulnerability aspects, based on vulnerability quantification parameters, a vulnerability index is defined. Same formulas for calculating vulnerability indexes are used as for the Vulnerability of Belgrade today.

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Vulnerability of population – no people expected in the area during flood period – index 0

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – no economic activity – index 0

Agricultural land – area with predominant agricultural and farming activity;

Vulnerability of population – less than 5 people per km² present in the area – index 1

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Family houses – housing area covered with single family houses and some apartment buildings;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Industry – area covered by big industry companies and infrastructure;

Vulnerability of population – 5 - 50 people per km² present in the area – index 2

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Densely populated urban area – area covered with high rise apartment and office buildings, large market areas, vital roads and infrastructure, government administration and public buildings, with high economic activity;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Overall vulnerability level – for every identified land use zone, a sum of vulnerability indexes is defined and based on following formulas, level of overall vulnerability is determined.

Sum of indexes of 3 vulnerability aspects = 0 → no vulnerability

Sum of indexes of 3 vulnerability aspects between 1 and 3 → low vulnerability

Sum of indexes of 3 vulnerability aspects between 4 and 6 → medium vulnerability

Sum of indexes of 3 vulnerability aspects between 7 and 9 → high vulnerability

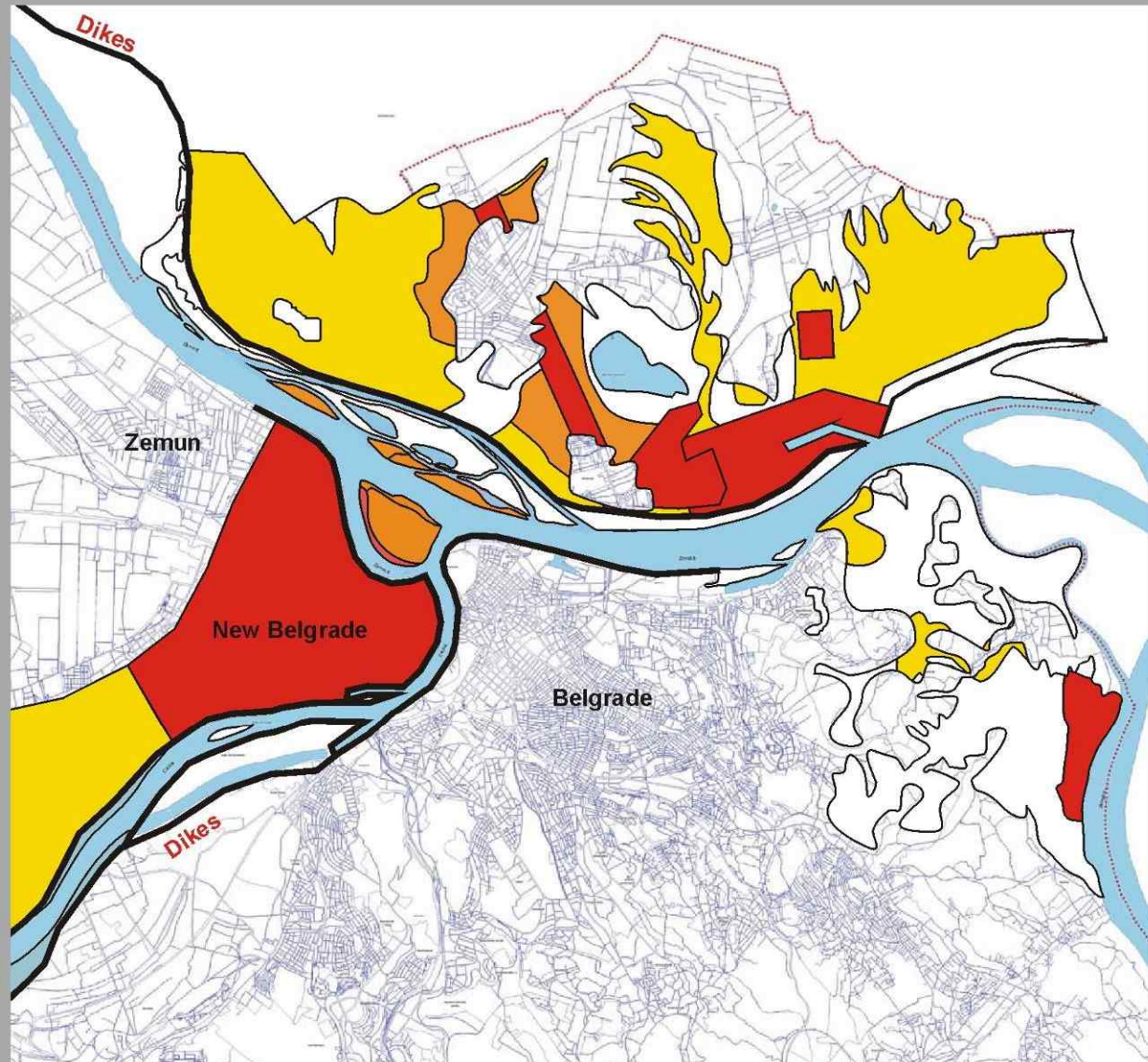
Zone No.	Aspects of Vulnerability			overall vulnerability	overall vulnerability
	vulnerability of population	vulnerability of constructed environment	vulnerability of economic activity		
1 - Green area	0	0	0	0	no vulnerability
2 - Agricultural land	1	0	1	2	low vulnerability
3 - Family houses	3	3	1	7	high vulnerability
4 - shops and small industry	3	3	3	9	high vulnerability
5 - industry	2	3	3	8	high vulnerability
6 - densely populated urban area	3	3	3	9	high vulnerability

**Overall vulnerability map of
Belgrade following the scenario
of uncontrolled development**

**Legend - Overall vulnerability map;
Scenario of uncontrolled development**

- Zone 1 - High overall vulnerability
- Zone 2 - Medium overall vulnerability
- Zone 3 - Low overall vulnerability
- Zone 4 - No vulnerability
- Dikes

Scale 1:150,000



Flood risks in Belgrade following the scenario of uncontrolled development

With uncontrolled construction on the Great Island of War and occurrence of 100 year flood it can be expected that the important part of the island surface will be covered with deposited material and not function as a retention area. Depending on the amount of deposit material that the Danube would be carrying from upstream and number and size of obstacles on the island, size of formed obstacle can vary from medium to huge. Depending on length of flood and level of water, danger of dyke collapse can vary. In case of New Belgrade dyke collapse, former retention area (New Belgrade is constructed on former swamp) would be filled with water. This would cause the danger of liquefaction as sand on which whole New Belgrade is constructed could become saturated with water. (*Liquefaction is a process in which soil material, such as sand, can develop characteristics of a liquid when saturated with water. This often leads to collapse of buildings that are constructed on this soil.*) Buildings in New Belgrade are predominantly constructed on deep foundation columns which would be an advantage in this scenario, but risk for the people and economy remains.

For flood risk calculation in Belgrade a following methodology was applied. To calculate flood risk in an analyzed area, quantification of flood hazards and quantification of overall vulnerability for the specific area was calculated. As risk is, by definition, result of level of hazard and level of vulnerability, a following formula was used for calculation of flood risk on the specific area:

Overall flood risk index = flood hazard x overall vulnerability (all analyzed for specific area)

Flood hazard level, defined by probability of occurrence and intensity of the phenomenon, was calculated as high, medium, low and no hazard and

for each level of hazard a quantification value was assigned (or index number):

High flood hazard (probability of occurrence of flooding within 10 years) – index 3

Medium flood hazard (probability of occurrence of flooding within 30 years) – index 2

Low flood hazard (probability of occurrence of flooding within 100 years) – index 1

No flood hazard – index 0

Overall vulnerability level, as sum of 3 vulnerability aspects, was calculated as high, medium, low and no vulnerability, depending on quantification parameters. For overall level, a quantification value was assigned (or index number):

High overall vulnerability – index 3

Medium overall vulnerability – index 2

Low overall vulnerability – index 1

No vulnerability – index 0

After performing calculation of overall risk index, overall flood risk is described as high, medium, low or no risk based on the following criteria:

Overall risk index between 6 and 9 → high flood risk

Overall risk index between 3 and 5 → medium flood risk

Overall risk index between 1 and 2 → low flood risk

Overall risk index = 0 → no flood risk






Calculated flood risk is presented in a table and on the map:

Zone No.	overall vulnerability	vulnerability index	hazard	hazard index	overall flood risk index	overall flood risk
1 - Green area	no	0	low	1	0	no
	no	0	medium	2	0	no
	no	0	high	3	0	no
2 - Agricultural land	low	1	low	1	1	low
	low	1	medium	2	2	low
	low	1	high	3	3	medium
3 - Family houses	medium	2	low	1	2	low
	medium	2	medium	2	4	medium
	medium	2	high	3	6	high
4 - shops and small industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
5 - industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
6 - densely populated urban area	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high

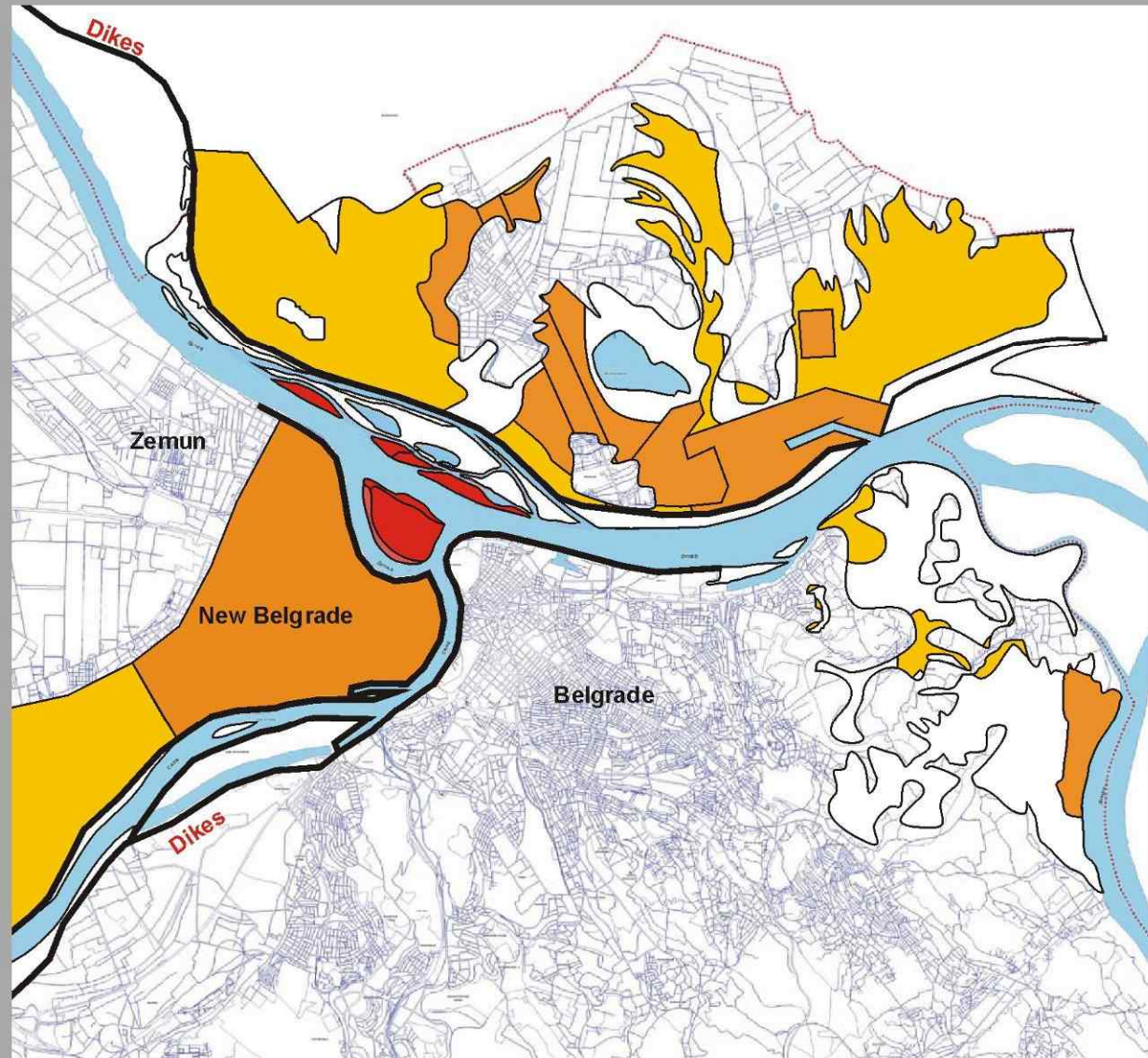
**Flood risks in Belgrade
following the scenario of
uncontrolled development**

Inhabited river islands are in the
high risk zones and New Belgrade
area is in the medium risk zone

Legend - Overall flood risk map;
Scenario of uncontrolled development

-  Zone 1 - High overall flood risk
-  Zone 2 - Medium overall flood risk
-  Zone 3 - Low overall flood risk
-  Zone 4 - No flood risk
-  Dikes

Scale 1:150,000



Short-term and long-term impact of the scenario of uncontrolled development

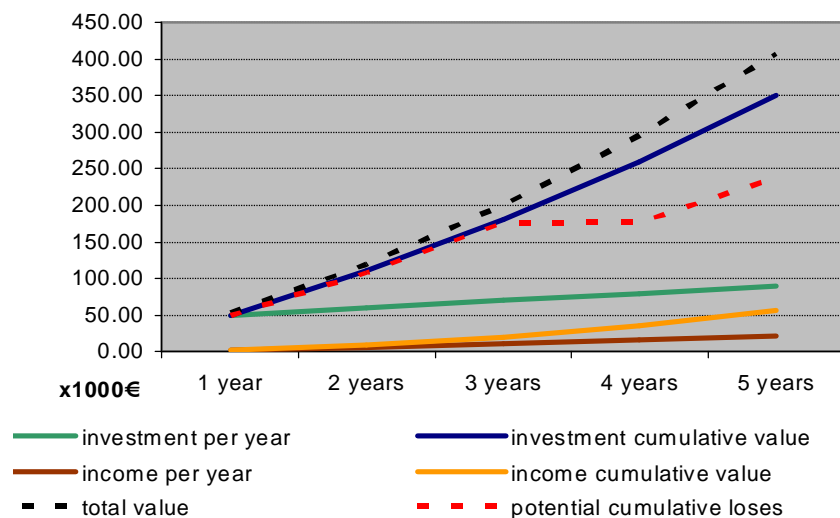
Cost-benefit analysis in case of hazardous event and in case of undisturbed development

Scenario of uncontrolled development assumes that investments would increase with time during the analyzed period of short-term development (next 5 years) and long-term development (next 25 years). Investments undertaken within this scenario would start as small private investments of 50,000 EUR of construction investment per year and increase by 10,000 EUR every year. Assumed income out of economic activities is 3,000 EUR per every 50,000 EUR of construction investment.

Potential cumulative losses in case of hazardous event (100 year flood) can be calculated as destruction of 80% of the constructed environment and approx 3 years to recover economic activities *during the first 3 years* of development. *During the next 5 years* it is assumed that potential cumulative losses in case of 100 year flood can be calculated as destruction of 50% of the constructed environment and approx 3 years to recover economic activities (due to increase of quality of construction in the 2nd phase of this scenario). In the *following 5 years* losses are calculated as 30% of the constructed environment and approx 3 years to recover economic activities, due to further increase of quality of construction. In the *following 10 years* and further losses are calculated as 100 - 150% of the constructed environment and approx 3 years to recover economic activities, due to increase of the flood hazard area on the area of New Belgrade. In the following years losses assumption would increase significantly more due to higher flood risk for the New Belgrade area.

Scenario of uncontrolled development, short-term impact (5 years), undisturbed process:

scenario of uncontrolled development undisturbed process, short term impact					
	1 year	2 years	3 years	4 years	5 years
investment per year	50.00	60.00	70.00	80.00	90.00
investment cumulative value	50.00	110.00	180.00	260.00	350.00
income per year	3.00	6.60	10.80	15.60	21.00
income cumulative value	3.00	9.60	20.40	36.00	57.00
total value	53.00	119.60	200.40	296.00	407.00
potential cumulative losses	49.00	107.80	176.40	176.80	238.00



This calculation results with 57,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 350,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 407,000 EUR

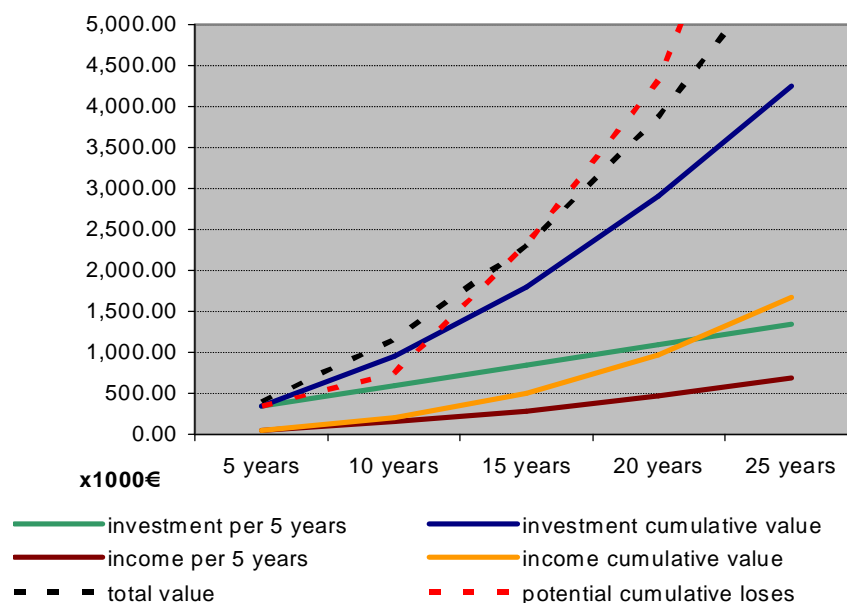
Potential cumulative losses in case of hazardous event (100 year flood) are calculated for each year as destruction of 80% (first 3 years) / 50% (following 5 years) of the constructed environment and approx 3 years to recover economic activities (income for the calculated year x 3).

scenario of uncontrolled development undisturbed process, short term impact					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	50.00	110.00	180.00	260.00	350.00
total cumulative income	3.00	9.60	20.40	36.00	57.00
PROFIT	-47.00	-100.40	-159.60	-224.00	-293.00

Financial analysis of the scenario of uncontrolled development in case of undisturbed development for the short-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of uncontrolled development, long-term impact (25 years), undisturbed process:

scenario of uncontrolled development undisturbed process, long term impact					
	5 years	10 years	15 years	20 years	25 years
investment per 5 years	350.00	600.00	850.00	1,100.00	1,350.00
investment cumulative value	350.00	950.00	1,800.00	2,900.00	4,250.00
income per 5 years	57.00	154.71	293.14	472.29	692.14
income cumulative value	57.00	211.71	504.86	977.14	1,669.29
total value	407.00	1,161.71	2,304.86	3,877.14	5,919.29
potential cumulative losses	346.00	749.14	2,319.43	4,316.86	8,451.43



This calculation results with 1,669,290 EUR cumulative income of the economic activities on the Island for the period of 25 years (long-term impact) and cumulative investment of 4,250,000 EUR in constructed facilities.

Total value in this scenario for the long-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 5,919,290 EUR

Potential cumulative losses in case of hazardous event (100 year flood) are calculated for each 5 years as destruction of 80% (first 3 years) / 50% (following 5 years) / 30% (following 5 years) / 100% (following 5 years) / 150% (following 5 years) of the constructed environment and approx 3 years to recover economic activities (income for the calculated year x 3).

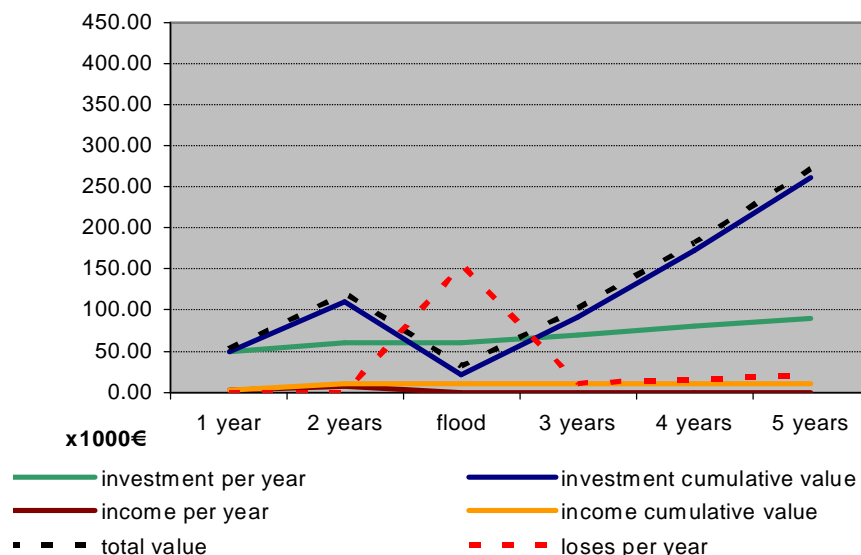
Potential cumulative losses after 15 years of undisturbed development start to exceed cumulative investment value because of endangering the area of New Belgrade.

scenario of uncontrolled development undisturbed process, long term impact					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	350.00	950.00	1,800.00	2,900.00	4,250.00
total cumulative income	57.00	211.71	504.86	977.14	1,669.29
PROFIT	-293.00	-738.29	-1,295.14	-1,922.86	-2,580.71

Financial analysis of the scenario of uncontrolled development in case of undisturbed development for the long-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of uncontrolled development, short-term impact (5 years) - case of 100 year flood in the 3rd year:

scenario of uncontrolled development case of 100 year flood in 3rd year						
	1 year	2 years	flood	3 years	4 years	5 years
investment per year	50.00	60.00	60.00	70.00	80.00	90.00
investment cumulative value	50.00	110.00	22.00	92.00	172.00	262.00
income per year	3.00	6.60	0.00	0.00	0.00	0.00
income cumulative value	3.00	9.90	9.90	9.90	9.90	9.90
total value	53.00	119.90	31.90	101.90	181.90	271.90
loses per year	0.00	0.00	154.80	10.80	15.60	21.00



This calculation results with 9,900 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 350,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of 100 year flood in the 3rd year is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 271,900 EUR
In case of big hazardous event (100 year flood) within the short-term period loses can be calculated as 80% of the constructed environment and 3 years to recover economic activities:

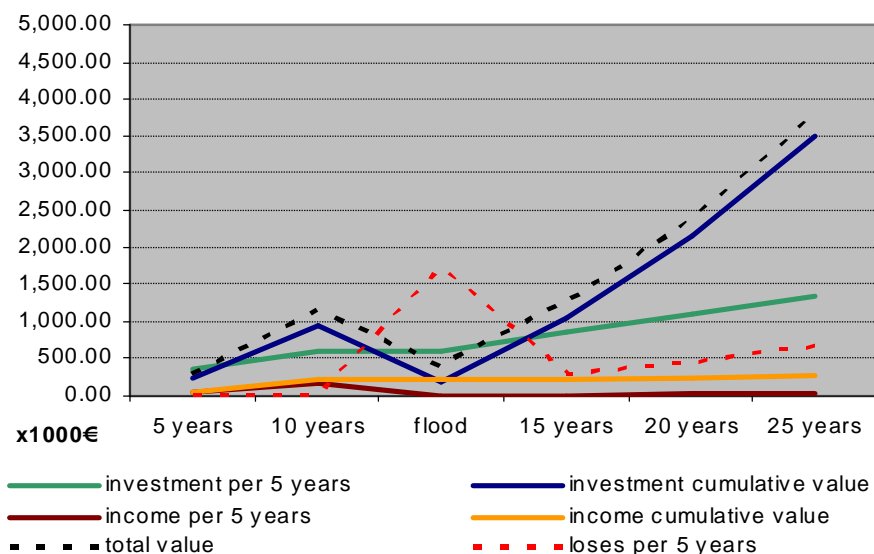
Total loses for 100 year flood in short-term period (during the 3rd year):
 0.8 x 180,000 (constructed environment)
 + 10,800 (income in the 3rd year)
 + 15,600 (income in the 4th year)
 + 21,000 (income in the 5th year)
 = 191,400 EUR

scenario of small changes case of 100 year flood in 3rd year					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	50.00	100.00	150.00	200.00	250.00
total cumulative income	3.00	9.00	9.00	9.00	9.00
PROFIT	-47.00	-91.00	-141.00	-191.00	-241.00

Financial analysis of the scenario of uncontrolled development in case of 100 year flood in the 3rd year for the short-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Scenario of uncontrolled development, long-term impact (25 years) - case of 100 year flood in the 15th year:

scenario of uncontrolled development case of 100 year flood in 15th year						
	5 years	10 years	flood	15 years	20 years	25 years
investment per 5 years	350.00	600.00	600.00	850.00	1,100.00	1,350.00
investment cumulative value	250.00	950.00	190.00	1,040.00	2,140.00	3,490.00
income per 5 years	57.00	154.71	0.00	5.00	15.00	30.00
income cumulative value	57.00	211.71	211.71	216.71	231.71	261.71
total value	307.00	1,161.71	401.71	1,256.71	2,371.71	3,751.71
loses per 5 years	0.00	0.00	1,733.14	288.14	457.29	662.14



This calculation results with 261,710 EUR cumulative income of the economic activities on the Island for the period of 25 years (long-term impact) and cumulative investment of 4,250,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of 100 year flood in the 15th year is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 3,751,710 EUR
In case of big hazardous event (100 year flood) in the 15th year loses can be calculated as 80% of the constructed environment and 3 years to recover economic activities:

Total loses for 100 year flood in long-term period (during the 15th year):

0.8 x 1,800,000 (constructed environment)
+ 36,140 (income in the 15th year)
+ 39,290 (income in the 16th year)
+ 42,340 (income in the 17th year)
= 1,557,700 EUR

scenario of uncontrolled development case of 100 year flood in 15th year					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	350.00	950.00	1,800.00	2,900.00	4,250.00
total cumulative income	57.00	211.71	216.71	231.71	261.71
PROFIT	-293.00	-738.29	-1,583.29	-2,668.29	-3,988.29

Financial analysis of the scenario of uncontrolled development in case of 100 year flood in the 15th year for the long-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

Conclusion:

Financial analysis of the scenario of uncontrolled development shows that the result of the development in all 4 analyzed processes (undisturbed development for the short-term period; undisturbed development for the long-term period; 100 year flood in the short-term period; 100 year flood in the long-term period) is always far below the profitable level – cumulative income is always significantly lower than the cumulative investment.

In addition potential cumulative loses after 15 years of uncontrolled development start to exceed cumulative investment value because of endangering the area of New Belgrade.

**Scenario 3 – scenario of sustainable development
(proposed development scenario for the Great Island of War)**

Sustainable development approach is based on analysis of existing resources of the Island, type of possible investments on the Island and different impacts of the development scenarios. All existing resources and values of the Island are considered and impact of the scenarios on all different aspects of society, economy and environment is considered.

Scenario of sustainable development tries to analyze significance of the Island development on larger scale - on the town level and on the country level. It tries to construct a modern symbol of the city which would not have any negative effect on the existing numerous values of the area. Sustainable development approach calculates investment that would be profitable both in case of undisturbed development and in case of a big hazardous event.

Objectives of sustainable development scenario respects guidelines of the city land use plans and preserves natural environment of the Island.

Sustainable development approach starts with the cost-benefit analysis of the Island development and based on these results defines the frame and guidelines for further actions.

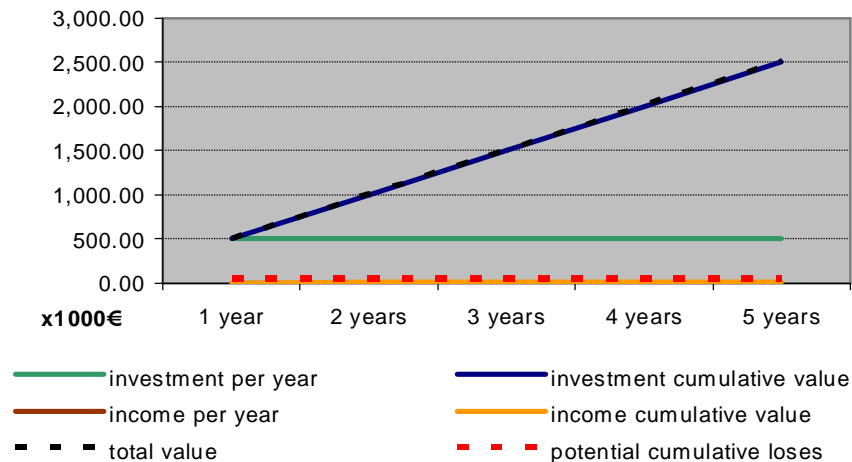
Scenario of sustainable development assumes that major investment would be undertaken during the 1st period (5 years) and further investment would serve as maintenance of the already existing facilities. Analysis of the profit for the assumed investment are carried out for the short and long term period (5 and 25 years). For the level of investment that would prove profitable (income cumulative value exceeding investment cumulative value), further analysis are carried out to check the potential loses in case of hazardous event. Analysis of the development in case of hazardous event in the 3rd year and in the 15th year are done and potential loses are calculated for occurrence of 100 year flood during every year in next 25 years.

Based on these financial analysis and following the town land use guidelines as well as other demands and values such as environmental, historical and social, design concept is developed.

**Financial analysis for the sustainable development approach
(cost-benefit analysis in case of hazardous event and in case of
undisturbed development for the short and long-term period)**

**Scenario of sustainable development, short-term impact (5 years),
undisturbed process:**

scenario of sustainable development undisturbed process, short term impact					
	1 year	2 years	3 years	4 years	5 years
investment per year	500.00	500.00	500.00	500.00	500.00
investment cumulative value	500.00	1,000.00	1,500.00	2,000.00	2,500.00
income per year	3.00	3.00	3.00	3.00	3.00
income cumulative value	3.00	6.00	9.00	12.00	15.00
total value	503.00	1,006.00	1,509.00	2,012.00	2,515.00
potential cumulative losses	50.00	50.00	50.00	50.00	50.00



This calculation results with 15,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 2,500,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 2,515,000 EUR

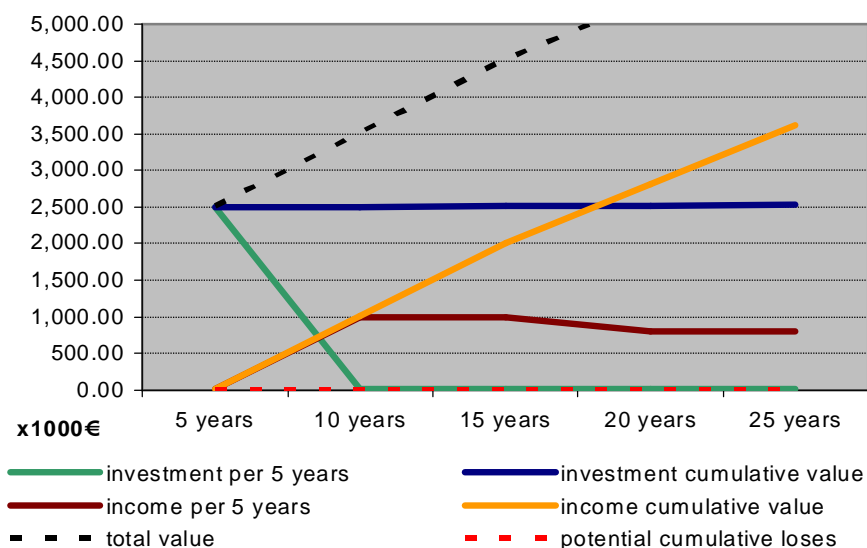
Potential cumulative losses in case of hazardous event (100 year flood) are assumed 50,000 EUR for each year. These potential losses are calculated as maximum values and are valid only for the construction period – losses of construction material stored in the flooded area of the construction site.

scenario of sustainable development undisturbed process, short term impact					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	500.00	1,000.00	1,500.00	2,000.00	2,500.00
total cumulative income	3.00	6.00	9.00	12.00	15.00
PROFIT	-497.00	-994.00	-1,491.00	-1,988.00	-2,485.00

Financial analysis of the scenario of sustainable development in case of undisturbed development for the short-term period shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment. This NEGATIVE value is a result of major investment that can not be profitable in the short-term period.

Scenario of sustainable development, long-term impact (25 years), undisturbed process:

scenario of sustainable development undisturbed process, long term impact					
	5 years	10 years	15 years	20 years	25 years
investment per 5 years	2,500.00	5.00	5.00	10.00	10.00
investment cumulative value	2,500.00	2,505.00	2,510.00	2,520.00	2,530.00
income per 5 years	15.00	1,000.00	1,000.00	800.00	800.00
income cumulative value	15.00	1,015.00	2,015.00	2,815.00	3,615.00
total value	2,515.00	3,520.00	4,525.00	5,335.00	6,145.00
potential cumulative loses	0.00	0.00	0.00	0.00	0.00



With completion of construction, income through economic activity of the complex significantly rises and after approx 18 years from the beginning of construction, cumulative income value is equal to cumulative investment value. From that moment on, almost complete income can be considered as profit (maintenance costs are considerably low compared to the income).

This calculation results with 3,615,000 EUR cumulative income of the economic activities on the Island for the period of 25 years (long-term impact) and cumulative investment of 2,530,000 EUR in constructed facilities.

Total value in this scenario for the long-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 6,145,000 EUR

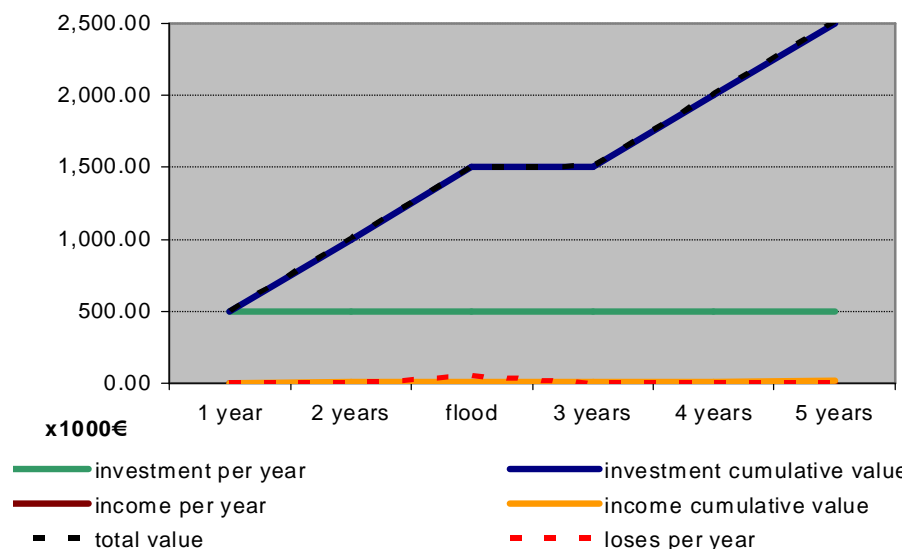
Potential cumulative loses in case of hazardous event (100 year flood) in the long-term period **do not exist**, as area prone to flooding is in its original form and level of vulnerability in all aspects is zero. After construction period of 5 years, construction site is clear and no damage can happen in case of 100 year flood.

scenario of sustainable development undisturbed process, long term impact					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	2,500.00	2,505.00	2,510.00	2,520.00	2,530.00
total cumulative income	15.00	1,015.00	2,015.00	2,815.00	3,615.00
PROFIT	-2,485.00	-1,490.00	-495.00	295.00	1,085.00

Financial analysis of the scenario of sustainable development in case of undisturbed development for the long-term period shows that the PROFIT value is after 18th year always POSITIVE – total cumulative income significantly rises and becomes higher than cumulative investment.

Scenario of sustainable development, short-term impact (5 years) - case of 100 year flood in the 3rd year:

scenario of sustainable development - case of 100 year flood in 3rd year						
	1 year	2 years	flood	3 years	4 years	5 years
investment per year	500.00	500.00	500.00	550.00	500.00	500.00
investment cumulative value	500.00	1,000.00	1,500.00	1,550.00	2,050.00	2,550.00
income per year	3.00	3.00	0.00	3.00	3.00	3.00
income cumulative value	3.00	6.00	6.00	9.00	12.00	15.00
total value	503.00	1,006.00	1,506.00	1,559.00	2,062.00	2,565.00
loses per year	0.00	0.00	50.00	0.00	0.00	0.00



This calculation results with 15,000 EUR cumulative income of the economic activities on the Island for the period of 5 years (short-term impact) and cumulative investment of 2,550,000 EUR in constructed facilities.

Total value in this scenario for the short-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 5 years = 2,515,000 EUR

Cumulative losses in case of hazardous event (100 year flood) in the 3rd year are assumed 50,000 EUR. These are the losses of construction material stored in the flooded area of the construction site.

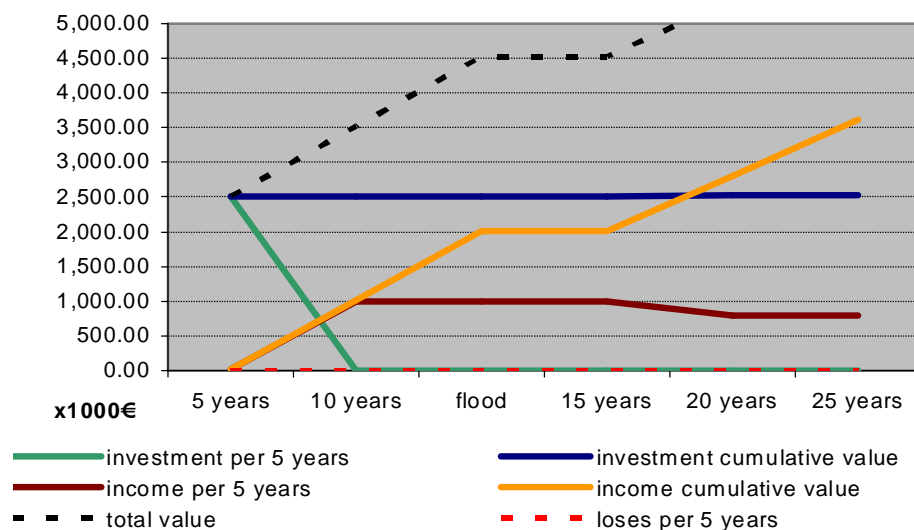
scenario of sustainable development case of 100 year flood in 3rd year					
	1 year	2 years	3 years	4 years	5 years
total cumulative investment	500.00	1,000.00	1,550.00	2,050.00	2,550.00
total cumulative income	3.00	6.00	9.00	12.00	15.00
PROFIT	-497.00	-994.00	-1,541.00	-2,038.00	-2,535.00

Financial analysis of the scenario of sustainable development in case of 100 year flood in the 3rd year shows that the PROFIT value is always NEGATIVE – total cumulative income is always significantly lower than the total cumulative investment.

This NEGATIVE value is a result of major investment that can not be profitable in the short-term period.

Scenario of sustainable development, long-term impact (25 years) - case of 100 year flood in the 15th year:

scenario of sustainable development case of 100 year flood in 15th year						
	5 years	10 years	flood	15 years	20 years	25 years
investment per 5 years	2,500.00	5.00	5.00	5.00	10.00	10.00
investment cumulative value	2,500.00	2,505.00	2,510.00	2,510.00	2,520.00	2,530.00
income per 5 years	15.00	1,000.00	1,000.00	1,000.00	800.00	800.00
income cumulative value	15.00	1,015.00	2,015.00	2,015.00	2,815.00	3,615.00
total value	2,515.00	3,520.00	4,525.00	4,525.00	5,335.00	6,145.00
loses per 5 years	0.00	0.00	0.00	0.00	0.00	0.00



This calculation results with 3,615,000 EUR cumulative income of the economic activities on the Island for the period of 25 years (long-term impact) and cumulative investment of 2,530,000 EUR in constructed facilities.

Total value in this scenario for the long-term period in case of undisturbed development is calculated as: cumulative investment value + cumulative income value for the period of 25 years = 6,145,000 EUR

For hazardous event (100 year flood) that would occur in the period after the construction is finished (period of construction is estimated at 5 years), no losses are possible to happen. **Cumulative investment value is the same** in this scenario for the hazardous event and for the undisturbed development. With occurrence of major flood, an **increase of economic activity** is to be expected as a result of high interest of visitors to watch the phenomenon.

scenario of sustainable development - case of 100 year flood in 15th year					
	5 years	10 years	15 years	20 years	25 years
total cumulative investment	2,500.00	2,505.00	2,510.00	2,520.00	2,530.00
total cumulative income	15.00	1,015.00	2,015.00	2,815.00	3,615.00
PROFIT	-2,485.00	-1,490.00	-495.00	295.00	1,085.00

Financial analysis of the scenario of sustainable development for the long-term period in case of 100 year flood are the same as in the case of undisturbed development – analysis show that the **PROFIT** value is after 18th year always **POSITIVE** – total cumulative income significantly rises and becomes higher than cumulative investment.

Conclusion:

Based on financial analysis of the sustainable development approach we can conclude that investment module of approx 2,5 MIO EUR, that would respect guidelines of the city land use plans and natural flow processes of two big rivers, would be long-term profitable, both in case of undisturbed development and big hazardous event (100 year flood).

Additionally, impact of such investment would provide significant income through high construction activity and, moreover, through higher tourism activity, which would provoke many related economic activities to grow.

Considering LARGE-SCALE IMPACTS (tourism and related economic activities with country-wide benefit), financial analysis of the PROFIT of the sustainable development approach can be estimated at approx HALF OF THE TIME calculated through this financial analysis (this development scenario would become profitable after 10, rather than after 18 years – both in case of undisturbed development and major hazardous event).

Design of the Recreational Center positioned above the Great Island of War and the confluence area

STARTING INPUTS

Starting inputs for the design process are outcomes of **analyzed scenarios, financial impacts of the scenarios, resources and values of the area, city land use guidelines, natural flow process of two big rivers and environmental protection** of the area.

Economy analysis input:

Investment module of 2,5 MIO EUR, realized in period not longer than 5 years should be profitable in not longer than 18 years, including construction period.

Analyzed scenarios input:

Resourceful area of the island should be treated with great care, or most of the resources and values will be destroyed. Careful and multidisciplinary approach is necessary for planning of the development of this area.

Hydrology analysis input:

Existing retention areas (such as the Great Island of War) should be preserved in order to protect natural flow processes of the two big rivers. Any construction on the island should not act as an obstacle that can cause deposition of the material carried by the rivers during floods. Deposition of material on the island during floods, would cause higher flood risk for the lower areas in Belgrade (especially New Belgrade – former swamp area, where saturation process might occur).

During the 100 year flood that occurred in Belgrade 3 years ago, the Great Island of War was completely flooded (water level was from 2 to 4 meters above the ground on the complete area of the Island).

City land use guidelines:

Official city land use plans for this area are not fully elaborated. The whole area of the Great Island of War is marked as protected and recreational area that is to be further elaborated through public discussions and design contests. Some small illegal housing is taking place on the island these days.

Environmental protection:

The Great Island of War is habitat for about 196 bird species and about 500 plant species, and it includes a natural fish breeding ground.

In case of flood protection of the island and greater presence of men, most of these plant and bird species would permanently disappear from this area.

Resources and values of the Island:

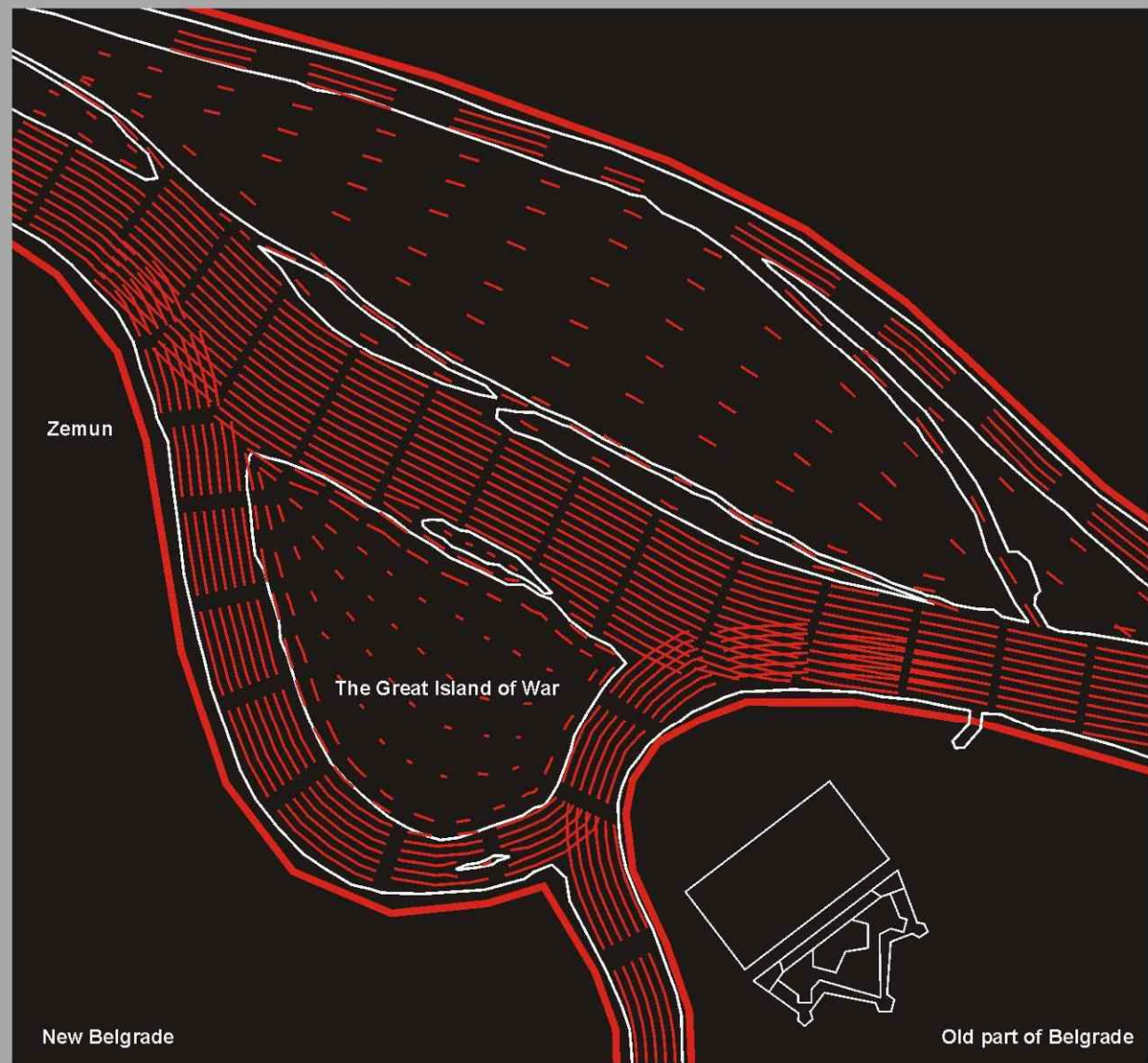
The Great Island of War covers a huge surface (1,579 km²) and it is situated in the very center of the city. Most attractive parts of the city are overlooking the island: Kalemegdan fortress, promenades and restaurants on river banks, best hotels etc.

Design PROCESS

Based on analyzed *STARTING IMPUTS* design process was opened with hydrology inputs.

Hydrology of the two rivers during 100 year flood is analyzed in order to determine exact flow direction and velocity on different analyzed areas, considered to be suitable for construction. Results of these analysis are presented on the chart *Flow direction and velocity lines during 100 year flood*. Length and density of the flow lines presented on the chart, indicate flow direction and velocity of the flow during 100 year flood. Based on achieved results, position, shape and orientation of the support columns is determined. These results are presented on the charts *Position and shape of columns determined by flow direction and velocity*.

After positioning of the support columns, all other inputs are taken into account to develop the design of the Recreational Centre.



Flow direction and approximate velocity during 100 year flood

Flow direction and velocity lines (length and density of lines indicates flow velocity)

Dikes

Scale 1:33,000

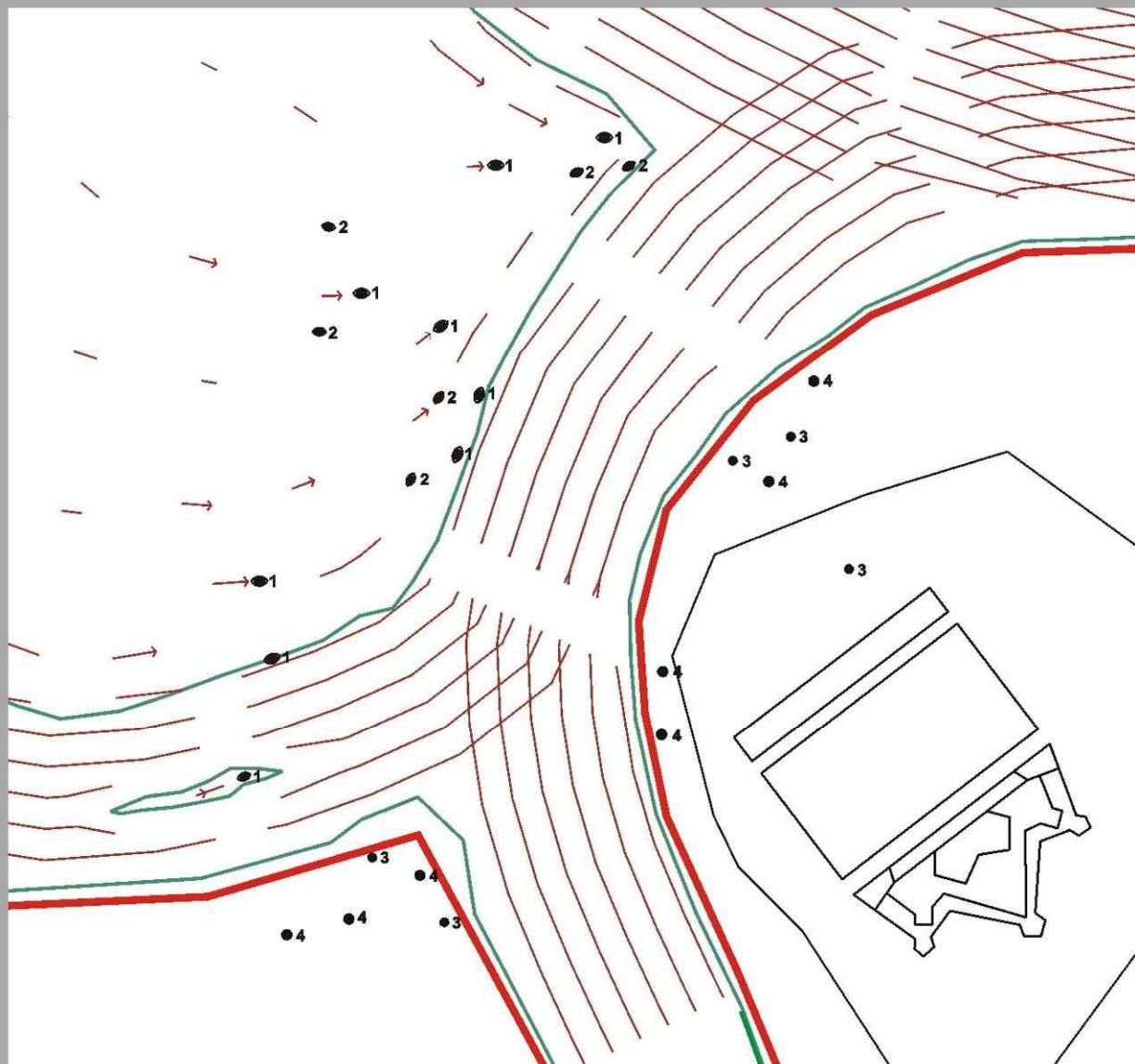
Position and shape of "columns",
determined by flow direction and velocity


 "Columns" - support
structures with
communication and



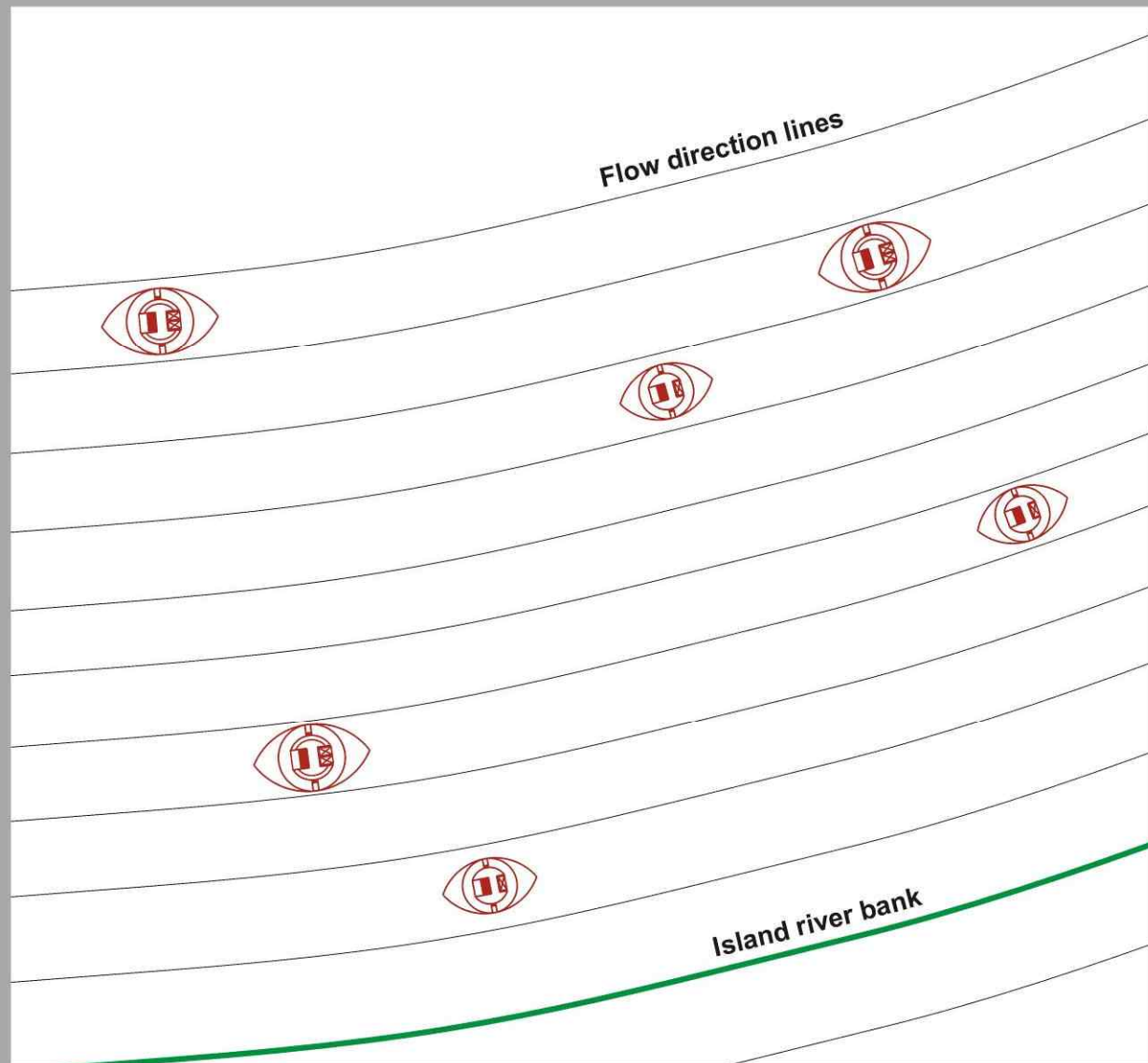

 Dikes

Scale 1:10,000



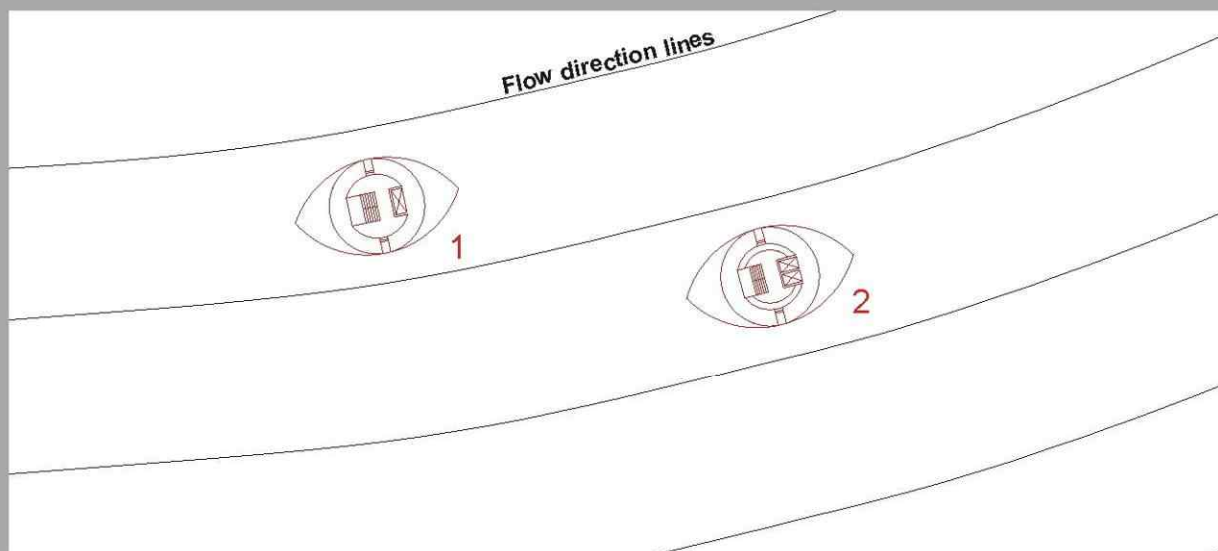
Position and shape of “columns”
(support structures with communication
and installation shafts), determined by
flow direction lines

Scale 1:1,000



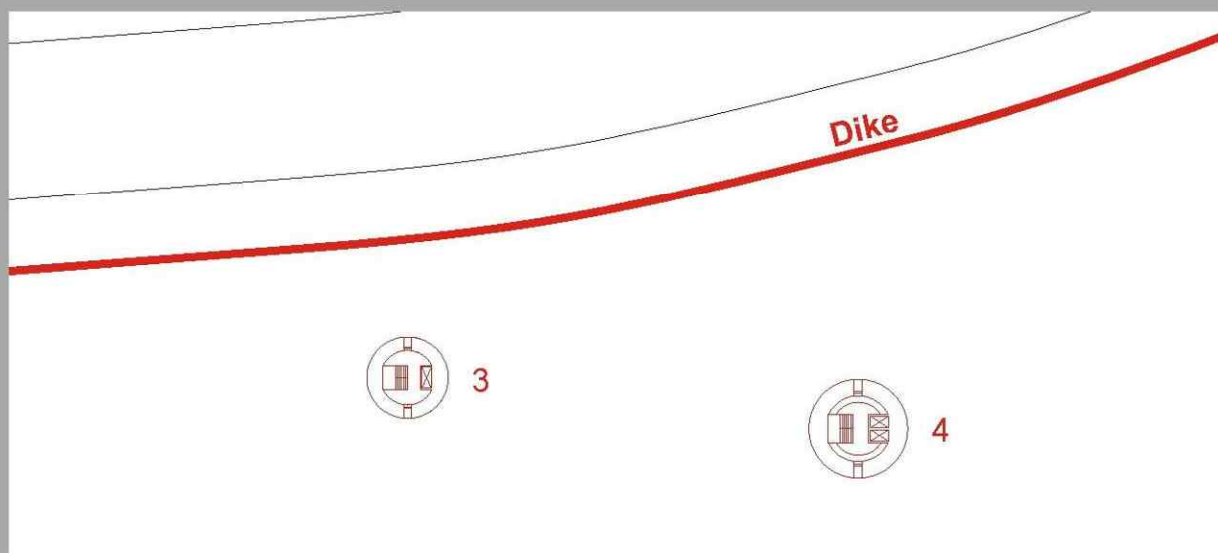
**"Columns" type 1 and 2- support structures
for flood prone areas; constructed of
reinforced concrete, with communication
and installation shafts inside**

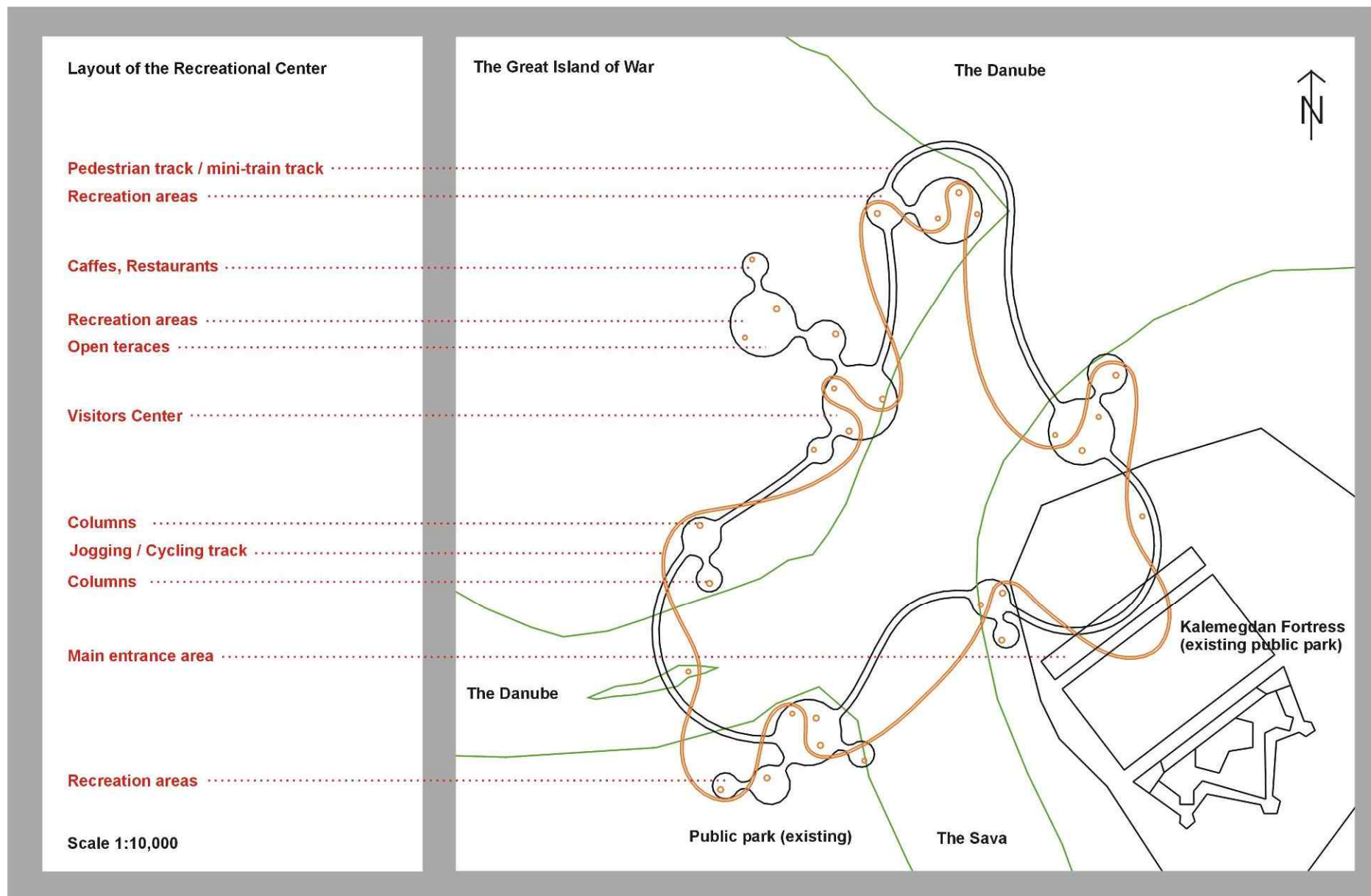
Scale 1:200

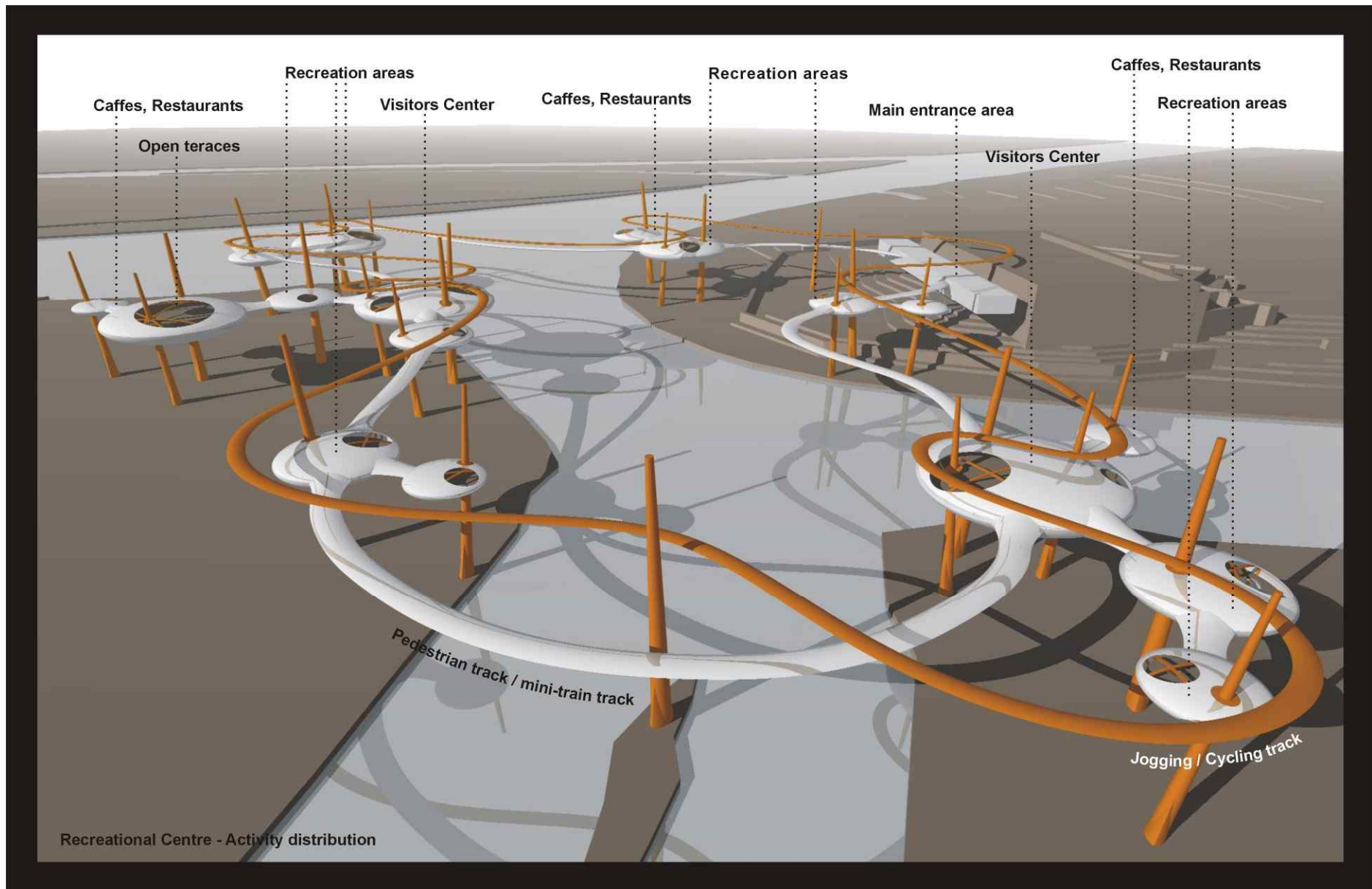


**"Columns" type 3 and 4- support structures
for flood protected areas; constructed of
reinforced concrete, with communication
and installation shafts inside**

Scale 1:200



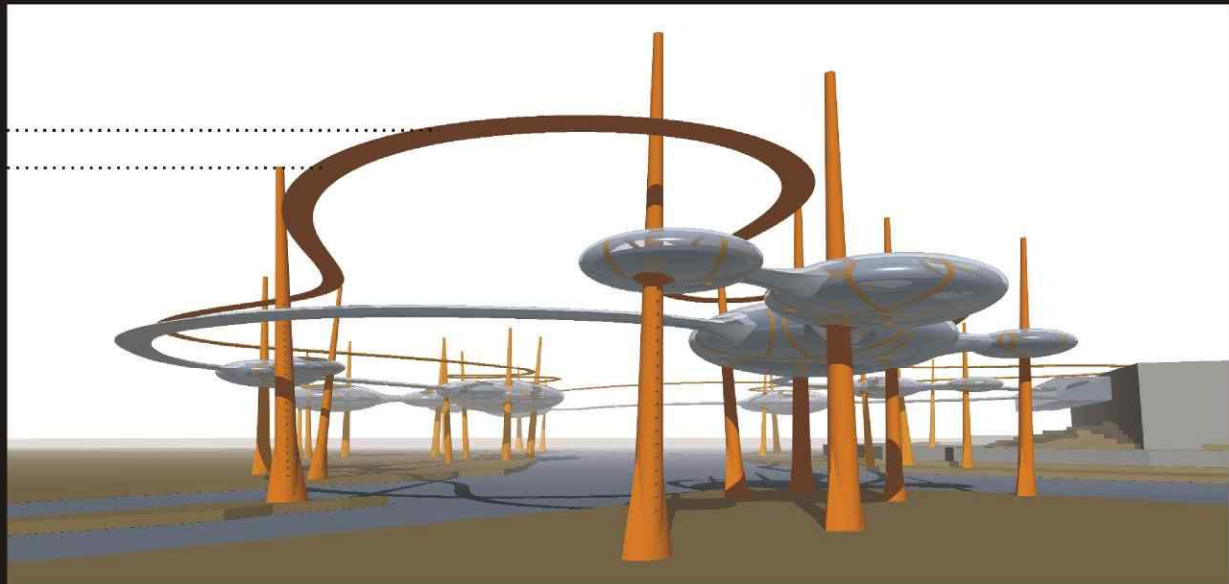




Communication

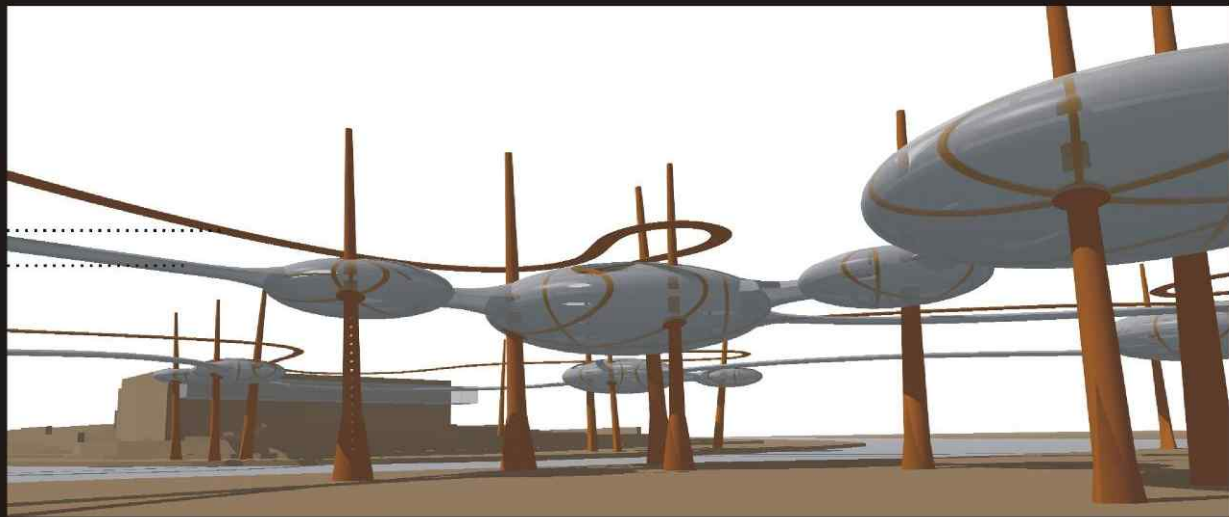
Jogging and cycling track

Pedestrian track with mini-train beneath



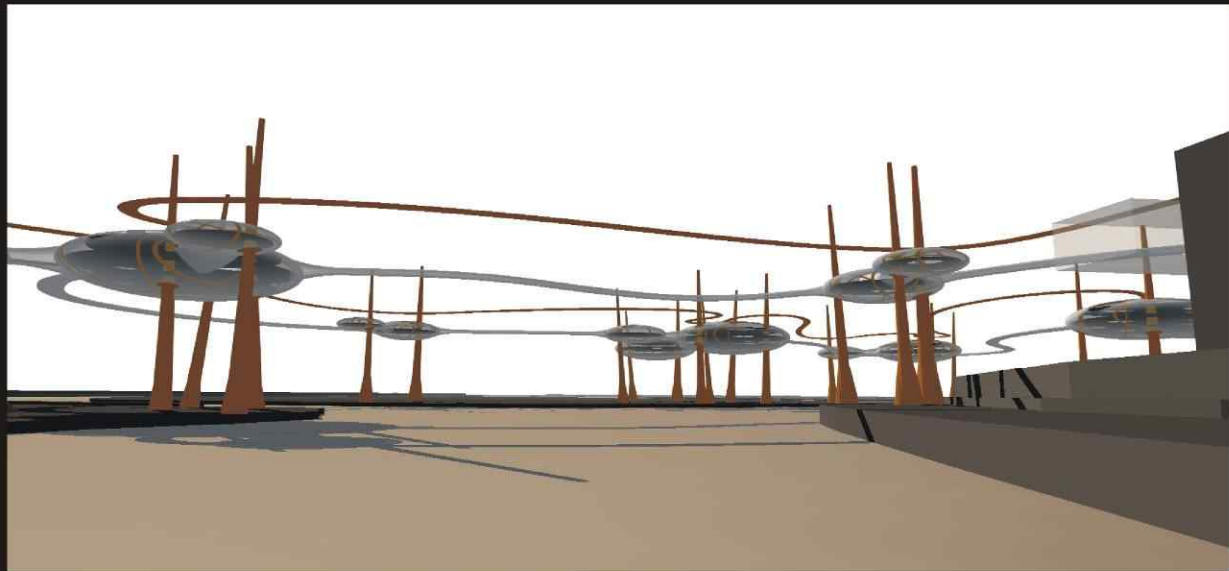
Jogging and cycling track

Pedestrian track with mini-train beneath



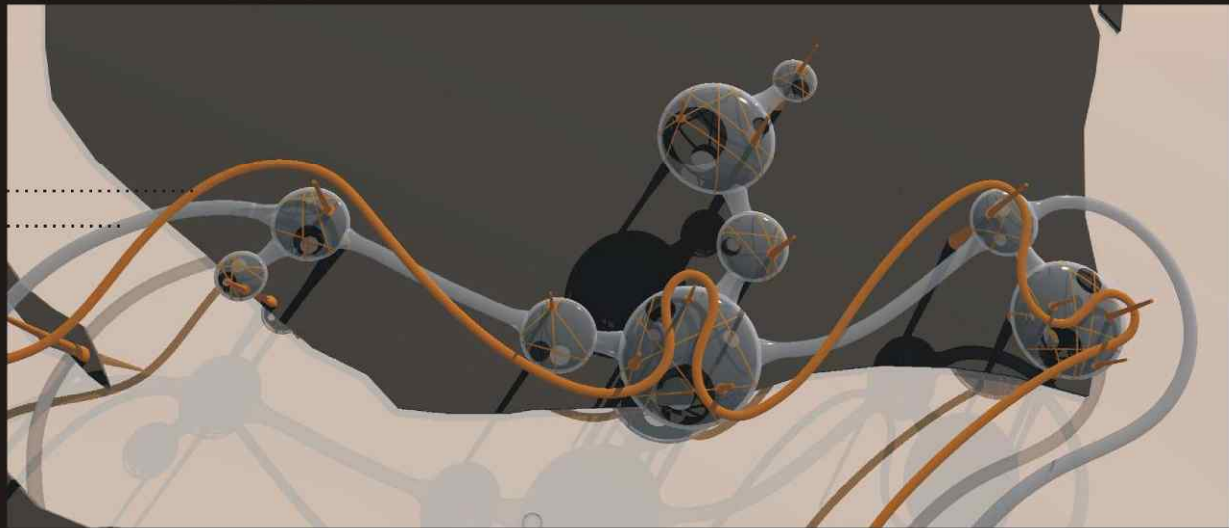
Communication

View of the Recreational Center
From the Sava river



Jogging and cycling track
Pedestrian track with mini-train beneath

Aerial view of the Recreational Center

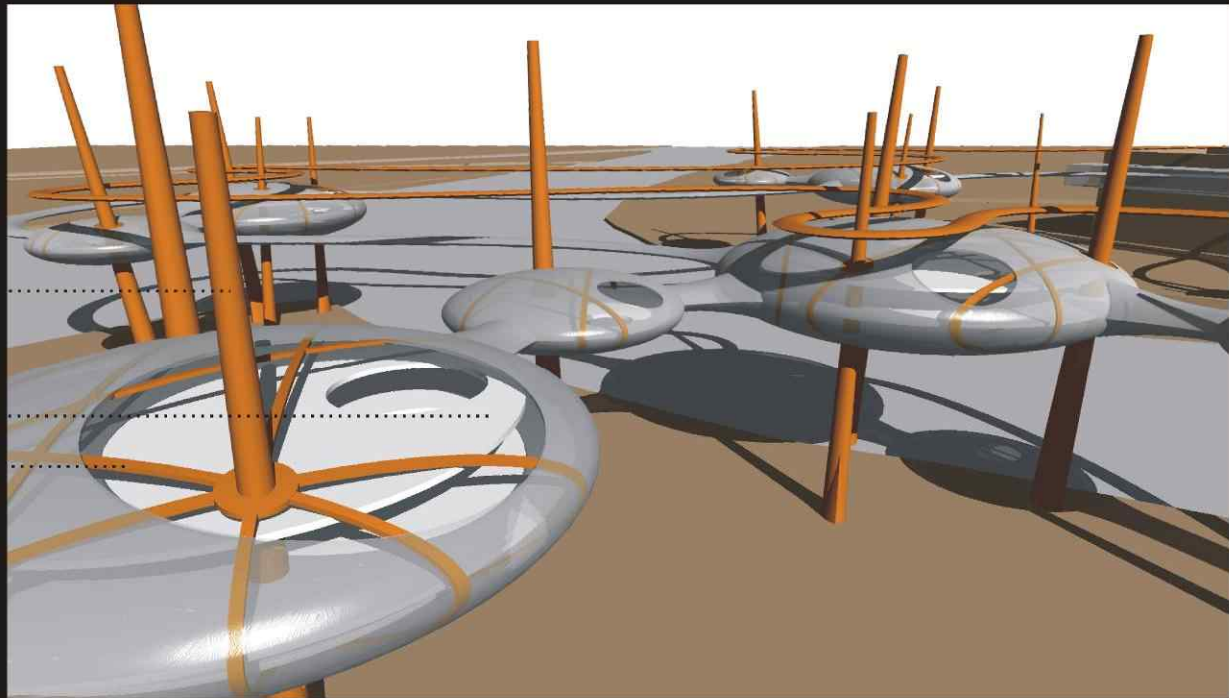


Construction

Column

Steel grid slabs

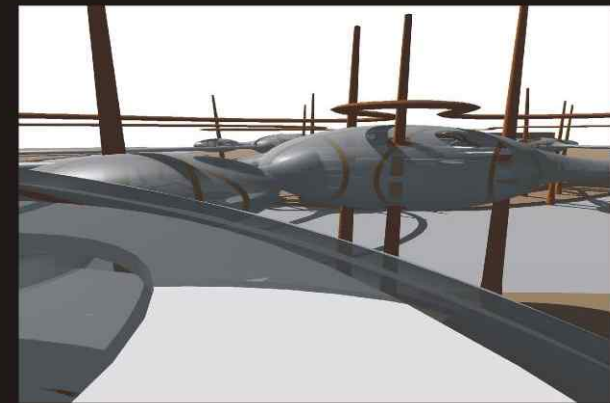
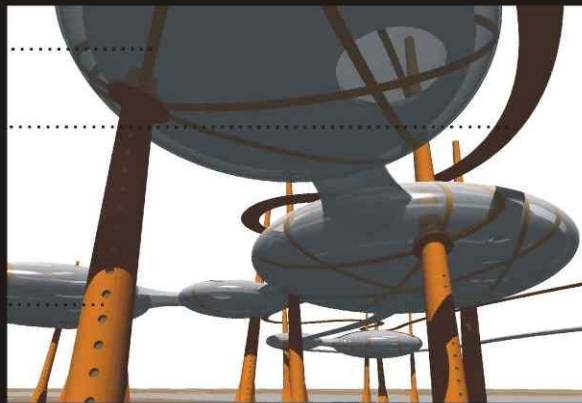
Circular ribs



Circular ribs

Jogging and cycling track

Column



Environment protection

Aerial view of the Recreational Center

The Centre connects already existing recreational areas with pedestrian tracks



Environment protection

**View of the Recreational Center
From the Kalemegdan fortress**

**Complete structure of the Center is
elevated 50m above the ground**



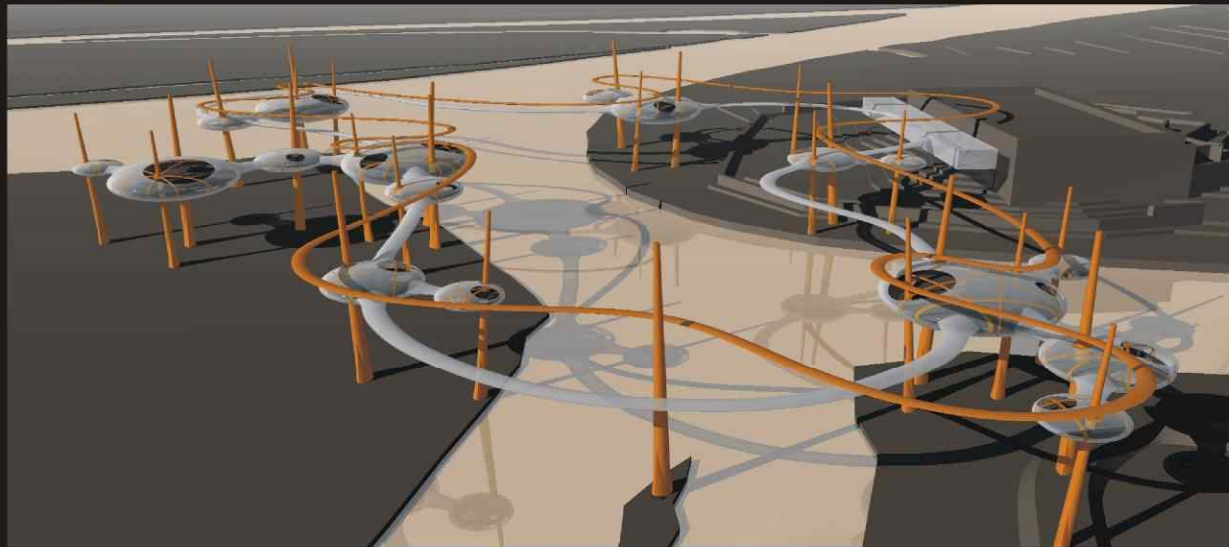
**View of the Recreational Center
over the Great Island of War**

**Access to the Island surface is limited to
evacuation and maintenance purposes**

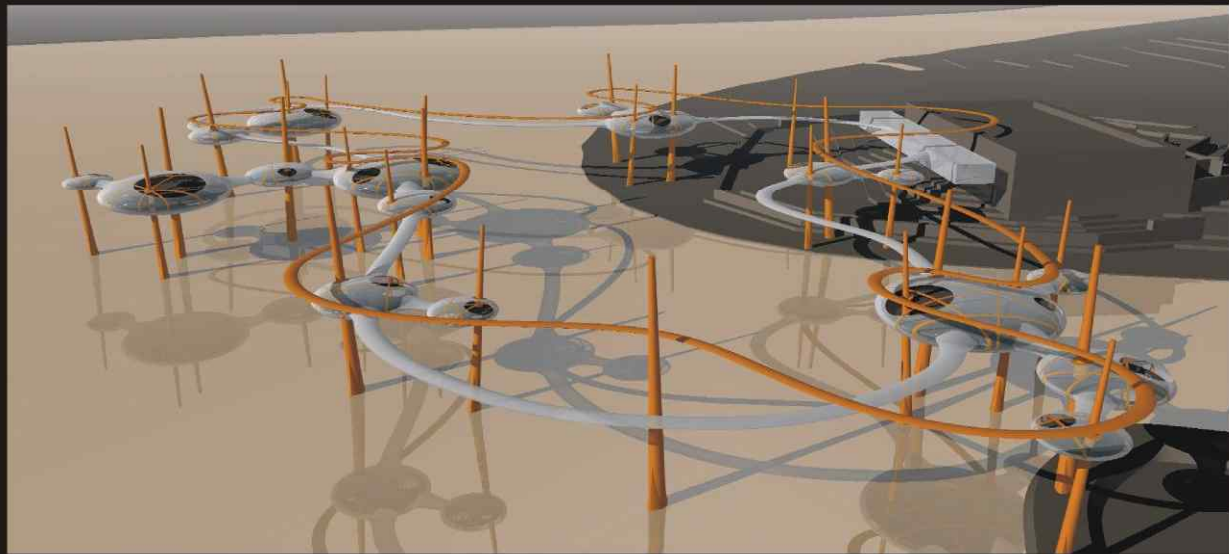


Flood occurrence

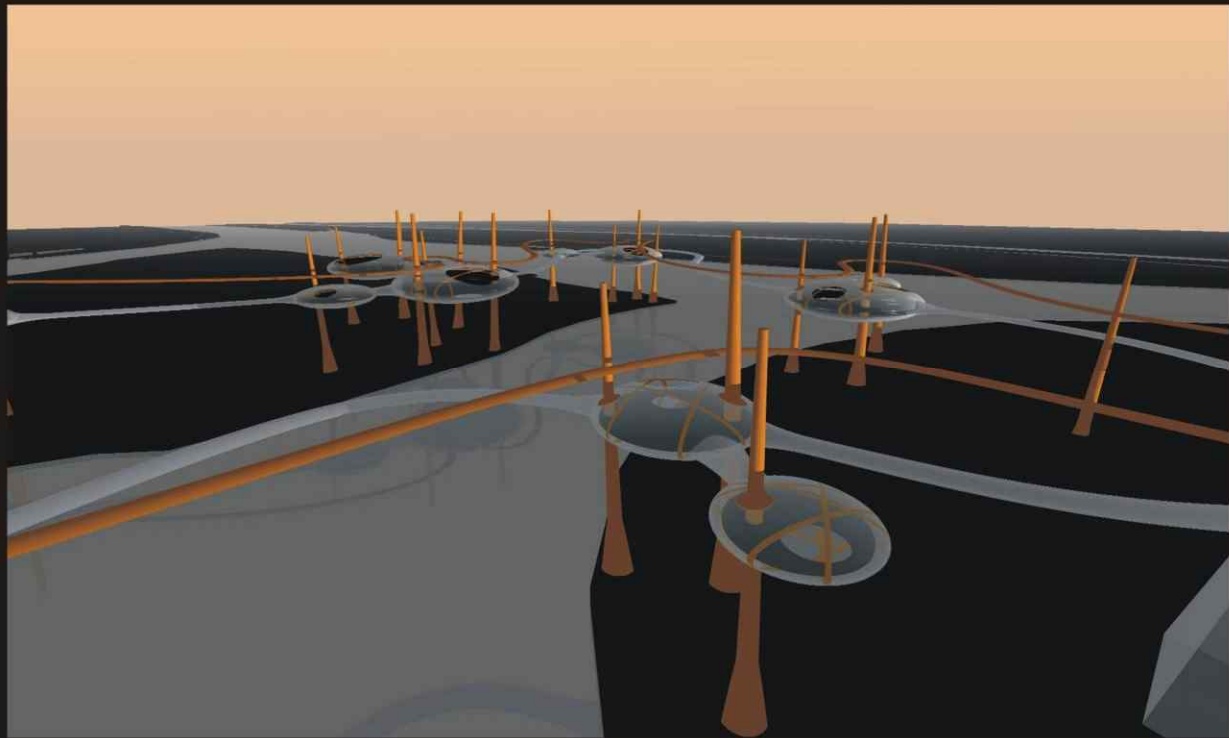
**Overall view of the Recreational Center
With average water level**



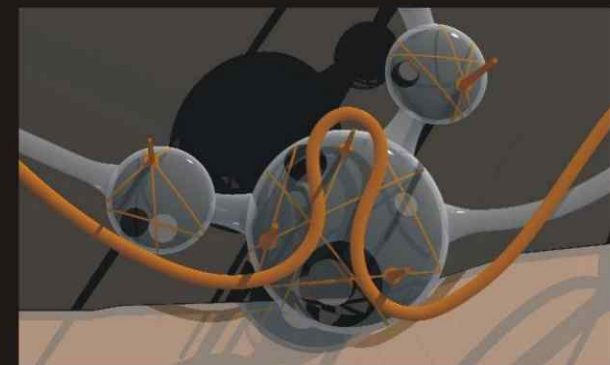
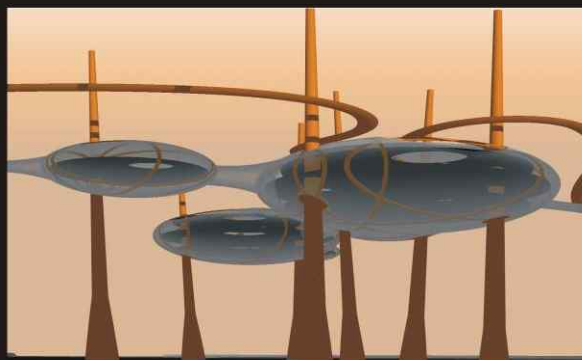
**Overall view of the Recreational Center
During 100 year flood**
(Water level reached half height of the dike)



Design concept



Design concept of the Center is derived from the natural forms of the surrounding natural environment and modern materials and technology used for its construction



Design OVERVIEW

Concept

Complete complex of the Recreational Center is placed in the air above the Island and above the river banks opposite the Island.

Complex is easily accessible from Kalemegdan (Belgrade fortress), most important tourist sight in Belgrade today. Recreational Center, itself, connects existing recreational areas: Kalemegdan fortress and public park on the confluence of two rivers. There is no visitor access to the Great Island of War from the Recreational Center, therefore, the Island completely remains in its natural form.

Design concept of the Center is derived from the natural forms of the surrounding natural environment on one side and modern materials and technology used for the construction of the Center.

Recreational Center is comprised of big light spaces and open air terraces occupied with recreational area, visitor centers, restaurants, cafés and glass pedestrian corridors overlooking the preserved natural environment of the Island and river banks.

Construction

Complete Recreational Center is placed in the air, supported by columns. Columns are made of highly reinforced concrete, hollow inside, containing installation and communication shafts. Horizontal slabs are made of steel grid which extends through all parts of the Recreational Center and pedestrian passages and holds complete structure together. Circular steel ribs are connecting columns with slab grid and providing support for the glass façade. Columns are inclined to provide better seismic stability. Pedestrian passages are steel grid structures covered with glass supported by steel cables hanging from the top of the columns.

Function

Predominant function of the Recreational Center are different recreational activities accompanied by supporting activities such as visitors centers, restaurants, cafés, multifunctional areas, open terraces etc. Pedestrian corridors are designed to act as walking, jogging and bicycle tracks, with detachable glass-roof covers.

Communication

Main access to the recreational center is from the Kalemegdan fortress. Facilities of the recreational center are on the same height as the upper terrace of the Fortress, therefore visitors can easily access the Center either on foot, by bike or by electrical mini-train running under the pedestrian tracks.

Recreational Center can also be accessed through communication shafts placed within the Columns. In this way it is possible to approach the Center from the river banks opposite the Great Island of War.

Access to the Great Island of War from the Center is possible through the communication shafts but is only reserved for emergency situations and maintenance.

Communication between different parts of the Recreational Center is provided through pedestrian corridors and by mini-train running under the pedestrian area.

Environment protection

With complete structure of the Centre elevated approximately 50m above the Island level and access to the Island limited to maintenance and evacuation purposes only, present condition of the environment protection on the Island can be considered to remain unchanged after the construction of the Centre.

Vegetation on the Island would keep its natural form and presence of birds and wild animals would remain as it is today, since all the constructed facilities and activities within the Recreational Centre would not cause disturbance or pollution of the Island.

Flood occurrence

Support columns of the Center are designed to present a minimum obstacle to the natural river flow. They are positioned on the Island where flow velocity is low during floods and they are shaped to minimize deposition of river material.

As described in the chapter “*Financial analysis for the sustainable development approach*”, flood occurrence would not in any way affect functioning of the Recreational Center. With occurrence of flood, visit to the Centre would even increase, as glass rooms of the Centre would provide excellent view of this natural phenomenon. Therefore, with occurrence of flood, economic activities of the Recreational Centre would become even more profitable.

Sustainability

Exclusive location of constructed premises is a simple guarantee for a high visitor interest for the Recreational Centre which would consequently bring high economic activity. Intensive economic activity in and around the Centre (including tourism related economy) in the analyzed periods (5 and 25 years) would provide profit estimated in the chapter “*Financial analysis for the sustainable development approach*”.

Flood hazards in Belgrade following the scenario of sustainable development

Hydrology of the Danube and Sava rivers during floods can be considered to remain as it is today after this development scenario. During the construction of the columns of the recreational center, flow process during floods would be slightly changed (due to presence of different construction equipment that would present an obstacle for natural flow during flood). However, this change can be avoided, since floods that are caused by The Danube and Sava rivers are not flash floods, and with regular monitoring all losses can be prevented by moving the construction equipment and material away from the area prone to flooding. Therefore, flow process of both rivers can be considered unchanged during the whole period of this development scenario. In other words, hydrology condition in Belgrade and downstream would remain as it is today.

Profit that would be achieved through this development scenario could be used to solve problem of areas in Belgrade that are endangered with floods today. Areas in Belgrade, north of the Danube, although protected by dikes are marked as low flood hazard areas in Belgrade today (according to official city land use maps). Although these areas were not flooded during the last 100 year flood, underground water table level raised to the level which caused some damage on the agricultural land. Profit made through this scenario could be used to reinforce the dikes protecting this area, to clean natural river channels and river banks and remove all deposited material and to apply local measures to protect agricultural land from high underground water table level (by adding layer of soil material).





Profit gained through this development scenario could also be used to relocate the activities that are vulnerable from the area that would remain prone to flooding. Amount of retention area in Belgrade would be slightly increased (thanks to river channels and river banks cleaning from deposited material) and this would result with minimum flood risk in Belgrade area.

Flood hazards in Belgrade following the Scenario of sustainable development

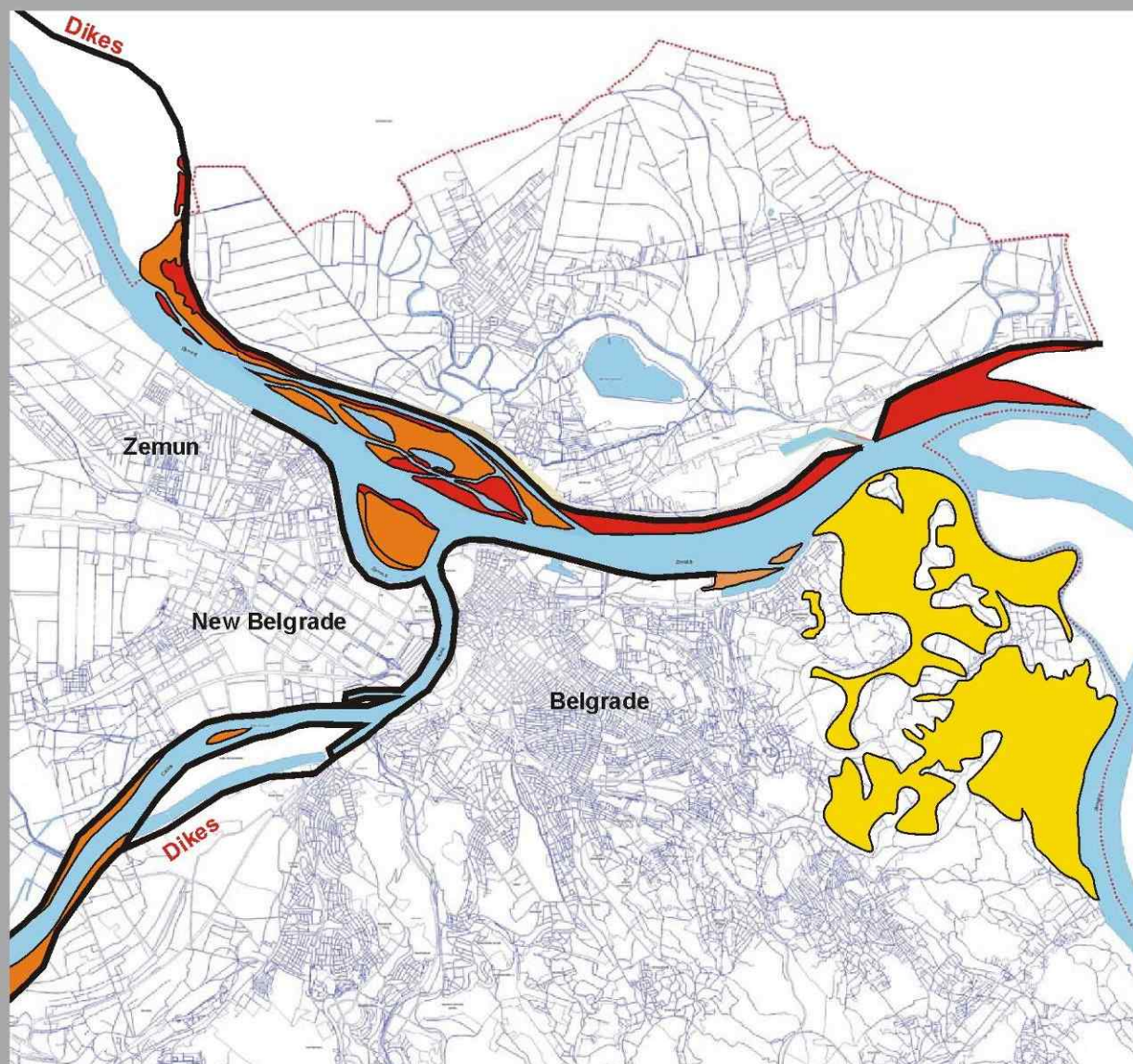
Area in hazard of floods is reduced compared to Belgrade today –

Zones with high underground water table level are flood protected with local measures – by reconstruction of dikes and maintenance of the flow in the natural river channels by cleaning the deposited material

Legend - Flood hazard map;
Scenario of sustainable development

-  High flood hazard zone
-  Medium flood hazard zone
-  Low flood hazard zone
-  Zone with high underground water table level
-  Dikes

Scale 1:150,000



High flood hazard zones - areas with expectancy of flooding within 10 years return period.

Medium flood hazard zones - areas with expectancy of flooding within 30 years return period.

Low flood hazard zones - areas with expectancy of flooding within 100 years return period.

Vulnerability in Belgrade following the scenario of sustainable development

Part of the funds gained through this development scenario would be used to relocate the activities that are vulnerable from the area prone to flooding. Areas with high and medium overall vulnerability would be removed from the area of flood hazard.

Vulnerability of the areas in Belgrade prone to flooding following the scenario of sustainable development is analyzed through the same vulnerability aspects and in the same methodology as for the vulnerability of Belgrade today. Three aspects of vulnerability are considered in determining an overall vulnerability level of analyzed areas: vulnerability of population, vulnerability of constructed environment and vulnerability of economic activity. Methodology of analysis consist of 4 steps:

Step 1 - Defining land use map for the analyzed area

Step 2 - Vulnerability quantification through 3 vulnerability aspects

Step 3 - Vulnerability quantification for different land use zones

Step 4 - Overall vulnerability level and vulnerability map

Based on these 3 analyzed vulnerability aspects, for every identified zone in the hazardous area a specific vulnerability index is defined. Following the 4 methodology steps, an overall vulnerability level is determined and presented in the vulnerability map.

Defining land use map for the analyzed area following the scenario of sustainable development – changes of the land use are not visible on the Great Island of War as all the proposed activities are above the island and rivers

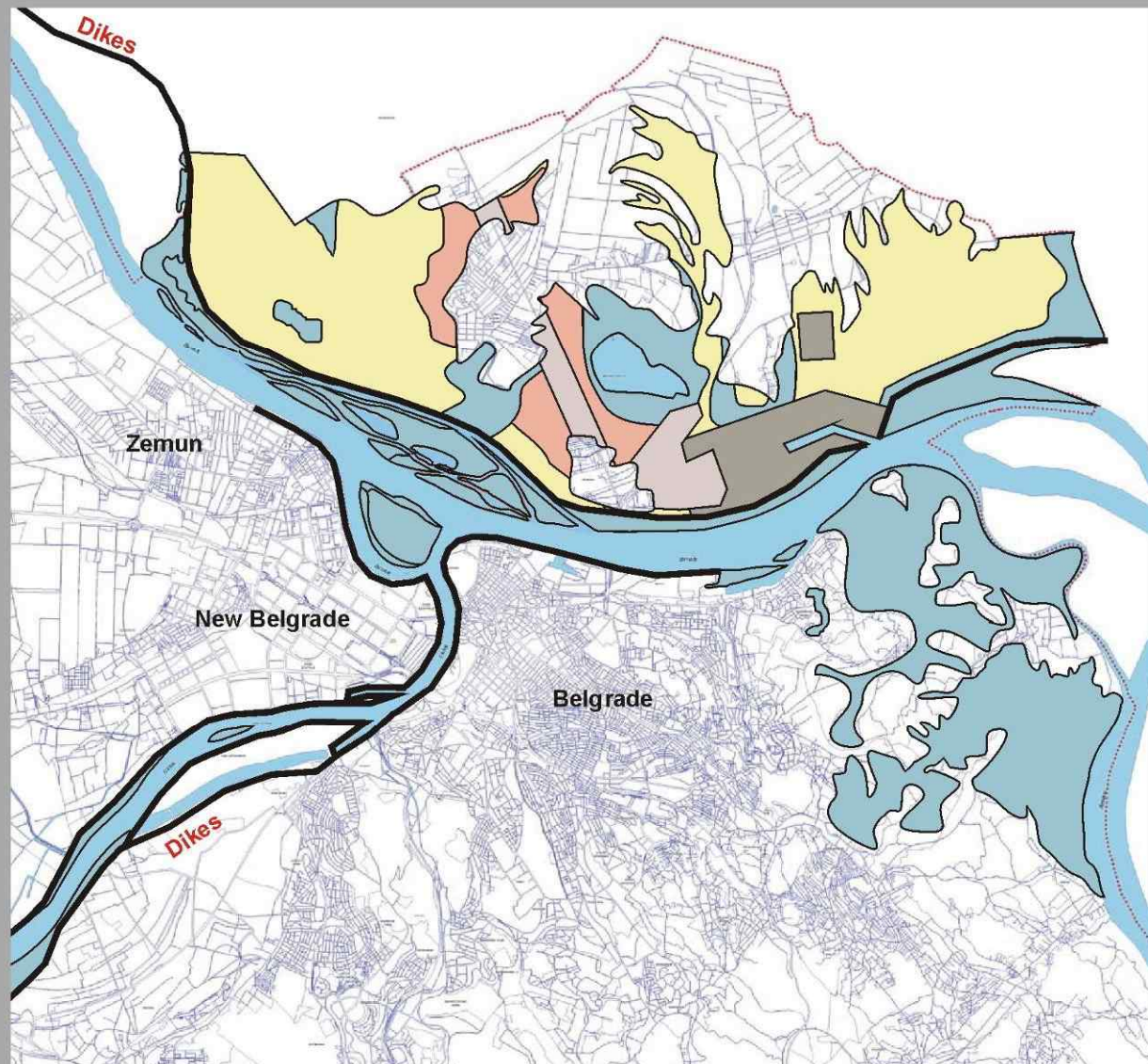
Land use map of Belgrade following the scenario of sustainable development

Changes of land use are not visible on the Great Island of War as all the land surface remains green area in natural form

Legend - Landuse map;
Scenario of sustainable development

-  Zone 1 - green area
-  Zone 2 - agricultural land
-  Zone 3 - family houses
-  Zone 4 - shops and small industry
-  Zone 5 - industry
-  Dikes

Scale 1:150,000



Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Agricultural land – area with predominant agricultural and farming activity;

Family houses – housing area covered with single family houses and some apartment buildings;

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Industry – area covered by big industry companies and infrastructure;

Densely populated urban area – area covered with high rise apartment and office buildings, large market areas, vital roads and infrastructure, government administration and public buildings, with high economic activity;

Vulnerability quantification through 3 vulnerability aspects – same *vulnerability quantification parameters* are used to calculate vulnerability indexes for 3 vulnerability aspects, as for the Vulnerability of Belgrade today.

Vulnerability quantification for different land use zones – for each land use zone, through all 3 vulnerability aspects, based on vulnerability quantification parameters, a vulnerability index is defined. Same formulas for calculating vulnerability indexes are used as for the Vulnerability of Belgrade today.

Green area – area covered with vegetation in natural form; no buildings or infrastructure; area with extensive recreation activity during summer period;

Vulnerability of population – no people expected in the area during flood period – index 0

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – no economic activity – index 0

Agricultural land – area with predominant agricultural and farming activity;

Vulnerability of population – less than 5 people per km² present in the area – index 1

Vulnerability of constructed environment – no constructed environment – index 0

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Family houses – housing area covered with single family houses and some apartment buildings;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – low economic activity (less than 5 people professionally active per 1 km²) – index 1

Shops and small industry – more densely constructed area with shops, public facilities and small enterprises;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Industry – area covered by big industry companies and infrastructure;

Vulnerability of population – 5 - 50 people per km² present in the area – index 2

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Densely populated urban area – area covered with high rise apartment and office buildings, large market areas, vital roads and infrastructure, government administration and public buildings, with high economic activity;

Vulnerability of population – more than 50 people per km² present in the area – index 3

Vulnerability of constructed environment – more than 20% of area surface covered with buildings and infrastructure; Presence of public and facility buildings and lifelines – index 3

Vulnerability of economic activity – high economic activity (more than 50 people professionally active per 1 km²) – index 3

Overall vulnerability level – for every identified land use zone, a sum of vulnerability indexes is defined and based on following formulas, level of overall vulnerability is determined.

Sum of indexes of 3 vulnerability aspects = 0 → no vulnerability

Sum of indexes of 3 vulnerability aspects between 1 and 3 → low vulnerability

Sum of indexes of 3 vulnerability aspects between 4 and 6 → medium vulnerability

Sum of indexes of 3 vulnerability aspects between 7 and 9 → high vulnerability

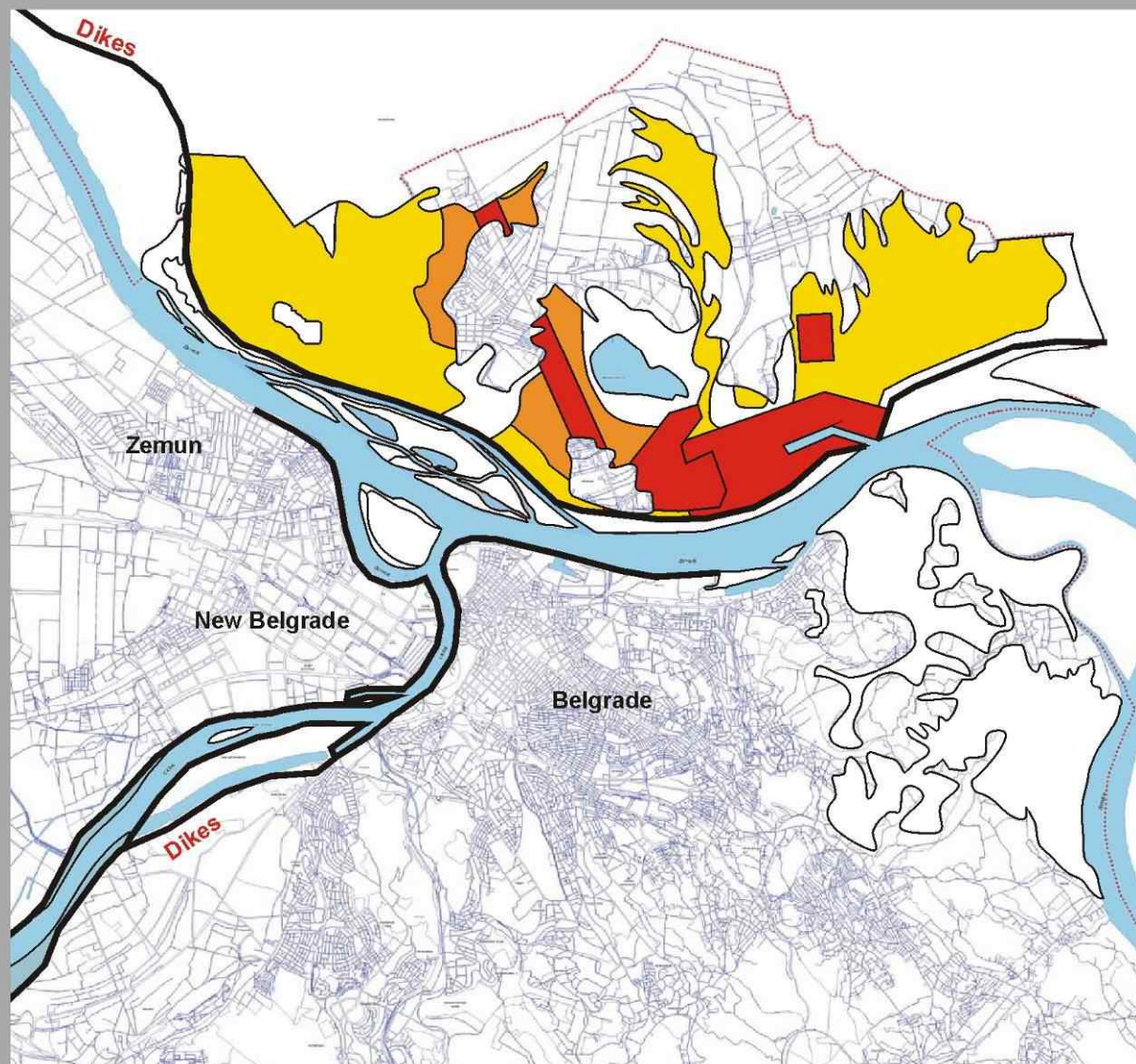
Zone No.	Aspects of Vulnerability			overall vulnerability	overall vulnerability
	vulnerability of population	vulnerability of constructed environment	vulnerability of economic activity		
1 - Green area	0	0	0	0	no vulnerability
2 - Agricultural land	1	0	1	2	low vulnerability
3 - Family houses	3	3	1	7	high vulnerability
4 - shops and small industry	3	3	3	9	high vulnerability
5 - industry	2	3	3	8	high vulnerability
6 - densely populated urban area	3	3	3	9	high vulnerability

**Overall vulnerability map of
Belgrade following the scenario
of sustainable development**

**Legend - Overall vulnerability map;
Scenario of sustainable development**

- Zone 1 - High overall vulnerability
- Zone 2 - Medium overall vulnerability
- Zone 3 - Low overall vulnerability
- Zone 4 - No vulnerability
- Dikes

Scale 1:150,000



Flood risks in Belgrade following the scenario of sustainable development

For flood risk calculation in Belgrade a following methodology was applied. To calculate flood risk in an analyzed area, quantification of flood hazards and quantification of overall vulnerability for the specific area was calculated. As risk is, by definition, result of level of hazard and level of vulnerability, a following formula was used for calculation of flood risk:

Overall flood risk index = flood hazard x overall vulnerability (all analyzed for specific area)

Flood hazard level, defined by probability of occurrence and intensity of the phenomenon, was calculated as high, medium, low and no hazard and for each level of hazard a quantification value was assigned:

High flood hazard (probability of occurrence of flooding within 10 years) – index 3

Medium flood hazard (probability of occurrence of flooding within 30 years) – index 2

Low flood hazard (probability of occurrence of flooding within 100 years) – index 1

No flood hazard – index 0

Overall vulnerability level, as sum of 3 vulnerability aspects, was calculated as high, medium, low and no vulnerability, depending on quantification parameters. For overall level, a quantification value was assigned (or index number):

High overall vulnerability – index 3

Medium overall vulnerability – index 2

Low overall vulnerability – index 1

No vulnerability – index 0

After performing calculation of overall risk index, overall flood risk is described as high, medium, low or no risk based on the following criteria:

Overall risk index between 6 and 9 → high flood risk

Overall risk index between 3 and 5 → medium flood risk

Overall risk index between 1 and 2 → low flood risk

Overall risk index = 0 → no flood risk

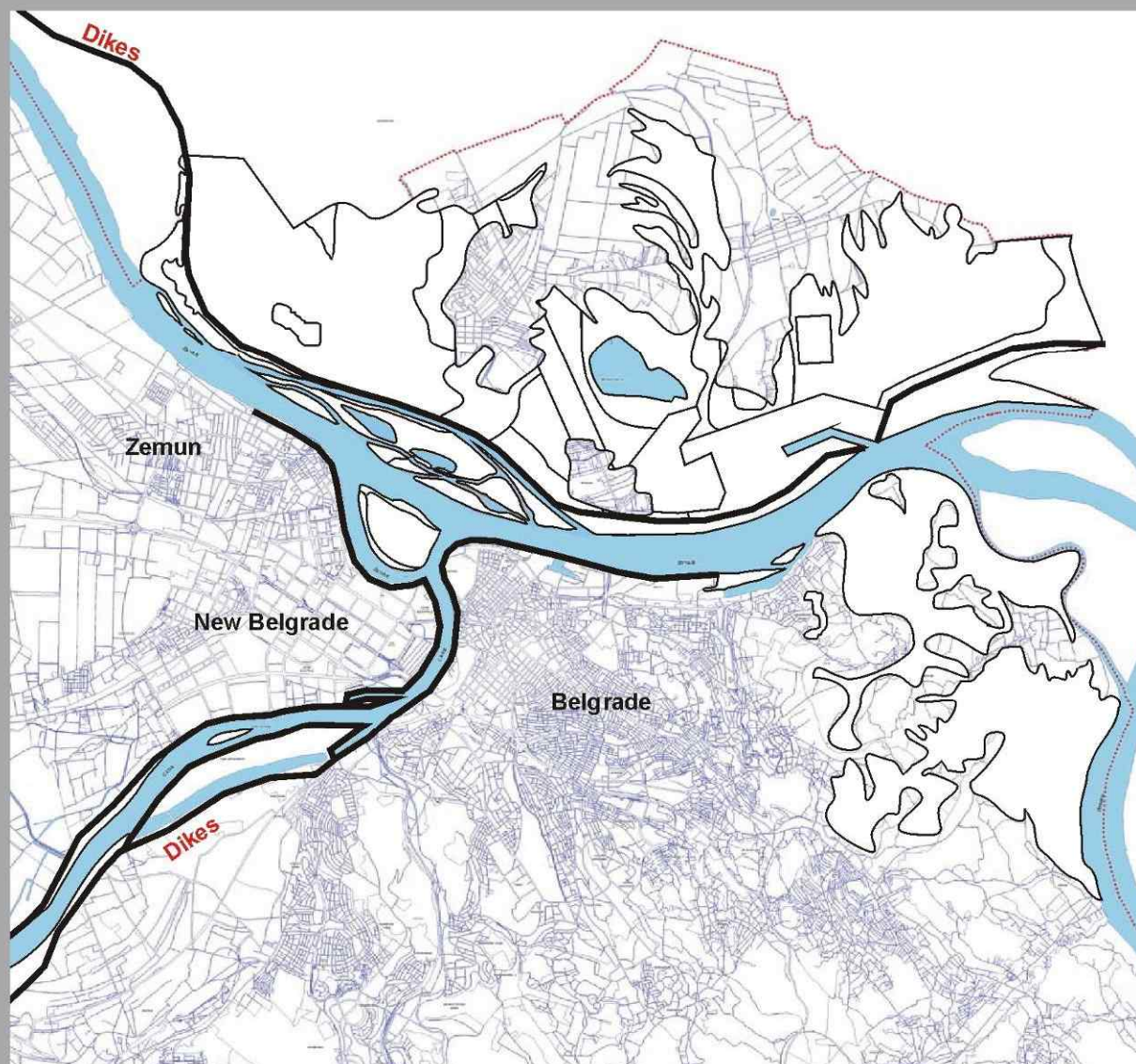
Zone No.	overall vulnerability	vulnerability index	hazard	hazard index	overall flood risk index	overall flood risk
1 - Green area	no	0	low	1	0	no
	no	0	medium	2	0	no
	no	0	high	3	0	no
2 - Agricultural land	low	1	low	1	1	low
	low	1	medium	2	2	low
	low	1	high	3	3	medium
3 - Family houses	medium	2	low	1	2	low
	medium	2	medium	2	4	medium
	medium	2	high	3	6	high
4 - shops and small industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
5 - industry	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high
6 - densely populated urban area	high	3	low	1	3	medium
	high	3	medium	2	6	high
	high	3	high	3	9	high

Flood risks in Belgrade following the scenario of sustainable development

Legend - Overall flood risk map;
Scenario of sustainable development

- Zone 1 - High overall flood risk
- Zone 2 - Medium overall flood risk
- Zone 3 - Low overall flood risk
- Zone 4 - No flood risk
- Dikes

Scale 1:150,000



Flood risks following the sustainable development scenario - Conclusion

Results of the scenario of sustainable development would be:

- *increase of the amount of retention area in Belgrade, thanks to cleaning of the river banks and beds of the river channels from the deposited material;*
- *relocation of vulnerable activities from the area prone to flooding;*
- *protection of agricultural land in Belgrade area, north of the Danube from high underground water table level by applying local protection measures (by reinforcing the dikes protecting this area and by adding layer of soil material on the agricultural land)*

Following this development scenario level of flood risk in Belgrade area would be decreased compared to level of flood risk today. With increase of the amount of retention area in Belgrade, flood risk for the areas downstream would also be reduced.

Conclusion – comparison of the 3 development scenarios

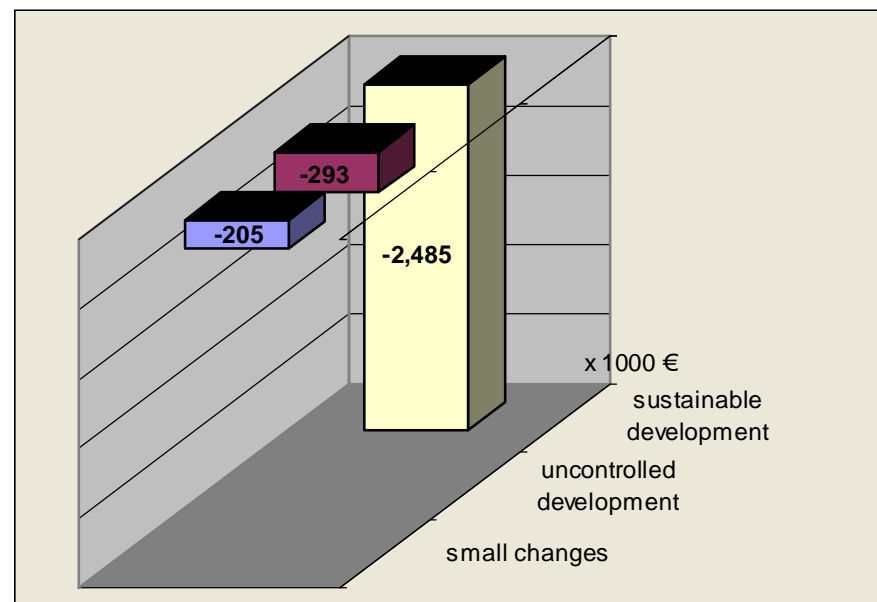
Key parameters for comparing the 3 analyzed scenarios of development are: **level of profit** and **potential losses** in case of undisturbed development and in case of hazardous event for short and long term period of analysis.

Level of profit (already analyzed for each scenario) is a difference between complete investment within the scenario and complete income.

Potential losses (already analyzed for each scenario) are sum of damage of the constructed and natural environment and economic activities as well as losses of human lives, due to occurrence of hazardous event.

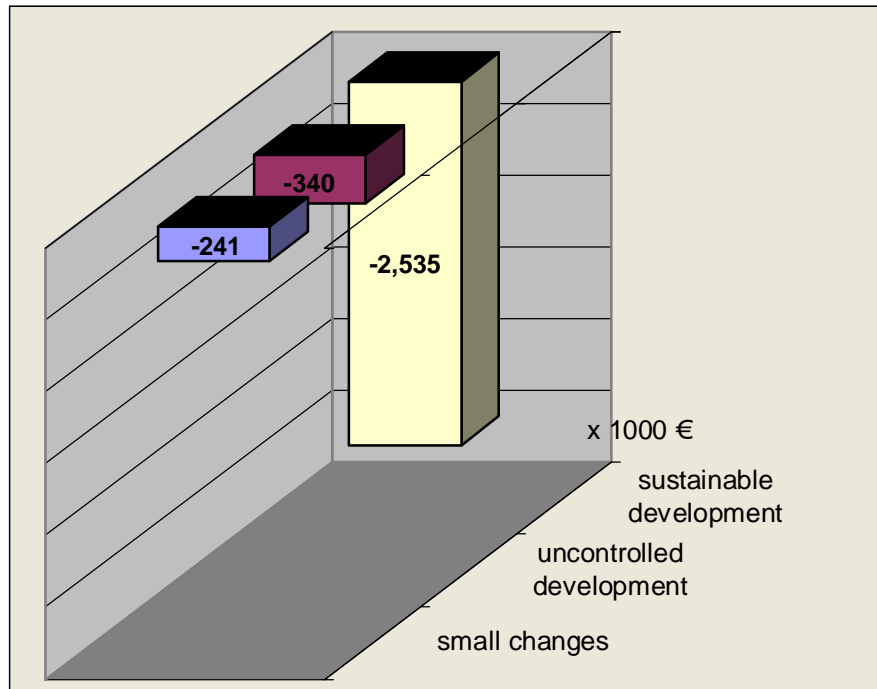
Profitability evaluation

Analyzed results of the 3 scenarios of development of the Great Island of War in case of **undisturbed development** for the **short term** period (5 years) indicate that none of the scenarios would prove profitable – investment is always higher than the income.



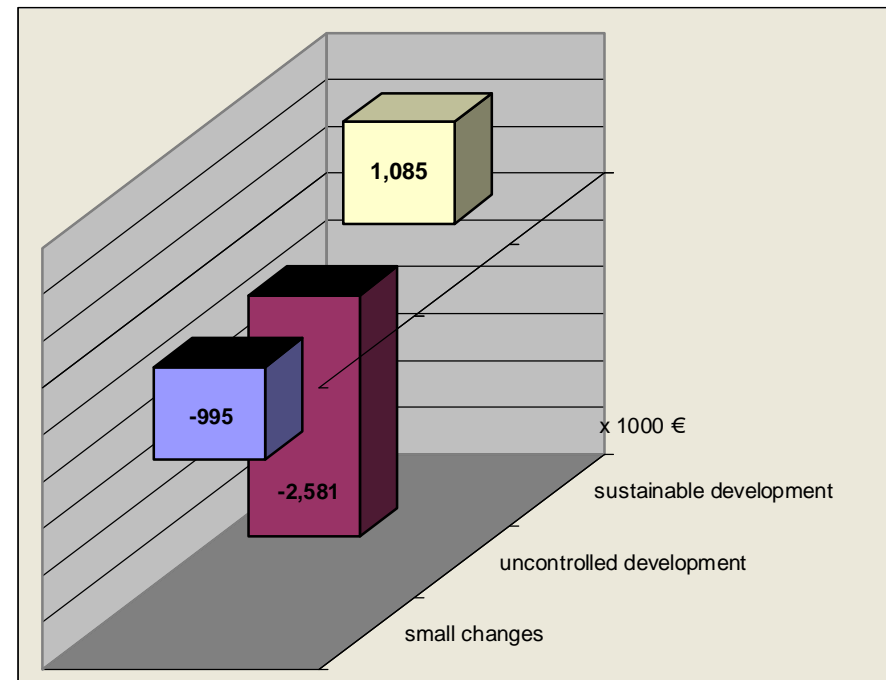
Profitability evaluation – short term period, undisturbed development

Analyzed results of the 3 scenarios of development of the Great Island of War in **case of occurrence of the hazardous event** for the **short term** period (5 years) indicate that none of the scenarios would prove profitable – investment is always higher than the income.



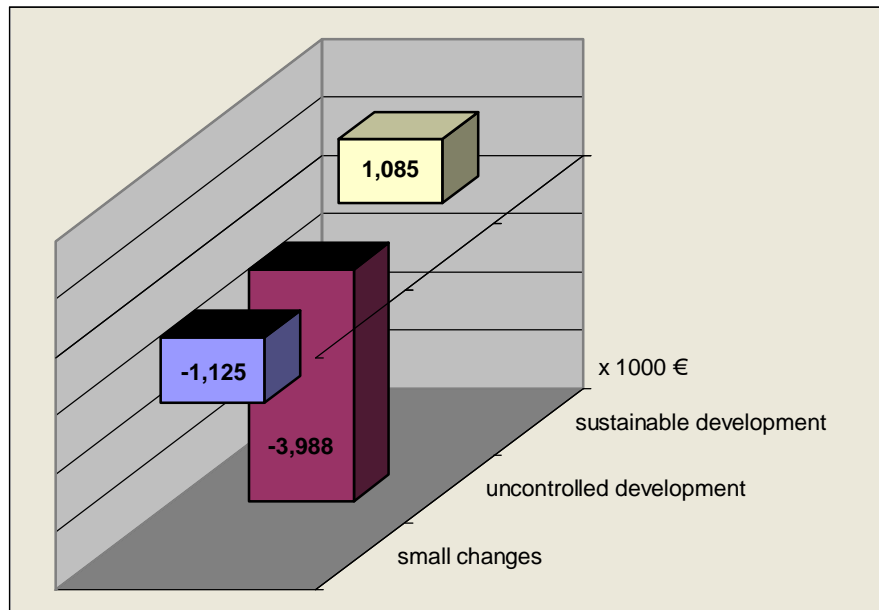
Profitability evaluation – short term period, occurrence of 100 year flood

Analyzed results of the 3 scenarios of development of the Great Island of War in **case of undisturbed development** for the **long term** period (25 years) indicate that only sustainable development scenario would prove profitable – with this approach income becomes higher than the investment in the 18th year of the analyzed development process.



Profitability evaluation – long term period, undisturbed development

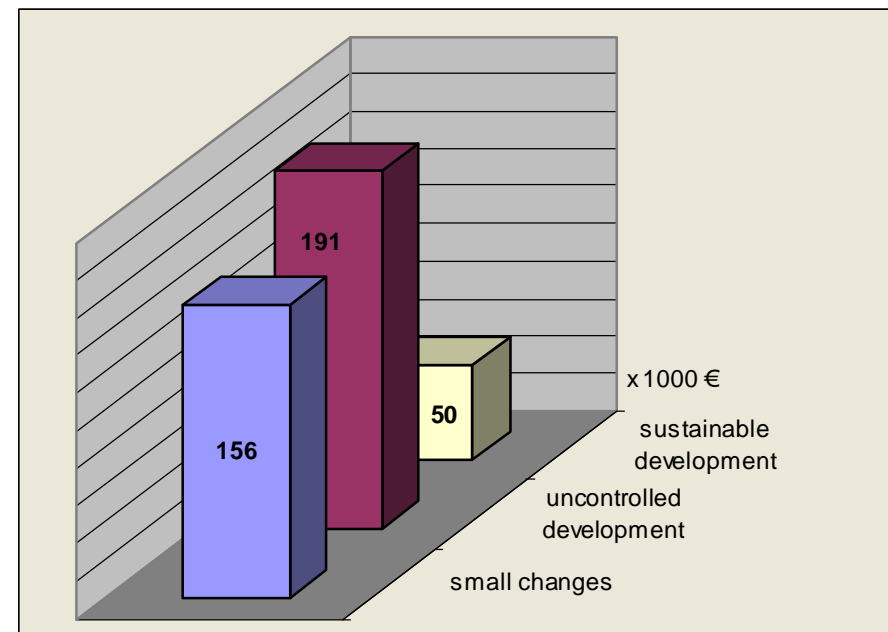
Analyzed results of the 3 scenarios of development of the Great Island of War in **case of occurrence of the hazardous event** for the **long term** period (25 years) indicate that only sustainable development scenario would prove profitable – with this approach income is higher than the investment and flood occurrence does not have any negative effect on the income.



Profitability evaluation – long term period, occurrence of 100 year flood

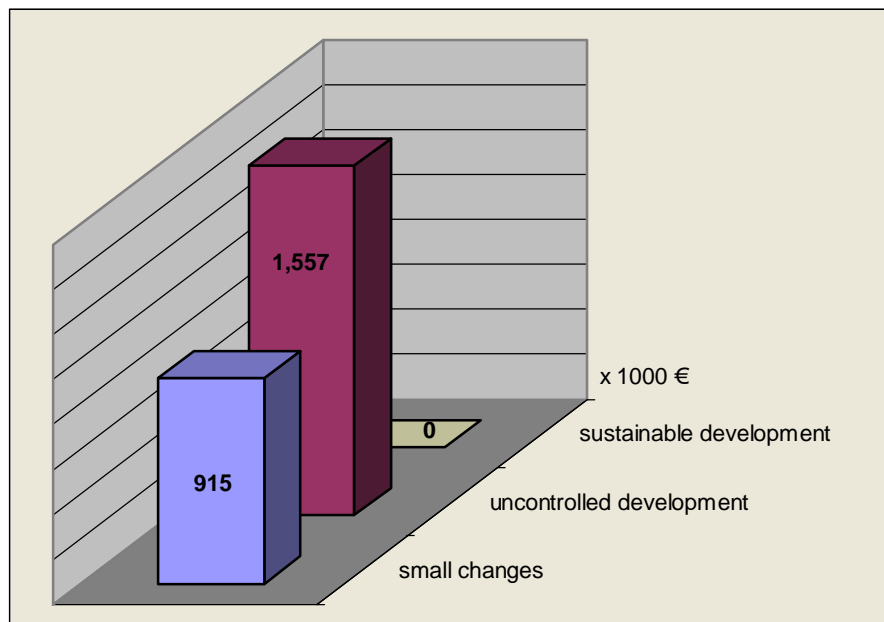
Potential losses evaluation

Analyzed results of the 3 scenarios of development of the Great Island of War in **case of occurrence of the hazardous event** for the **short term** period (5 years) indicate that losses would be most severe in case of uncontrolled development, while in case of sustainable development losses would be relatively small.



Potential losses evaluation – short term period, occurrence of 100 year flood

Analyzed results of the 3 scenarios of development of the Great Island of War in **case of occurrence of the hazardous event** for the **long term** period (5 years) indicate that losses would be very severe in case of uncontrolled development, while in case of sustainable development scenario, there would be no losses at all.



Potential losses evaluation – long term period, occurrence of 100 year flood

Impacts of the 3 development scenarios on micro and macro level

Profitability evaluation show that scenario of small changes and scenario of uncontrolled development would prove unprofitable in all phases of process and both in case of undisturbed development and in case of hazardous event.

Sustainable development scenario shows big discrepancy between investment and income value in the short term period, while in the long term period the same scenario proves profitable. Reason for this is the dynamics of the investment process, which would practically finish after the 5 year period of construction (following period requires only maintenance of the constructed facilities).

Compurgation of losses due to hazardous event in the 3 analyzed scenarios shows that major losses would occur in scenario of uncontrolled development if the 100 year flood would occur in the long term period. If the hazardous event would occur in the short term period, difference between potential losses in 3 different scenarios would be smaller, as the complete losses would be smaller. For the sustainable development approach, evaluation of losses shows that, if the hazardous event would occur in the long term period, there would be no losses at all. Reason for this is that, after the construction of the Recreation Centre is completed, there would be no possible damage of the constructed facilities on the Island and, also, natural flow process of both rivers would not be affected.

Conclusion of the profitability and losses evaluation of the 3 analyzed scenarios is that the sustainable development approach would bring most benefits and minimum losses. Analyzed profit and losses are calculated for the micro level – the Island and the city of Belgrade.

Actual benefits of the sustainable development scenario would be larger and it can be assumed that the Recreation Centre would attract visitors not only from Belgrade. Modern construction and technology of the building would influence development of necessary infrastructure and services in the area and enhance economic activity. Significant building positioned on a remarkable location, such as the Great Island of War can become a city symbol which, if successful, has a long lasting and important impact on a town and country appearance.

Bibliography

Nikolić Biljana, Nešić Nevena (2002)

Projekat „Veliko Ratno ostrvo“ - Predlog za zaštitu Velikog i Malog Ratnog ostrva na Dunavu kod Beograda kao predela izuzetnih odlika.

Zavod za zaštitu prirode Srbije.

Beograd 2002.

Veselinović Milorad, Golubović-Čurguz Vesna

Some of the protected natural areas of the Belgrade region

Institut za šumarstvo, Beograd,

Cvejić Milijana (2002)

“Management of forest ecosystems in national parks and other protected areas”

Zavod za zaštitu prirode Srbije (2004)

ICPDR – International Commission for the Protection of the Danube River Secretariat

Action Programme for Sustainable Flood Protection in the Danube River Basin Flood Action Programme

Vienna International Centre, D0412

PO Box 500, 1400 Vienna, Austria

Student group, Faculty of Architecture, Belgrade (2006)

Project Belgrade – research and design of the Island development
presented on Venetian Architectural Biennale in 2006

IFRC, *World Disasters Report 2000*, Geneva 2000.

The Danube; the Sava; the Great Island of War

www.wikipedia

(2006)