Harmonization of the functional and environmental significance – Ibar hydropower plants and historical heritage of Ibar valley

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Abstract: This paper is an attempt to create a creative compromise between the strict functional requirements of water management structures and the specific landscape characteristics of the river valley, while trying to bring architectural forms with character as close as possible to the building tradition in the historical context, i.e., their interpretation in accordance with the technological characteristics and apprehension of this time and contemporary culture.

The design and construction of a system of ten hydropower plants on the Ibar River is in this sense a great challenge, due to a significant, hitherto unused hydro potential would be activated in a modern and efficient way, whereby gigantic structural facilities would be integrated into the natural environment by architectural action, by harmonic fitting of volumes and forms into the landscape characteristics of individual sites and the entire valley.

Conceptual attitudes have been formulated to define architectural solutions through the relationship between the purpose and function of facilities, the relationship to the natural environment and the relationship to the architectural heritage, while the basics for defining architectural forms have been drawn from typological characteristics, the application of forms and materials in modern conditions and from significance. Completely different spatial units, with different landscape characteristics and constraints, are connected with the same forms of the functional part of facilities, and with different shaping of the volume, a unique artistic visualization of the entire valley is created.

This is how the integrity of the system was achieved, but also the characterization of its parts, which makes the entire technical system more pleasant, and more attractive and valuable both in tourism terms and in general cultural sense. A significant foundation of the concept is the building tradition of the Raška School and the culture of the subject building rules, as well as the symbolic properties of the landmarks that relate to the age of the Serbian medieval state and the time of the Nemanjic dynasty. This highlights the particularity of ambiance physiognomy in the form of an unusual art formulation, by which Ibar hydropower plants will be recognized and memorized.

INTRODUCTION

Basics of the Ibar hydropower plants project

The Ibar River is one of the most significant unused hydro potentials in Serbia. The Ibar River course is 276 km long, and a basin area is 8,059 km². The average multi-year discharge of the Ibar River at the mouth to the Zapadna Morava is 63 m³/s.

Table 1. *Installed discharge (Qins), average annual generation (E_{annual}), installed power (P) and investment value for 10 Ibar hydropower plants [1]*

	HPP Bojanici	HPP Gokčanica	HPP Usce	HPP Glavica	HPP Cerje	HPP Gradina	HPP Bela Glava	HPP Dobre	HPP Maglic	HPP Lakat	**TOTAL**
Qins (m^3/s)	100	100	100	110	110	110	110	110	110	110	
E_{annual} (GWh)	36.008	38.245	35.235	37.189	50.134	41.841	55.476	55.895	52.191	54.399	**456.613**
P (MW)	10.23	10.95	9.81	9.68	13.19	11.17	14.56	14.49	13.4	13.5	**120.98**
Inv. (mil. €)	32.044	33.453	29.885	30.088	36.197	30.924	34.265	40.006	41.370	38.429	**346.661**

The concept of the Ibra hydropower potential use implies the construction of ten run-of-river hydropower plants (on the 55 km long section, river course between Raška and Kraljevo, with a total slope of about 150 m), integrated into the constraints defined by the existing roads (railway and main road) and inhabited areas (Usce, Bogutovac, etc.). [2]

The total power of hydropower plants is about 120 MW, and the average annual generation is more than 450 GWh.

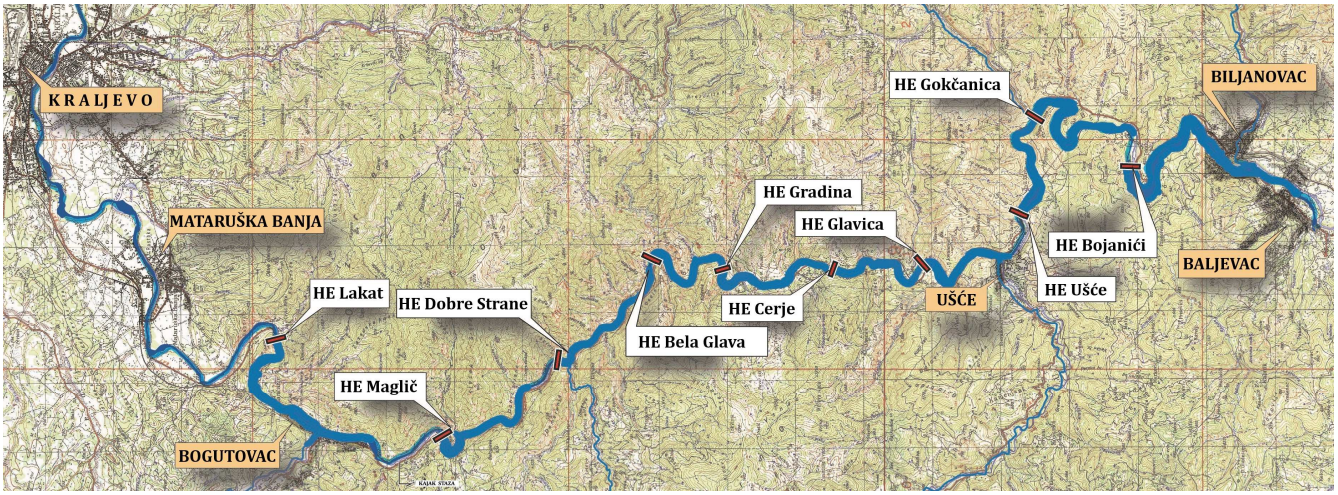


Figure 1. *Map with 10 Ibar hydropower plants [3]*

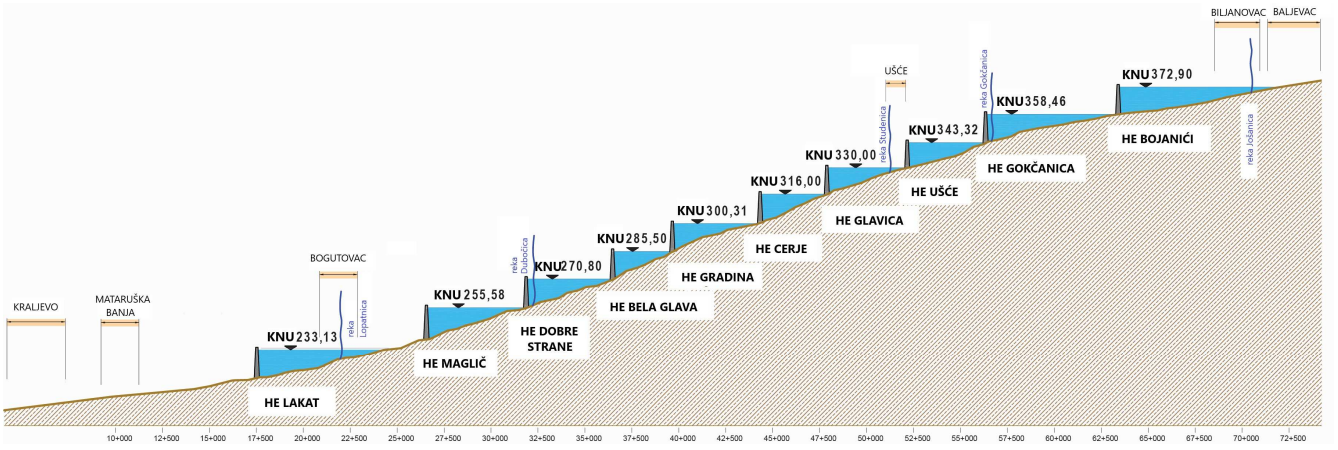


Figure 2. *Longitudinal profile of 10 Ibar hydropower plants[3]*

Basic attitudes on the impact of the Ibar hydropower plants construction on the environment and society

The concept of the Ibar hydropower plants project is based on the ultimate requirements that the positive impact of the construction of hydropower plants on the environment and society must be ensured, which was undeniably achieved by the design solutions.

Hydropower plants are run-of-the-river plants and will maintain stable water levels with very small oscillations, which will significantly contribute to the sound state of the river banks. The natural discharge mode in the Ibar River will not change, except in periods of extremely small inflows, when the hydropower system will increase natural discharges and provide environmentally friendly conditions downstream of each HPP in the system.

The hydropower system will not have a negative impact on the water quality in the Ibar River, as well as on the existing water supply sources. Actually, the reservoir basins act as settling basins, and then after clarification and aeration in turbines the water is discharged downstream.

Mathematical simulations were used to confirm that no conditions for thermal stratification in reservoirs that could activate unfavorable eutrophication processes exist.

A stable level in the reservoirs will provide greater safety for spawning of fish species and the whitebait. Construction of the so-called fish passes is also planned as part of the overall investment.

The full functionality of the main communications (railway line and Ibar Highway) will be preserved, both during construction and during the exploitation phase. Some dams of hydropower plants are designed to serve to traffic purposes as communications that facilitate access to cultural and historical monuments and rural dwellings.

Conditions for sports and tourism development will be also created. Stable levels in the lakes will provide for horticultural landscaping of the river banks including various facilities (dock, fishing platforms, pavilions, etc.). Aquatorium will provide an environment to become an attractive resort for citizens, especially in the summer months for swimming and water related recreation - still and wild water sports (construction of kayak trails).

One special feature of this project is that hydropower plants will be integrated into the environment in line with architectural and environmental harmony. This will further promote the historical aspect of this area, because a large number of monasteries, towns and fortifications of medieval Serbia are located along the Ibar River banks.

CONCEPTUAL STANCES OF ARCHITECTURAL SOLUTIONS FOR THE POWER PLANTS

The following starting points were adopted as the basis for defining the character of the overall architectural concept and as a framework to formulate the physiognomy of the entire system of ten hydropower plants in the Ibar Valley, as well as the special identities of facilities and ambiance units:

- Architectural solutions should largely follow the conditionalities defined on the basis of the energy efficiency criteria of the plant as a whole. Architectural solutions cannot contradict the functional characteristics of the complex and its parts, nor their basic technological and economic properties.
- Architectural solutions should represent the position of maximum protection of natural landscape, ecological and ambiance values that characterize the Ibar Valley.
- The historical protection of the elements of the remaining cultural heritage in the area is of particular value. Historical facts that make the area of the Ibar Valley one of a unique value of importance for the national historical identity and medieval statehood with the Nemanjic parentage, is a major obligation for the builders of 10 Ibar power plants.

In this sense, it is necessary to find an appropriate method so that the large-scale landscape and building intervention that will inevitably occur in the area, will not be devastating to the landscape values of the valley and its historical significance. Hence, the task is to adopt the architectural concept that is considerate of nature and of historical memory on the other hand. All the basic decisions regarding this project also emerge from this paragraph:

- All 10 hydropower plants should have a distinctive physiognomy based on an attentive attitude towards nature and a high degree of respect for the architectural heritage, the tradition of the Raška School and memory related to the Nemanjic era;
- These elements should give the system of Ibar power plants a specific appearance, a physiognomy that will differ from the usual appearance of industrial facilities of this type in our country and in the world;
- It is understood that the basic energy purpose of facilities and their functions must remain undisguised, but in those elements of the building unit that are less rigidly conditioned by engineering technical and technological constraints, subject facilities must be able to bring richer symbolism in line with the idea of raising the level of technical and general culture in our environment.

Attitude to the purpose and function of the facilities

Given the economic importance and technological characteristics of buildings and devices, architectural characteristics cannot be contrary to other aspects and criteria that condition this type of building. Therefore, the architectural concept must follow these conditions primarily at the level of functional organization of space and content, and also in terms of structure, application of materials and appearance of the whole. Non-functional, non-structural, and unsuitable architectural forms are not acceptable for this type of facility. The basic fact that hydropower plants belong to industrial architecture must not be clouded by any pretension regarding the purpose and appearance of buildings. The basic function and appearance of the facilities must be adequate in both senses. Architecture must express the purpose of these buildings, not some other non-industrial purpose (such as residential, hospitality, entertainment, recreational, sacral, etc.). Contradictions between the function and the architectural appearance of facilities are not allowed. illegibility and misunderstandings regarding form - meaning would be compromising for the investor, the project implementer and other participants in the project, and especially for architects who sign off the design and hold personal responsibility for this issue.

The basic functional and technical characteristics of the system of 10 Ibar power plants based on an identical model significantly condition the spatial layout of individual elements of the building as part of the whole.

The top of the dam, spillways, water cushions, position and size characteristics of the engine room, accesses to the crane track, technical access to the handling area, exits from the gallery, the fish pass and other elements are in a fixed relationship with each other, which makes the architectural assembly in all 10 sites significantly uniform in terms of typology.

The application of identical hydropower and also identical structural-technical solutions requires both the standardization of solutions and the position of functional elements within the whole.

Thus, the most architecturally significant corpus within an engine room is conditioned as a prototype in positional, sizing, outline and leveling terms.

However, there are conditions to avoid excessive rigidity, schematics and unpleasant unification characteristic of industrial building while adhering to these basic conditions in the closer definition of architectural forms.

To a certain extent, it is possible to vary the scope of the engine room - elements outside the firmly defined structural assembly. There is a possibility of smaller or larger recedence of the engine room's facade canvas, especially in the zone lateral to the access road and lengthwise to the handling plateau and transformers, while towards dam top and the water cushion, this possibility is significantly smaller.

Variant displacement of the position of the command center rooms (although connected to the edge zone adjacent to the dam top) is possible in the field of 2.5 structural modules with multiple cantilevers. The position of the staircase for access to the various elements of the engine room can also be varied multiple times.

Attitude to the natural environment

All 10 power plant architectural designs include the aspects of protection of the natural characteristics of the Ibar Valley - relief, riverbed, natural landscape, type of vegetation, etc. It is quite understandable that in this type of design, such an attitude can be contrary to other characteristics of the solution that cannot be influenced backwards, so the procedure is reduced to a careful assessment of the possibility that architectural solutions mediate (as much as possible) between complex engineering conditions that require radical interventions in the natural environment and the need for environmental, ambiance and historical protection as is necessary in this area on the other hand.

Soil and water are the basis of the energy and artistic-plastic properties of hydropower plants. Namely, the system of 10 Ibar power plants is significantly determined by specific natural geomorphological environment, as well as hydrotechnical and hydropower conditions of the construction of this type of facilities.

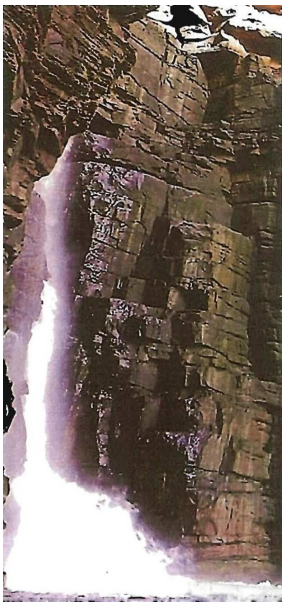


Figure 3. *Nature energy: an impressive sight of the soil and water energy bond, a striking image of great symbolic strength that leaves no one indifferent (*photos are the designer's visual inspiration taken from the Internet and they do not represent specific facilities/objects and sculpture**s,** but a leitmotif for the artist (sculptor) in creating future new symbols)*

These elements are extremely important for the spatial and artistic-plastic characteristics of architectural solutions of hydropower plants. In addition to the functional and technical role of buildings that architectural forms must follow and properly express, they should also contain unambiguous information on the essence of the building, its purpose and goals, and be suggestive and aesthetically appealing.

The architecture of 10 Ibar hydropower plants must express the strength of nature and its multiple values, those productive - economic, but also artistic-plastic, also very strong, and even unique.

The basis of architectural forms are forms from nature, but supported by the human hand. In other words, forms of nature, although powerful and visually striking, cannot respond to the structural needs without the help of human hands.

Figure 4. *The action of the human hand on forms in the nature. The illustration shows man-made architecture of forms found in nature (*)*

Architectural solutions at 10 power plants should be inspired by the idea of synthesizing natural forms and experiences that man has come up with in the processing of raw materials throughout history.

Attitude to the architectural heritage

An important role in architectural design is the conceptual determination that buildings contain a certain ***historical reference*** in response to the fact that buildings are located in an area of great historical value and importance for cultural and historical memory of national importance. In this regard, there is an obligation to base architectural design on the respect of certain characteristics of authentic architectural heritage of this land. This primarily refers to the basic ***character and spirit of the form*** coming from the heritage, not to the concrete forms inherent in the historical context. Namely, it is about the need to properly read the essential stylistic characteristics, the architecture of the region of the Ibar Valley from the 12th-13th century and the entire building tradition that followed in the subsequent periods. Therefore, it is not a question of direct imitation and mechanical copying of recipes and models from history, but of the need for their creative, contemporary interpretation. Naturally, this approach and respect for heritage requires careful and versatile analysis of relevant historical material, distinguishing essential elements from those relevant to this type of facilities. The next step is the required research of acceptable solutions and finally the ***author's interpretation***, which must not be a direct imitation and copying, but a creative synthesis at the level of association and evocation of historical experience and its application in accordance with the level of contemporary building knowledge and experiences.

In addition to universal civilizational experiences in building structures in a single space, the indigenous architectural experience and all that specific, charteristic experience related to the deeper historical and cultural layers inherent in this particular environment for which these buildings are intended is very important.

The space of the Ibar Valley is connected with the historical memory of the Serbian people and the idea of Serbian medieval statehood. This fact is indelibly linked to the sense of national identity, which places the obligation of certain memorial protection of the area before the hydropower plant builders.

Figure 5. *Silhouette of a medieval ruler on a horse – Nemanjic with a spear in the shape of a scepter. Strong encouragement of awareness of one's own historical identity (*)*

The time of Nemanjic in the structural aspect represents a wider Byzantine heritage where typologically very similar, and to a large extent identical recipes in the building of military, public, and economic structures and those for other uses on the land of medieval Serbia, were developed.

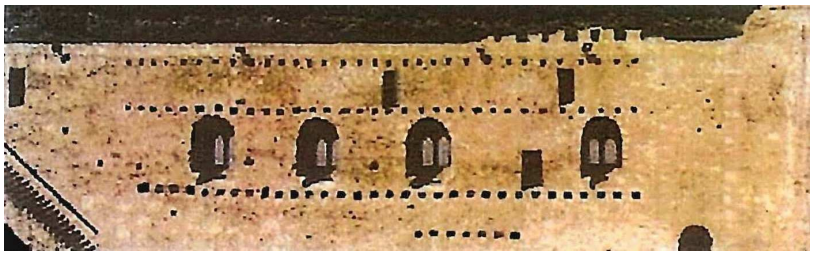


Figure 6. *Example from the Greater Byzantine Building Heritage Fund (*)*

The autochthonous variant of the accepted Byzantine cultural heritage is the experience of the Raska School of Serbian medieval building tradition. The architectural characterization of the facilities of the Ibar Power Plants must be linked to these two experiences and strong supports in the protection of the historical identity of the Ibar and wider Serbia.

On the other hand, modernity is a civilizational and cultural challenge and obligation. Modernity brings new experiences based on new knowledge that as a rule go beyond the previous ones, especially the distant ones. [4]

Figure 7. *An example of a modern structure in industrial facilities. Characteristic manuscript of contemporary times. The Nemanjic period did not imitate any previous period, just as it should not be expected to copy us in future generations. Each generation has its own historical role to play (*)*

For the above reason, the literal application of forms from historical heritage is not a recommended alternative. Direct borrowings from history - replicas and banal copies bring more damage than benefits to cultural identity, because they act as imitations, coulisse or lies, i.e., deception that compromises both modernity and historical role models themselves. A superficial resemblance to history is a weak alibi for the lack of creative potential.

Therefore, it has been decided to find a way of creatively combining the experiences of the past with the knowledge and spirit of modernity in the architectural design of 10 Ibar power plants.

FOUNDATIONS OF ARCHITECTURAL FORM DEFINITION OF IBAR HYDROELECTRIC POWER PLANTS

Typological characteristic of the architectural form

A number of elements can be distinguished from the rich architectural heritage, which could be a good inspirational basis for this type of design, unlike others, which, although valuable and interesting, even aesthetically valuable, would not be advisable, because they are in a sharp contrast with the purpose of the facilities in an artistic and meaningful way. First of all, in typological sense, an inspiring foundation for architectural forms definitions can be sought in the architectural experience of a profane (not sacral) character, as well as in the architecture of public (not residential) buildings. The architecture and complex of hydropower plants can be matched with primarily strong, rustic forms, energetically expressive, striking and unusual, certainly different from those slightly corny and sentimental ones we encounter in folklore everyday life, or those typical of the places of worship, temples and shrines. This conceptual attitude leads to distinguishing role models, as follows:

- fortresses,
- protections,
- fortifications,
- stone walls,
- supports,
- abutments,
- counterforts,
- military facilities,
- shelters and warehouses,
- commercial facilities,
- service and craft facilities,
- related forms and shapes from nature (rocky slopes, caves, drifts, embankments, shears, etc.)

Also, an inspiring foundation for shaping the architectural form can be found in a number of structural and architectural elements that we encounter on various buildings from historical heritage such as:

- towers and roofs,
- belvederes and porches,
- underpinnings and niches,
- walkways and cornices,
- arrow slits,
- teeth (serration/beams and columns),
- balconies (machicolations and consoles),
- gates, vaults and ports,
- windows (monophores, biphores, triphores),
- columns, silts, pilasters, etc.

All these elements of the dictionary of architecture characteristic for the emergence and development of forms inherent for the Raska School deserve full attention, because they are characteristic for the valley of Ibar and the time of Nemanjic, as well as for the later centuries-old tradition and evolution of the indigenous typology of architectural forms.

Application of form and materials in modern environment

The aforementioned typological characteristics of the shape must undergo two types of adaptation to modern conditions and specific application. On the one hand, it is necessary to adapt in the field of application of materials and crafts (this is a necessary reliance not only on traditional materials but also on contemporary ones), and on the other hand this is about the need for visual actualization of forms (although forms have a retro-orientation they must be unequivocally modern as they should belong to the contemporary era and culture of this time). This will require creative stylizations of original forms, their revitalization, decomposition, merging into new, previously non-existent, combinations and intertwining implementations with the help of modern technology, but with due respect of the basic characteristics of the architecture of the Raška School, which are, among others, as follows:

- simplicity and calmness of general tectonics;
- legibility and comprehensibility of the composition;
- harmony, proportionality and finesse of proportion;
- characteristic expression of firmness and dignity;
- high aesthetic level of shape;
- the quality of the details and the top level of craftsmanship and
- legibility and memorization of the art theme.

All this implies the introduction of the contemporary spirit of author architecture and artistic expression.

Symbolism

An important conceptual attitude in architectural design related to this task is the decision that all power plants, in addition to having architectural characterization - a specific "image", should also have their own sign - a symbolic mark that ties them to the collective memory and the Ibar Valley notion as the "Valley of Kings" or "Valley of Lilac", well entrenched in the consciousness of the people as a space of strong representation of their own historical identity. The idea of the project implementer that every power plant, apart from the name of the site, bears the name of one of the Nemanjic Familiy members undoubtedly expresses deep respect for that identity and the effort to strengthen it even more. In support of these efforts, this design also contains a proposal that every power plant has a particularly roadside (along the main road) easily visible visual mark in a prominent place - a sign of recognition, a symbol that is easily recognizable and easy to remember (in the sense: I passed by that sign; I will be at that sign, etc.), and at the same time a symbol related not so much to a specific personality, but to a general notion that marks a wider historical time and the entire culture of the people. This attitude is motivated by the fact that some general concept can facilitate to mark an industrial facility - a power plant in an even easier and more communicative (and certainly without any objection) manner, than to use a prominent name of a nobleman, king or priest. In this sense, a number of general terms (which are associated with history) could be available, such as:

- Nemanjić fountain - falcon bird,
- archer - Knight squire,
- messenger - a common man,
- Dragon figure - Helen of Anjou,
- ruler - Symbol of Nemanjic.

These are therefore concepts that would be Nemanja about the dynasty (and not specific names), then the knighthood culture, the order of priests, workers, travelers, hunters and other concepts included in the general popular concepts of the historical era in the Valley of the Kings and Lilacs. Names of personalities are for deep respect and learning about them through books, museums and sacred places, and for wider use are more appropriate concepts from traditions, customs, stories, poetry, legends and other equally important, beautiful sources useful for the people's sentiment.

ANALYSIS OF THE IMPACT AND SPECIFICITY OF THE ARCHITECTURAL CONCEPT

Units and their impacts

Views about the special characteristics of individual designs within the system of 10 hydropower plants were formulated and decisions were made on the basis of an analysis of the technical characteristics of hydropower plants, an analysis of relevant historical documents, as well as a visit to all sites in the field and the photo documentation.

Based on all relevant elements, a list of 55 influences was formed, classified into 4 problem units, based on which the choice for the forms of conceptual definition of each of the 10 power plants will be made. These are: location characteristics (25 influences), function-form relationship (6 influences), form-meaning relationship (10 influences) and form - other aspects relationship (14 influences).

The special characteristics of hydropower plant designs are shown in Table 2.

Table 2 shows how the concepts are influenced by the relief and morphological characteristics of the valley, the direction and length of the dam, the distance from the main road, the height difference used to perceive the facilities, the time of analysis, etc. Behind these primary influences are the specifics of the function-structure-form relationship as a series of technical conditions, and then very important issues related to the aspects of nature protection and historical protection. Finally, there is another group of influences concerning the general physiognomy of space and architecture, the forms that should carry visual identity and meanings, as well as issues related to the choice of materials and other factors of impact. All together, these influences determine the spatial and visual characteristics of the architecture of individual sites.

Four problem units are listed in a vertical sequence with color highlights for easier tracking, and individual impacts are entered in columns below the names of individual power plants.

Table 2. *Units and their impacts [3]*

			HPP LAKAT	HPP MAGLIČ	HPP DOBRE STRANE	HPP BELA GLAVA	HPP GRADINA	HPP CERJE	HPP GLAVICA	HPP USCE	HPP GOKČANICA	HPP BOJANICI
Relationship: MICROLOCATION - WIDER AREA OF THE IBRA VALLEY	Position in the area	left	×	×	×	×	×	×	×			
		right								×	×	×
	The relief of the valley and the course of the riverbed	in the river curve		×	×	×	×					
		in the course	×					×	×			
		width wise								×	×	×
	Dam top length	< 105 m			95							
		105-140 m	114			130	120	121				
		> 140 m		148					193	155	134	195
	Height of the dam top versus road	±0.0				±0.0					+0.5	
		< 5 m		-3.5	-8.5		-3.5			-1		
		> 5 m	-15					-9	-4.95			-9
	Facility perception time	< 30 "		5-15	10-25		20-30				25-30	
		30-50"	30-35					40-50	40-20			
		> 50"				65-10				55-60		65-55
	Engine room distance from the road	< 20 m	18		5		12	11				
		20-50 m		33		25					28	
		> 50 m							100	105		80
	Technical access	from the road	×	×	×	×	×	×	×		×	
		from the other								×		×
	Passability - traffic	no passability	×		×	×						
		pedestrians and		×					×		×	×
		road					×	×		×		
	Close to attractive amenities	in the ambiance		×								
		nearby	×			×				×		
		isolated			×		×	×	×		×	×
F - K - F	Connected functions	connected		×	×	×	×	×	×		×	
		partially								×		
		autonomous	×									×
	Scale Priorities	funct. struct.						×				
		func. - form	×		×	×	×			×	×	×
		form struct.		×					×			
Relationship: FORM - MEANING	Hydro power aspect	distinctive	×	×	×	×	×	×	×		×	×
		atonic								×		
	Nature protect. aspect	significant			×	×	×	×	×			
		very significant	×	×						×	×	×
	Historical aspect	retro				×			×	×	×	
		associative	×		×		×					
		symbolic		×				×				×
	Relationship to modernity	irrelevant								×		
		moderate	×		×	×	×	×	×		×	
		stressed		×								×
Relationship: FORM AND OTHER ASPECTS	Stress on form in space	stressed							×	×		×
		restrained	×		×	×	×	×			×	
		discrete		×								
	Form and background relationship	direct environment	×	×	×	×	×	×	×	×	×	×
		remote landscape	×						×	×	×	×
		sky	×	×	×	×			×	×	×	×
	Form-material relationship	composite	×	×	×	×	×	×	×	×	×	×
		Natural mater.	×						×	×	×	×
		new materials		×			×	×			×	×
	Architectural point	composition	×						×	×	×	×
		facade plan			×	×	×	×				
		detail		×	×	×	×	×			×	
	Symbolization	dynasty assoc.	×				×				×	×
		longer historical		×	×	×		×	×	×		

The table is easy to read, for example: that, looking upstream, to the left of the main road, there are seven, and to the right only three hydropower plants; in the curve of the riverbed there are four out of ten sites; that the length of the dam top is the shortest at the Dobra Strana HPP (95 m), and the longest at Glavica, Usće and Bojanić HPPs; that the height of the dam top at the level of the main road is only present at the Bela Glava HPP and Gokčanica HPP, and that in 4 hydropower plants the top of the dam is about 2 to 5 m lower than the level of the road, while in 4 HPPs this height difference is greater than 5 m, in Cerje and Bojanić about 9 m, and in HPP Lakat the top of the dam is as much as 15 m lower than the main road.

The table also shows that the time of perceiving the hydropower plant complex is different, that in four sites that time is less than 30", in three sites 30-50", and that the longest perceiving time is over a minute, from both directions, only at HPP Usce and Bojanici. The table shows that the shortest distance between the main road and the engine room is one of the Dobre Strana HPP - less than 5 m, that the mean distance is 20-30 m (Lakat, Maglic, Bela Glava), that for three power plants (Bojanić, Glavica and Usce) this distance is over 50 m, and for the furthest one, HPP Usce, even more than 105 m. They are very interesting and of great influence on the specificities of the site and many other indicators that are read from the table, such as those on the technical approach, passability- traffic, proximity to attractive amenities, as well as data on the characteristics of the relationship functions - form - structure, relationship form - meaning (energy aspect, aspect of environmental protection, historical aspect), significance of the relationship to modernity, etc.

There are sections at the end of the table showing the peculiarities of the site regarding the need of stress of form in space, the relation of form and natural ambiance - background, the relation of form and material, as well as data on what should be the architectural points - on the composition, facades or details of the building in individual sites. Finally, the table shows which sites should have a striking symbolization - dynasty related (the first and the last HPP), and that the others are dominated by symbolization that marks the wider Nemanjic and other historical time of this area.

Architectural concepts of hydropower plants

One can draw the conclusion from all the analyzed impacts that there is a specificity of architectural concepts of all ten power plants. These specificities can be expressed concisely by setting ten different architectural themes and their associated symbols that show the essences of the character or identity of individual power plants (Table 3).

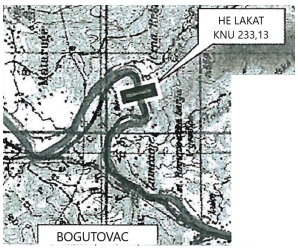
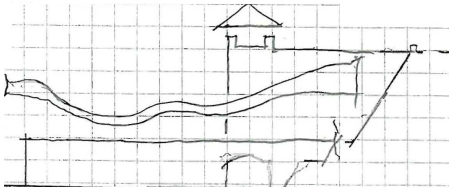
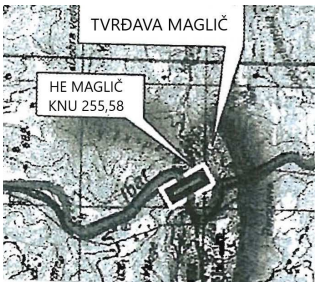
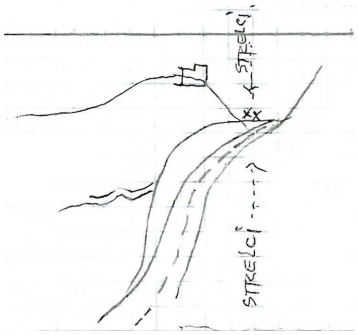
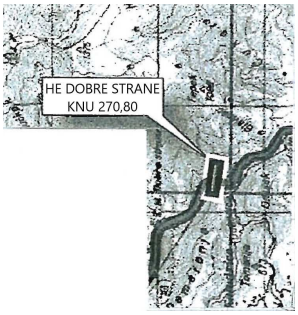
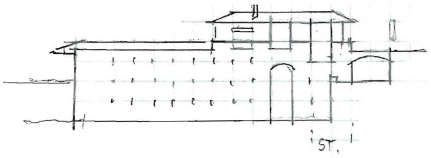
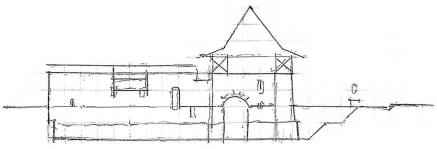
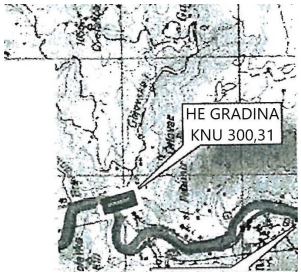
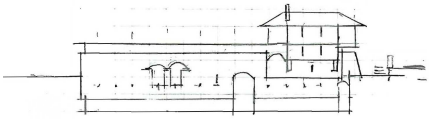
Table 3. *Specifics of architectural concepts [3]*

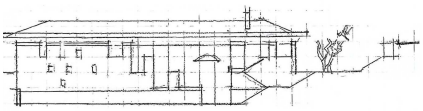
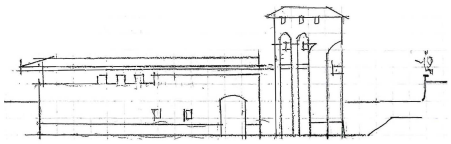
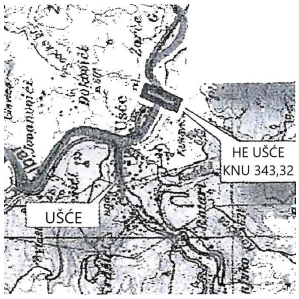
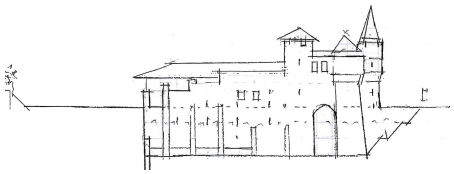
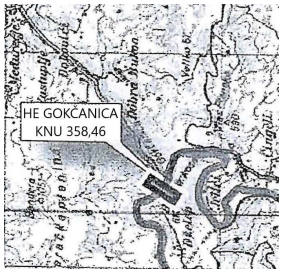
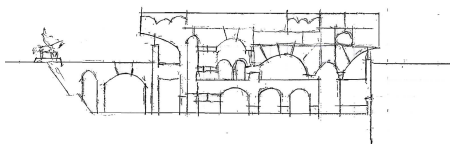
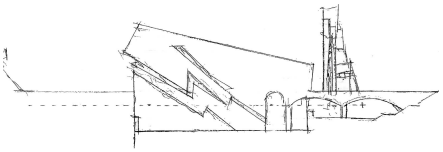
Site		Theme	Symbol
1.	HPP LAKAT	− roof garden and tower	− Nemanjić fountains
2.	HPP MAGLIČ	- camouflage shield	− soldiers − archers
3.	HPP DOBRE STRANE	− flat wall and gate	− the messenger
4.	HPP BELA GLAVA	- roof porch	− dragon figure
5.	HPP GRADINA	− inn and lodging	− ruler
6.	HPP CERJE	− large forest	− falcon bird
7.	HPP GLAVA	− tower - belvedere	− knight squire
8.	HPP UŠĆE	- ruler's palace	− an ordinary man
9.	HPP GOKČANICA	− Byzantine ports	− Helen of Anjou
10.	HPP BOJANIĆI	− water power	- symbol of Nemanjic

OUTPUT ATTITUDES ON THE SPECIAL LANDSCAPE AND ARCHITECTURAL CHARACTERISTICS OF THE HYDROPOWER PLANT DESIGNS

The basic architectural characteristics have been defined on the basis of aforementioned – key forms affecting the physiognomy of the ambience and the picturesqueness of the 10 Ibar hydropower plants landscape.

Table 4. *Artistic-formative peculiarities - visual themes - characters of 10 HPPs - comparative perspective [5]*

Location	Artistic expression	Feature
1. HPP LAKAT 		Basic architectural feature: The composite form consists of two spatial elements: the wavy surface of the roof garden above the engine room and the vertical form of the tower in the annex.
2. HPP MAGLIČ 		Basic architectural feature: Neutralization of the HPP's problematic presence in the landscape of protected area. The camouflage shield of the green scarp along the main road prevents the unwanted presence of the hydropower plant facility near the fortress. Only the town and the archers (of bronze) on the edge of the scarp towards the view of the town are in sight.
3. HPP DOBRE STRANE 		Basic architectural feature: Horizontally directed form - entirely under steep single slope roof. Separated tower on the upper floors accentuates the verticality with its triangular base.
4. HPP BELA GLAVA 		Basic architectural feature: The roof porch dominates the space, command rooms are located under.
5. HPP GRADINA 		Basic architectural feature: The inn and lodging - The architecture of the engine room follows the tradition of the Byzantine school and the spirit of monumentality. The emphasis is on the angular motif that refers to oriental experiences in construction of housing forms – lodging.

Location	Artistic expression	Feature
6. HPP CERJE 		Basic architectural feature: Horizontally directed form - entirely under the roof. Part of the wall is open – glazed.
7. HPP GLAVICA 		Basic architectural feature: A composite form composed of a laid down lower part and a vertical rising at the dam top access.
8. HPP USCE 		Basic architectural feature: The physiognomy of this complex of hydropower plants is characterized by the idea of group form. From the basic form defined by the engine room corpus, several elements of artistically shaped are distinguished, similarly to towers and fortresses of medieval ruler's courts in the area of striking dwellings and fortifications.
9. HPP GOKČANICA 		Basic architectural feature: An embossed stone facade canvas of an engine room, lavishly shaped by numerous perforations in arcuated window holes with a clear orientation to Byzantine cultural heritage.
10. HPP BOJANICI 		Basic architectural feature: The engine room is shaped sculpturally - like a large stone.

Note: *In addition to the general position of the site, Table 4 provides a brief description of the essential characteristics, i.e., the peculiarities of the concepts of each of the 10 architectural themes. The attached sketch specifies the subject concepts and provides visual presentation, which defines the basis for a more detailed look at ideas, and then a closer elaboration through architectural designs.*

PRESENTATION OF LANDSCAPE CHARACTERISTICS AND ARCHITECTURAL SOLUTIONS OF THE IBAR HYDROPOWER PLANTS

HPP Lakat

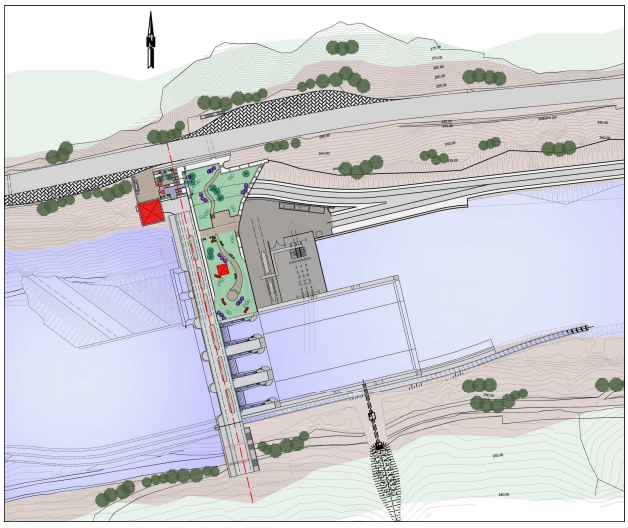
As-is state of landscape characteristics

This is the longest section (9 km) in the Ibar power plant system.

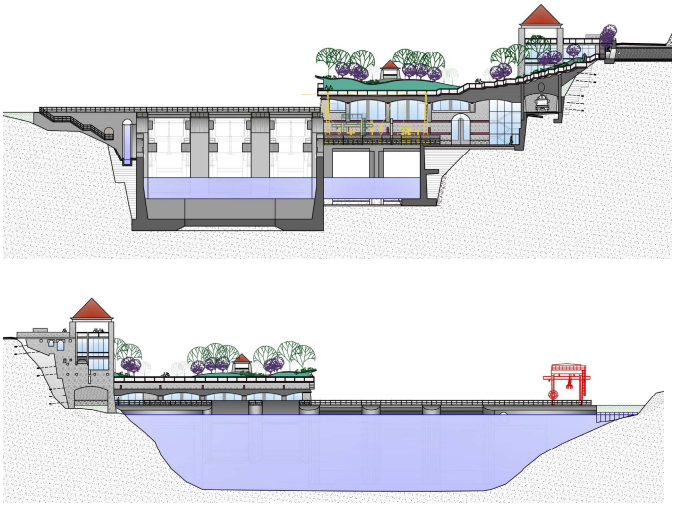
Natural characteristics give it the property of a pleasant area with alternating pronounced relief and calmer parts. The dwelling of Bogutovac and a narrow strip of arable land along the river indicate the proximity of the City of Kraljevo along the access roads from the south-west.

The route is directed under a mild angle down to the south-northeast with two sharp "elbow" curves between which the first in a series of hydropower plants was designed. The corridor of the riverbed extends in a funnel-like shape downstream from Maglič and has an asymmetrical slope in the profile of the banks, especially in the zone of the mouth of the left tributary of Lopatnica. The soil is humus-rich, and mostly in the expanded zone near Bogutovac. The rockiest site is in the zone of "elbow" curves and partly under rockfall upstream of the future dam profile.

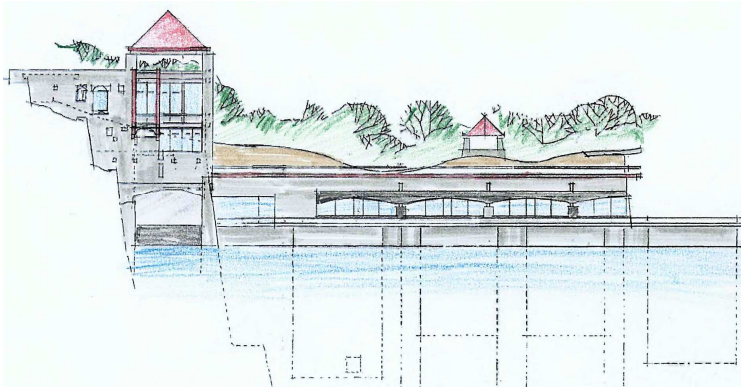
The forestation is intense in the higher relief zones and along the riverbed, where the developed deciduous vegetation dominates. There is a zone of arable land along the riverbank in the lower course, and north is dominated by the zone of an attractive riverbed.



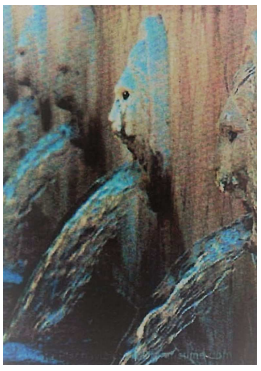
Layout of the dam with the Lakat hydropower plant



Downstream and upstream appearance of the HPP Lakat



Theme – Roof garden and a tower



Symbol - Nemanjić fountain (*)

Figure 8. *Lakat Hydropower Plant*

All of the length of the entire existing main road is routed on the left bank. It lies mostly on natural soil and at relatively low levels in relation to the riverbed. The railway route, near the elbow curve, enters the tunnel, and in the middle part, near Bogutovac, it crosses the bridge from the right to the left bank of the river, looking upstream, and thus the railway

follows the riverbed along this entire section. Railway is set in several places on cuts and embankments with retaining walls and water culverts.

The dwelling of Bogutovac is located on the lowest and most widespread part of the section around the mouth of Lopatnica River, in a bay, bordered by two sides with marked relief and inhabited slopes on the right bank (looking upstream), which together maker a significant spatial benchmark at the entrance to the central part of the Ibar Valley.

Historical facilities are located in the immediate vicinity.

Summary of the designed state

The Lakat hydropower plant dam forms a very spacious reservoir, one of the two largest in the system (0.718 km^2). Such a wide and long water table will be a major contribution to the landscape as it will appear dominantly pleasant and visually soothing. The dam has a north-south orientation, with a 114 m long dam top.

Surrounding pronounced relief surrounded by rich greenery in the waterfront reflected in the water mirror will contribute to a pleasant image of the overall experience in passing or in the stay on the lake and in the environment.

Roads, embankments and new cuts in the soil are not of such magnitude as to impair natural values.

The dam and spillways of HPP Lakat as the first in a row or the last, was designed with the intention of having a special content and visual ambiance value in addition to hydrotechnical ones. This is largely due to the concept of architectural solutions of the engine room and associated facilities, including a wavy roof garden of lilac trees and a tower, supplementary facilities that contribute to the scenicity of the entire ambience.

Part of the preserved natural riverbed near Maglič contributes to the landscape features of the section, where the sports and recreational character of this place will be enhanced by landscaping and respective equipment.

HPP Maglič

As-is state of landscape characteristics

This is one of the longer sections (5.5 km), in the Ibar power plant system. The natural features give it the appearance of a narrow gorge with both steep sides. The most important and strongest landscape impression is made by the fortress Maglič on one of the elevations just to the left of the dam. The vegetation alternates and contributes to the picturesque ambience together with the fortress.

The route stretches northwest-southeast, with two pronounced meanders at the beginning and in the central part of the riverbed section. The first meander is in the zone of the Magličfortress highland foot, and the second is in the middle of the route.

The slopes in the profile of the river banks are steep on both sides along almost the entire section length. The left and right valley sides of this section are relatively symmetrical. At the beginning of the section, the right bank is rocky and mostly bare, while the left bank is partly rocky, and partly covered with humus.

Forest is poorly represented, and the forest can be found on the right bank in the higher parts of the slope. Deciduous vegetation dominates. Grassiness is more intense on the left bank of the section.

All of the length of the entire main road is routed on the left bank. The road is mostly in the cut and is hypsometrically higher than the Ibra riverbed for over 5 m. The railway route, at the beginning of this section, enters the tunnel, then, near the mouth of the Maglašnica River into the Ibar River exits the tunnel, then crosses over Maglašnica and runs along the right bank for about 1.5 km, where it again enters the 400 m tunnel. After exiting the tunnel, the railway line runs along the right bank up to the end of the section.

The railway is mostly in the cut and to smaller extent on the embankment. Retaining walls and culverts are present along the railway.

There are no major dwellings along this section. One small dwelling is located along the main road on the left bank, opposite the fortress Maglič.

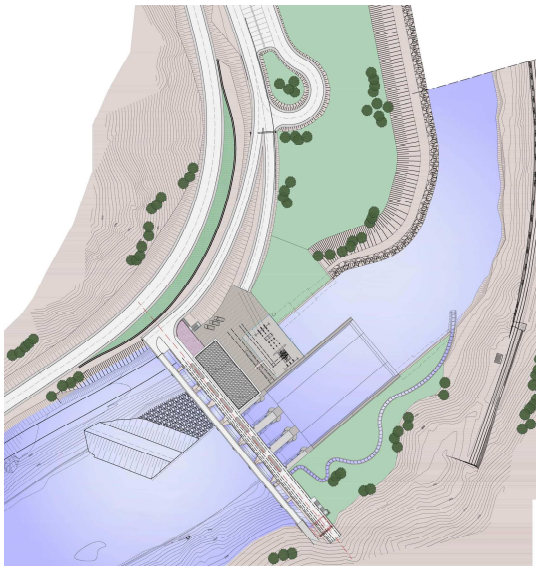
Historical buildings are present in this environment.

Summary of the designed state

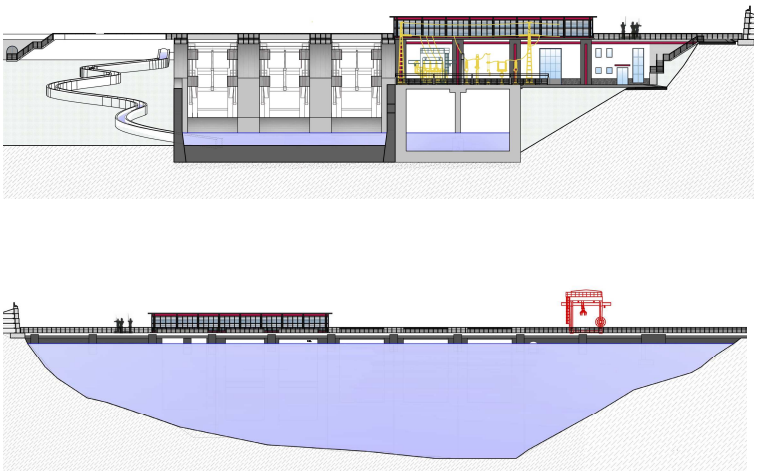
The designed state adds the following significant impacts to the existing natural and built-up characteristics:

One of the larger reservoirs in the system is formed by the Maglic dam and hydropower plant. The water table is 0.320 km^2 will contribute to the overall experience in passing or staying on the lake and in the overall environment, together with the highland and the fortress Maglič at the top. The dam is oriented northwest-southeast and a dam top is 148 m long. The main road will be submerged along a 3.7 km long section. A new main road has been designed that is elevated about 11 m versus the old submerged one. Around the dam zone and along the designed road, there is a green shield, rich in humus and grassed, secured by gabions descending down to the access road leading to the dam top. This structure will protect the ambience unit of the Maglic fortress, where the hydropower plant with a dam will not be visible from the road, and the grass will mitigate the interventions in the field and restore the tameness of the environment. Such a solution arises from the concept of architectural solutions of the engine room and associated contents. A new pedestrian bridge is also designed upstream of the dam, extending over the water table.

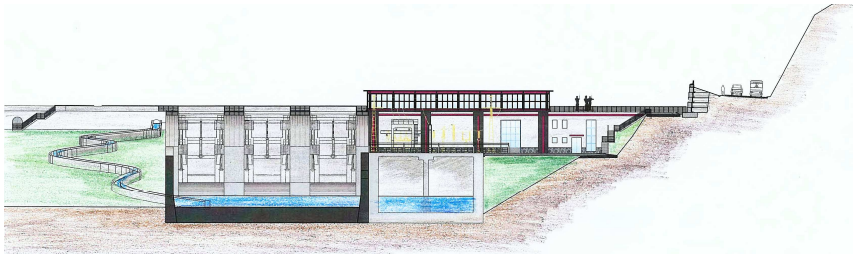
The architectural forms in the dam zone are atonic.



Layout of the dam with the Maglic hydropower plant



Downstream and upstream appearance of the HPP Maglic



Theme – Camouflaged shield [6]

Symbol - Soldiers (archers) (*)

Figure 9. *Maglič Hydropower Plant*

HPP Dobra Strane

As-is state of landscape characteristics

With a 4.5 km long riverbed, this section belongs to the sections of medium length. The natural features give it the appearance of a narrow gorge with both steep sides. Since there are no dwellings or individual facilities, with steep slopes, this section looks a little wild. It is not covered with dense forest, but there are parts with rocky river banks. These changes in relief contribute to the impression of diversity along this section.

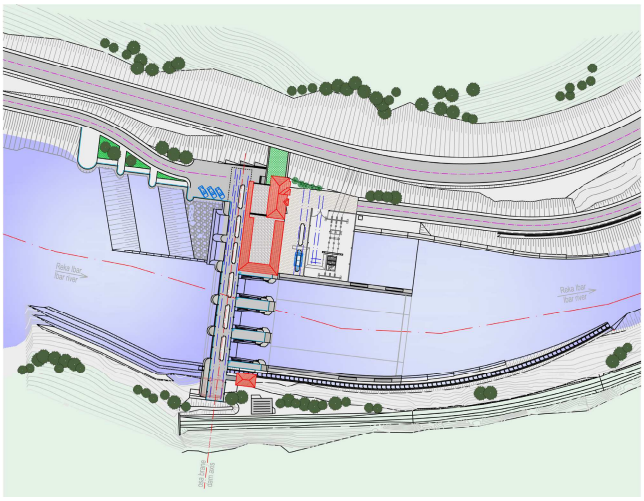
The riverbed route stretches northwest – southeast with one curve at the beginning of the section, upstream from Dobre Strane. The riverbed of small width along the entire section, the river valley is with steep and symmetrical sides with inclination > 30°. The riverbed expands at the end of the section, in the zone of the Ibar's right tributary of Stolski Potok. The soil is predominantly rocky along the entire section, except for the narrow humus belt along the riverbed.

Forest coverage is sporadic along the entire section, while at the beginning of the section in the left flank of the future dam, the forests are rare. Deciduous vegetation is present, and in the embankments below the main road and the railway, there are sporadic shrubs. The grassiness of this section is poor.

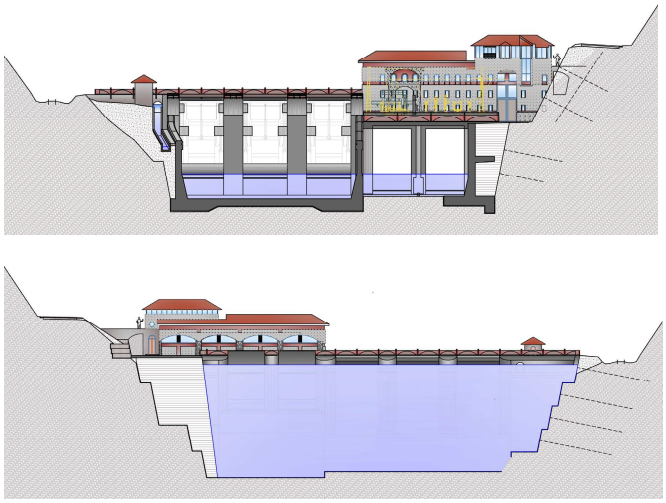
All of the length of the entire main road is routed on the left bank. It is mostly located in the cut and at higher elevations than the riverbed. The main road includes a bridge over the Bresnica River at the beginning of the section. The railway route, immediately upstream of the future dam, enters about 300 long tunnel, and after exiting the tunnel runs along the left bank of the riverbed along this entire section. The railway is mostly in the cut and to smaller extent on the embankment. On a long part of this section, retaining walls were built along the railway line. There are no retaining walls next to the railway line on the upstream part of the section in the length of about 1 m. The culverts in the railway zone are present along the entire section.

There are no inhabited places, nor individual objects on the section Dobre Strane-Bela Glava, except for one hospitality facility at the beginning of the section, in the zone of the mouth of the Bresniće River into Ibar River on the left bank, next to the main road.

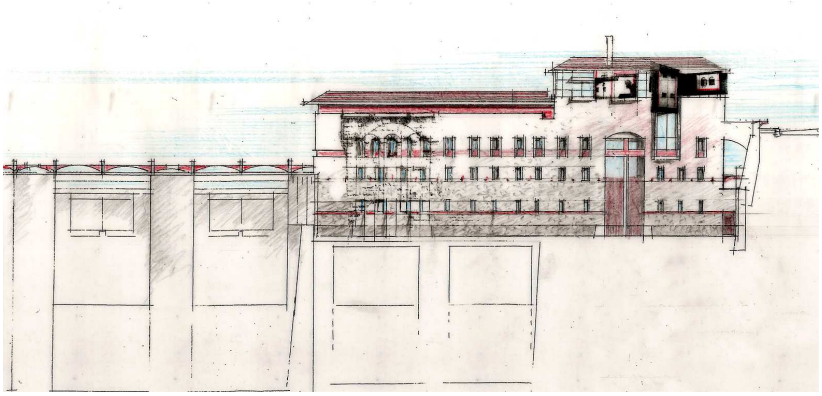
Historical facilities are located in the vicinity.



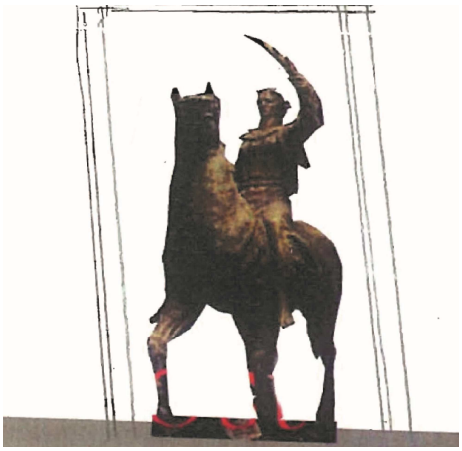
Layout of the dam with the hydropower plant



Downstream and upstream appearance of the HPP



Theme – Flat Wall and Gate



Symbol of the Messenger (*)

Figure 10. *Dobre Strane Hydropower Plant*

Summary of the designed state

Dobre Strane dam and hydropower plant form the smallest reservoir in the system of 0.254 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam has a west-east orientation and the length of the dam top is 95 m. This is also the shortest dam top in the system. The main road will be submerged along a 2.3 km long section. A new main road has been designed that is elevated about 11 m versus the old submerged one. The engine room is coated with stone and covered with tiles and with inn-like shape tames the environment. The playful facade provides for a play of shadows and a full-empty relationship. Such a solution arises from the concept of architectural solutions of the engine room and associated contents. A new pedestrian bridge is also designed upstream of the dam, extending over the water table. The architectural forms in the dam zone are moderately accentuated.

HPP Bela Glava

As-is state of landscape characteristics

This is the shortest section in the Ibar power plant system - 3.5 km long. Vegetation is intense both in terms of deciduous forests and grassland, on the medium slopes of the Ibar River. The natural features provide for a landscape splendor. There are no constructed facilities in this section except bridges and retaining walls, but the landscape looks soothing and relaxing, not wild.

The course of the riverbed is north-south at the beginning and end of the section, while in a short curve in the central part the riverbed it runs westward. The corridor of the riverbed is under medium slope, the valley sides are relatively symmetrical, and the profile of the riverbed is of greater width. At the beginning of the section, the terrain is mostly rocky on the left bank, while on the right bank humus is sporadically present on the surface. Upstream, above the riverbed, the terrain is rocky, except for the narrow strip along the river, with a humus layer on the surface.

The forestation of the terrain is intense at the beginning of the section on both river banks, and then less looking upstream, especially in higher parts of slopes. Deciduous vegetation, sometimes also shrubs are present. The grassiness is intense on both river banks at the beginning of the section. Also, at the end of the section, grassed areas on the left bank are present in the part of the slope above the main road.

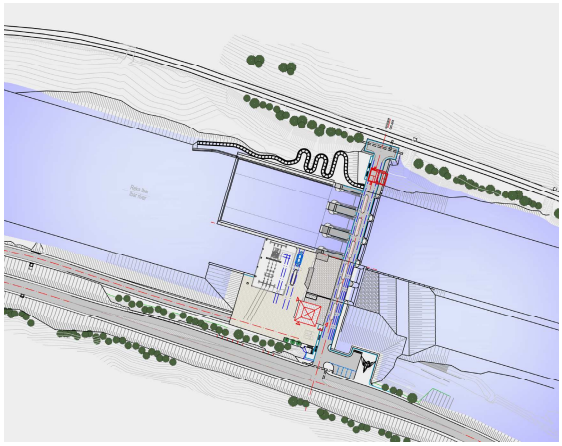
All of the length of the entire main road is routed on the left bank. It is mostly located in the cut and at higher elevations than the riverbed. The railway route is on the right bank of the Ibar River at the beginning of the section, in the zone of the future Bela Glava dam. The railway is on the embankment in this part - about 400 m long. The railway then enters the tunnel about 1 km long, and after exiting the tunnel (downstream from the mouth of the Brezanska River into the Ibar River), it follows the riverbed on the right bank along this entire section. Behind the tunnel, the railway is partly on the embankment, and partly in the cut and mostly secured by retaining walls. The culverts are located in the walls zone, one of which at the beginning of the section, and three culverts upstream of the tunnel Bela Glava.

On the section Bela Glava – Gradina there are no dwellings, nor individual facilities.

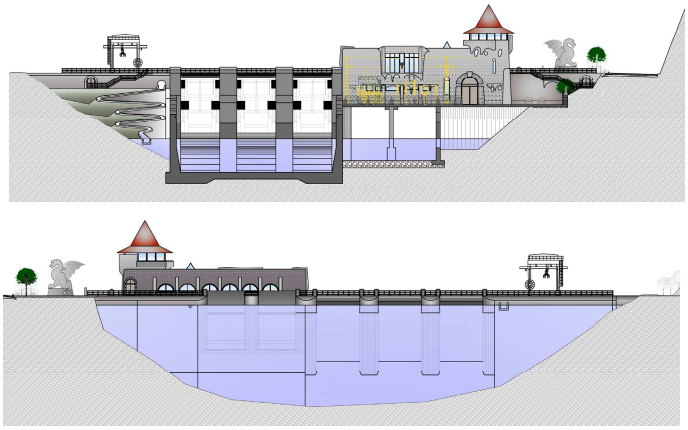
Historical facilities are located in the vicinity.

Summary of the designed state

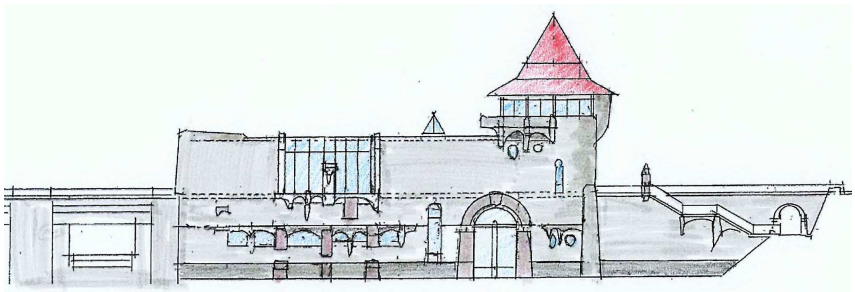
The Bela Glava dam and hydropower plant form a reservoir, which is one of the smaller ones in the system – 0.267 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam stretches southwest-northeast with a dam top length of 130 m. The main road will be submerged along 1.6 m long section. A new main road has been designed that is elevated about 9 m versus the old submerged one. The engine room is coated with stone and has amorphous shapes. Together with the monument of the great dragon in front of the dam and the hydropower plant, it participates in the ambient image, somewhat like a fairytale, integrated into the equally magical ambience. This is largely due to the concept of architectural solutions of engine room and associated contents where each architectural solution had its own path, its own guideline and idea. Architectural forms are moderately accentuated.



Layout of the dam with the hydropower plant



Downstream and upstream appearance of the HPP



Theme – Roof porch

Symbol – Dragon (*)

Figure 11. *Bela Glava Hydropower Plant*

HPP Gradina

As-is state of landscape characteristics

This is one of the medium length sections of 4.4 km in the Ibar power plant system. Natural characteristics give it the appearance of a riverbed with steep banks on both sides, although the profile of the riverbed is one of the wider ones. The Polumir dwelling contributes to a picturesque ambience. The forestation by deciduous plants and grassiness is more intense on the left side (looking upstream), while on the right side rocky parts and sometimes erosions occur.

The course of the riverbed runs north-south, with a short curve at the beginning of the section, which turns westward. The slopes in the profile of the banks are steep on both sides of the valley at the beginning of the section. Upstream, the slopes are milder. The left and right valley sides are relatively symmetrical at the beginning of the section, while the upstream side is mostly asymmetrical. In the zone of the future dam, the riverbed is of short width, while its width increases upstream. At the beginning of the section, the left bank above the main road is intensively rocky, while on the opposite side it is partially rocky, and mostly covered with humus. Upstream, humus is present on a wide stretch. Traces of erosion are visible sporadically on both sides of the valley.

The forestation is intense in the higher relief zones, dominated by deciduous vegetation. The shrubbery is sporadically developed in the lower parts of the terrain. Grassiness is intense both on the left and on the right bank upstream of the future dam. On the profile of the future dam, the grassiness is intense on the right bank.

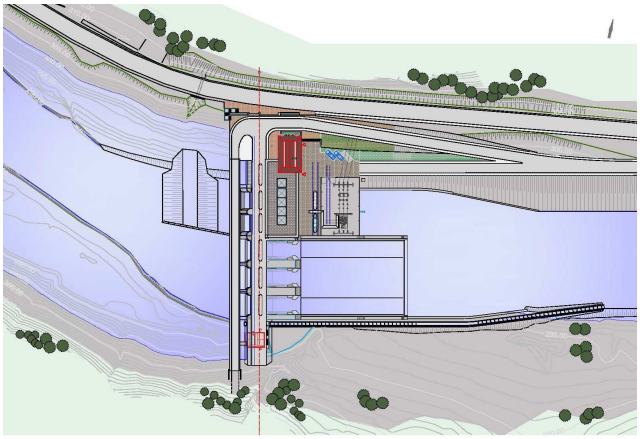
All of the length of the entire main road is routed on the left bank. The road is in a cut at the beginning of the section, at an altitude of over 10 m versus the riverbed. Then, upstream, the road lies for the most part on natural ground. The railway route at the beginning of the section runs through the tunnel Polumir, about 600 m long, and then along the embankment up to the Gajevska River. A railway bridge runs across the Gajevska River and from there on the railway runs further along the embankment. The Polumir railway station is also in this zone. Upstream from the Polumir station, the railway still runs along the embankment, and upstream from the mouth of the Livadski Stream mainly along the embankment. The railway is safeguarded by retaining walls and culverts.

The dwelling of Ploumir is located on the lowest and most widespread part of the section around the mouth of the Gajevska River, in a bay, bordered by two lateral sides with a marked relief as well as inhabited slopes on the right bank (looking downstream).

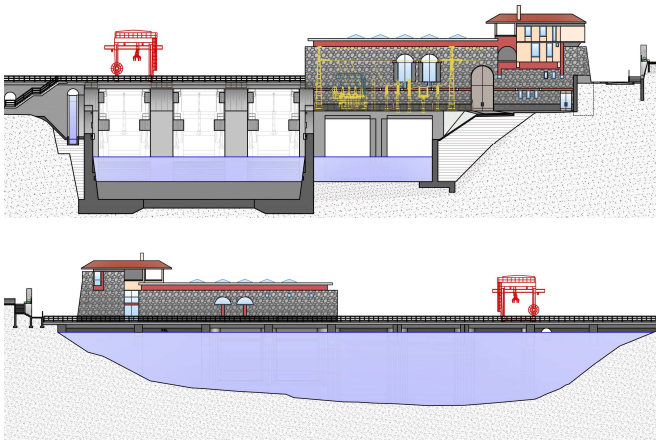
Historical facilities are located in the vicinity.

Summary of the designed state

The Gradina dam and hydropower plant form a reservoir, that belongs to the middle-sized reservoirs (0.352 km^2) of the system. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam stretches north-south and the dam length is 120 m. It belongs to the dams with shorter tops in the system. The main road remains the same as before, and one part of the dam will host a parking lot with a descent to the dam and the mark of the Nemanjić dynasty in accordance with the concept of architectural solution of engine room and associated facilities. The engine room is coated with stone and covered with tiles and with inn-like shape tames the environment of the large concrete structure. The architectural forms in the dam zone are moderately accentuated.



Layout of the Gradina dam with the hydropower plant



Downstream and upstream appearance of the HPP Gradina

Theme – Inn and Lodging

Symbol – Ruler (*)

Figure 12. *Gradina Hydropower Plant*

HPP Cerje

As-is state of landscape characteristics

This is one of the medium length sections of 3.6 km in the Ibar power plant system. The natural characteristics give it the appearance of a landscape with forested slopes. Deciduous forests are present, with many beautiful grassy areas and arable land, with rocky area occurring only sporadically. The right bank is steeper, and the profile of the riverbed is of medium width up to 30 m. The presence of small dwellings, as well as the railway bridge and tunnels, complete the landscape.

The course of the riverbed stretches north-south, with a westward curvature, in the upstream part of the section. At the beginning of the section, i.e., in the zone of the designed dam, the riverbed profile is asymmetrical, the left side is of medium slope, while the right side is very steep. Upstream, both banks are very steep up to the central part of the section, and there the river valley widens and the profile has a medium slope. The terrain is partly rocky at the beginning of the

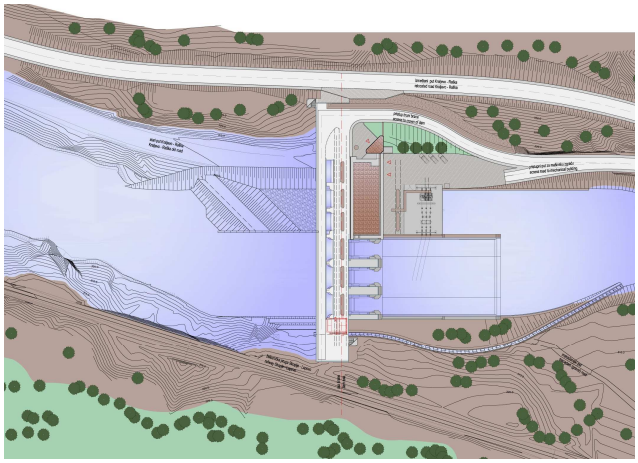
section. Humus soil is more present on the right bank in the higher parts of the relief, while on the opposite bank, humus is tied to the narrow belt along the Ibar riverbed, as well as to a part of the terrain above the main road. Upstream from the location of the future dam, up to the middle of the section, the terrain is intensely rocky on both river banks. Next, the rocky soil and humus cover dominating at the end of the section, are present interchangeably on the left bank of the Ibar River.

The forestation is intense in the higher relief zones and along the riverbed, where the developed deciduous vegetation dominates. In the upstream part of the section, along the river bank, the areas of arable land are alps present. In this upstream part, grassiness is intense on both sides of the valley, while at the beginning of the section it is only sporadic.

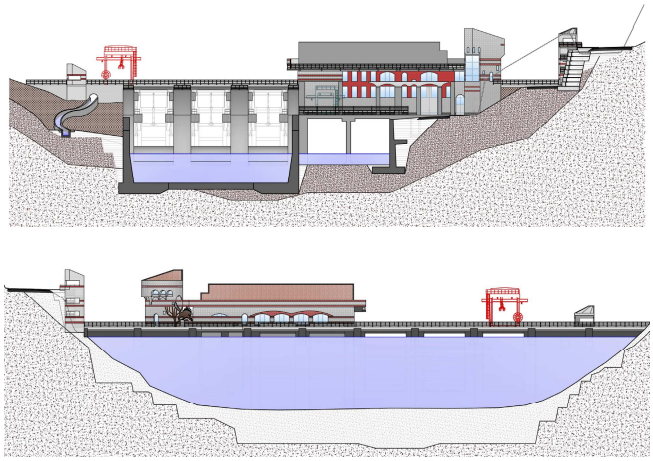
All of the length of the entire main road is routed on the left bank. The road is in a cut along a major portion of the section, while in the upstream part of the section it is mostly on natural soil and at higher levels versus the river bed. The railway route is on the right bank at the location of the future dam, at an altitude of about 15 m above the Ibar riverbed, in the cut. About 1 km high retaining wall stretches along the railway, and then the railway runs through the tunnel "Jagnjilo" - about 400 m long. After the tunnel, the railway is still on the right bank, predominantly on the embankment, with a few shorter sections in the cut. One retaining wall is built in this upstream part. In the zone of the Ibra riverbed turning towards west, the railway crosses the bridge over the Ibar River and enters the "Pusto Polje" tunnel. On this section of the railway, culverts were also built in addition to the retaining walls.

At the beginning of the section, in the higher parts of the terrain, there is a small dwelling of Cerje. There is also a small dwelling in the upstream section.

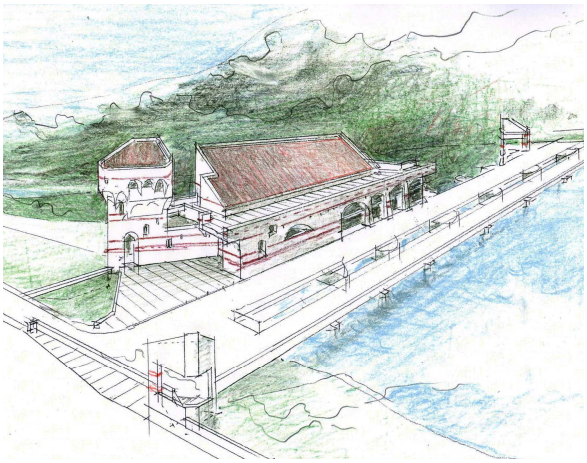
Historical facilities are located in the vicinity.



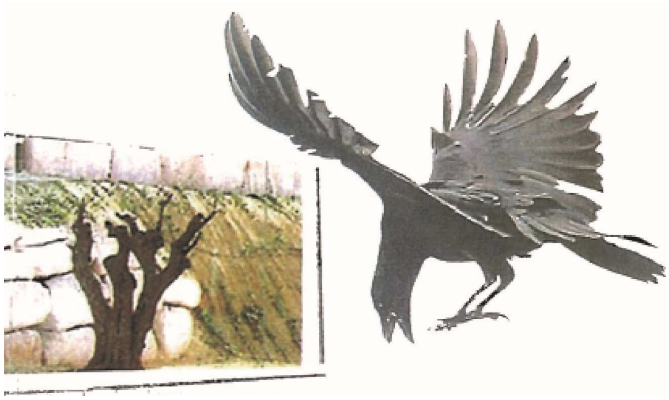
Layout of the Cerje dam with the hydropower plant



Downstream and upstream appearance of the Cerje HPP dam



Theme – Great Forest



Symbol – Falcon Bird (*)

Figure 13. *Cerje Hydropower Plant*

Summary of the designed state

The Cerje dam and hydropower plant form a reservoir, which is one of the smaller ones in the system – 0.258 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam stretches west-east and the length of the dam top is 121 m (one of the shorter tops in the system). The main road will be submerged along a 2.3 km long section. A new main road has been designed that is elevated about 17 m versus the old submerged one. The engine room is lined with a fine, not coarse stone and covered with shingles, and together with the landmark of this dam set by the architectural concept of the engine room and its accompanying contents, alludes to the Austrian Oak and Austrian Oak forest. The gazebo is formed along the main road, on the left, closer to the dam. From there the staircase goes down to the dam top. The architectural forms in the dam zone are moderately accentuated.

HPP Glavica

As-is state of landscape characteristics

With a 5.0 km long riverbed, this section belongs to the longer riverbed sections. One bank is with a mild and the other with a sharper slope. Dwelling is located in the parts that look like valleys along the Ibar River. The most significant populated place in the entire system is certainly Ušće, located at the mouth of the Studenica River into the Ibar River. There are deciduous forests and grassy areas on the opposite side, but also sporadic erosion and barren land. Conifers also occur in higher relief structures. The presence of three bridges, two railway bridges and one passenger bridge complete the picture of the landscape of a larger dwelling.

The course of the riverbed stretches northwest – southeast, with a sharp curve at the beginning of the section, where the Ibar River turns towards west. At the beginning of the section, i.e., at the location of the designed dam, the profile of the banks is asymmetrical, i.e., the left bank is with smaller slope, and the right bank is with steep slope. The riverbed is characterized by a large width along this section. At the beginning of the section, the terrain is partially rocky on the right bank, with a humus blanket present along the riverbed. At the location of the future dam, the left bank is covered with a humus blanket, and the next upstream parts of the terrain above the main road are partly rocky. Slope erosion is noticeable on the right bank, at the beginning of the section, especially in the higher parts of the slopes.

Forestation is sporadic on the right bank of the Ibar River, while on the left it is mild, and in the zone of the future dam it is practically non-existent - the surface of the terrain is intensely grassed. Grass surfaces are also present on the right bank in a narrow belt along the Ibra riverbed. In the downstream part of the section, the forested zones are characterized by deciduous vegetation and going upstream, deciduous vegetation is mostly present at lower levels closer to the riverbed, while the higher parts of the slope are under conifers.

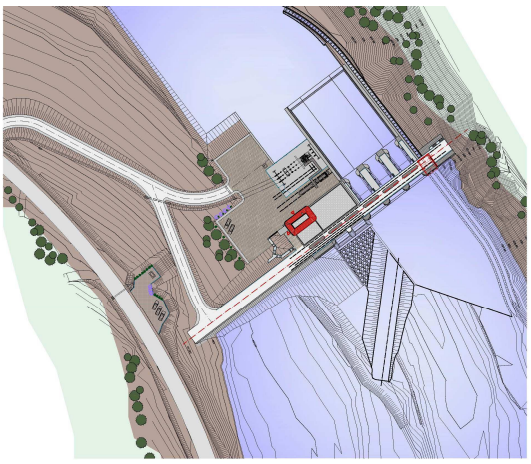
The main road is routed on the left bank all the way to the Ušće dwelling, where it crosses the bridge over the Ibar to the right bank. The most of road length along the section is on the ground, and a smaller part is in the cut. There is no railway at the future dam site, i.e., the railway passes through the tunnel "Pusto Polje", which is on the left bank and well away from the site planned for the construction of the dam. After exiting the tunnel, the railroad crosses the bridge from left to right bank. After the tunnel, the railway is mostly on the embankment, and behind the bridge, on the right bank in the cut, and less often in the cutting. On the right bank, long retaining walls and more culverts were built along the railway.

There are economic facilities on the left bank immediately downstream of the railway bridge over the Ibar. Upstream of the railway bridge, there are also several individual residential buildings on the left bank. Certainly, the most significant dwelling on this section is Ušće, located at the mouth of the Studenica River (left tributary) to the Ibar River. There is an economic facility in Ušće, on the right bank of Studenica. Upstream from Ušće, the less populated place is situated on the expanded, left bank of the Ibar River.

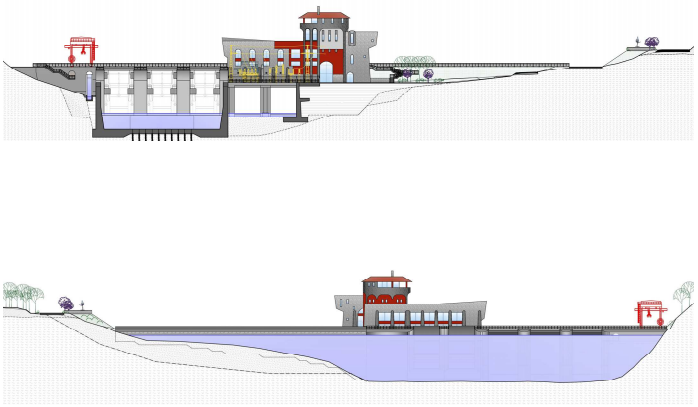
Historical facilities are located in the vicinity.

Summary of the designed state

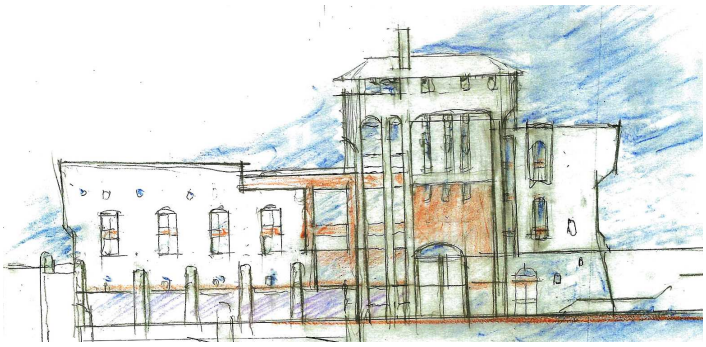
The Glavica dam and hydropower plant form a reservoir, which is one of the middle-sized in the system – 0.327 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The main road remains the same, and an access road to the dam top is designed downstream of the dam. The dam stretches southwest-northeast with a 193 m long dam top. This is one of the longest tops in the system and therefore a wide profile. The engine room is coated with stone. The solution originated from the concept of architectural solutions of the engine room and associated contents together with the selection of features, on this and all other HPPs. The features are located next to the parking lot on the highway. The architectural forms in the dam zone are accentuated.



The layout of the Glavica dam with the hydropower plant



The downstream and upstream appearance of the HPP



Theme – Tower-Belvedere [7]

Symbol – Knight Squire (*)

Figure 14. *Glavica Hydropower Plant*

HPP Ušće

As-is state of landscape characteristics

This is one of the medium length sections of 3.8 km in the Ibar power plant system. The natural characteristics give it an appearance of a broader profile with a smaller and medium bank slope. Forestation is mild, a little available forest is both deciduous and coniferous vegetation. Intense grassiness is present in the lower parts, while the higher parts are rocky. There are occasional erosions on both sides of the river. There are no major dwellings, only small ones as well as individual economic facilities.

The riverbed route stretches west-east with a slight curve directed north in the upstream end of the section. The profile of the valley has different slopes of the banks, i.e., the right bank is characterized by a medium slope, while the left bank is milder slope. The riverbed profile is characterized by a large width along the entire section.

At the beginning of the section, in the left flank of the future dam, the soil is characterized by a humus in a wide front, while on the opposite bank humus is sporadic, in the narrow belt along the Ibra riverbed. Upstream, in the central part of the section, the humus layer is dominant on the surface of the terrain. The slopes are rocky on the right bank of the Ibar, in the part above the main road, in the far downstream and upstream part of the section.

In terms of vegetation, the terrain is characterized by poor forestation, intensive grassiness and the presence of agricultural crops along the riverbed. Mild forestation is mainly of deciduous vegetation, and the highest parts of the relief, near Gokčanica, are dominated by coniferous vegetation.

All of the length of the entire main road is routed on the right bank. It is in the cut at the beginning of the section, and then on the embankment. Retaining walls are set along the main road – on the hill side, and partly towards the river. Upstream of the railway bridge, the main road up to the end of the section is again in the cut.

The railway route also runs along the right bank of the Ibar River, parallel to the main road and at slightly lower levels

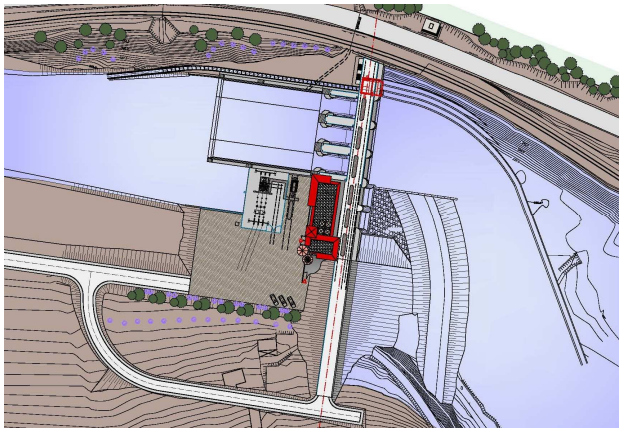
- about 1 km long. The railway then crosses the bridge onto the left bank of the Ibar River and enters the 1100 m-long Dzelep tunnel. The railway mostly runs along the embankment in this section, and only a small part is in the cut. There are several culverts along the railway and one small retaining wall at the future dam site.

In the most widespread part of the section, there are small dwellings on the right bank, as well as individual economic facilities. Individual residential buildings are present on the left bank in the downstream part of the section.

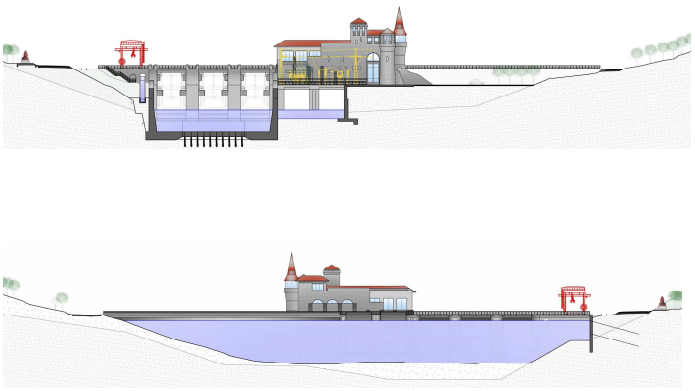
Historical facilities are located in the vicinity.

Summary of the designed state

The Usce dam and hydropower plant form a reservoir, which is one of the middle-sized in the system – 0.421 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam stretches southwest-northeast and the dam top is 155 m long. One part of the dam is backfilled dam, which is justified by the fact that the profile is one of the wider ones in the system. The main road remains the same, and the access to the dam is designed from the opposite bank from the main road. The engine room is coated with stone and covered with tin plate sheet. Such a solution arises from the concept of architectural solutions of the engine room and associated contents. In the aforementioned concept, a landmark was assigned for this dam, which is located along the main road. The architectural forms in the dam zone are accentuated.

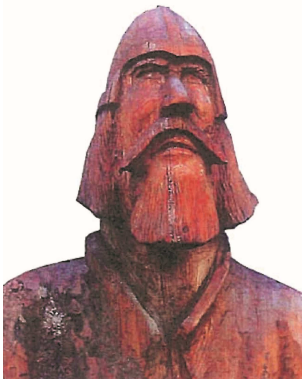


Layout of the dam with the Ušće hydropower plant



Downstream and upstream appearance of the HPP Ušće

Theme – Ruler's Palace [8]



Symbol – Ordinary Man (*)

Figure 15. *Ušće hydropower plant*

HPP Gokčanica

As-is state of landscape characteristics

This is one of the longer sections (6.6 km), in the Ibar power plant system. Natural and relief features give it the epithet of the most vivid section with alternating hills of different heights and valleys grassed or sown with agricultural crops. The banks are medium steep and the profile of the riverbed is not narrow. The presence of small populated places elevates the landscape.

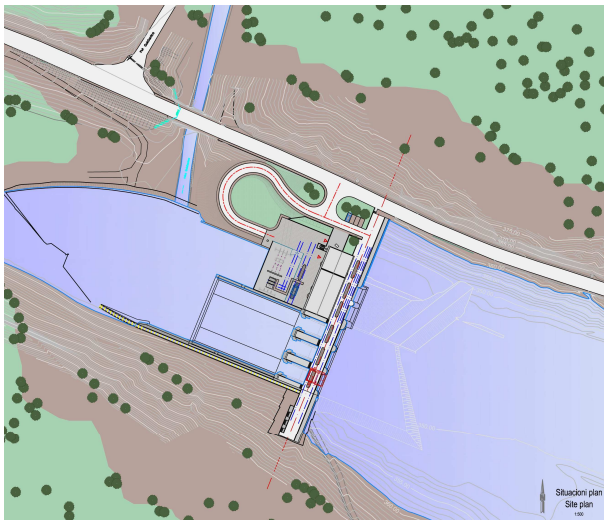
The riverbed route stretches north-south, and in the upstream part near Bojanić it changes direction to run west-east. The riverbed is characterized by two long curves between which the riverbed stretches north-east-southwest. The section is characterized by a variable width of the riverbed – in the downstream part, up to the first bend of the river, the riverbed is narrow, and then expands on the right bank. Upstream of the second river course curve, the riverbed expands on the left bank. At the future dam site, the terrain is intensively rocky, and then upstream, humus is present in a wide belt in the part where the riverbed again stretches north-south. The higher parts of the relief are rocky.

At the beginning of the section, forestation is sporadic, and deciduous and coniferous vegetation alternates in different heights. In the central part of the section, deciduous vegetation dominates in the higher parts of the slopes, while in the lower parts, shrubs and intense grassiness are present. Agricultural crops were also planted in the extended parts of the riverbed.

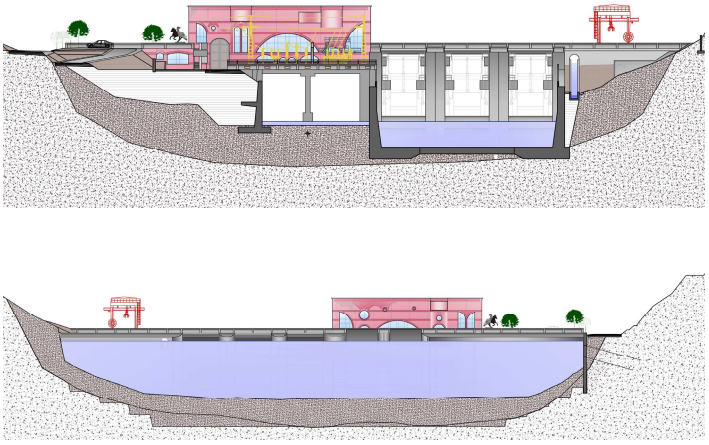
All of the length of the entire main road is routed on the right bank. The road is mostly in a cut. In some cases, the stability of the cut along the main road is safeguarded by retaining walls. At the future dam site, the railway line is not visible, as it passes through the Dželep tunnel on the left bank. After exiting the tunnel, the railway runs along the left bank and it is located at a much higher position than the riverbed. The railway line is in this part in the cut, secured by high retaining walls, and then in the part of the terrain where the river valley significantly expands, the railway line is on the embankment for several hundred meters, and then again in the cut. In the upstream part of the section, the railroad crosses the bridge over the Ibar River from left to right bank.

On the lowest and wide part of the section there are small dwellings and individual residential buildings. In the downstream part of the section, one small dwelling is located on the right bank, while in the most upstream part, one dwelling is on the left bank of the Ibar.

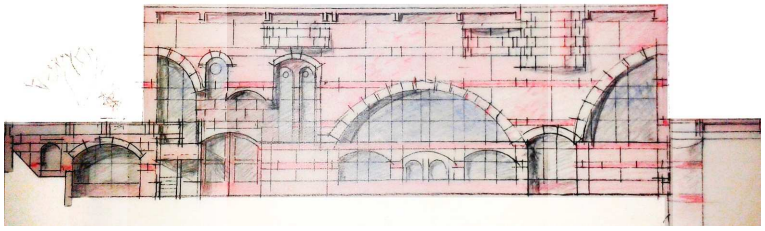
Historical facilities are located in the vicinity.



Layout of the dam with the hydropower plant



Downstream and upstream appearance of the HPP



Theme – Byzantine ports [9]

Symbol – Helen of Anjou (*)

Figure 16. *Gokčanica hydropower plant*

Summary of the designed state

The Gokčanica dam and hydropower plant form a reservoir, which is one of the bigger in the system – 0.651 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The main road remains the same and is almost at the level of the dam top, which is usually not the case with other dams. The dam stretches southwest-northeast and the dam top is 134 m long. The engine room is lined with fine stone, full brick and various terracotta shapes. The refined facade dominates with tenderness and fine ornaments, as well as color. Such a solution arises from the concept of architectural solutions of the engine room and associated contents. The selected feature of this dam is dedicated to the gentler sex from the Nemanjić dynasty – Helen of Anjou. The plateau in front of the monument can be accessed from the main road. Small parking lot is also provided. The architectural forms in the dam zone are atonic.

HPP Bojanići

As-is state of landscape characteristics

This 7.8 km long section belongs to the longest section in the system.

The course of the riverbed on this section often changes direction due to three larger meanders. It stretches 1.7 km southwest-northeast in the direction of the bridge at the intersection of roads to Jošanica Spa and Baljevac. The riverbed for the next 2 kilometers stretches south-east-northwest and 1 kilometer ahead of the dam it stretches west-east. The riverbed width along the entire section ranges between 20 to 40 meters. The river valley is almost always steep on one side, and on the other side with a mild slope, asymmetrical sides with a slope of 10 to 30°. The soil along the river and on river terraces contains humus, while rocky soil is dominant on steep sides.

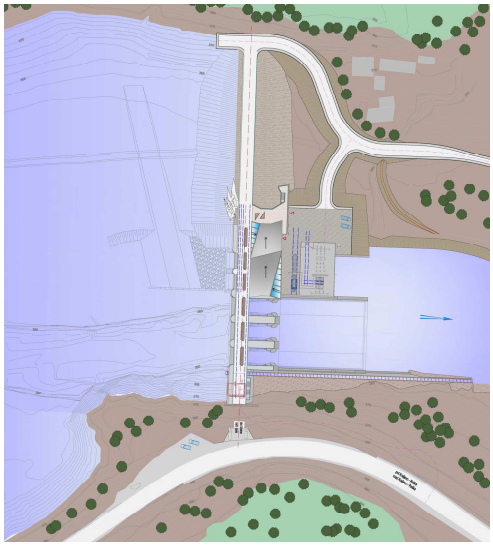
The forestation is sporadic along the entire section. Somewhat more lush vegetation is present immediately next to the riverbed, while in the rest of the area it is poorly developed, and occurs sporadically. Deciduous vegetation is present, and in the embankments below the main road and the railway, there are sporadic shrubs. Grassiness is highly developed in the alluvium, while the rocky slopes are barren land.

The main road is located on the right side from the dam to the intersection of roads to Jošanica Spa and Baljevac, where it crosses onto the left bank. It is mostly located in the cut and at higher elevations than the riverbed. The tail section of the reservoir hosts a bridge over the Ibar River that leads to the left side towards Baljevac. The railway route, immediately upstream of the future dam, exits the Bojanići tunnel, and after exiting the tunnel, it runs along the left bank, and then crosses over the meander, where it runs for about 900 meters on the right bank and returns to the left bank via the bridge near the Lučice dwelling. The railway is mostly on the embankment, and smaller section is in the cut. On a long part of this section, retaining walls were built along the railway line. The culverts in the railway zone are present along the entire section.

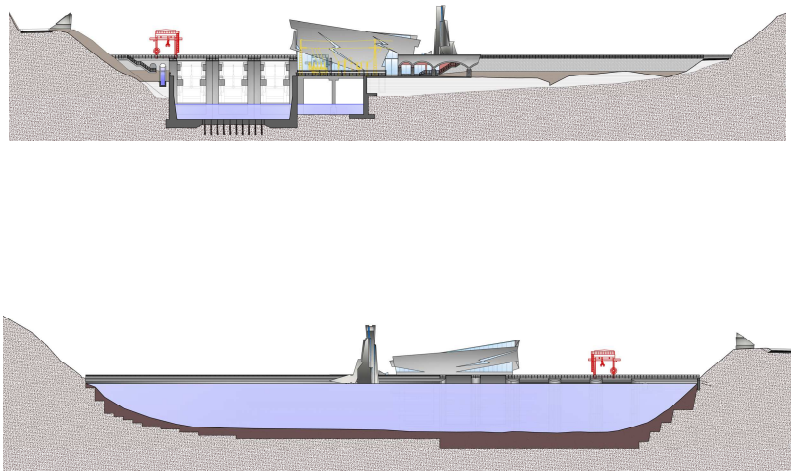
There are two smaller hamlets within the Bojanić dwelling on the section above the Bojanić dam site. The larger dwelling Lučice stands out in the upstream section and Baljevac na Ibru is located in the tail part of the reservoir. Historical facilities are located in the vicinity.

Summary of the designed state

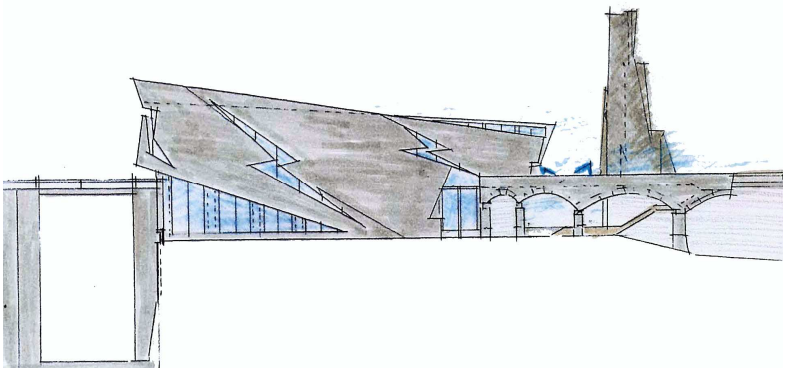
The designed state adds the following significant impacts to the existing natural and built-up features: The Bojanići dam and hydropower plant form a reservoir, which is the largest in the system – 1.443 km^2. The water table will add a pleasant image to the overall experience as one passes or lingers on and around the lake. The dam stretches north-south and the dam top is 195 m long. This top is also the longest in the system, so part of the dam is backfilled in the part which is not in touch with the riverbed. The engine room is made of concrete and glass and has a futuristic approach. Such a solution arises from the concept of architectural solutions of the engine room and associated contents. As an additional content, a vertical rock with several waterfalls occurs on the dam top. The selected landmark for this dam is located near the parking lot on the highway, and the access road to the dam is designed on the opposite bank. The architectural forms in the dam zone are accentuated.



Layout of the dam with the hydropower plant



Downstream and upstream appearance of the HPP



Theme – Water Strength

Symbol – Symbol of Nemanjić [10]

Figure 17. *Bojanići Hydropower Plant*

CONCLUSION

The architectural action within the whole project of the 10 power plants system in the Ibar Valley aims to mediate between the energy function of hydropower plants and the natural and historical values of the area where they are located. In other words, architectural solutions seek to reconcile the technique and the natural and historical values of the site and to help them to be in as little conflict and antagonism as possible, and to realize their mutual harmony and fruitfulness as much as possible.

The architectural solutions of this project therefore strive for a harmonious fit of volumes and forms into the landscape characteristics of individual site and the entire valley, and on the other hand they strive to get as close as possible to the building tradition of this area and their interpretation in accordance with the technological characteristics of this time and the general spirit, apprehension and contemporary culture.

Subject architectural designs rely on unique conceptual orientations that connect them into a whole - a system of architectural solutions that are characterized by the same basic attitudes, concepts, a common inspirational foundation for the choice of words - that is, architectural vocabulary and syntax - the rules of their connection. On the other hand, above this common foundation, the project defines a number of completely different spatial units that have their own special and specific identities that are easily recognized and memorized.

This is how the integrity of the system was achieved, but also the characterization of its parts, which makes the entire technical system more humane, tame, pleasant, and more attractive and valuable both in tourism terms and in general cultural sense. In this sense, significant support of the concept and individual designs was found in the general thematic connection of designs with the building tradition of the Raška School and the culture of the subject building rules, as well as the symbolic properties of the landmarks that relate to the age of the Serbian medieval state and the time of the Nemanjic dynasty.

One can conclude that the entire image and landscape value, cultural attractiveness and even educational significance, is particularly contributed by the architectural design of the characteristics of facilities and ambience, relying on the tradition of forefathers and wider historical events. This highlights the particularity of ambiance physiognomy in the form of an unusual art formulation, by which Ibar hydropower plants will be recognized and memorized.

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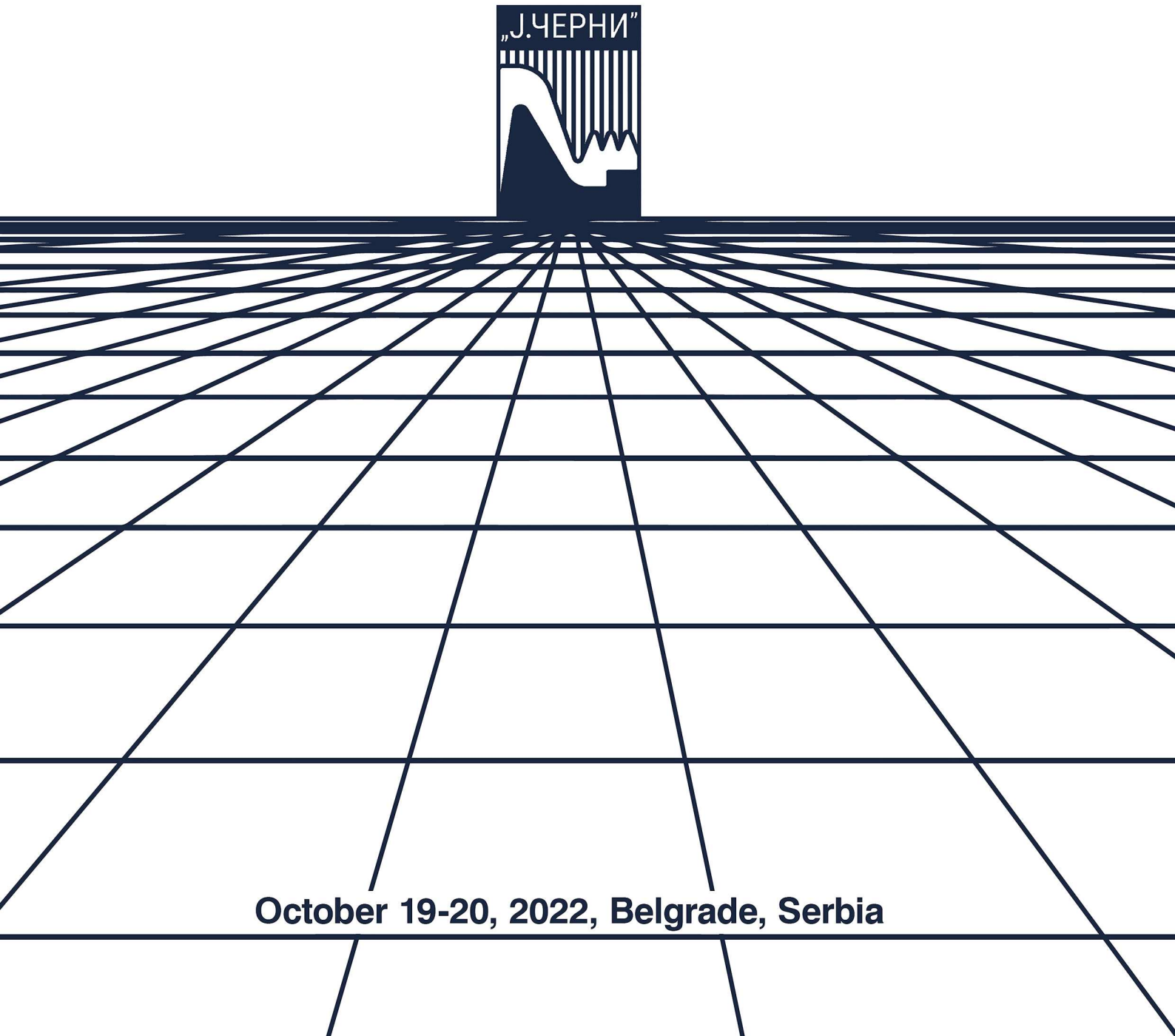

October 19-20, 2022, Belgrade, Serbia

EDITORS
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PREFACE

Institute of Hydrology was established in 1947 within the Serbian Academy of Sciences. The Hydraulics Laboratory was established that same year within the Federal Ministry of Electricity, a predecessor of the later Hydropower Institute created in 1950. These two institutions were soon merged under the auspices of the Serbian Academy of Sciences into the Hydrotechnical Institute Eng. Jaroslav Černi. This Institute merged with the Serbian Water Management Institute in 1959 to create today's Jaroslav Černi Water Institute.

Over the past decades, the Institute has been the backbone of scientific research in the field of water in Serbia and the former Yugoslavia. The international scientific conference Contemporary Water Management: Challenges and Research Directions is organized to celebrate 75 years of the Institute's long and successful history. The Scientific Board selected 26 papers to provide readers with the best view of the current research results, as well as the further scientific research directions and potential challenges in the future. Selected papers are classified into six conference topics according to the corresponding research field, although one should note that most of the presented works is multidisciplinary, which is after all a characteristic of a modern problem-solving approach in the field of water. Hence, the chosen conference topics and corresponding papers represent only one possible way of classification of the presented works.

We wish to express our gratitude to the International Scientific Board and the Organizing Committee of this international conference for their efforts in selecting the papers, reviewing, and organizing the conference. We also wish to express our gratitude to all the authors of selected papers for the time they spent presenting the results of their research in a way suitable for this conference, and for contributing to the celebration of 75 years since the establishment of the Jaroslav Černi Water Institute. Respecting the importance of jubilee and wishing to express gratitude to previous generations of scientific workers, the Honorary Committee was also formed.

Following the path of previous generations, the Institute's present and future staff remain privileged, and under duty and obligation to continue and improve the scientific and research work of the Institute in the years and decades to come.

Belgrade, October 2022

Editors

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