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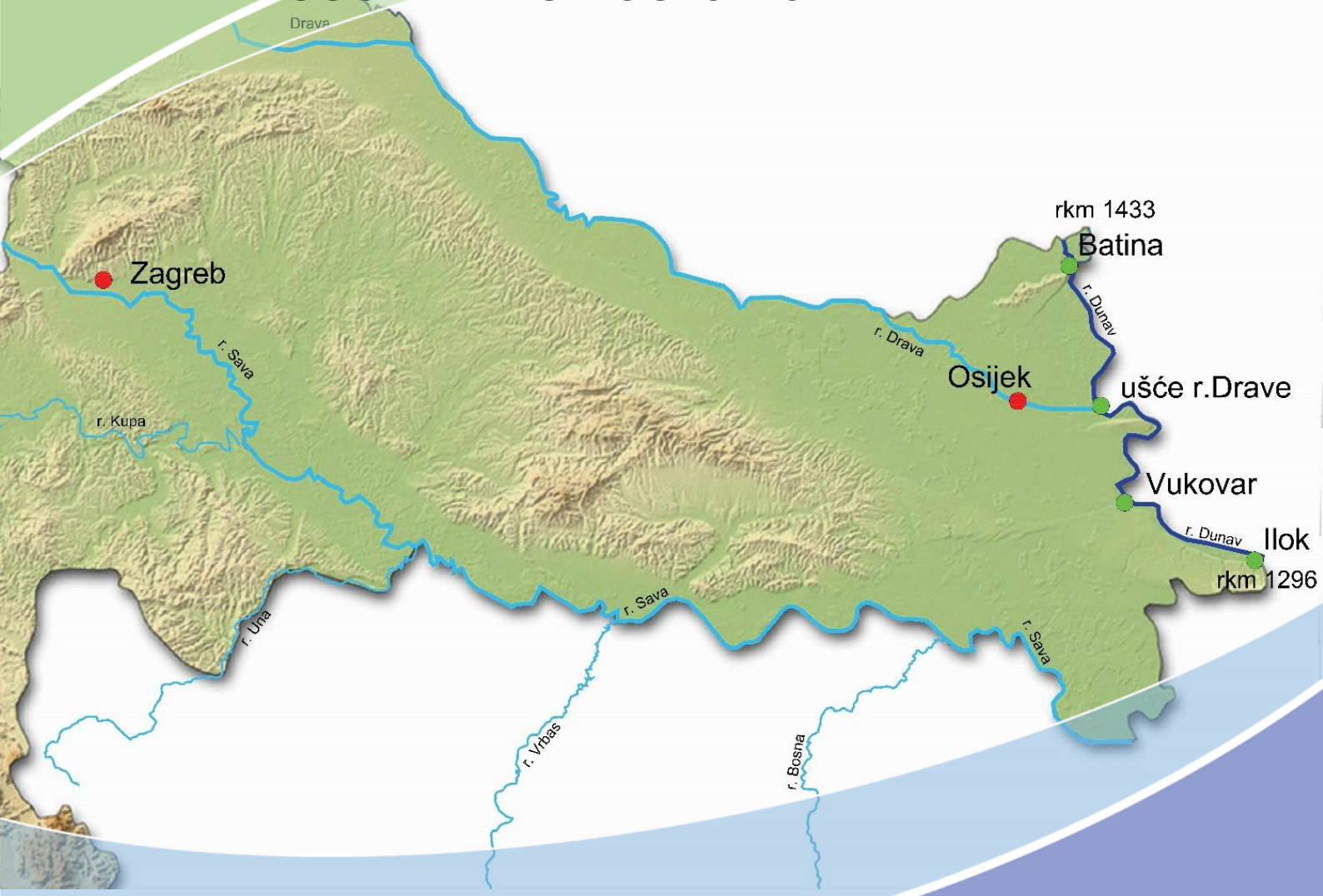
ANALYSIS OF THE EXISTING STATE

MONITORING OF HYDROLOGICAL, HYDRAULIC AND MORPHOLOGICAL CHARACTERISTICS OF THE DANUBE RIVER AND INVENTORY OF BIODIVERSITY COMPONENTS ON THE JOINT CROATIAN-SERBIAN SECTOR OF THE DANUBE RIVER - ANALYSIS OF THE EXISTING SITUATION



hidroing d.o.o. za projektiranje i inženjering Osijek

Client: Ministry of the Sea, Transport and Infrastructure

Project number: I-2206/23

In Osijek, October 2024

Preparing FAIRway2 works in the Rhine Danube Corridor (2019-EU-TM-0262-S and 2019-HR-TMC-0263-S)

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CLIENT:	Ministry of the Sea, Transport and Infrastructure
LOCATION:	Danube river from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary)
MAIN DESIGNER:	Igor Tadić, Ms.C.E.

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In Osijek, October 2024

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CONTENT:

1 INTRODUCTION

1.1 Purpose and goals of the project

The Republic of Croatia has a wide network of inland waterways which includes three main rivers: the Sava River, the Drava River and the Danube River.

In its entire flow through the border zone between Croatia and Serbia, the Danube River is a prerequisite for the survival of natural flood ecosystems, the areas of which are already limited by flood protection measures carried out in the past.

The waterways in the Republic of Croatia are an underutilized natural traffic and tourism potential. Maintaining the navigable route within the fairway is a prerequisite for ensuring safe navigation and its representation in the intermodal transport of goods, i.e. the redirection of part of the goods from other modes of transport.

The Republic of Croatia is a signatory of the European Agreement on Main Inland Waterways of International Importance (AGN agreement) since 1997 which has been in force since 1999. With that agreement, Croatia committed itself to prepare and maintaining the mentioned waterways within declared classes. According to the AGN agreement, waterways on four (4) rivers in the Republic of Croatia are part of the European network of inland waterways:

- E 80: The Danube river from rkm 1295,5 (Ilok) to rkm 1433,1 (border with Hungary),
- E 80-08: The Drava river from the Danube river confluence to Osijek, rkm 0+000 do rkm 22+000
- E 80-12: The Sava river from Sisak from the border with Serbia rkm 210+800 to rkm 594, including the part of the waterway on the Kupa to "Stara luka" in Sisak rkm 5+900

The Danube River in Croatia, throughout its length within the Republic of Croatia (from rkm 1433.1 Batina to rkm 1295.5 Ilok) of 137.6 rkm is an international waterway of VIc class.The waterway is marked and there is an international obligation of the Republic of Croatia to maintain it. Some of the critical places for navigation on the Danube River are connected with the appearance of shoals within the waterway.

Several factors negatively affect navigation on the joint Croatian/Serbian part of the Danube river from rkm 1433.1 to rkm 1295.5. Concretely: the hydro-morphological conditions are extremely dynamic and can seriously affect the condition of navigation. In accordance with the Directive on habitats (92/43/EEC), Danube river as an ecosystem is crucial for preserving the living conditions of flora and fauna.

The overall goal of this project is to ensure the foundation for a joint strategy and coordinated activities of Croatia and Serbia to maintain the Danube as an important international waterway in a way that does not threaten the remaining ecosystems and their biodiversity and will be continuously adapted to the current conditions of the river and its banks using appropriate adaptive planning. In order to achieve this, the collection of relevant hydrological,

hydraulic and morphological data was carried out, as well as the collection and inventory of components of biodiversity (fish, birds, river benthos and flooded habitats) on the joint Croatian/Serbian part of the Danube from river rkm 1433.1 to rkm 1295.5. which are combined in a geo-information (GIS) database. The collected data will contribute to the definition of conservation goals for the management plans of river basins in Croatia. The collected data will contribute to the definition of conservation goals for the management plans of river basins in Croatia in accordance with the Directive on habitats (92/43/EEC) and European Commission guidelines: https://ec.europa.eu/environment/nature/natura2000/management/guidance_en.htm).

The concept of infrastructure development of inland waterways is aimed at increasing the safety and efficiency of inland navigation. The arrangement of waterways is aimed at users, and this means ensuring smooth and safe navigation for ships with maximum composition in accordance with the class of waterways.

All analyzes carried out as part of this project are in accordance with the following directives:

- The Environmental Impact Assessment Directive - EIA Directive (Directive 2011/92 / EU, amended Directive 2014/52 / EU)
- The Habitats Directive (Directive 92/43/EEC of May 21, 1992 on the conservation of natural habitats and wild fauna and flora)
- The Birds Directive (Directive 2009/147 / EC of the European Parliament and the Council of November 30, 2009 on the protection of wild birds)
- Framework directives on water (directive 2000/60 / EC of the European Parliament and the Council of October 23, 2000, especially with the requirements of Article 4, paragraph 7

The ultimate goal is to improve the navigability conditions, i.e. the navigation conditions on the inland waterways.

1.2 Steps in project implementation

The implementation of the project "Monitoring of the hydrological, hydraulic and morphological characteristics of the Danube River and the inventory of biodiversity components on the joint Croatian-Serbian sector of the Danube River" is based on the relevant directives of the European Union and related action programs arising from these directives.

For the purposes of creating the project, it is needed to:

- analyze the current situation on the joint Croatian-Serbian sector of the Danube waterway [from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary)],
- perform monitoring of parameters relevant to waterway maintenance,
- carry out an inventory of the components of biodiversity and
- create a geo-information (GIS) system that will include data collected by monitoring on the corresponding local server.

The data should be in a form and quantity sufficient to carry out quality analyzes that will be the basis for drawing conclusions in order to assess changes in the condition of the riverbed in the planning period. At the same time, it is necessary to take into account the existing monitoring (tracking) and apply knowledge about these measurements during the implementation of the monitoring in question. When choosing methods, frequency, etc., modern scientific and technical knowledge should be used.

During the creation of this Elaborate, practical frameworks were used for the implementation of such projects according to with special reference to:

- defining the scope of the project
- organization of the planning process
- project execution
- monitoring of parameters relevant to the maintenance of the waterway, including the state of the environment
- valid local legislation and EU directives and international conventions
- similar projects already implemented in other countries of the Danube basin

1.3 Description of the project location

The Danube river rises in the Black Forest, enters through Bavaria (Regensburg and Passau) into northern Austria (passing through Linz and Vienna), then through the south of Slovakia where it passes through Bratislava, crosses over Hungary (through Budapest) from north to south and enters eastern Croatia between Baranja and the river island of Karapandža. Then it breaks out on the border of Croatia and Serbia (Vojvodina) and roughly follows the border between Croatia and Serbia. It passes by Vukovar, and near Ilok, it leaves Croatia and enters Serbia. The confluence of the Danube River with the Black Sea is located in a delta that is located in Romania and Ukraine.

Figure 1.1. The course of the Danube river.

The length of the river is 2,857 km, which makes the Danube the second longest river in Europe (after the Volga). The total Danube basin covers an area of approximately 817,000 km^2 and extends over 10 countries.

The average annual flows of the Danube are significant - they average 1,760 m^3/s near Vienna, 2,443 m^3/s near Batina, 3,144 m^3/s near Erdut, and 6,430 m^3/s at the mouth of the Black Sea.

The project section of the Danube River from rkm 1433.1 (Batina) to rkm 1295.5 (Ilok) is located in the east of the Republic of Croatia, in the Osijek-Baranja and Vukovar-Srijem counties, along the border with the Republic of Serbia.

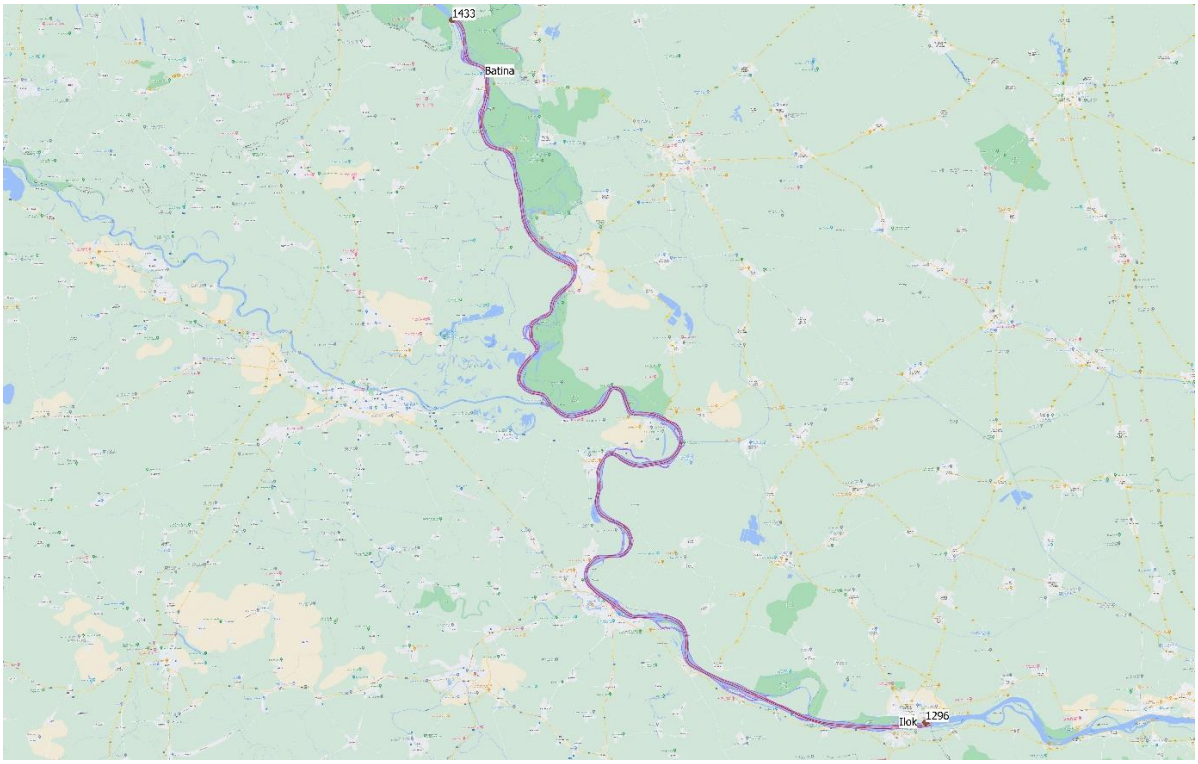


Figure 1.2. Overview of the project area.

The beginning of the section (1433+000 rkm) is located on the border of Croatia with Hungary and Serbia, and the end of the section (1295+500 r.km) is near the town of Ilok.

The river partly serves as a natural border between Croatia and Serbia. Vukovar is the largest and most important Croatian city on the banks of the Danube River throughout Croatia. The city of Osijek is also close to the Danube River, located about 20 kilometres from the confluence of the Danube River and the Drava River, which is the second largest tributary of the Danube.

2 ANALYSIS OF THE EXISTING SITUATION

2.1 Collection and review of substrates

In accordance with the Project Terms of Reference, the client has submitted the following input data and substrates related to the fulfilment of the tasks of the project:

- Geodetic and hydrographic measurements of the relevant section of the Danube River from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Characteristic water levels of the Danube River for navigation (LNWL, HNWL),
- List of critical sections,
- Danube river waterway boundaries from rkm 1295.5 (Ilok) to rkm 1433.1 (border with Hungary),
- Transport-technological substrates (data on the movement of ships (logs of navigation), traffic elements and gauges of the waterway)
- Water level/flow measurement data at hydrological stations: Batina, Aljmaš, Dalj. Vukovar and Ilok, with files on:
    - hydrological stations
    - cross-sections
    - satiation of river kilometres
    - critical sections (area and points)
    - waterway (area and axis)
    - river regulatory object

All the above-mentioned substrates and other information were used to create an analysis of the existing state on the relevant section of the Danube River.

2.2 The morphological and hydro-morphological characteristics of the project area

The Danube River and its bed with fields is the border area of the Republic of Croatia with the Republic of Serbia. Today's characteristics of the Danube bed are the result of geological development during the last 2.4 million years from the end of the Pliocene and during the Pleistocene, as well as anthropogenic regulatory works from 1783 onwards. From the end of the Pliocene until now, three natural development stages can be distinguished:

1. At the beginning of the climatic cooling at the end of the Neogene (at the end of the Pliocene) and before the beginning of the Pleistocene period, the Danube appears in the Pannonian Basin in the area between Sopron and Bratislava (Szádecki, 1938). The analysis of the roundness of the gravel grains indicates that the river then flowed south and somewhere in the Barcs area it flowed into Slavonsko jezero, which was a remnant of the Pannonian Sea.

2. Due to the influence of tectonic movements at the beginning of the Pleistocene in the central part of the Pannonian basin, the Danube turned east towards Višegrad (strait upstream of Budapest) and in the area of today's Budapest it reached the present confluence between the Danube and the Tisza. As this area intensively descended, the Danube formed a large basin through which it flowed towards the SE, affecting the then existing basin of Lake Tisa.

3. Further tectonic movements of a negative sign (sinking) in the mid-Pleistocene in the Budapest-Mohács interspace caused the Danube to turn south during the younger Pleistocene and in the Holocene (Pécsi, 1959, Bognar, 1982, 1990). These movements continue until our days. They are evidenced by gravel deposits covered with aeolian sediments (loess and aeolian sands) accumulated by the activity of the Danube in the Danube-Tisa confluence (Schmidt et al., 1958). At that time, the valley between Paksa and Mohács (the so-called Kalocska subsidence) was also activated, as indicated by the great thickness (40-50 m) of the gravelly and sandy Danube reservoirs. The development of the floodplain forced the Danube to turn north-south in its flow. According to modern geodetic measurements, the floodplain is still lowering at a rate of about 1 mm per year (Joó, 2003). Thanks to this, the bed of the Danube and its younger Pleistocene terrace in the area of Mohács were formed. The tectonic movements of a negative sign (subsidence) in the northern foothills of Bansko brdo also had an important influence on this. The Danube-Tisa canal, which was built in the 19th century. century coincides with the general flow direction of the Danube during the early Holocene from Batina to Bečej into the Tisa River. The formation of the younger basin in Banat undoubtedly influenced the mentioned direction of the Danube flow during the Holocene. Therefore, it can be concluded that in the younger Pleistocene and the beginning of the Holocene, the Danube mostly took, generally speaking, the current flow direction. It was also the time of the "meeting" of the Danube and the Drava, with the fact that the hydrographic junction of their mouth migrated to its current position under the influence of intensified tectonic subsidence in the Apatin-Kopački basin. Thanks to the drying up of Lake Slavonia and its tributaries and the deposition of thick deposits of loess and aeolian sands, the Drava formed its present-day lowland, which, according to the results of the latest

geomorphological and geological research, is no older than the younger Pleistocene and Holocene (Lovász, 1964, Bognar, 1982, 1990, 2005 and Bognar-Schweitzer, 2003).

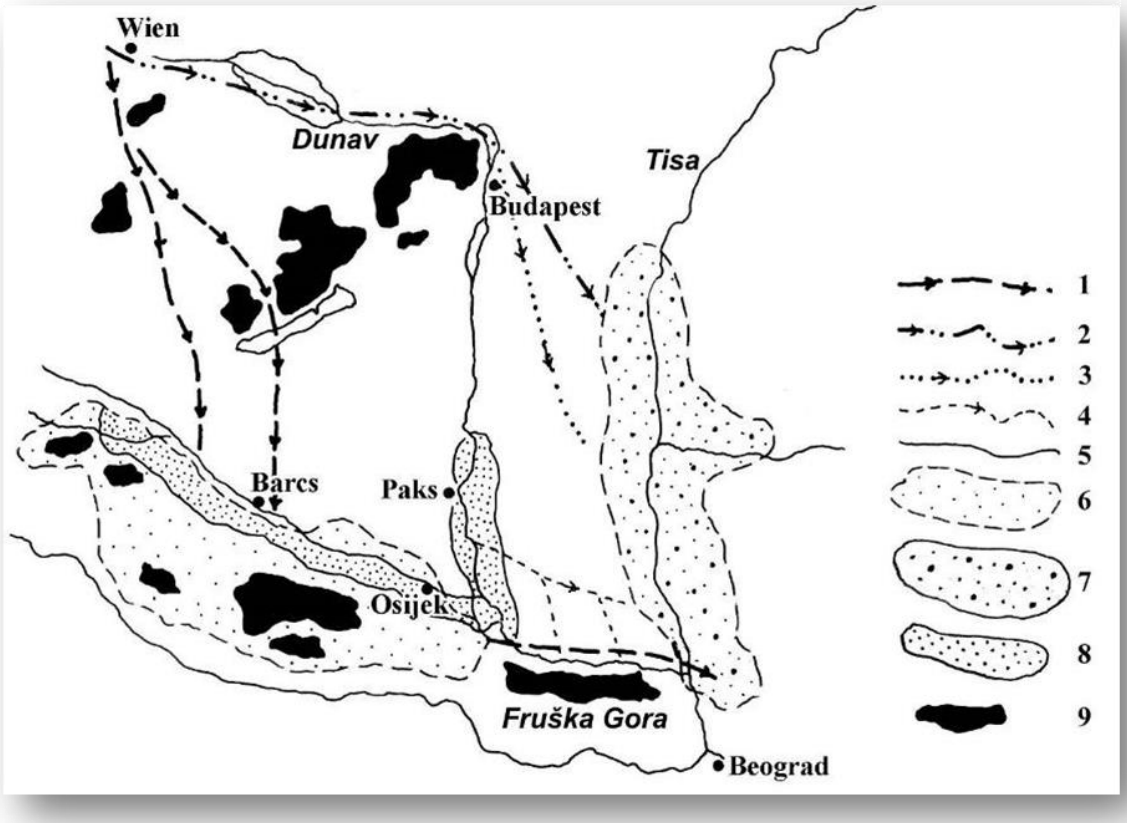


Figure 2.1. Development of the Danube course from the Pliocene to the Holocene (according to the cartographic contributions of Somogyi S., 1961, Sümeghy J., 1956 and Franyó F., 1966).

Where is: 1. outflow direction at the end of the Pliocene, 2. outflow direction at the beginning of the Pleistocene, 3. outflow direction during the Pleistocene, 4. outflow direction at the beginning of the Holocene, 5. current outflow direction, 6. Pliocene and Pleistocene basin (Slavonsko jezero), 7. Pliocene-Pleistocene basin (lake Tisa), 8. Holocene basin (Dravski rov, Pakša rov), 9. mountain structures.

In the period that preceded the start of regulatory works at the beginning of the XIX. st. The Danube had all the characteristics of a natural watercourse in the researched sector, which flowed mainly with the mechanism of the waters of the middle course, and in the wider area of Apatin with the mechanism of the waters of the lower course.

In the tectonic sense, the lowland part of the Baranja region represents a typical floodplain area, which for the most part falls within the framework of the Drava basin. According to the work of Prelogović and Urumović (2002), who elaborated in detail the geological structure of Baranja and the wider area, the Danube lowland with the river bed and its field participates in the structural units Mecsek-Villány-Baranja (1st), then Sombor-Apatin (2nd), Drava Basin (3rd), with smaller compression structures. The direction of movement of the Mecsek-Villány-Baranja structural unit is towards the SE and the east, which had, and still has, a significant

influence on the development of the Danube bed system. As documented, the shifts of the Danube bed can be traced since the 14th century. paragraph here (Bognar, 1990, p. 185), this is irrefutably proven by what was said previously. At the same time, it is necessary to emphasize the influence of the fault along the NW and SE edge of the Bansko brdo compression structure and the fault along the southern edge of the Baranjska loess plain to Bački Monoštor (W-E), then the Apatin fault W-E from Lug to Apatin, the Kopački rit (NW-SE) and the Erdut fault (W-E to SW-NE, Prelogović, Urumović, 2002). The aforementioned shifts resulted in the formation of a number of smaller local sub-basin structures that show a tendency to migrate their center of gravity in time and space (Bognar, 1990, 2003).

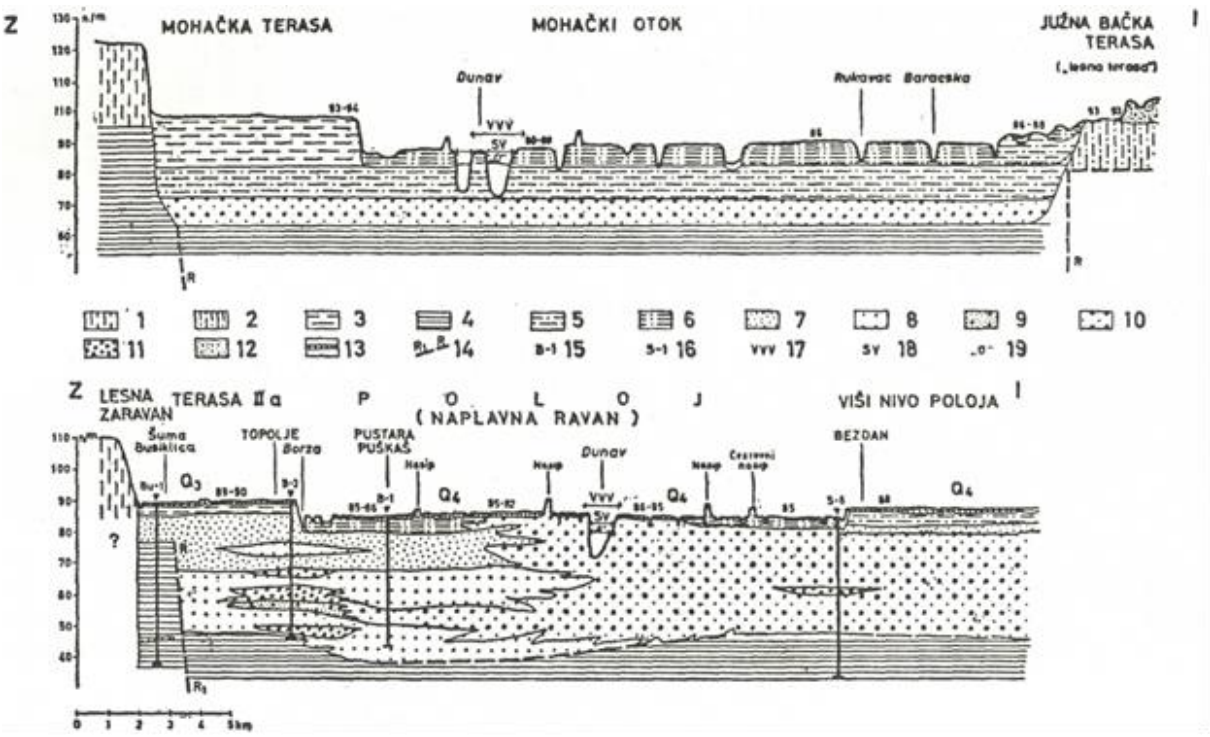


Figure 2.2. Transverse geomorphological-geological profiles through the field and terraced lowlands of the Danube River north of Bansko brdo.[1]

Where is: 1. loess, 2. sandy loess, 3. fluvial loess and loess-like sediments, 4. clays, 5. silt, 6. loess-like field sediment, 7. fine sand, 8. coarse sand, 9. gravelly sand, 10. sandy gravel, 11. gravel, 12. aeolian sand, 13. recent pedological horizon, 14. fault, 15. well mark, 16. probe mark, 17. very high water level, 18. medium water level, 19. "O" water meter point (according to data from the Cadastre of Boreholes of Northern Croatia, RGN faculty, Zagreb.).

The Danube field is not complete, but occurs in two fragments, the northern smaller one and the southern larger one, which are separated from each other by the NE part of Bansko brdo, which the river contacts with a tectonically predisposed loess and basalt sandesite steep section about 80 m high. The northern part of the field is the extreme SW part of the younger

[1]The upper profile gives a cross-section of the Danube lowland in Hungary from the Mohács Terrace to the South Bačka Terrace (according to Pécsi, 1959). The lower profile gives a cross-section of the Northern Baranja loess plain up to Bezdan (Bognar, 1990).

oval morphostructures filled mainly with quaternary sediments of fluvial and aeolian origin, the Danube filled the basin with its sediments during the younger Pleistocene and Holocene: gravels, gravelly sands, medium to fine-grained sands, loamy sands, sandy loams and clays prevail.

The deposits show a characteristic cross-stratification, which points to the platonic features of the area. An increase in the thickness of lava deposits from Mohács towards Bansko brdo was determined.

Generally speaking, the geological-geomorphological profiles of the northern and southern parts of the Danube basin indicate a very well-defined fluvial rhythm and, possibly, in the relict subsidence of Tikveš Castle and further south towards Kopački rit, a less pronounced rhythm. This would indicate a two-phase tectonic movement during the younger Quaternary. At the same time, this can also explain the absence of a Danube terrace south of Bansko brdo, since apparently the downward trend lasted throughout the younger Quaternary, so the river shaped its blueness during that time interval by the mechanism of the waters of the middle and lower course.

Morphological analyzes are necessary when studying water flow regimes and when designing regulatory buildings. In nature, there are watercourses whose sections are subject to short-term or long-term changes, as well as sections that are stable over a longer period of time. The multitude of different influences (water flow, ice and sediment transport, longitudinal slope of the bottom, coarseness of sediment, vegetation, and the human factor) and the complexity of the process make morphological analyzes particularly complicated and complex.

It is very important to carry out constant monitoring of the morphological changes of the riverbed both on the measurement (recording) profiles and globally for longer sections of the watercourse. There are data on measurements and monitoring of morphological changes on record profiles in earlier periods.

Watercourses can be found in nature where morphological changes can be observed faster or slower. The Danube River is an alluvial watercourse in the largest part of its course, where morphological changes occur over a long period of time, that is, there are no sudden and progressive changes. The hydraulic geometry of the bed is in a constant process of adaptation to changes in water flow and sediment transport.

The most significant processes in the development of the river flow are:

- the process of periodic widening of the river bed
- meandering process
- the process of wandering the river bed

The types of processes that will dominate a watercourse largely depend on the mobility of the material from which the river bed and banks were formed. Both processes are observed to a greater or lesser extent in one watercourse.

The process of periodic widening of the riverbed dominates the watercourse with high mobility of the river sediment. The transport of river dunes takes place relatively quickly, and

river banks are stable under the influence of vegetation or the cohesion of the material from which they were formed. Considering the relative resilience of the banks, meandering of the riverbed cannot occur. River dunes that travel downstream protect one bank from erosion, causing a more or less uniform erosion of the bank. In this way, the river bed widens.

This process is not unambiguous, after the extension reaches a certain limit, the river flow cuts the dune at the point of its connection with the coast, forming a new initially narrow rectilinear bed. In this way, several backwaters are formed with dams between them. After this, the process of periodic expansion gradually appears again. The parts of the river course where this process takes place mostly retain a rectilinear plan form.

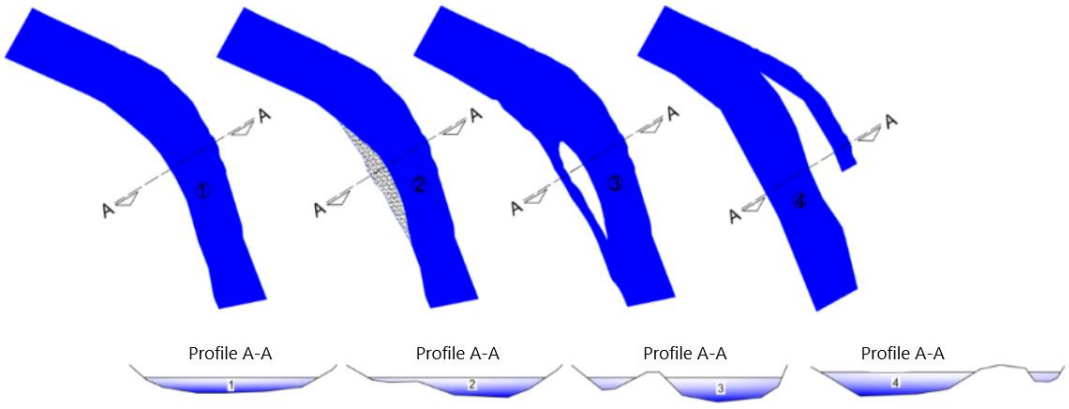


Figure 2.3. Representation of the periodic expansion of the river flow.

The process of meandering, as well as the process of expansion, has a periodic character. Over time, the curvature of the river reaches such a degree that at one point only a crossing occurs, i.e. the formation of a new shortened river bed. This new river bed begins to meander again.

In one morphological cycle, one profile goes through all stages of its development.

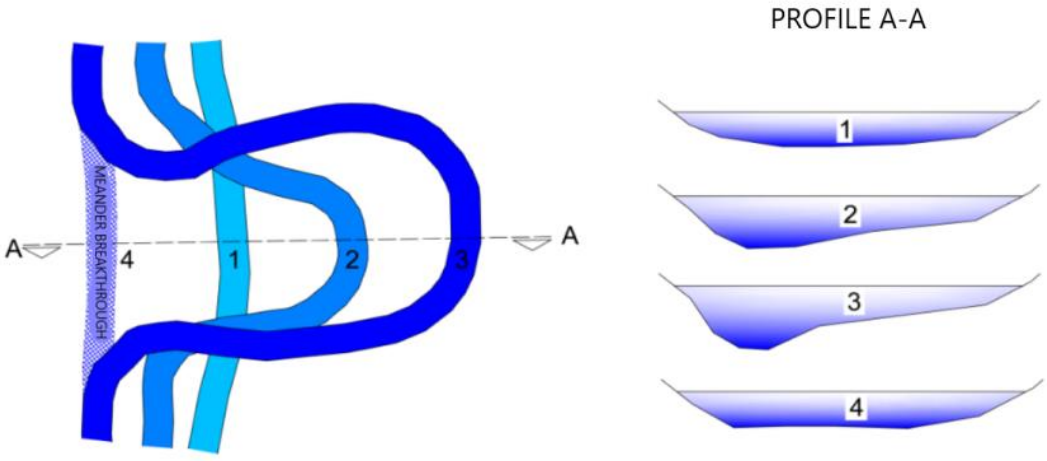


Figure 2.4. Representation of the meandering of the river course.

Wandering of the river flow occurs in rivers whose bed is formed in extremely mobile material, including river banks. Since the trough cannot maintain its proper shape, it develops in width. As a consequence of this, there are numerous backwaters divided by Adam, constantly changing their position and shape.

There are many different influences that affect the morphology of the river course, the most important of which are: water flow, sediment transport, longitudinal slope of the bottom, coarseness of sediment that dictates absolute roughness, alluvial formations as a cause of alluvial roughness, vegetation and the human factor.

It is well known that there is a certain dependence between the hydrological conditions of the watercourse and the deformation of the river bed, because the most intensive changes in the bed occur at high water levels.

This dependence, however, is largely influenced by another parameter- the input of sediment from the upstream sector into the observed watercourse zone. It is obvious that the river flow, under conditions of increased transport capacity for sediment at higher flows and speeds, will erode the bed in the observed sector, if it is not burdened by sediment from upstream sectors. The process of bed deformation is very complex and must be observed in spatial and temporal continuity.

Generally speaking, however, it can be assumed that the process of bed erosion is related to large waters, that is, that after the passage of a large water wave, deepening of the bed should be expected.

Separating individual influences is very difficult, they are all quite interdependent. The complexity of the processes taking place in the river bed makes any predictions of morphological changes ungrateful.

2.3 Hydrological and hydraulic substrates

There are a number of hydrological stations on the Danube River that have been operating for many years monitoring characteristic hydrological parameters. Statistical processing of data series provides authoritative data that serve as indicators of the hydrological situation of watercourses and are used as authoritative data in the design function.

In the following chapters, for the purposes of this project, water levels and flows (for the period 2001-2021) at the Batina, Aljmaš, Dalj, Vukovar and Ilok water measuring stations and the water levels at the Osijek water measuring station were analyzed. The concentration and transfer of suspended sediment (for the period 2018-2021) at the water measuring stations Batina, Dalj and Ilok were also analyzed.

Table 2.1. Analysed hydrological stations with general characteristics:

RIVER	STATION	CODE	F	″0″		Distance from the estuary	Start of work
			(km^2)	HDKS	HTRS		
				(m.a.s.l..)	(m.a.s.l.)	rkm	
DUNAV	BATINA	5170	210.250,0	80,45	80,188	1224+840	9.3.2001
	ALJMAŠ	5001	251.573,0	78,08	77,833	1381+500	1.1.1909
	DALJ	5130	--	75,204	74,953	1354+200	11.10.1985
	VUKOVAR	5070	253.147,0	76,188	75,936	1336+500	1.1.1856
	ILOK	5024	253.737,0	73,968	73,7	1301+500	1.1.1856
DRAVA	OSIJEK	5053	39.982,0	81,481	81,255	18+960	1.1.1827

Table 2.2. Analysed hydrological stations and the parameters monitored:

RIVER	STATION	Water level	Flow	Water temperature	The appearance of ice	Suspended sediment concentration	Transmission of suspended sediment
		H	Q	Tv	L	SK	SG
		(cm)	(m^3s^{-1})	(^0C)	(%)	(gm^3)	(t)
DUNAV	BATINA	+	+	+	-	+	+
	ALJMAŠ	+	+	+	-	-	-
	DALJ	+	+	+	-	+	+
	VUKOVAR	+	+	+	-	-	-
	ILOK	+	+	+	-	+	+
DRAVA	OSIJEK	+	-	+	-	-	-

Table 2.3. Available time intervals of the parameter measurement at the analyzed hydrological stations:

RIVER	STATION	Water level	Flow	Water temperature	The appearance of ice	Suspended sediment concentration	Transmission of suspended sediment
		H	Q	Tv	L	SK	SG
		(cm)	(m^3s^{-1})	(^0C)	(%)	(gm^3)	(t)
DUNAV	BATINA	2001. - 2021.	2001. - 2021.	2002. - 2021.	--	2018. - 2021.	2018. - 2021.
	ALJMAŠ	1923. - 2021.	2001. - 2021.	1970. - 2021.	--	--	--
	DALJ	1985. - 2021.	2001. - 2021.	1985. - 2021.	--	2018. - 2021.	2018. - 2021.
	VUKOVAR	1969. - 2021.	2001. - 2021.	1948. - 2021.	--	--	--
	ILOK	1947. - 2021.	2001. - 2021.	1948. - 2021.	--	2018. - 2021.	2018. - 2021.
DRAVA	OSIJEK	1952. - 2022.	--	1948. - 2022.	--	--	--

The graphic attachments show the durability and frequency curves for both water levels and flows, as well as the characteristic values of the recorded water levels and flows. Analyzes and displays are given for low, medium and high water level and flow. According to the same data, the trend of minimum, average and maximum annual water levels and flow was analyzed. The graphs also show the linear trends of each series. For water measuring stations where sediment is measured, a presentation of daily concentrations and transport of suspended sediment is given.

2.3.1 Water measuring station Batina

Water levels

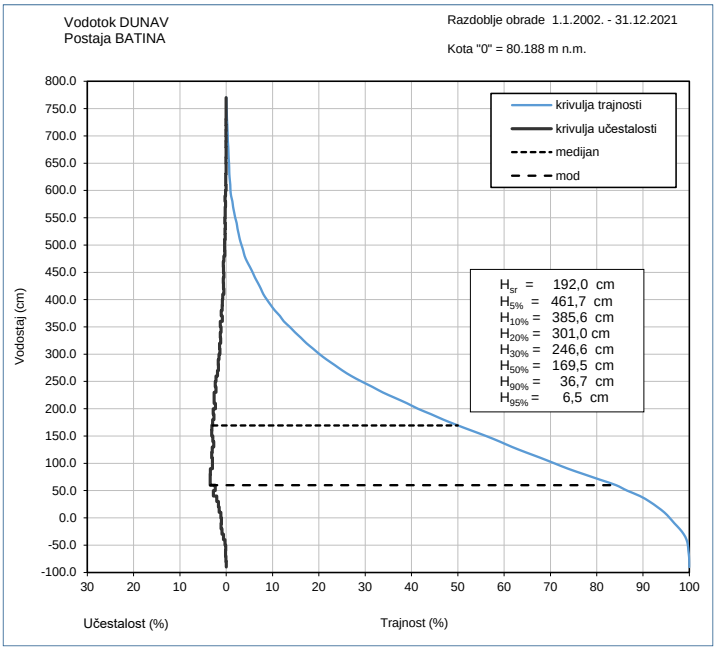


Figure 2.5. The curve of durability and frequency of the water level (cm) of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

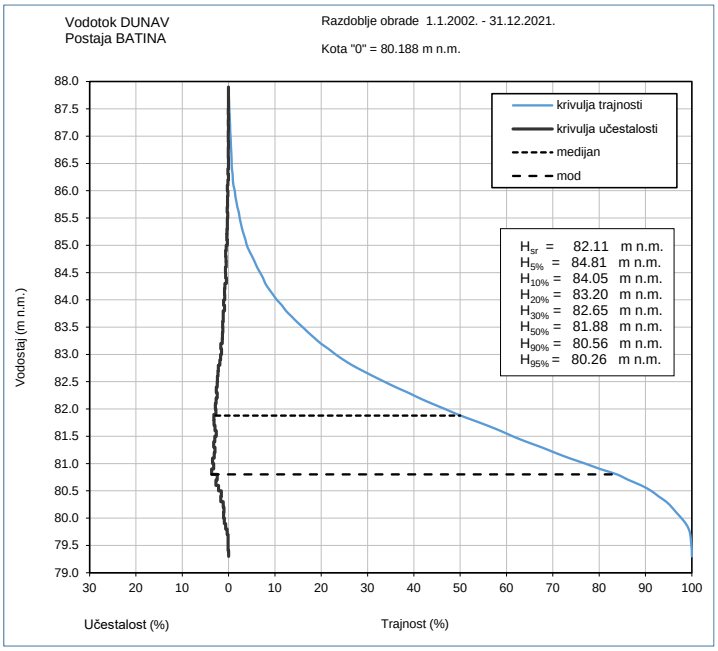


Figure 2.6. The curve of durability and frequency of the water level (m.a.s.l.) of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

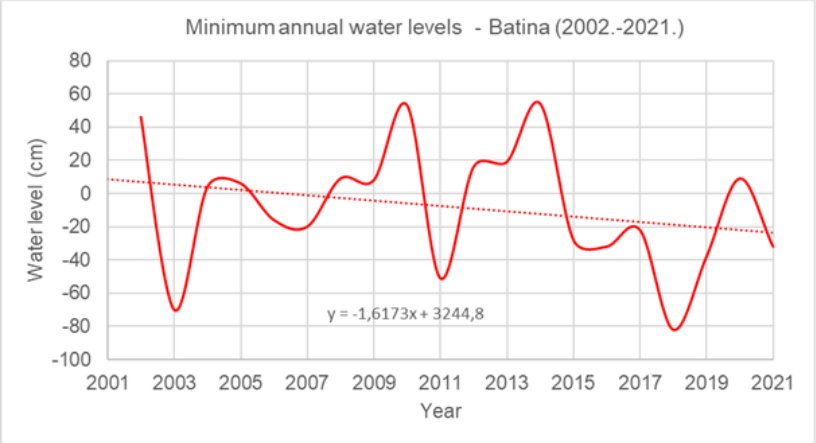


Figure 2.7. Presentation of series of characteristic minimum annual water levels of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

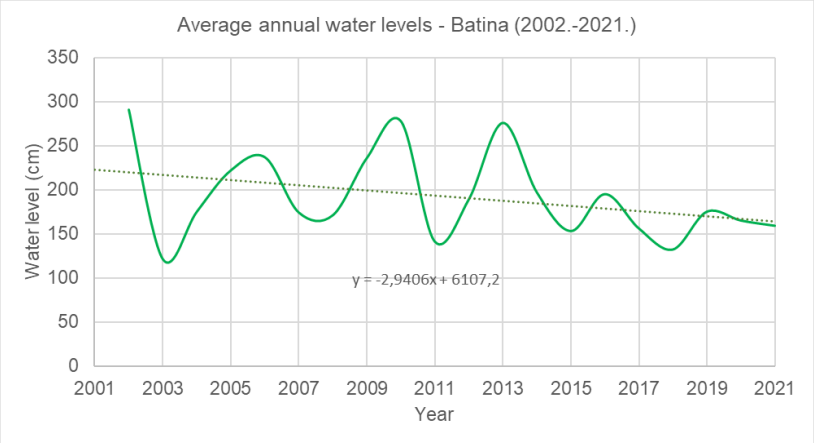


Figure 2.8. Presentation of series of characteristic average annual water levels of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

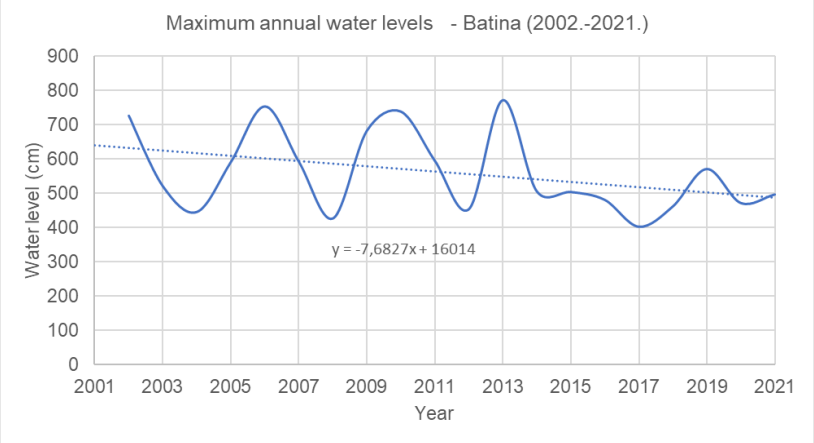


Figure 2.9. Presentation of the series of characteristic maximum annual water levels of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

Flows

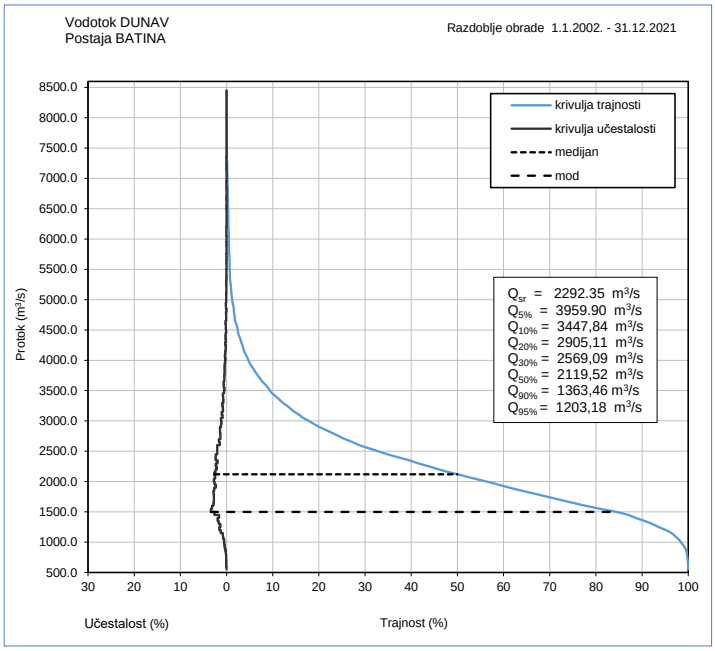


Figure 2.10. Curve of durability and frequency of flow (m^3/s) of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

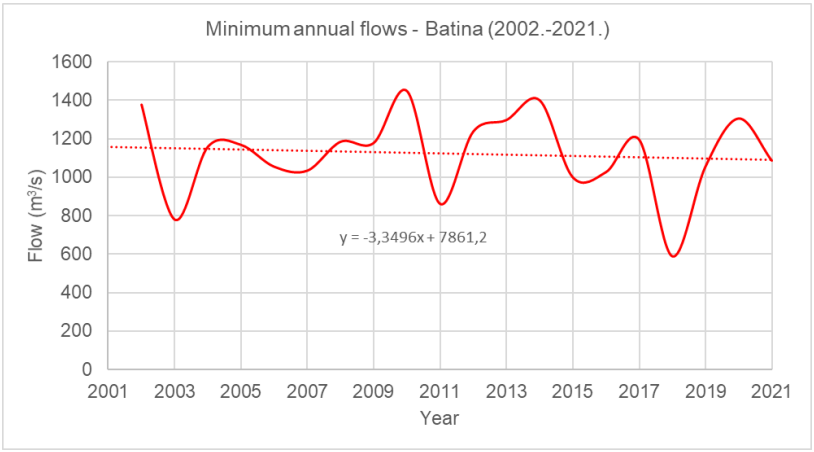


Figure 2.11. Presentation of series of characteristic minimum annual flows of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

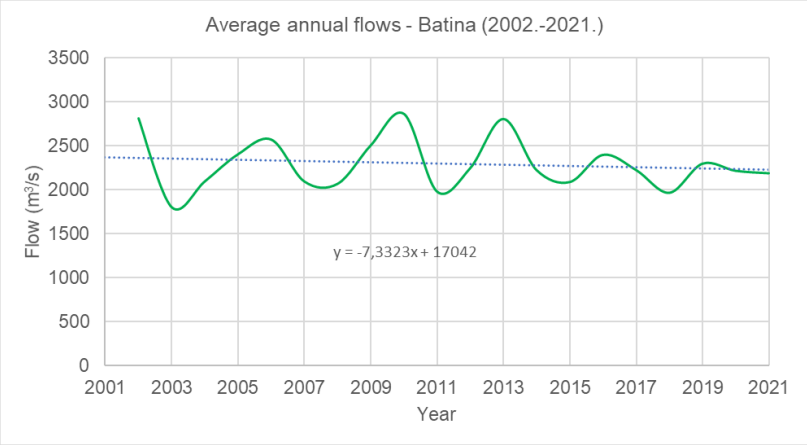


Figure 2.12. Presentation of series of characteristic average annual flows of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

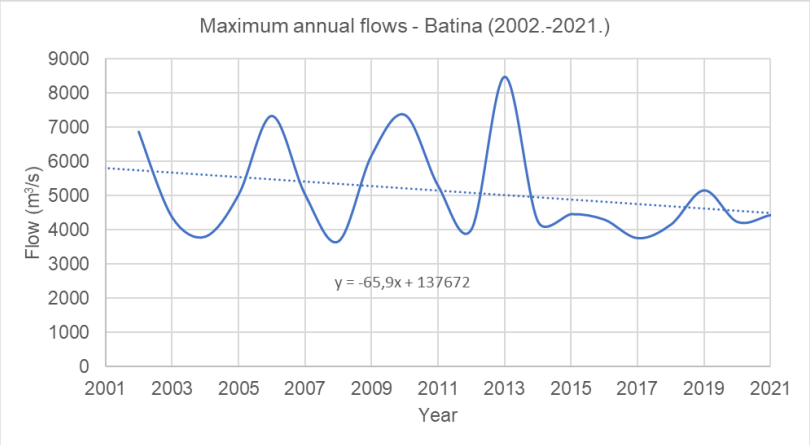


Figure 2.13. Presentation of the series of characteristic maximum annual flows of the Danube River at the water measuring station Batina in the period from 2002 to 2021.

Deposit

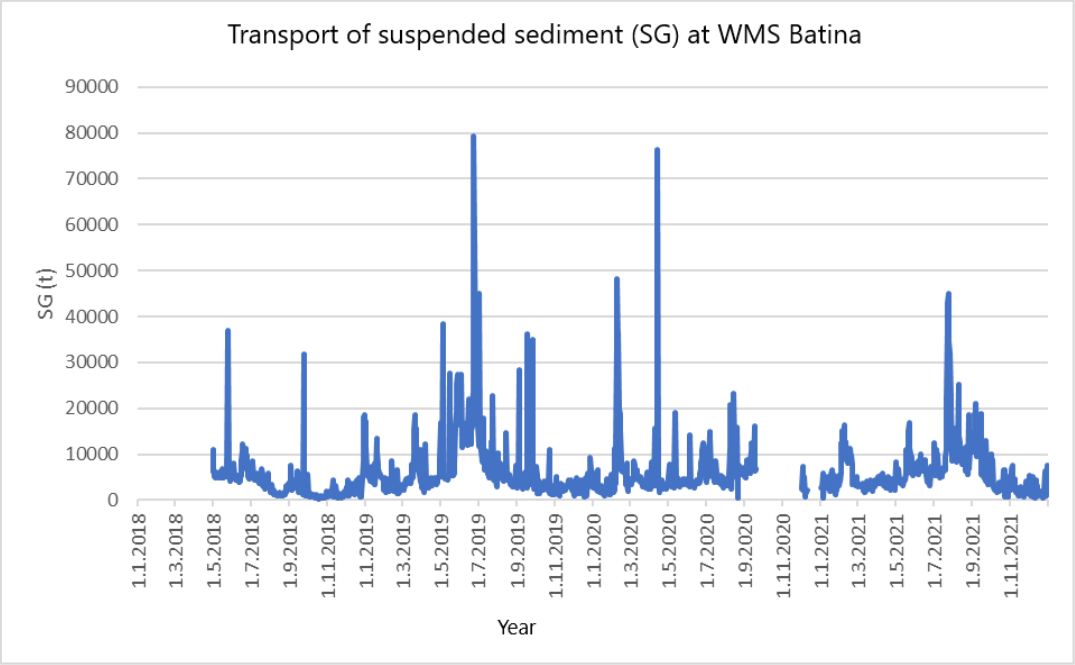


Figure 2.14. Transport of suspended sediment at WMS Batina.

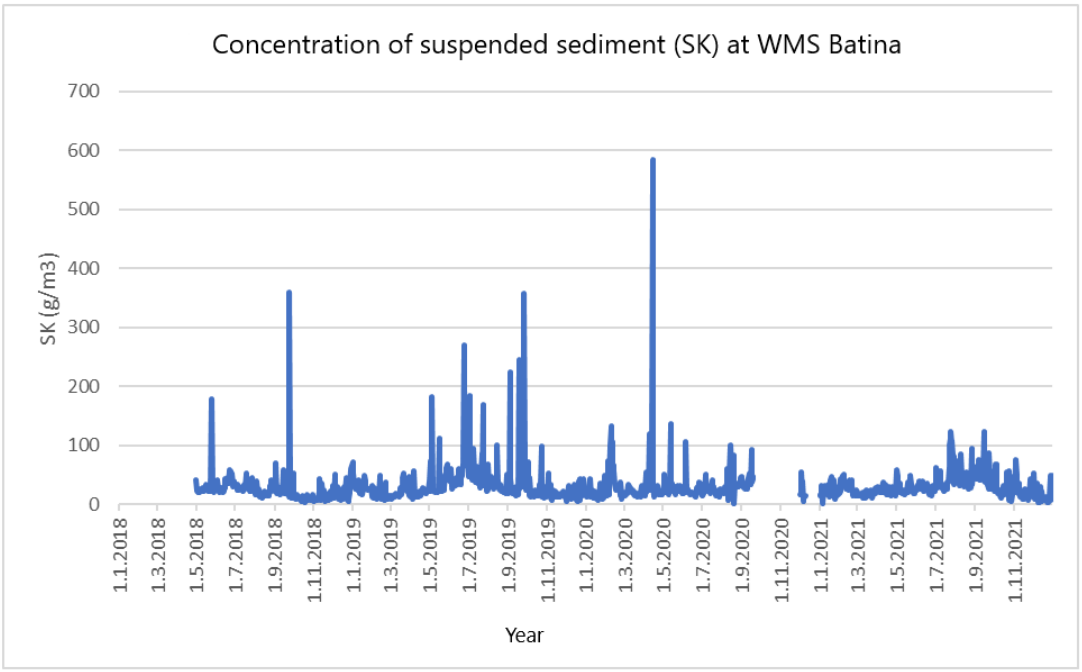


Figure 2.15. Concentration of suspended sediment at WMS Batina.

2.3.2 Water measuring station Aljmaš

Water levels

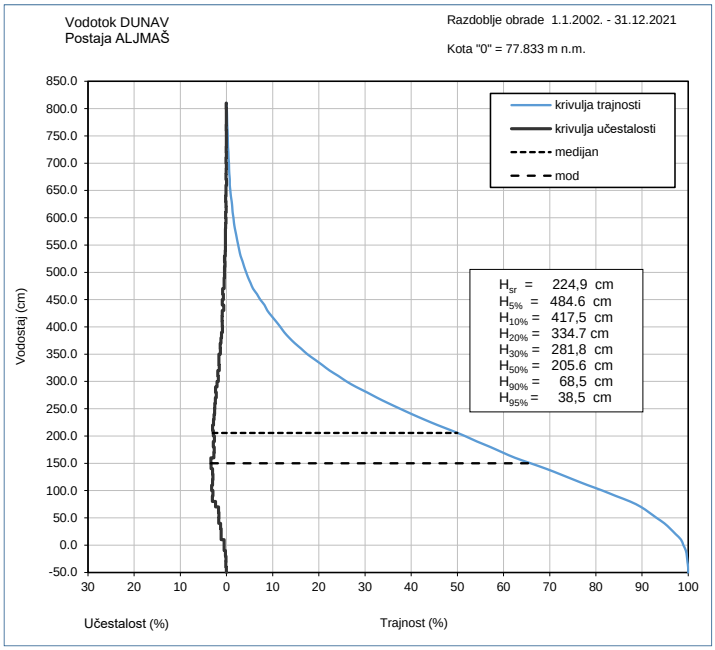


Figure 2.16. The curve of durability and frequency of the water level (cm) of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

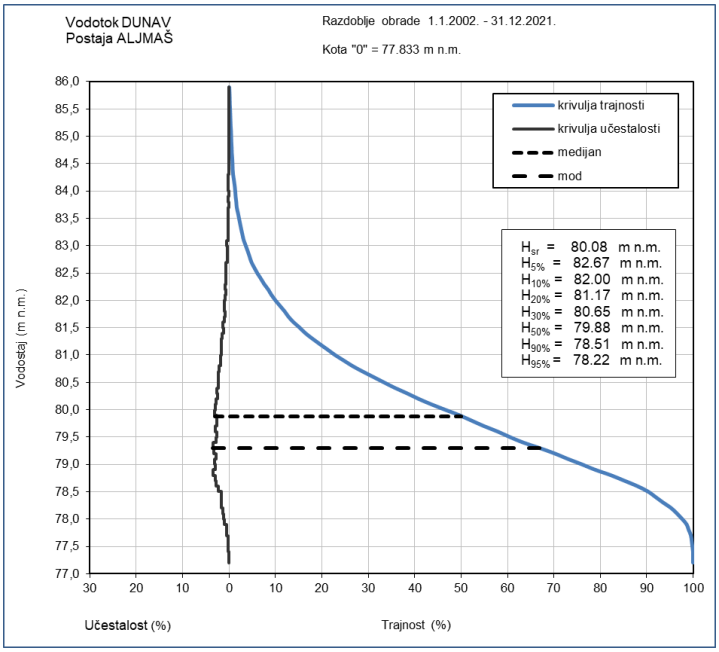


Figure 2.17. The curve of durability and frequency of the water level (m.a.s.l.) of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

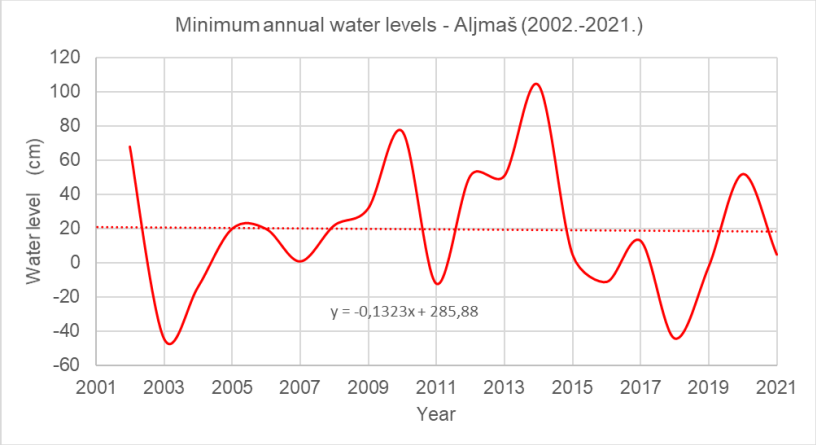


Figure 2.18. Presentation of series of characteristic minimum annual water levels of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

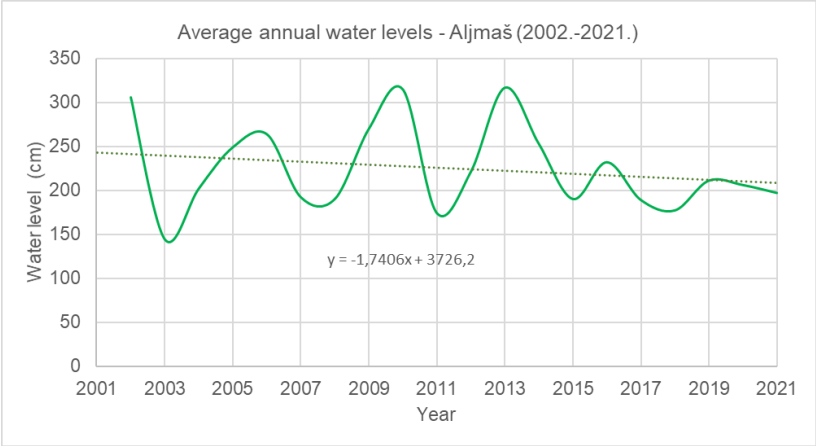


Figure 2.19. Presentation of series of characteristic average annual water levels of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

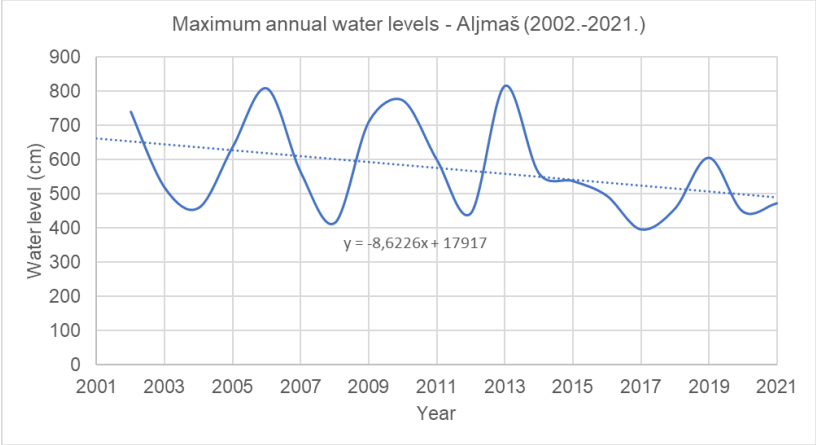


Figure 2.20. Presentation of series of characteristic maximum annual water levels of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

Flows

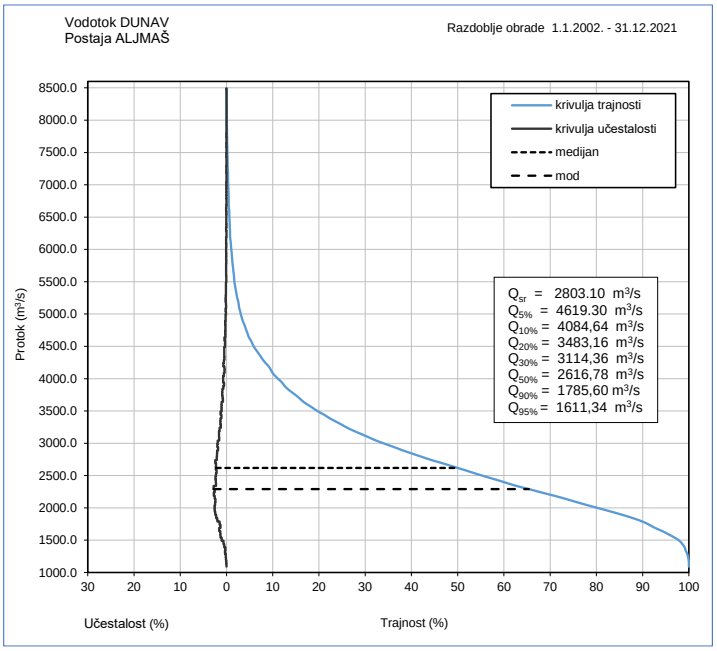


Figure 2.21. The curve of the duration and frequency of flow (m^3/s) of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

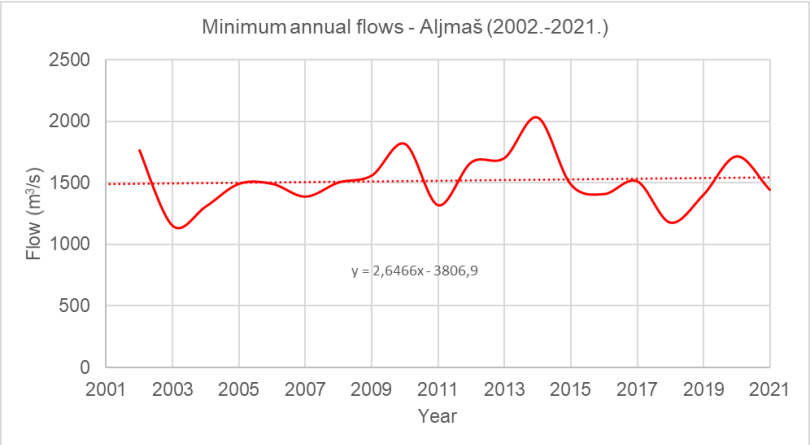


Figure 2.22. Presentation of series of characteristic minimum annual flows of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

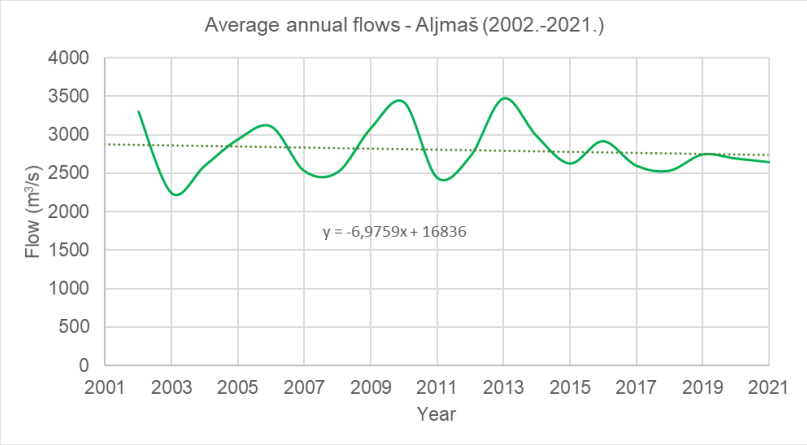


Figure 2.23. Presentation of series of characteristic average annual flows of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

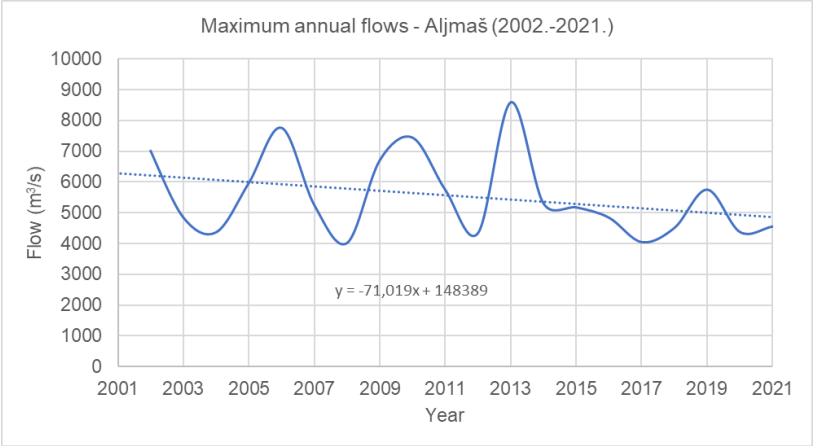


Figure 2.24. Presentation of series of characteristic maximum annual flows of the Danube River at the water measuring station Aljmaš in the period from 2002 to 2021.

2.3.3 Water measuring station Dalj

Water levels

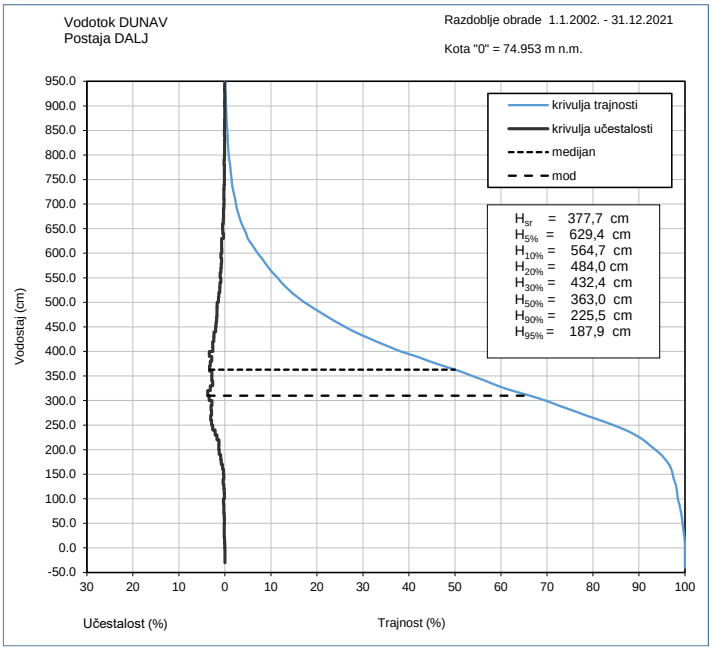


Figure 2.25. The curve of durability and frequency of the water level (cm) of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

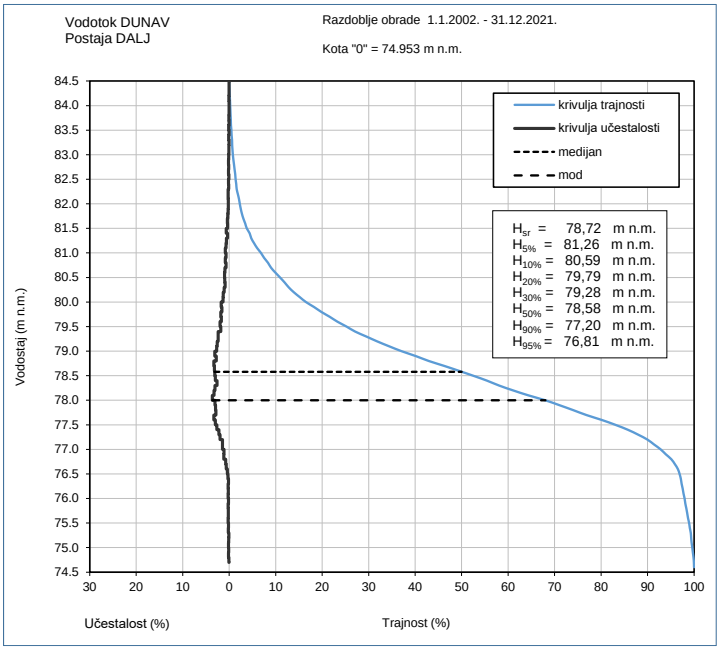


Figure 2.26. The curve of durability and frequency of the water level (m.a.s.l.) of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

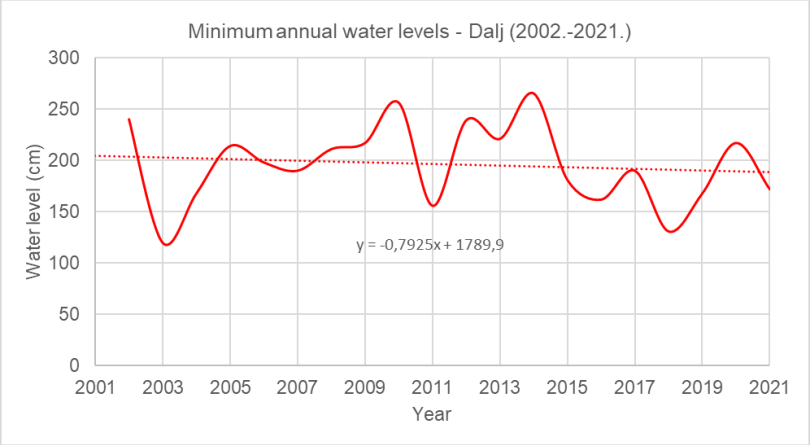


Figure 2.27. Presentation of series of characteristic minimum annual water levels of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

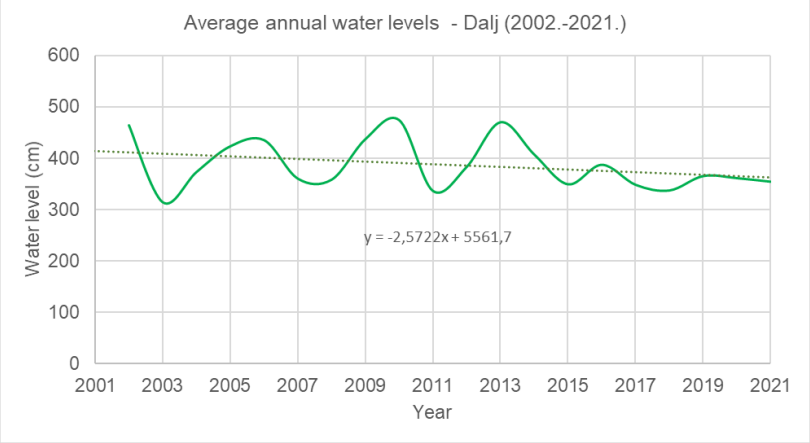


Figure 2.28. Presentation of series of characteristic average annual water levels of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

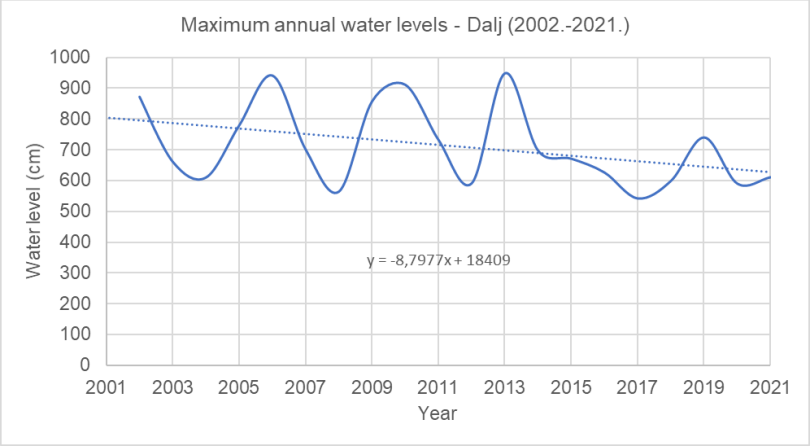


Figure 2.29. Presentation of series of characteristic maximum annual water levels of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

Flows

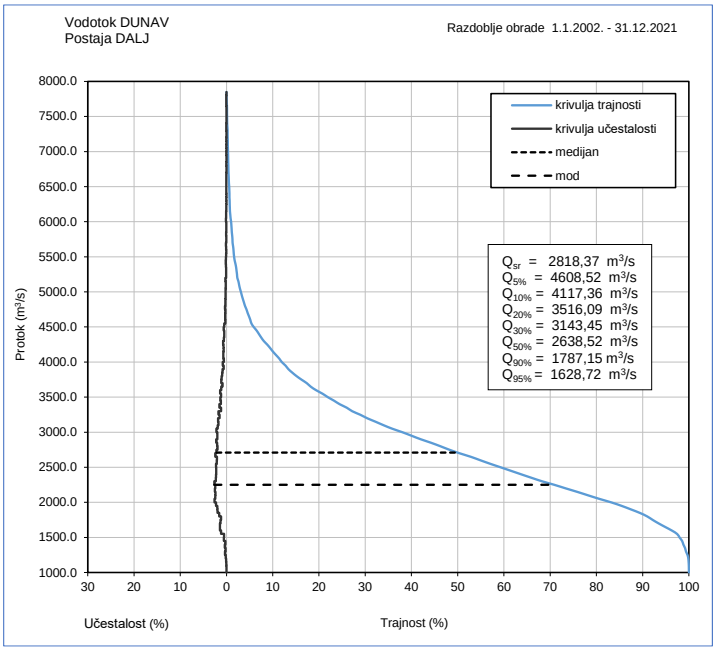


Figure 2.30. Curve of the duration and frequency of flow (m^3/s) of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

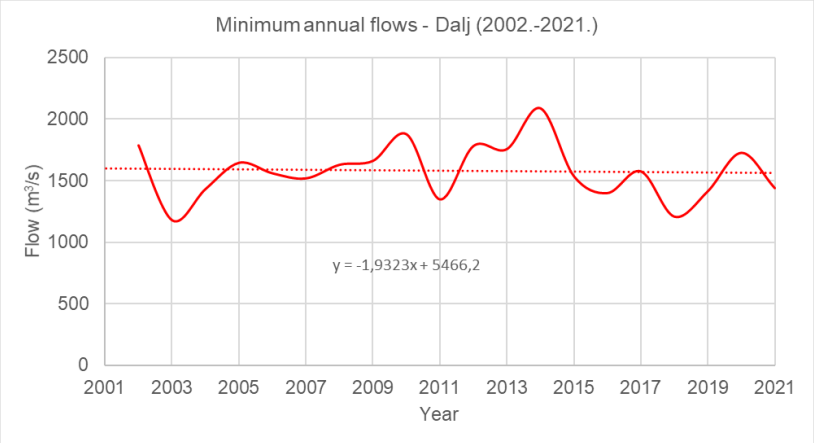


Figure 2.31. Presentation of series of characteristic minimum annual flows of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

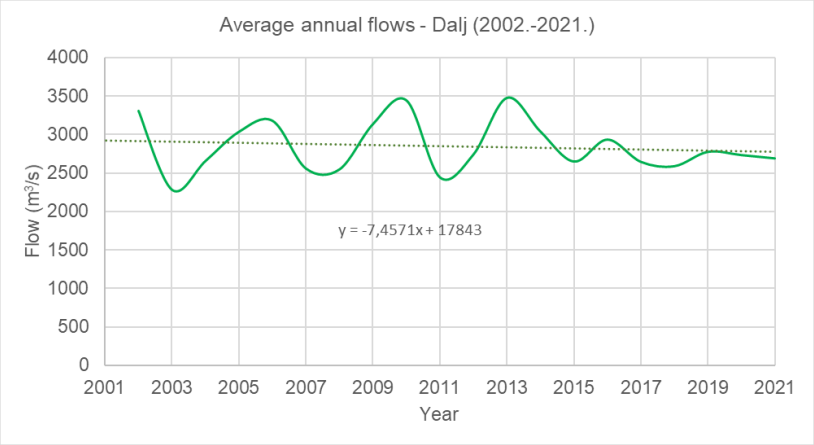


Figure 2.32. Presentation of series of characteristic average annual flows of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

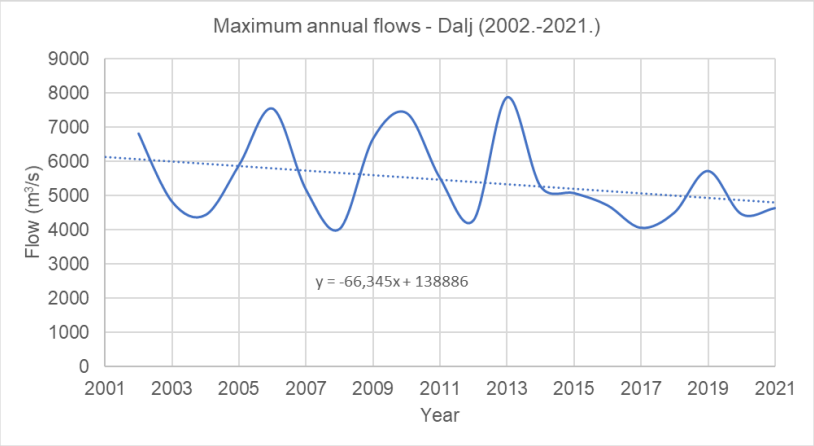


Figure 2.33. Presentation of series of characteristic maximum annual flows of the Danube River at the water measuring station Dalj in the period from 2002 to 2021.

Deposit

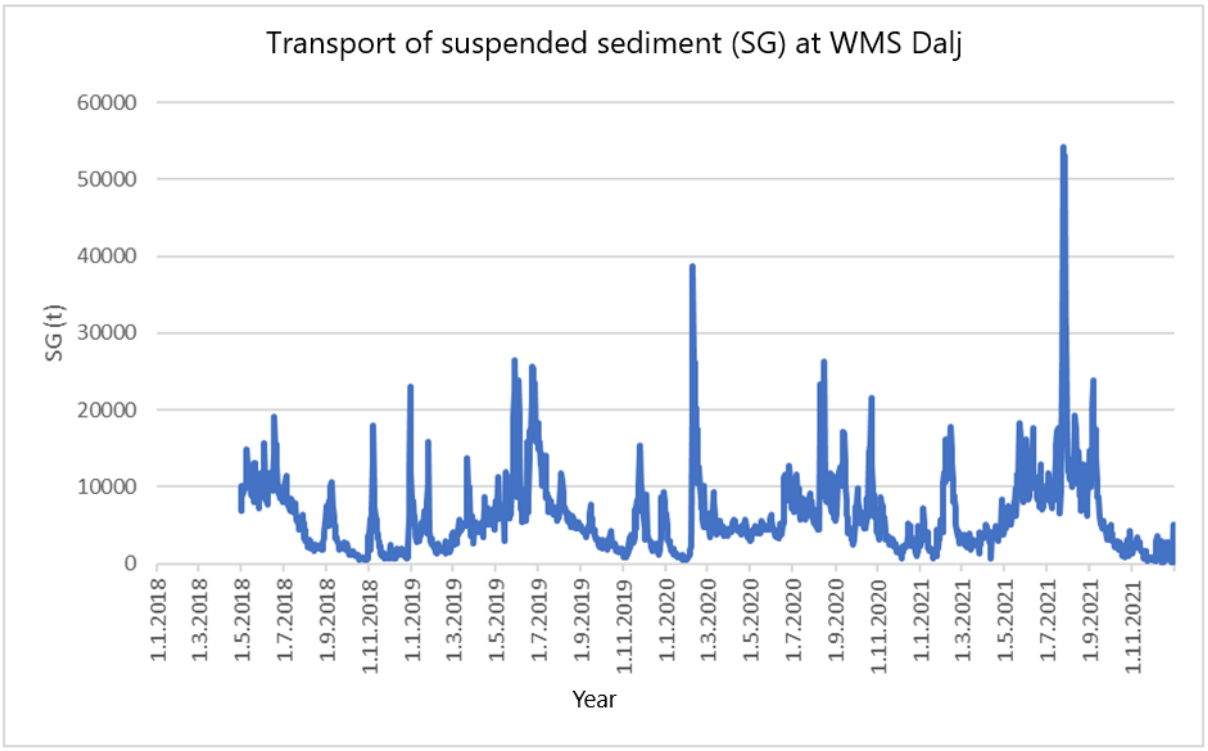


Figure 2.34. Transport of suspended sediment at WMS Dalj

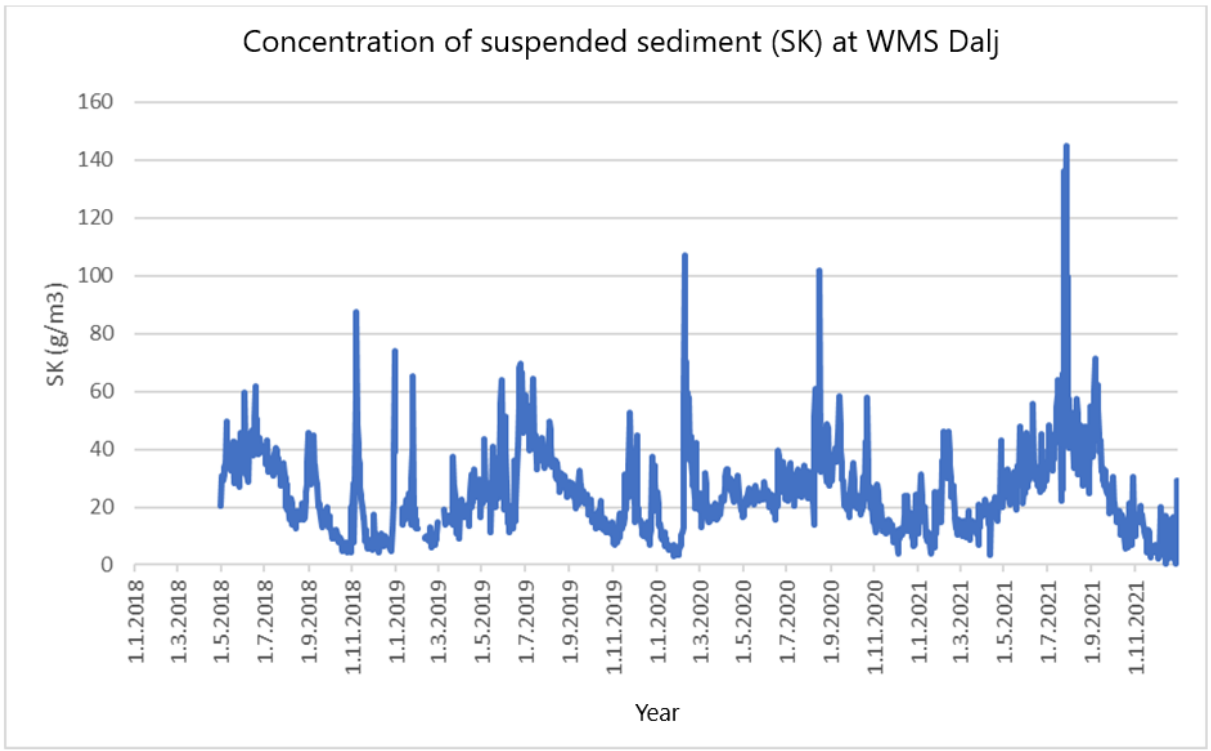


Figure 2.35. Concentration of suspended sediment at WMS Dalj.

2.3.4 Water measuring station Vukovar

Water levels

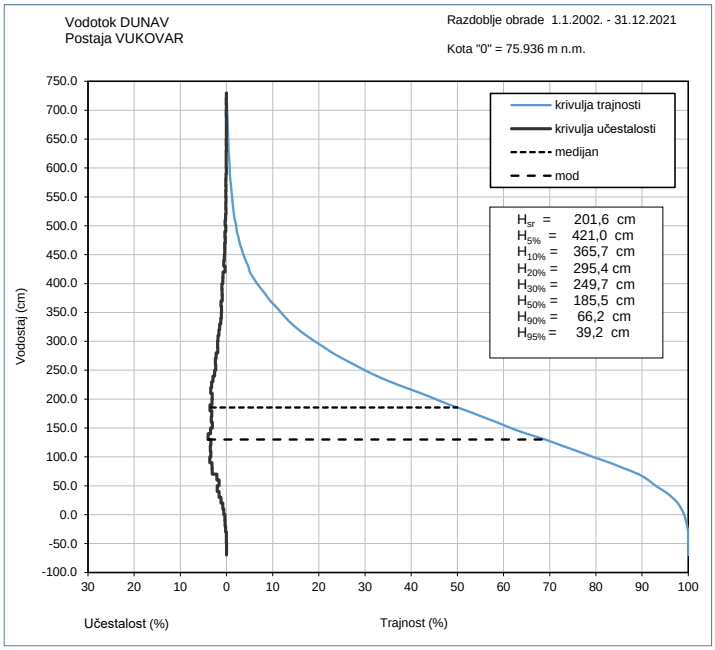


Figure 2.36. Curve of durability and frequency of the water level (cm) of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

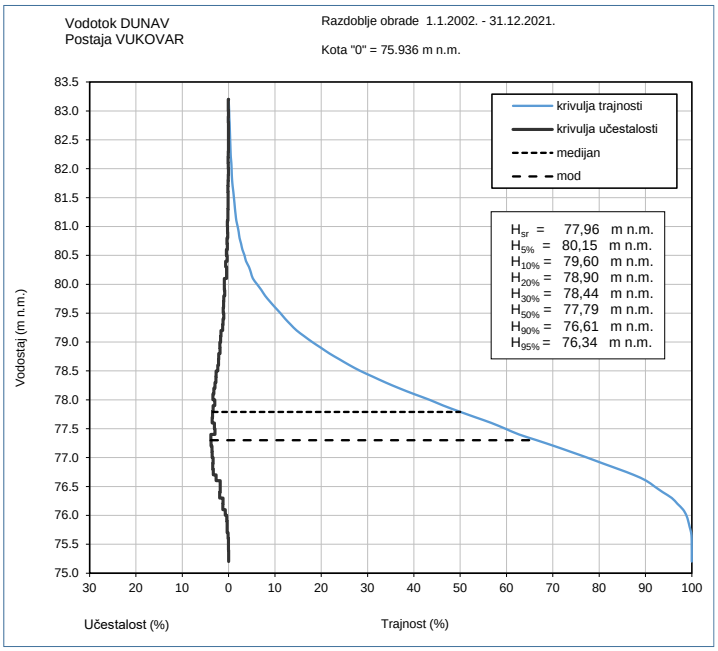


Figure 2.37. The curve of durability and frequency of the water level (m.a.s.l.) of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

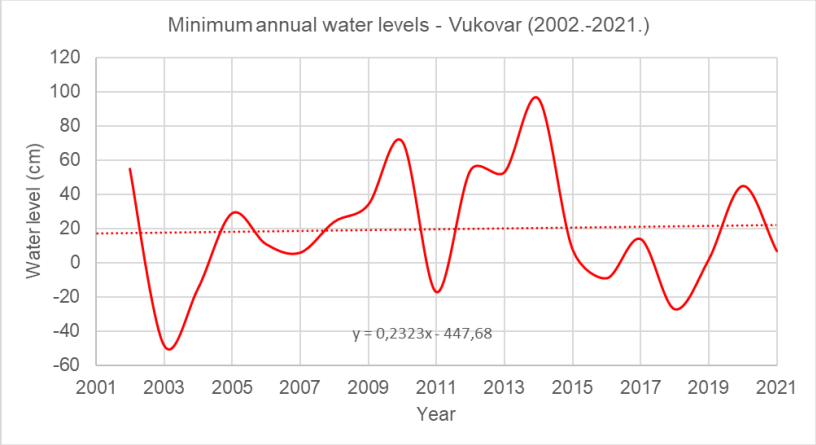


Figure 2.38. Presentation of series of characteristic minimum annual water levels of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

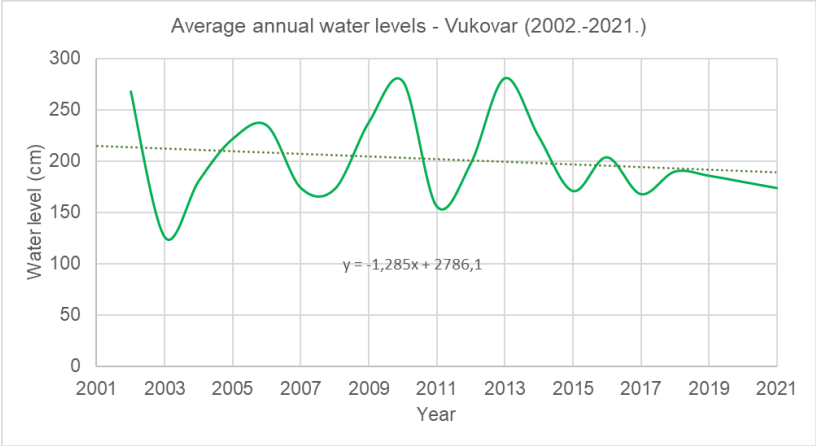


Figure 2.39. Presentation of the series of characteristic average annual water levels of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

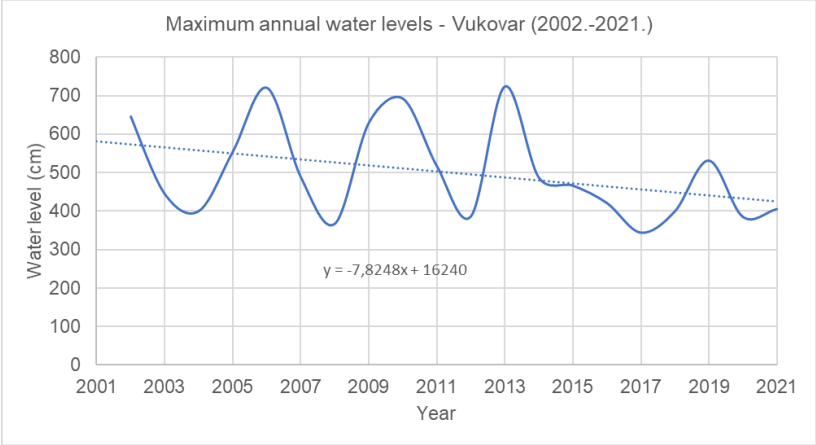


Figure 2.40. Presentation of series of characteristic maximum annual water levels of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

Flows

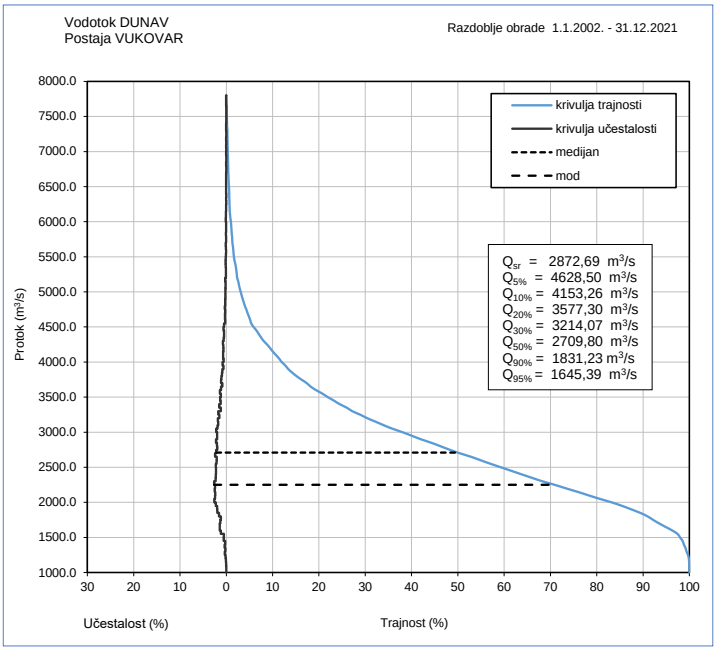


Figure 2.41. The curve of the duration and frequency of flow (m³/s) of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

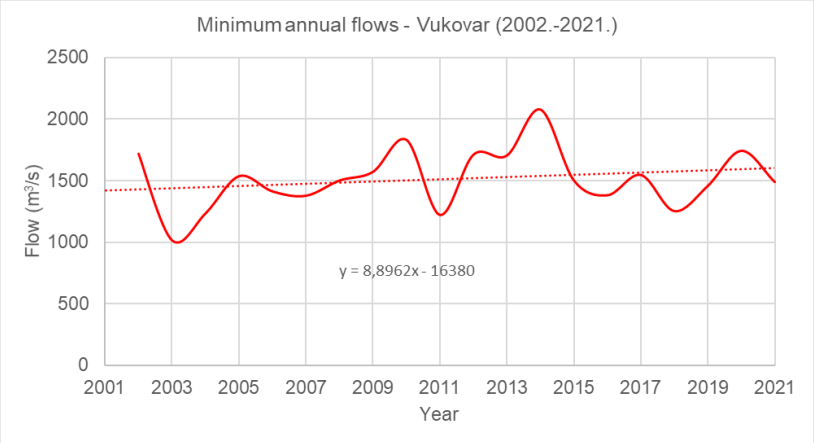


Figure 2.42. Presentation of series of characteristic minimum annual flows of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

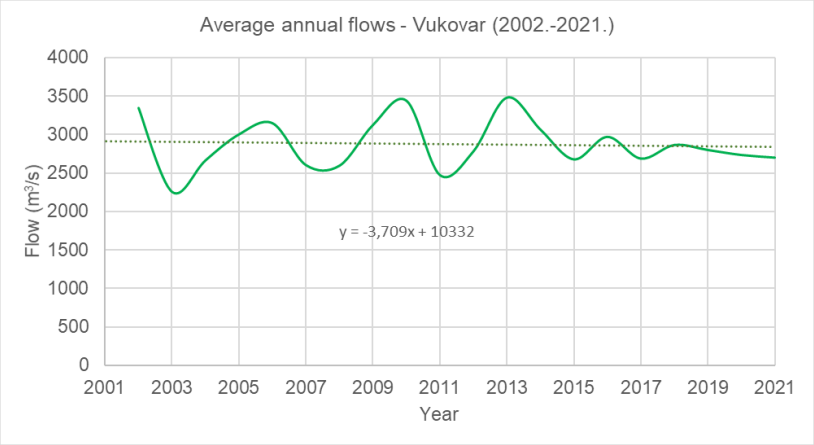


Figure 2.43. Presentation of series of characteristic average annual flows of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

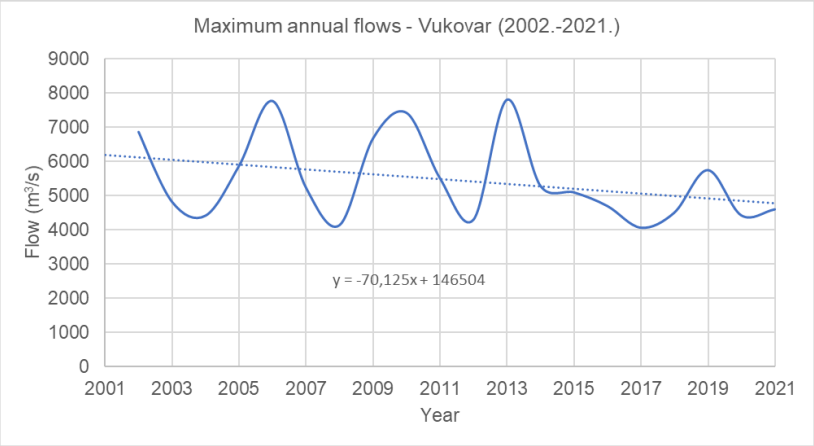


Figure 2.44. Presentation of series of characteristic maximum annual flows of the Danube River at the water measuring station Vukovar in the period from 2002 to 2021.

2.3.5 Water measuring station Ilok

Water levels

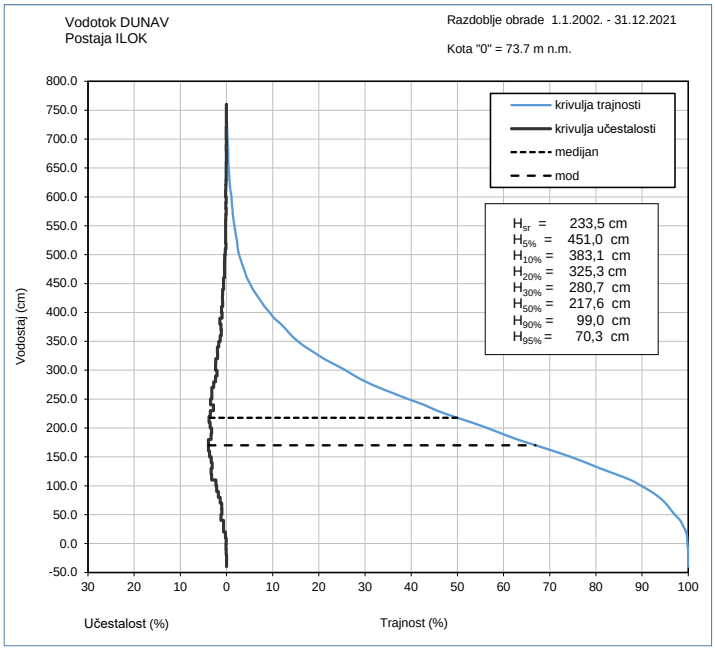


Figure 2.45. The curve of durability and frequency of the water level (cm) of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

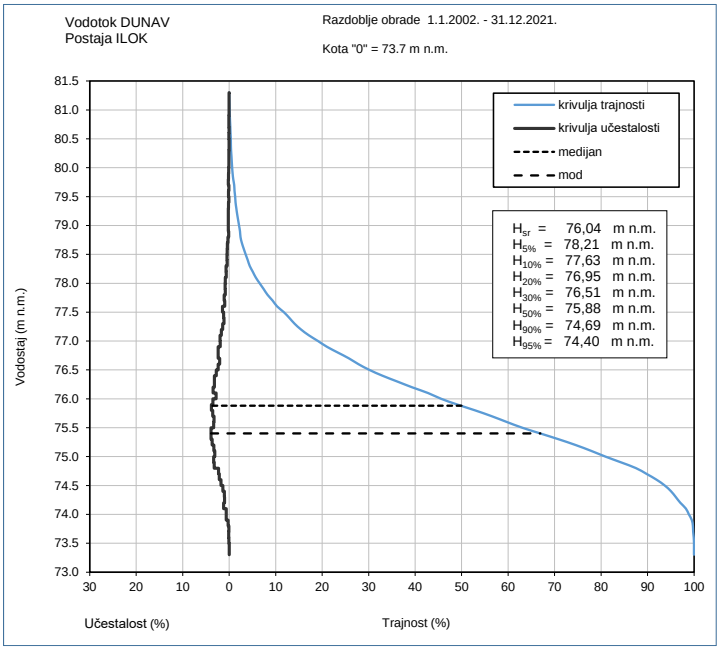


Figure 2.46. The curve of the durability and frequency of the water level (m.a.s.l.) of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

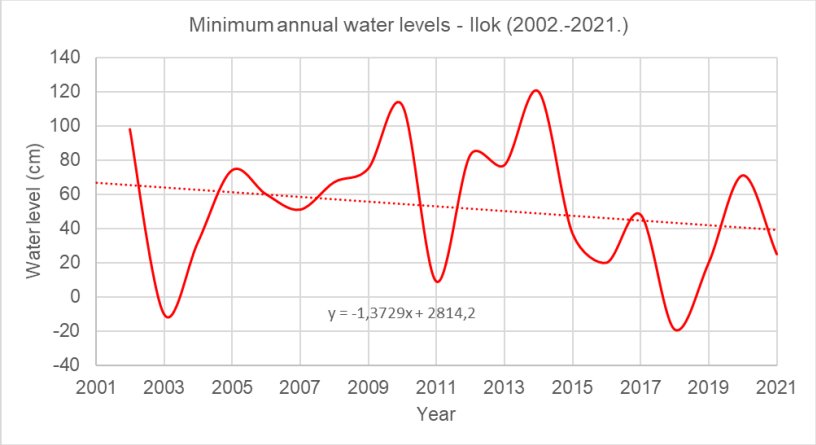


Figure 2.47. Presentation of series of characteristic minimum annual water levels of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

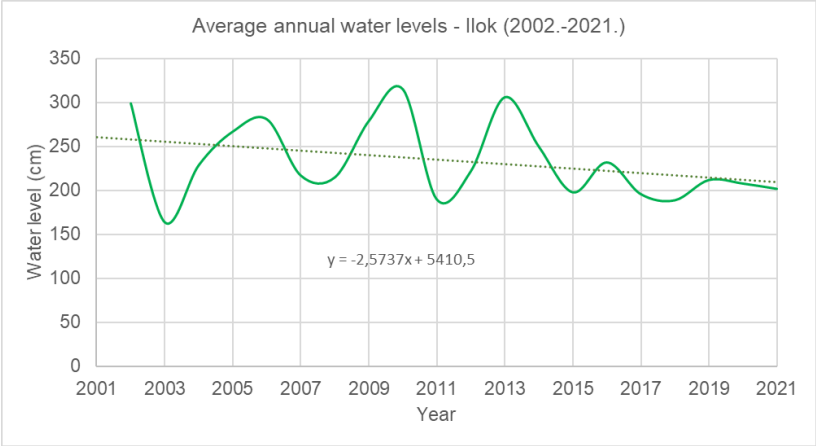


Figure 2.48. Presentation of series of characteristic average annual water levels of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

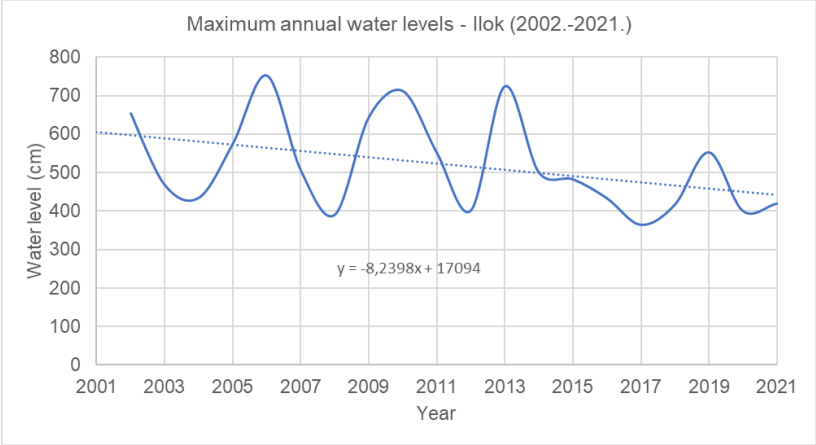


Figure 2.49. Presentation of series of characteristic maximum annual water levels of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

Flows

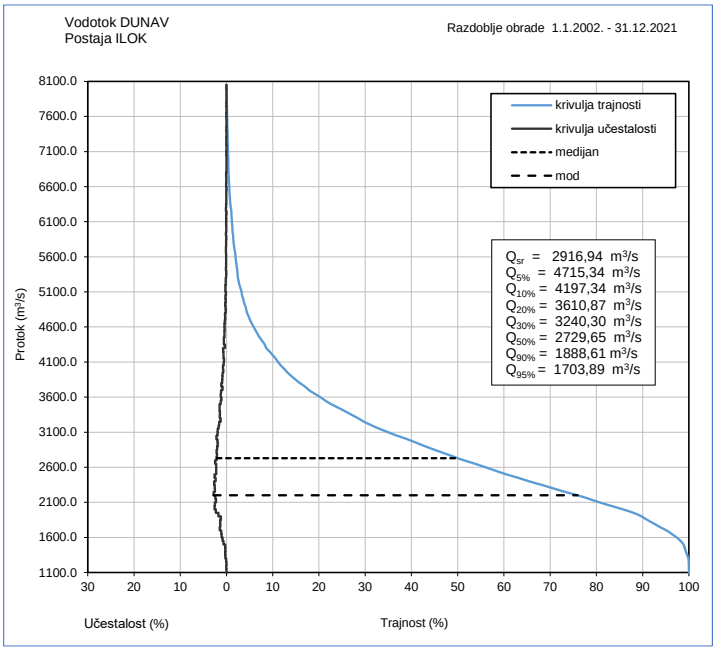


Figure 2.50. The curve of the duration and frequency of flow (m^3/s) of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

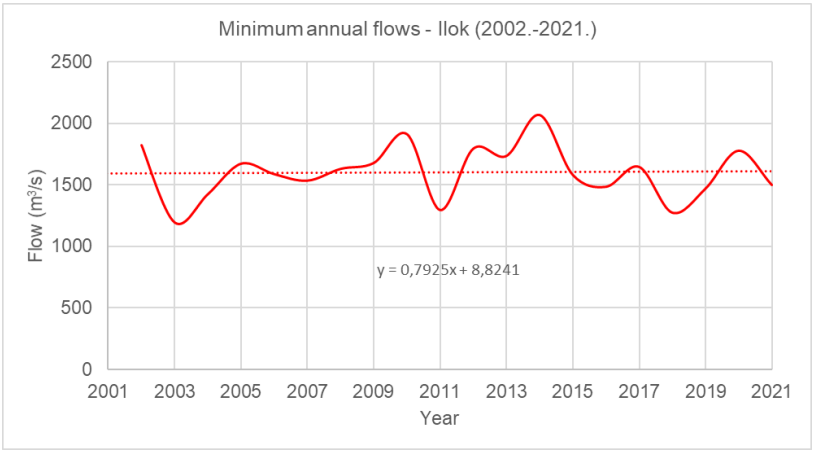


Figure 2.51. Presentation of series of characteristic minimum annual flows of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

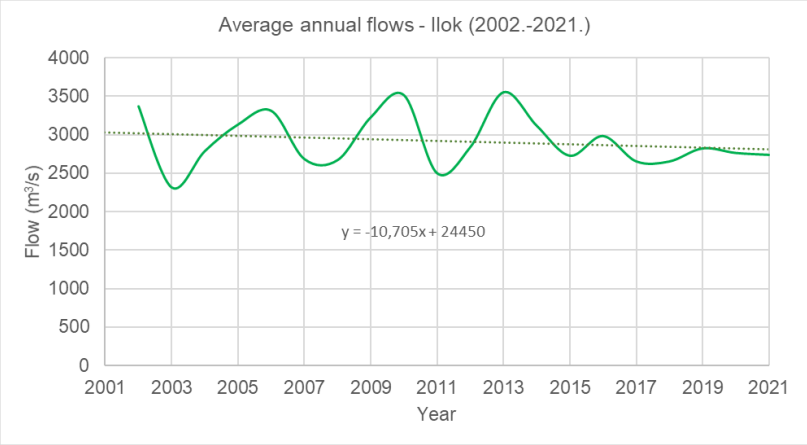


Figure 2.52. Presentation of series of characteristic average annual flows of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

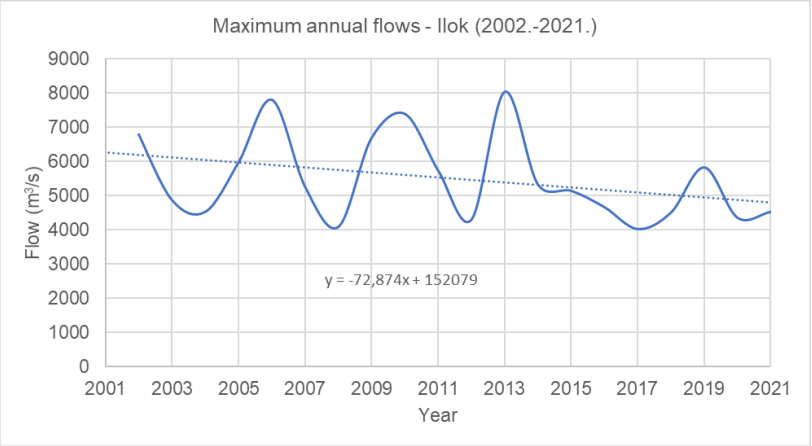


Figure 2.53. Presentation of series of characteristic maximum annual flows of the Danube River at the water measuring station Ilok in the period from 2002 to 2021.

Deposit

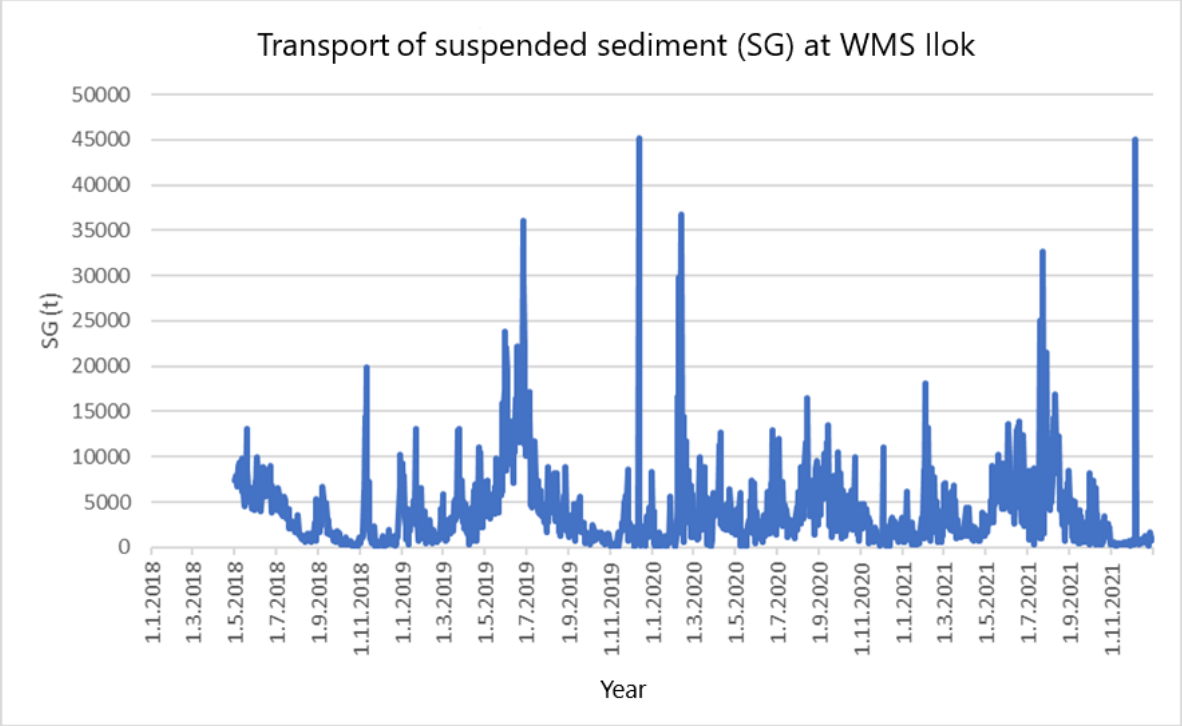


Figure 2.54. Transport of suspended sediment at WMS Ilok.

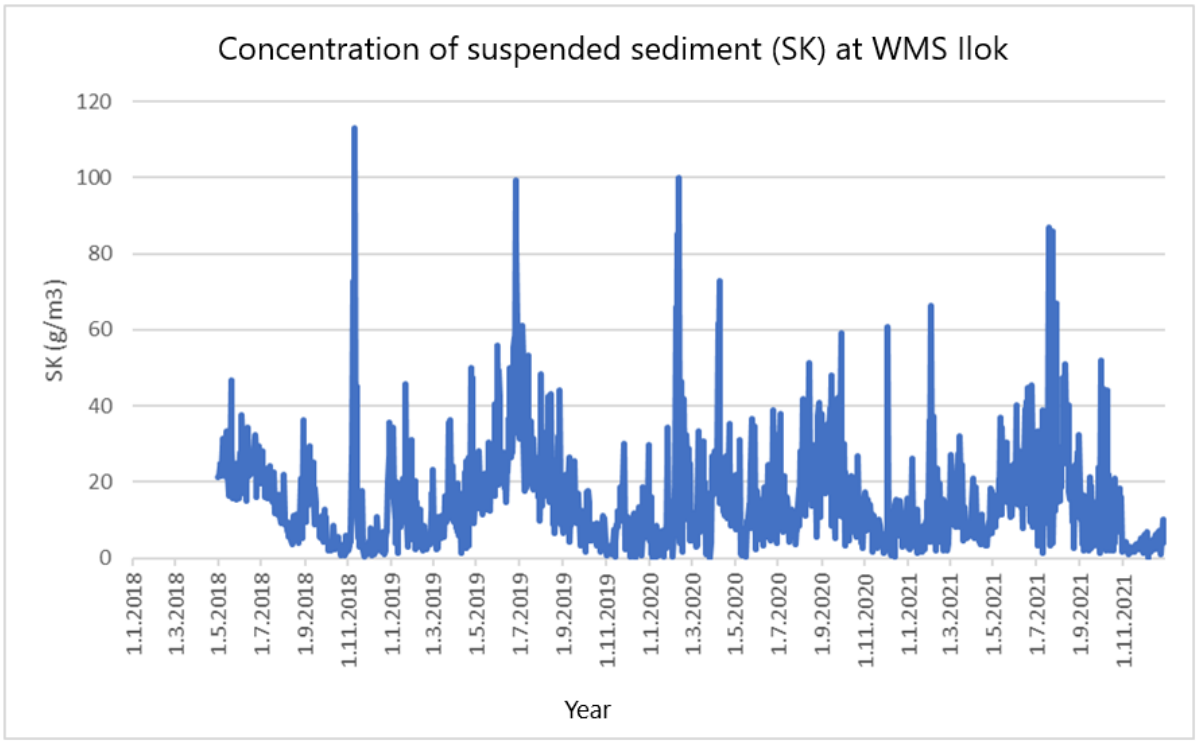


Figure 2.55. Concentration of suspended sediment at WMS Ilok.

2.3.6 Water measuring station Osijek

Water levels

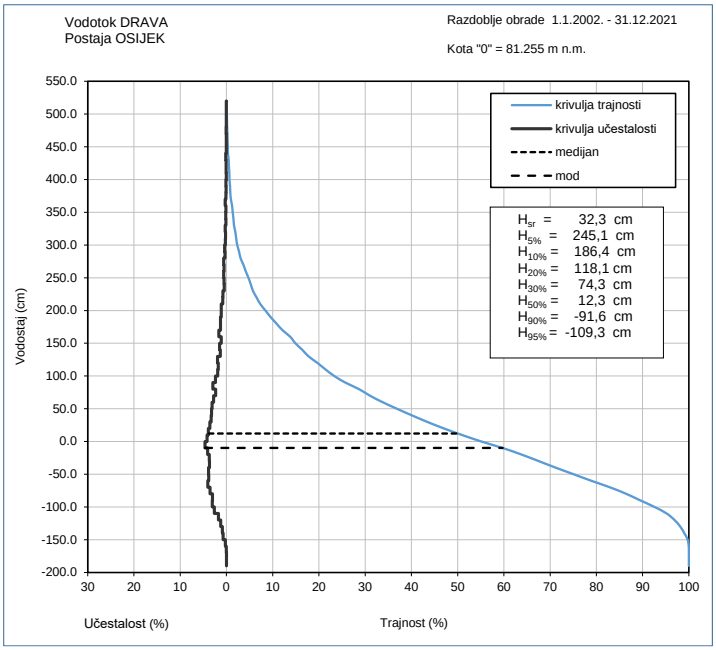


Figure 2.56. The curve of durability and frequency of the water level (cm) of the Drava River at the water measuring station Osijek in the period from 2002 to 2021.

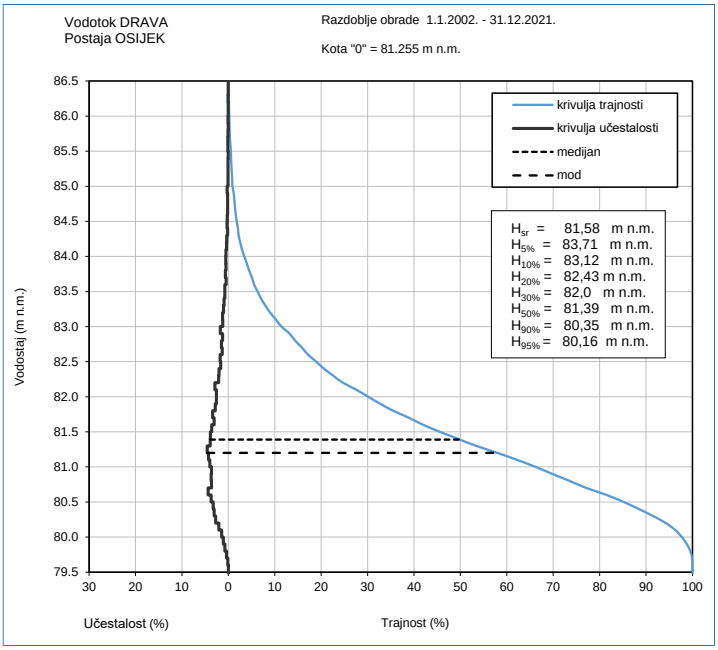


Figure 2.57. The curve of durability and frequency of the water level (m.a.s.l.) of the Drava River at the Osijek water measuring station in the period from 2002 to 2021.

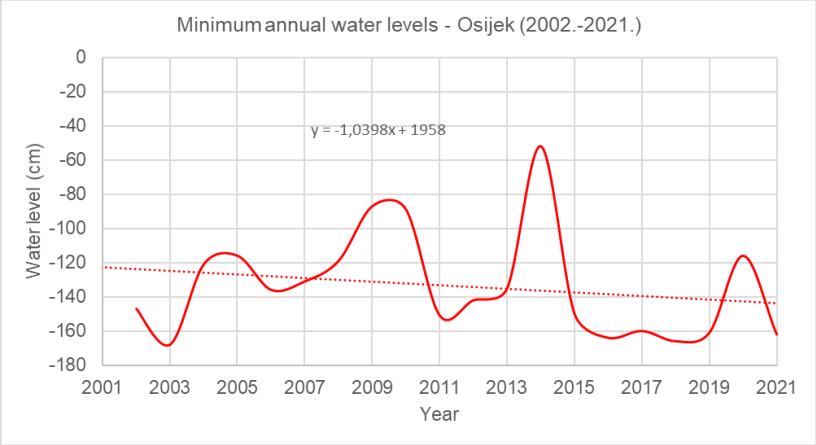


Figure 2.58. Presentation of series of characteristic minimum annual water levels of the Drava River at the water measuring station Osijek in the period from 2002 to 2021.

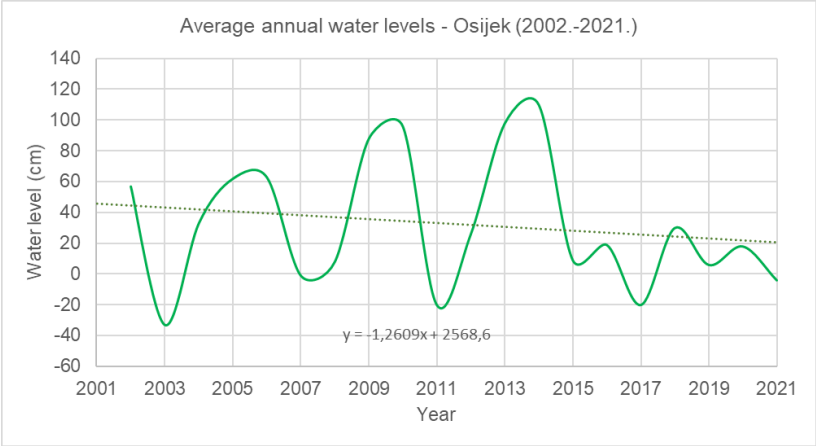


Figure 2.59. Presentation of series of characteristic average annual water levels of the Drava River at the water measuring station Osijek in the period from 2002 to 2021.

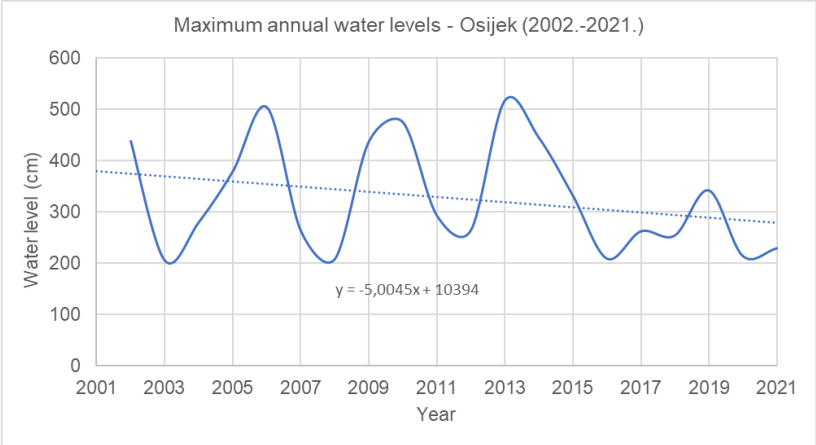


Figure 2.60. Presentation of series of characteristic maximum annual water levels of the Drava River at the water measuring station Osijek in the period from 2002 to 2021.

2.3.1 Conclusion of the hydrological and hydraulic analysis

Speed and flow recordings and measurement of the transfer of suspended and dragged sediment (monitoring) in accordance with the project task must be carried out during the duration of low, medium and high water levels.

For this purpose, the water level intervals for the water measuring stations Batina, Aljmaš, Vukovar and Ilok, where the planned monitoring will be carried out, are determined below.

Through statistical processing of the data, average values were obtained in certain time intervals and following data calculated:

- The highest water level (H_{max}) = the highest recorded water level from the 20-year observation period
- High water level ($H_{10\%}$) = is the water level determined based on a statistical calculation of the durability of the water level from 20 year-timeline, and corresponds to a water level of 10% durability.
- Ordinary/medium water level ($H_{50\%}$) = the water level determined based on a statistical calculation of the durability of the water level from the 20 year-timeline, and corresponds to the water level of 50% durability.
- Low water level ($H_{90\%}$) = the water level is determined based on a statistical calculation of the durability of the water level from the 20 year-timeline and corresponds to the water level of 90% durability.
- Lowest water level (H_{min}) = The lowest recorded water level from the 20 year-timeline

Table 2.4. Water level (high, medium and low water levels) for the water measuring stations Batina, Aljmaš, Vukovar and Ilok:

Water measuring station	H_{max}	$H_{10\%}$	$H_{50\%}$	$H_{90\%}$	H_{uman}
Batina	772,0	385,6	192,0	36,7	-82,0
Aljmaš	815,0	417,5	224,9	68,5	-68,0
Vukovar	723,0	365,7	201,6	66,2	-48,0
Ilok	752,0	383,1	233,5	99,0	-27,0

Below, a graphic analysis of the water measuring stations in question is given, i.e. a display of the series of characteristic annual water levels of the Danube River at the water measuring stations Batina, Aljmaš, Vukovar and Ilok in the period from 2002 to 2021 with a display of high, medium and low water levels.

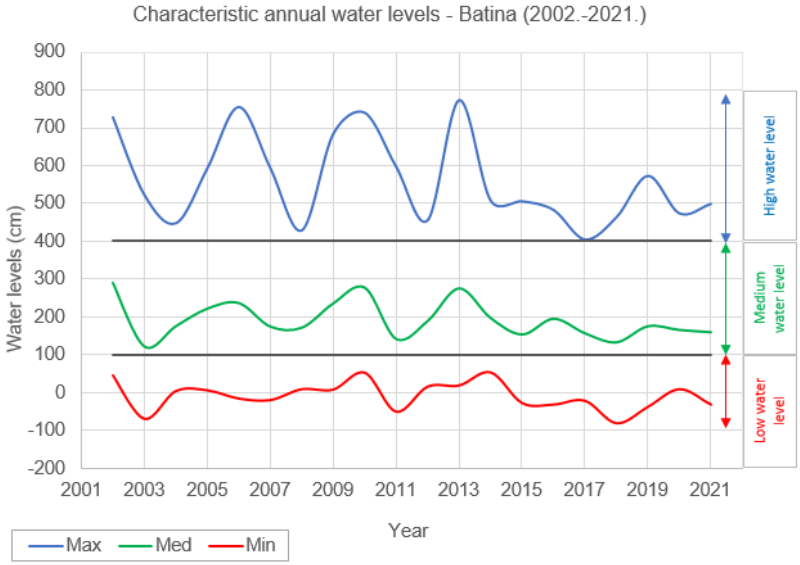


Figure 2.61. Display of a series of characteristic annual water levels of the Danube at the water measuring station Batina in the period from 2002 to 2021 with the display of high, medium and low water levels.

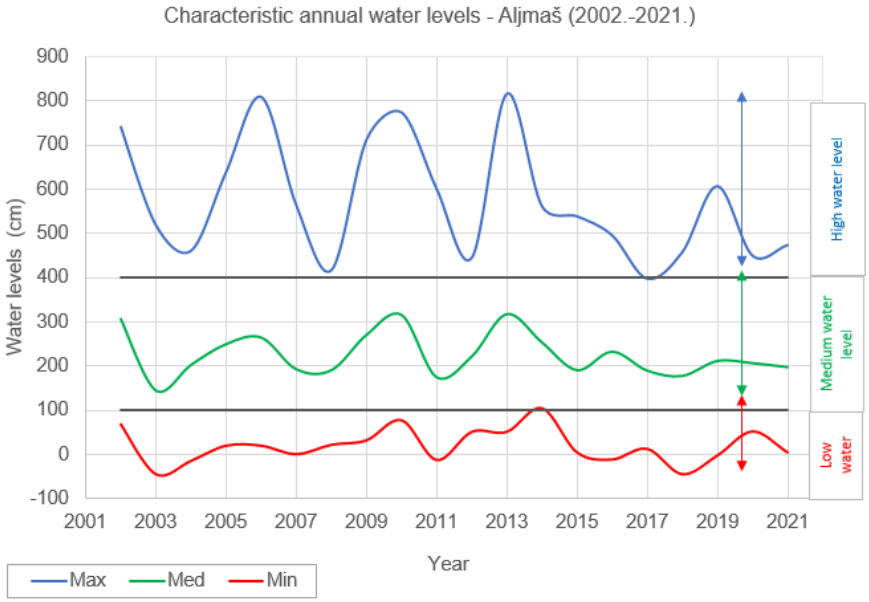


Figure 2.62. Display of a series of characteristic annual water levels of the Danube at the water measuring station Aljmaš in the period from 2002 to 2021 with the display of high, medium and low water levels.

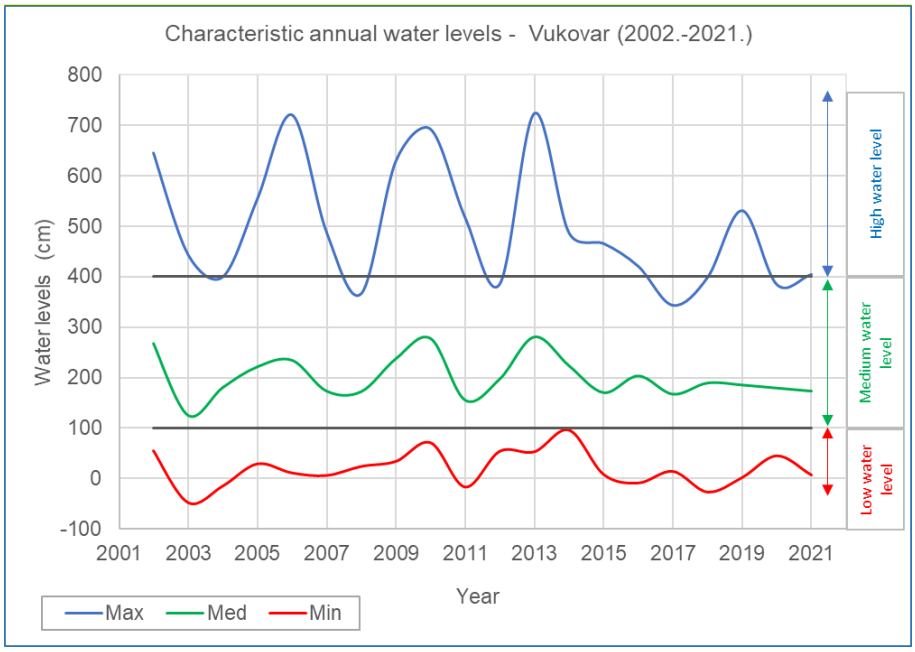


Figure 2.63. Display of a series of characteristic annual water levels of the Danube at the water measuring station Vukovar in the period from 2002 to 2021 with the display of high, medium and low water levels.

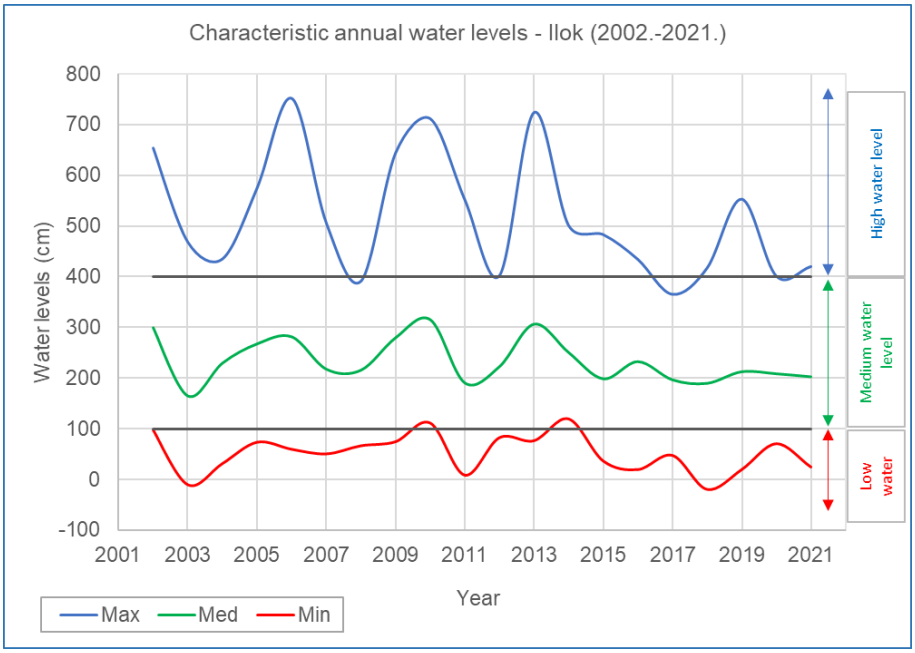


Figure 2.64. Display of a series of characteristic annual water levels of the Danube at the water measuring station Ilok the period from 2002 to 2021 with the display of high, medium and low water levels.

In accordance with the data processed above, to facilitate the monitoring of the water level, and all for the needs of field measurements, unique values (intervals) were selected for the

high, medium and low water levels of the entire area of the Danube River in question, from km 1433.1 (Batina) to km 1295.5 (Ilok):

- **Low water level < 100 cm**
- **Average water level from 100 cm to 400 cm**
- **High water level > 400 cm**

2.4 Environmental protection aspects

2.4.1 State of the water body in the subject area

Table 2.5. State of the Danube and Drava water bodies:

Water body	The length of the water body	Alteration	Ecological state	Chemical state	Total state
CDRI0001_001, Danube	88,2 km + 19,4 km	natural	very bad	good	**very bad**
CDRI0001_002, Danube	50,8 km + 26,6 km	natural	bad	good	**bad**
CDRN0002_001, Drava	29,5 km + 22,4 km	modified	bad	good	**bad**

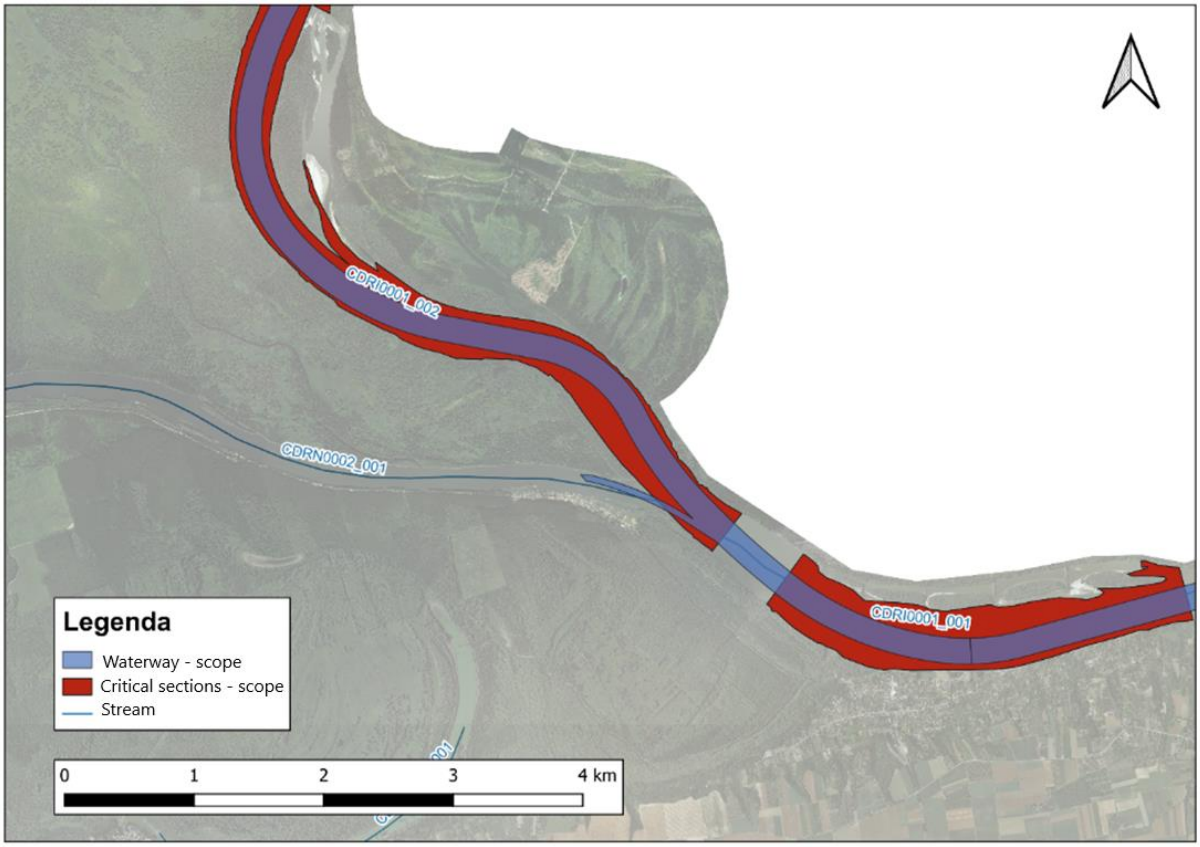


Figure 2.65. Water bodies in the project area.

2.4.2 Protected areas according to the Law of Nature Protection

Law on Nature Protection (OG 80/13, 15/18, 14/19, 127/19) defines nine categories of protected areas. The national categories correspond to the largest extent to one of the internationally recognized IUCN categories of protected areas (International Union for

Conservation of Nature). The reference database and the only official source of data on protected areas in the Republic of Croatia is the Register of Protected Natural Values. Data source: Ministry of Economy and Sustainable Development (2020): the web portal of the Information System of Nature Protection „Bioportal“ (http://www.bioportal.hr/gis/).

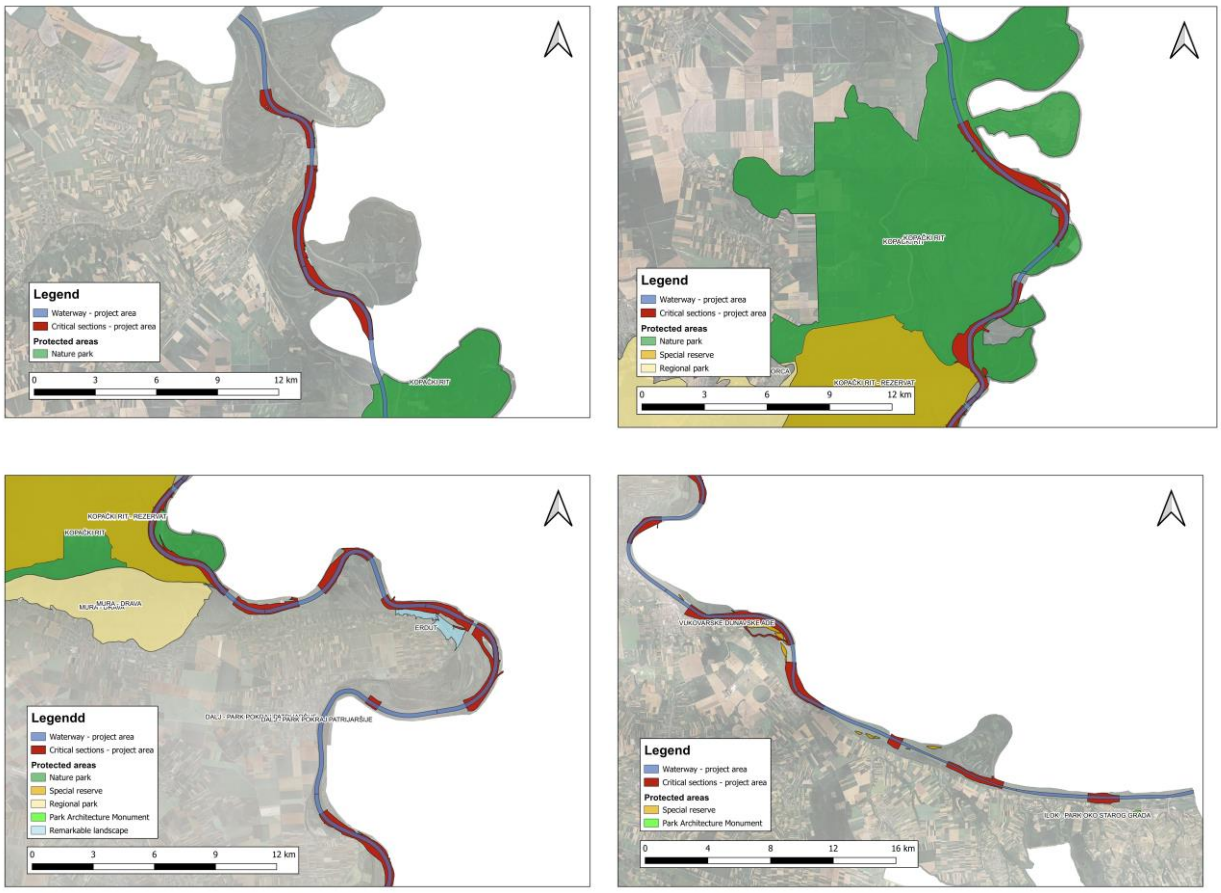


Figure 2.66. Protected areas under the Nature Protection Law.

Table 2.6. Protected areas in the area of the Danube River and the confluence of the Drava and the Danube:

Protected area	**Protection category**	**Description**
Kopački rit	Nature park	The Kopački rit nature park is a floodplain in Baranja, in the north-east of Croatia, between the rivers Danube in the east and Drava in the south. It was founded in 1976. The nature park has a total size of 17,700 ha (177 km^2), of which the Special Zoological Reserve covers 8,000 ha (80 km^2). Kopački rit is one of the largest fluvial-marsh plains in Europe.
Kopački rit – reserve	Special reserve	The southern part of the Park was declared a Special Zoological Reserve, and due to the importance of Kopački Rit as a habitat for a large number of birds, in 1986 it was included in the List of Important Ornithological Areas of Europe (IBA). Its international significance was additionally confirmed in 1993 by its inclusion on the List of Wetlands of International Importance in accordance

Protected area	**Protection category**	**Description**
		with the Ramsar Convention.
Mura – Drava	Regional park	On February 10, 2011, the Government of the Republic of Croatia passed the Decree on the Proclamation of the Mura-Drava Regional Park. This is also the first regional park in the Republic of Croatia. Its total area within all five counties it covers is 87,680.52 ha. The purpose of protecting the ecosystem of the Mura-Drava Regional Park is to preserve the natural types of habitats threatened at the national and European level, all taxa that inhabit them, the preservation of exceptional landscape values, geological heritage and cultural-traditional heritage.
Erdut	A significant landscape	It was protected in 1974, with a total area of 160 ha. The landscape is very endangered. Throwing plant waste leads to the withdrawal of trees and bushes and soil erosion, and such waste behaves like a compost site. The edge of the loess plain is threatened by arable land and vineyards located right next to the protected landscape. Heavy machines used for tilling the soil and collecting the harvest severely damage its integrity. Within the protected landscape are the Klifovo loess slopes, vineyards, a castle with a park and the remains of a medieval town.
Dalj – park near Patrijaršija	A monument of park architecture	It was protected in 1973. and its area is 1,21 ha. In addition to its horticultural value, it also has an important cultural and historical significance as well as its location. The area of the park is actually an elevated terrace of the Danube with a view of the river itself and Bačka.
Vukovarske Dunavske ade	Special reserve	The special forest vegetation reserve Vukovarska ada extends together with the islet of Daka on the left bank of the Danube opposite the city of Vukovar, and has been protected since 1989. in the Special Reserve. It is mostly covered by rite forests of black and white poplar, and partly by plantations of Canadian poplar, and beaches partially shaded by trees stretch along the banks of the Danube.
Ilok – park near Old town	A monument of park architecture	The park in Ilok was protected in the category of monuments of park architecture as early as 1973, as an area of great and rich cultural and historical significance for the town of Ilok and the area of today's Vukovar-Srijem County. It was decorated in the 18th and 19th centuries, but later the style was significantly changed. It is located on an elevated terrace above the Danube around the old town and the church.

2.4.3 Ecological network - Natura 2000 areas

Decree on the ecological network and competences of public institutions for the management of ecological network areas (OG 80/19) defines a list of species and habitat types whose preservation requires the designation of the area of the Ecological Network is established (reference list of species and habitats) including priority wild species and priority natural habitat types, expert criteria for determination of SCI and SPA, the criteria according to which the European Commission evaluates the SCI in terms of its importance for the European

Union, method of identification and list of SCI, SAC and SPA with the associated target species, i.e. habitat types of those areas, the way borders are displayed and the cartographic representation of SCI, SAC and SPA, and the way of displaying the zoning of all the mentioned areas about the distribution of target species and habitat types. Below is an overview of the Ecological Network areas that are located near the project area.

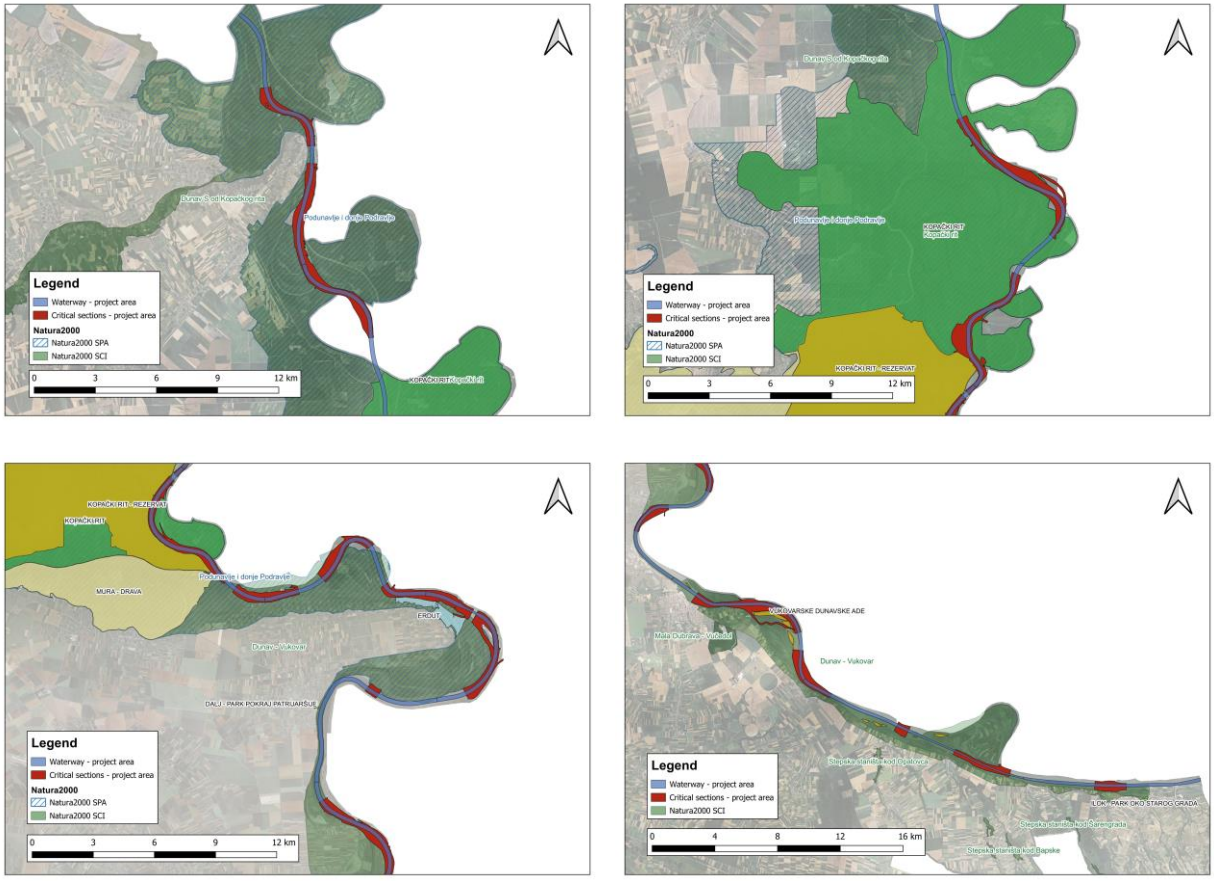


Figure 2.67. Natura 2000 ecological network on the project area.

Conservation goals and measures are prescribed by the Ordinance on conservation goals and conservation measures for target bird species in the areas of the Ecological Network (OG 25/20, 38/20). Conservation objectives for SCI are published on the Ministry's website (https://www.dropbox.com/sh/3r4ozk30a21xzdz/AADuvuru1itHSGC_msqFFMAMa?dl=0).

Table 2.7. List of ecological network areas in the subject area:

HR1000016	*Podunavlje i donje Podravlje*	***POP***	*https://interni.bioportal.hr/ekomreza/natura/report/site?site-code=HR1000016*
HR2001309	Dunav S od Kopačkog rita	***POVS***	*https://interni.bioportal.hr/ekomreza/natura/report/site?site-code=HR2001309*
HR2000394	Kopački rit	***POVS***	*https://interni.bioportal.hr/ekomreza/natura/report/site?site-code=HR2000394*
HR2000372	Dunav - Vukovar	***POVS***	*https://interni.bioportal.hr/ekomreza/natura/report/site?site-code=HR2000372*

2.5 Overview of legal regulations

2.5.1 Spatial-planning substrates

By analyzing spatial planning documents, it can be determined that in all valid spatial planning documents (both at the state and lower levels), which cover the area of the Danube River, great importance is attached to the arrangement of the waterway. The project in question is located in the area covered by the following spatial planning documents.

Spatial plan	Relevance to the document
SPATIAL PLAN OF THE COUNTY	
Spatial plan of Osijek-Baranja County (/02., 4/10., 3/16., 5/16., 6/16.-refined text, 5/20., 7/20.-refined text, 1/21 ., 3/21.-refined text, 16/22. and 1/23.)	- During the construction and arrangement of waterways in the County, it is necessary to maintain the high standard of the international VI. classes on the Danube waterway
Spatial plan of Vukovar-Srijem County (Official Gazette of Vukovar-Srijem County 07/02, 08/07, 09/07, 09/11, 19/14, 14/20, 22/21)	- River transport includes the Danube river waterway - During the arrangement and construction of waterways in the County, it is necessary to achieve the standard: international waterway on the Danube of VI-c class
SPATIAL PLAN OF THE MUNICIPALITY	
Spatial plan of the municipality of Draž (Official Gazette of the Municipality of Draž" number 3/05, 5/11, 9/14, 9/15, 4/18, 7/18-correction and 5/20-refined text)	- Maintenance and necessary reconstructions of the international waterway on the Danube River are planned
Spatial planning of the Municipality of Kneževi Vinogradi ("Official Gazette of the Municipality of Kneževi Vinogradi" No. 5/05, 5/06 - corrected, 5/09, 3/12, 14/12, 15/19, 9/ 20.-refined text, 14/20., 18/21.-refined text)	- Maintenance and necessary reconstructions of the international waterway on the Danube River are planned
Spatial development plan of the Municipality of Bilje (Official Gazette of the Municipality of Bilje" No. 8/05, 2/16, 8/16-correction, 9/16-refined text, 2/22 and 8/22-refined text)	- In the Plan, water management interventions are planned for the maintenance of the waterway on the Drava and Danube rivers
Spatial planning plan of the Municipality of Erdut (Official Gazette of the Municipality of Erdut" number 32/06, 45/09 - corrected, 52/12, 56/13 and 78/19)	- The waterway on the Danube is VI. class, and enables navigation of vessels and standard compositions throughout the year.
Spatial plan of the Municipality of Borovo (Official Gazette of the	- The Danube River is navigable along its entire course along the borders of the Municipality of Borovo

Spatial plan	Relevance to the document
Municipality of Borovo 05/04, 07/10, 03/13 04/16)	
Spatial plan of the City of Vukovar (Official Gazette of the City of Vukovar No. 01/06, 04/12, 11/15, 12/18)	- An international waterway on the Danube River has been designated by special regulations for the development of river traffic
Spatial plan of the Municipality of Lovas (Official Gazette)	- On the territory of the Municipality of Lovas, the Danube has a waterway - international (VIc class)
Spatial plan of the town of Ilok (Official Gazette)	- River traffic within the area of the City of Ilok refers to the international waterway on the Danube, VI. class with associated navigation safety facilities
SPATIAL PLANS OF AREAS OF SPECIAL CHARACTERISTICS	
Spatial plan of the area of special features PP „Kopački rit“ (NN24/06)	- In the area of limited use, the construction of regulatory buildings is allowed in order to maintain the waterway on the Drava and Danube rivers, as well as the technical and economic maintenance of watercourses, regulatory and protective buildings
Spatial plan of the area of special features of the multi-purpose Danube-Sava canal (NN 121/11)	- River buildings with associated buildings, plants and devices are existing river structures

2.5.2 The strategic documentation of the Republic of Croatia

An overview of strategic documents relevant to the arrangement of the waterway and the establishment of river traffic on the Danube River (adopted by the relevant authorities of the Republic of Croatia) is presented in follow table:

Strategy/program	Relevancy of the document
SPATIAL PLANNING DOCUMENTATION	
The Strategy of Spatial Planning of the Republic of Croatia (OG 76/13)	- need to build a technically equipped navigable river network and its inclusion in the new European system - for all significant interventions should be preceded by studies of overall economic justification and environmental impact studies, with foreseen measures to mitigate negative consequences.
Spatial Development Strategy of the Republic of Croatia (OG 106/17)	- characterization of river traffic - lack of an accepted long-term plan for the construction of harbours and waterways.
Spatial planning program of the Republic of Croatia (OG 50/99, 96/12, 84/13)	- Determining the status of border rivers and waterways with neighbouring countries and application of the general international laws on the use of inland waterways - When performing reconstructions or building new objects, interventions are to be performed according to the highest technological, economic and ecological criteria.
TRAFFIC AND NAVIGATION	

Strategy/program	Relevancy of the document
Traffic development strategy of the Republic of Croatia for the period from 2017 to 2030	River traffic is characterized by: - the disorganization of existing river facilities, primarily the existing waterways of the Sava and Drava river - lack of an accepted long-term plan for the construction of harbours and waterways - the incompleteness of the Sava-Danube canal project and the project for the arrangement of the Sava river waterway on the IV./V. class - the disorder of interstate relations in connection with the regime of navigation on the Sava and Danube.
Strategy for the development of river transport in the Republic of Croatia for the period from 2022 to 2032	The main priorities of inland navigation traffic are the establishment and maintenance of conditions for safe traffic on inland and international waterways, sector reorganization, development of international ports on inland waterways in accordance with international standards, and improvement of access to ports and their connections with other forms of transport. The strategy defines the goals and measures to be implemented in the next ten years that should result in a competitive and modern inland navigation system that will be integrated into the European transport network.
Medium-term plan for the development of waterways, harbours and wharfs of the Republic of Croatia for the period from 2022 to 2031	The medium-term plan defines operational plans for the development, arrangement and maintenance of waterways, the development of river information services and the development of ports and wharfs in the Republic of Croatia for nine years, in a manner aligned with the European and national regulatory and strategic framework, public policies and global development trends in the sector of inland navigation and transport in general. The difficulty in solving the bottlenecks of the waterway of the Danube River is represented by the interstate border between the Republic of Croatia and the Republic of Serbia on the common part of the waterway of the river.
Action Plan 2022 - 2024 for the implementation of the Medium-Term Plan for the Development of Waterways, Ports and Wharfs of the Republic of Croatia for the period from 2022 to 2031	The action plan for the period from 2022 to 2024 will provide a more detailed overview of measures and activities that will contribute to the achievement of special goals and ultimately the achievement of strategic goals defined by the Strategy for the Development of River Transport in the Republic of Croatia for the period from 2022 to 2032.
WATER	
Water management strategy **(OG 91/08)**	The transport strategy decided to strengthen more environmentally friendly forms of transport, i.e. rail, water and combined with insurance of: - good condition of the water - sufficient quantities of water of suitable quality for different forms of water - mitigating the harmful consequences in the environment caused by droughts and floods.
ENVIRONMENTAL AND NATURE PROTECTION	
National Environmental Protection Strategy (Official Gazette 46/02)	- Taking over international obligations in environmental protection - Defining trends in the field of environmental protection and necessary activities to improve the situation - Regional cooperation and encouragement of environmental protection development in the Drava basin.

Strategy/program	Relevancy of the document
National Strategy and Action Plan for the Protection of Biological and Landscape Diversity (Official Gazette 143/08)	- Valorization of the potential impacts of waterways on flora and fauna and wetland and water habitats - Ensuring the cooperation of the nature protection and river navigation sectors during the development of waterway development plans.
Strategy and Action Plan for the Protection of Nature of the Republic of Croatia for the Period from 2017 to 2025 (OG 72/2017)	This Strategy aims to preserve the diversity of living nature and to ensure its renewal in the territory of the Republic of Croatia. The goal is to maintain functional ecosystems and enable long-term sustainable development. It promotes the reduction of direct and indirect impacts on biodiversity and geodiversity, the sustainable use of natural resources, as well as the uniform distribution of profits arising from the use of genetic resources.

2.5.3 Overview of the laws of the Republic of Croatia

Law	Relevancy of the document
SPATIAL PLANNING AND CONSTRUCTION	
Law on Spatial Planning (OG 153/13, 67/17, 114/18, 39/19, 98/19)	The law defines: - Defining the basis of spatial arrangement in the territory of the Republic of Croatia - Monitoring of the situation in the space and area of spatial planning - Spatial planning conditions - Conditions for use (management), protection and management of the territory of the Republic of Croatia.
Law on Construction (OG 153/13, 20/17, 39/19, 125/19) **Regulation of the mandatory content of the conceptual project (OG 118/19,65/20)** **Regulation of mandatory content and equipment of building projects (OG 118/19,65/20)**	The law and regulations define: - The procedure for creating project documentation, environmental protection documentation and obtaining the necessary permits for construction - Arrangement and management of the construction site with the aim of environmental protection during the construction of the intervention.
Regulation on the determination of buildings, other interventions in the space and surface of state and regional (regional) significance (OG 037/14, 154/14,30/21,75/22)	The regulation defines: - Buildings of state importance are inland waterway buildings - ports and wharves on waterways of national significance, - international waterways with the associated facilities for navigation safety, - interstate waterways with associated facilities for navigation safety.
WATER	

Law	Relevancy of the document
Law of Water (OG 66/19, 84/21)	Law defines: - Water area of the river Danube - Planning documents for water management - Water area management plan - Status, construction, management, maintenance and authority over regulatory buildings. - The purpose of regulatory structures is capacity to defend against floods and ice, protection against erosion and establishment of navigation. - Use of water for navigation purposes.
Law on the financing of water management (OG 153/09, 90/11, 56/13, 119/15, 120/16,127/17,166/19)	Law defines: - The construction of regulatory and protective water structures is financed from the income from the water contribution.
Regulation of water quality standards (OG 96/19,20/23)	Regulation defines: - water quality standards for surface waters, including coastal waters and waters of the territorial sea, as well as groundwater - deadlines for achieving water environment protection goals - criteria for evaluating the state of water - monitoring of the water condition - classification of water conditions - standard of water quality.
Decision on the List of Waters of the First Order (Official Gazette 79/10)	Decision defines: - According to this decision, the Danube River belongs to INTERSTATE WATERS and natural waterways.
State flood defence plan (OG 84/10)	Plan defines: - The plan defines the planning and implementation of construction, reconstruction and extension of protective and regulatory water structures in the capacity of defence against floods and ice.
Draft Water Area Management Plan 2022 - 2027 (Croatian waters)	The plan defines: - The Water Area Management Plan 2022 - 2027 was prepared on the basis of the Water Act (Official Gazette, No. 66/19 and 84/21), which prescribes: Water Management Planning Documents (Article 37), Water Area Management Plan (Article 39) and Flood Risk Management Plan (Article 127). - Appendix I. Analysis of features of the water area of the Danube River is an integral part of the Water Area Management Plan 2013-2015 in the Republic of Croatia. The document prescribes an analysis of the features of the water area of the Danube River, an overview of the impact of human activity on the state of surface waters, including groundwater, as well as an economic analysis of water use. - In this document, the Danube River is defined as an international waterway VI.c. navigability class rkm 1295+500 – rkm 1433+000.
NAVIGATION	
Law on Navigation and Ports of Inland Waters (OG 144/21)	Law defines: - Navigation conditions on inland waters - Waterways, classification and maintenance conditions of waterways - Navigation rules and technical specifications of the vessel - Jurisdiction over waterways and the Port Authority.
Rulebook on technical maintenance of waterways (OG 62/09, 136/12, 41/17, 50/19)	Rulebook defines - tasks of technical maintenance of waterways and includes the following tasks maintenance of the depth of waterways and maintenance of navigation safety facilities for technical improvement of navigation conditions.

Law	Relevancy of the document
Rulebook on navigation on inland waters (OG 138/08 08/10, 74/10, 08/11, 39/12)	Rulebook defines: - marking of waterways - marking of the vessel - technical specifications of the vessel - water protection measures against pollution from vessels.
Rulebook on classification and opening of waterways on inland waters (OG 77/11, 66/14, 81/15)	Rulebook defines: - the Danube River in the section from rkm 01295+500 (Ilok) to rkm 1433+000 (Batina) as an international waterway of the inland waters of the Republic of Croatia of the VI.c navigability class.
ENVIRONMENTAL AND NATURE PROTECTION	
Law on Environmental Protection (OG 80/13, 78/15, 12/18 118/18)	Law defines: - fundamentals of environmental protection - handling in the case of transboundary impacts - participation and public information.
National Environmental Action Plan (OG 46/02)	Plan defines: - integration of environmental protection in other sectors - establishment of complete monitoring and a unique information system.
Law on Nature Protection (OG 80/13, 15/18, 14/19, 127/19)	Law defines: - protection of individual areas, habitats and species - determining the categories of protection of individual areas - defining the performance of interventions in the protected area - the procedure for determining compensatory conditions that are determined to mitigate or replace foreseeable damage to nature.
Regulation on the ecological network and the competencies of public institutions for the management of ecological network areas (OG 080/19)	Regulation defines: - areas of the national ecological network and guidelines for protection measures of ecological areas.
Rulebook on the list of habitat types and habitat map (OG 027/21)	Rulebook defines: - It provides a cartographic representation of habitat types and measures to preserve habitat types.
AIR	
Law on Air Protection (OG Gazette 127/19, 57/22)	The law defines the Prevention and reduction of air pollution is implemented: - - by applying the air protection measures established in the act on environmental impact assessment or the permit issued under a special regulation for a specific operation, during the design, construction and use of air pollution sources from Article 8, paragraph 2 of this Law - - by applying the air protection measures determined in the permit issued according to a special regulation, if the obligation to assess the impact on the environment is not prescribed for a specific intervention.

2.5.4 Overview of EU Directives and international conventions

Directive / International convention	Relevantnosti za dokument
NAVIGATION	
Danube strategy (24.06.2011)	Main goals of the strategy: - The connection of the Danube region - Environmental Protection - Building prosperity - Strengthening of institutional capacity and security in the Danube region.
The Law of Confirmation of the European Treaty on Main Inland Waterways of International Importance (AGN) (19.01.1996)	Accessing AGN governments commit themselves to the development and construction of their inland waterways and ports of international importance in accordance with the unique conditions agreed upon within their investment programs. The treaty emphasizes the importance of inland waterways transport, which, compared to other modes of inland transport represents economic and ecological advantages and therefore can contribute to the reduction of traffic congestion, traffic accidents and negative environmental impacts in the pan-European transport system. The AGN includes the technical and operational characteristics of E-ports, which stipulate that devices for the processing of waste, collected on vessels to ensure environmental protection, should be available in ports of international importance.
European Agreement on the International Carriage of Dangerous Goods by Inland Waterways (ADN) (26.05.2000)	The agreement defines: - technical requirements for the international transport of dangerous substances and articles in packages and bulk on inland waterway vessels and tankers, as well as unique provisions related to the construction and functioning of such vessels. - international requirements and procedures in terms of inspection, issuance of approval certificates, recognition of classification societies, supervision and training, and expert examination.
Convention on the collection, disposal and reception of waste generated during navigation on the Rhine and other inland waterways	The convention provides a classification of individual types of waste generated in inland navigation, divided into basic categories: - waste generated by the operation of the vessel: waste and wastewater generated on the vessel as a result of the operation and maintenance of the vessel; - oily and greasy waste resulting from the operation of the vessel: used oil, bilge water and other oily or greasy waste, such as used grease, filters, used rags and containers and packaging of such waste; - bilge water: oily water from the engine room, bilge; - other waste generated by the operation of the vessel: domestic waste, water, cleaning waste, residues and other special waste; - cargo-related waste: ship-generated waste and wastewater resulting from cargo. The convention also established a specific method of payment for the disposal of waste from vessels in such a way that the acceptance and disposal of waste are paid for through a universal fee when fueling the vessel.

Directive / International convention	Relevantnosti za dokument
Convention on the Navigation Regime on the Danube	The convention is an international legal instrument that regulates navigation on the Danube. and enables free navigation on the Danube in accordance with the interests and sovereign rights of the parties to the Convention. The primary tasks that fall within the Commission's competence include: - supervision of the implementation of the Convention provisions; - preparation of the general plan of the main works mentioned in the interests of navigation based on the proposals and projects presented by the member states and special river administrations and preparation of the cost estimate of such works; - consulting with Member States and making recommendations regarding the execution of the above-mentioned works, taking into account the technical and economic interests, plans and possibilities of individual states.
Convention on Cooperation on the Protection and sustainable use of the Danube River	The Convention constitutes the entire legal instrument for cooperation and transboundary water management in the river basin. The main objective of the Convention on the Protection of the Danube River is to ensure that surface and underground waters in the Danube River basin are managed and used sustainably and equitably, which includes: - preservation, improvement and rational use of surface and underground waters; - preventive measures to control hazards arising from accidents involving floods, ice or dangerous substances; - measures to reduce the entry of pollution from the Danube River basin into the Black Sea.
WATER	
Joint declaration on the guiding principles for the development of inland navigation and environmental protection in the Danube River basin (12.2007/01.2008)	- Define and ensure IWT prerequisites and objectives, as well as ecological integrity of rivers/floodplains, followed by consideration of the need to prevent deterioration, possible mitigation and/or restoration measures to achieve all ecological requirements - Ensure that there are no more technically feasible, environmentally better, and not disproportionately more expensive alternative means to achieve the set goal, in accordance with the requirements of Article 4(7) EU WFD - Try to avoid or, if this is not possible, minimize the impacts of structural/hydro-technical interventions in the river system through their mitigation and/or restoration, giving preference to reversible interventions - The use of best practice measures to improve navigation. "Working with nature" wherever possible, by implementing measures in accordance with the given natural river-morphological processes following the principle of minimal or temporary engineering intervention - Integral design of regulation facilities, taking into account hydro-technical, morphological and ecological criteria.
Danube River Basin Management Plan 2009-2015 (10.12.2009)	Take measures to improve the state of river continuity and reconnection of floodplains and wetlands. Take measures to improve the status of water bodies that are under the negative influence of significant hydrological modifications at the level of the entire basin

Directive / International convention	Relevantnosti za dokument
Convention on Cooperation in the Protection and sustainable use of the Danube River (29.06.1994)	The signatory countries will develop, adopt and apply relevant legal, administrative and technical measures and provide prerequisites and foundations for effective water quality protection and their sustainable use. The following activities and measures, planned or in progress, are subject to this Convention, to the extent that they cause or may cause transboundary consequences: - planned activities and measures in the area of waterworks, especially regulatory works, as well as the influence of objects located on or next to the watercourse on its water regime - prevention of environmental impacts including worsening of hydrological conditions, erosion, abrasion, flooding and sediment transport; ecosystem protection measures.
Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki) and the corresponding Protocol on Water and Health (17.03.1992)	The parties must cooperate in carrying out research and developing effective procedures for preventing, controlling and reducing transboundary consequences. For this purpose, the parties should, on a bilateral and/or multilateral basis, taking into account the research conducted by international forums, try to initiate or accelerate specific research programs, aimed, among others, at: - development of ecologically safe water structures and regulation methods.
European Union Water Framework Directive (2000/60/EC, 2455/2001/EC, 2005/646/EC)	Defines the following principles: - Integrity: the entire water system, i.e. the Danube River basin, should be taken into account - Integrated approach: the water system functions in connection with other sectors, such as in this particular case navigation, spatial planning, environmental protection, tourism and recreation - Transparency: it is necessary to ensure the participation of the public and consultation with all interest groups. - Economic approach: to ensure the economy of measures and efficient use of water through appropriate financial instruments. - Ecological approach: the overall goal is to achieve a good quality of the water body. This includes a good ecological status defined through extensive biological monitoring.
Directive of flood risk assessment and Management 2007/60/EC	- Establishing a framework for flood risk assessment and management to reduce the harmful consequences of floods in the Community for human health, the environment, cultural heritage and economic activity. - Preliminary flood risk assessments - Maps of flood risk and flood risk maps - Flood Risk Management Plans.
Directive of underground water 80/68/EEC, 2006/118/EC	Establishing special measures to prevent and control groundwater pollution: - Criteria for evaluating the good chemical composition of groundwater - Criteria for establishing and reversing significant and persistent upward trends - Preventing and limiting the introduction of pollutants into groundwater.
Directive on integrated pollution prevention and Control 96/61/EC	Achieving integrated pollution prevention and control. Measures that prevent and/or reduce emissions into air, water and soil. Implementation of a high level of protection from the environment.
Directive on the quality of water for fish and shellfish life, 78/659/EC, 79/923/EC, 2006/44/EC, 2006/113/EC	Protection and improvement of the quality of flowing and stagnant waters used for intensive fish and shellfish farming and the life of native freshwater fish and shellfish.

Directive / International convention	Relevantnosti za dokument
Directive on the conservation of birds living freely in nature 79/409/EC	Preservation of all bird species that appear naturally in the wild on the European territory of the member states. It includes the protection, management and control of these species and determines the rules for their exploitation.
Directive on the preservation of natural habitats and wild flora and fauna 92/43/EEC	A series of measures necessary to maintain or restore natural habitats and populations of wild flora and fauna.
ENVIRONMENTAL AND NATURE PROTECTION	
Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus 1998.)	All interested parties should be informed about the activities of the environmental impact assessment study: - legal entities that carry out activities in the area of impact of the project - government and non-government organizations - involve the public through the implementation of a public review as part of the environmental impact assessment procedure - make data from project documentation and studies available.
Convention on environmental impact assessment across national boundaries (Espoo 1991.)	Application of the Espoo Convention during the Preparation of the Conceptual Solution: - Notice to affected states - Confirmation of the affected state that it wishes to participate in the EIA procedure - Transfer of information from the country of origin of negative influence - Participation of the public in both countries - Preparation of documentation for EIA - Distribution of EIA documentation to competent authorities and the public of the affected country - Consultations between countries - Final decision - Issuance of documents with the final decision - Post-project analyses.
United Nations Convention on Biological Diversity (Rio de Janeiro 1992.)	Parties undertake to adopt national strategies, plans or programs for the protection of biological diversity and sustainable use of natural resources. In 1999, the Republic of Croatia passed its own National strategy and action plan for the protection of biological and landscape diversity (NSAP) in which she outlined the necessary actions to implement the Convention.
Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (Ramsar 1971.)	Assess the possible impact of the project in question on the area of Kopački rit and, accordingly, determine measures for protection and prevention of negative impact on this area. It is also recommended to propose alternative ways of achieving the goals of the regulatory interventions, i.e. alternatives to their construction if it is determined that a negative impact is possible during the use or construction of the intervention.
Convention on the Protection of European Wild Species and Natural Habitats (Berns Convention 1979.)	It is necessary to assess the impact of regulatory actions on the areas of the ecological network about the objectives of preserving the ecological network defined by the Decree on the Proclamation of the Ecological Network of the Republic of Croatia (OG 109/07) and per the opinion issued by the Ministry of Culture on the need to carry out the main evaluation of the project. The Ministry of Culture will decide on the acceptability of the intervention based on an assessment of the impact of the intervention on the area of the ecological network and proposed protection measures.

Directive / International convention	Relevantnosti za dokument
Convention on the Protection of Migratory Species of Wild Animals (Bonn Convention 1979.)	The signatories of the convention confirm the importance of the protection of migratory species and the agreement of the countries of the distribution area to act with this goal whenever possible and appropriate. The Kopački rit Nature Park, which provides a habitat for numerous migratory species, is located in the area of the proposed project, and it is necessary to take appropriate and necessary measures to preserve this habitat.
EU Directive on ensuring public participation in the Creation of certain plans and programs related to the Environment 2003/35/ EC	Predviđa public participation in the creation of certain plans and programs related to the environment, changes and additions due to public participation and access to justice.
EU Directive on the Assessment of the Effects of certain plans and Programs in the Environment 2001/42 EC	Ensuring a high level of environmental protection and contributing to the inclusion of environmental issues and the creation and adoption of plans and programs aimed at encouraging sustainable development.
EU Directive on public access to environmental information 2003/4/EC	Guaranteed right to access information about the environment, which is stored by or for public authorities, and determination of basic terms and conditions. Information about the environment is gradually becoming more available and widespread to the public, to achieve the greatest possible systematic availability and dissemination of environmental information in the public.
EU Directive on environmental responsibility and regarding the prevention and elimination of environmental damage and amendments to Directives 2004/35/EC, 2009/31/EC	Prevention of environmental damage in the observed area.
Ecological network NATURA 2000 (in accordance with EU directives on birds and habitats)	Defines areas important for the conservation or establishment of a favourable state of endangered and rare habitat types and/or wild taxa at the European and national levels. As part of the process of accession to the European Union, the Republic of Croatia has fully implemented the Natura 2000 ecological network).
EU Biodiversity Strategy until 2030.	The strategy addresses the five main drivers of biodiversity loss, sets out an improved management framework to fill remaining gaps, ensures full implementation of EU regulations and links all current efforts. This strategy is enterprising and encourages a positive spirit and action. It takes into account the fact that for the protection and restoration of nature, it will not be enough just to pass regulations.
AIR	
Directive on ambient air quality and cleaner air for Europe 2001/81/EC 2008/50/EC	Setting legally binding and non-binding limits for certain air-dispersed pollutants at the European Union level.
Directive on environmental air quality assessment and management 92/62/EEC, 1999/30/EC, 2000/69/EC, 2002/3/EC	Air quality control measures and instruments for enabling the successful implementation of the prescribed air quality measures.

2.5.5 Documentation concerning navigation and environmental protection

Document	Applicability of the document for the implementation of project in question
Manual of good practice in sustainable planning of waterways (PLATINA 3)	PLATINA manual is a manual that provides good practice guidelines for planning and managing projects to improve navigation on inland waterways. It contains, among other things: - Practical guidelines for the management of waterways in compliance with the principles of environmental protection. - Process of integral planning of waterways. - River ecology basics. - EU legislation in the field of navigation and environmental protection. - Examples of good practices of environmental river engineering on waterways. PLATINA manual was created as part of the EU NAIADES action plan, which is an initiative of the EU Council to improve navigation conditions in inland waterways as part of intermodal transport in the EU to ensure a sustainable and environmentally acceptable network of transport corridors.
Action plan NAIADES III	The main goals of the plan are to move more cargo across European rivers and canals and to facilitate the transition to zero-emission barges by 2050. The Action Plan also includes measures to accelerate and encourage investment in the development and introduction of innovative zero-emission and waste-free technologies for inland waterway vessels and ports and to help the sector continue with digital development.
Luxembourg Declaration on effective maintenance of waterway infrastructure on the Danube and its navigable tributaries (2012.)	The declaration expresses the intention of the countries of the Danube region to improve the conditions of navigation on the Danube River. The countries of the Danube region, signatories to this declaration, are committed to: - regular maintenance of the waterway, - compliance with the obligations undertaken by signing the AGN Agreement, taking into account environmental protection, - cooperation with other countries on waterway maintenance, - establishing a system of communication about the state of the used road, - monitoring of the implementation of activities on waterway maintenance - participation in the Danube Region working group and - active participation in the meetings.
EU Action Plan - Strategy of the European Union for the Danube Region, 2011.	This strategy aims to resolve the issue of uneven socio-economic development and insufficient investment in infrastructure in the Danube region. Many of the region's problems do not have borders - floods, transport and energy connectivity, environmental protection and security challenges require a unique approach. Ecological problems are particularly urgent because of the need to protect biological diversity and cultural heritage. In the field of transport, the strategy proposes the improvement of waterways and the establishment of an intermodal transport system. In the area of environmental protection, the strategy aims to re-establish and preserve water quality, manage environmental risks; and the preservation of biodiversity, landscape and air and soil quality

Document	Applicability of the document for the implementation of project in question
Manual "Assessments of the impact of plans and projects that significantly affect Natura 2000 areas - Methodological guidelines for the application of Article 6(3) and (4) of the Habitats Directive 92/43/EEC" and the Red Book (freshwater fish, birds, mammals, dragonflies, amphibians and reptiles, vascular flora)	The document was created to provide non-obligatory methodological assistance in the preparation of the impact assessment of interventions on the ecological network Natura2000 according to the Habitats Directive. The document describes the steps necessary for an adequate impact assessment, which include: - Screening (assessment on the need for assessment) - Preliminary or main evaluation of the impact on the ecological network - Alternative solutions analysis - Proceedings in the case when there are no alternative solutions and where significant impacts are possible, regardless of the proposed protection measures - Definition of compensation measures
Guidelines on Inland Waterway Transport and the Natura 2000 Network (European Commission, 2018)	These guidelines deal with aspects of planning and management of waterways about conservation measures and objectives of protected areas, and include chapters: - European Union legal framework - Importance of the river ecosystems - An integrated approach to the implementation of waterways improvement projects - Assessment of the impact on the environment and protected areas - Connections between EU directives - Overview of Natura 2000 areas along the river courses - Overview of Inland waterways
Manual "DanubeParks" Strategy for the preservation of protected areas and development of inland navigation", Vienna, 2012	The goals of the DanubeParks strategy are: - Assessment of the existing situation on the Danube River regarding the development of river transport and environmental protection - Defining specific requirements in the area of environmental protection and waterway development - Strengthening of capacities necessary for carrying out the process of integral planning - Analysis of available ways of harmonizing needs between environmental protection and navigation The Danube Parks strategy deals with: - An overview of the existing spheres of interest in the wider area of the Danube River, including the need for navigation and environmental protection - Needs for development of the Danube River and the Danube region - The application of available practices and tools for the integration of inland waterways and environmental protection - Active projects on the Danube
Manual "Inland waterway transport along the backbone of Europe - the Danube river. Impacts, threats and opportunities", WWF, 2002.	The aim of this manual is to analyze whether and in what way it is possible to develop sustainable navigation on the Danube River while preserving river ecosystems. This manual is divided into two parts: **River ecosystem,** which provides a description of the Danube River ecosystem by sections, the impact of navigation on ecosystems, and case studies of areas where there are significant conflicts between these two spheres of interest; and the second part **The needs of river transport,** which provides a description of navigation development trends, legal and legal frameworks, the status of the development of active projects and innovative solutions for the development of navigation in an environmentally friendly way.

Document	Applicability of the document for the implementation of project in question
Schwarz U. & Mohl A. (2009) "Drava-Mura Framework 2009-2020. Plan for the Protection and Revitalization of the Drava and Mura Rivers. WWF/Euronatur	The Drava and Mura River protection and revitalization plan presents the ecological values, international importance and protection status of these rivers. Furthermore, the document deals with historical data on the impact on river ecosystems through the construction of regulatory structures, sediment extraction and other interventions in the area. The document lists concrete examples and their impacts on the environment. In the following, the plan provides an analysis of the possibility of developing river transport in the future, along with examples of good practices in the maintenance of inland navigation and management of river ecosystems.
Schwarz U. (2013) Assessment of river and floodplain revitalization possibilities in the transboundary UNESCO biosphere reserve "Mura-Drava-Danube", WWF, Vienna.	This document deals with the possibilities of the revitalization of river ecosystems and the inundation belt in the area of the cross-border Mura-Drava-Danube reserve. In addition to the exceptional values of this area, for which it was declared a UNESCO reserve, this area is facing a reduction in the biodiversity of natural habitats and the loss of protected species. Revitalization possibilities can be divided into three groups: - minimum short-term revitalization potential – removal of existing revitalization buildings and connection of backwaters with the main river flow, - the maximum long-term potential of revitalization – expansion of the inundation zone/floodplains and - mid-term revitalization potential – defining priorities in floodplains outside the defensive dikes for reconnection with the main riverbed. The document analyzes the possibilities mentioned above in the area of the reserve and the possibilities of concrete application of these measures.

2.5.6 Conclusion on legal framework

In the last twenty years, river transport in the Republic of Croatia has lagged in development, especially compared to European parameters of river transport. At the moment, this segment of the transport infrastructure is not used enough, which is mainly due to the neglect of the waterway state and the difficulties in applying interstate agreements on the use of border rivers.

River traffic is currently active only on the Danube River, with small activity on Drava and Sava Rivers. However, navigable rivers in Croatia are not sufficiently regulated, that is, they are mostly in a natural (unregulated) state. There are numerous local bottlenecks, sharp turns with small navigable widths, shoals of insufficient depth and collapsed banks.

The stagnation or even decline of river traffic and its infrastructure in the last two decades is also reflected in the fact that Croatian river shipping infrastructure is technologically outdated. The neglect of river traffic is also reflected in the insufficient number, construction and equipment of river wharfs, ports and mooring places.

Rivers, apart from commercial use, also enable the development of river (nautical) tourism. Based on the analysis of the current situation as well as the analysis of spatial plans, legal regulations and strategic documents, it can be stated that initial steps in the development of river tourism as well as in the possibility of development have been made.

With transport development, it is necessary to evaluate and define future measures in the transport sector related to international and internal transport in all transport segments, taking into account European strategies and requirements (TEN-T, ERTMS, TSI,

environmental protection, climate protection and other general objectives) and be based on a comprehensive analysis of the situation and specific goals. As a result, it is necessary to reduce the impact of the transport system on climate change, reduce the impact of the transport system on the environment and increase the safety of the transport system with the additional goals of exploiting the potential of inland waterway navigation in the tourism segment, adapting the navigability conditions to traffic needs and preserving the necessary navigability level (if possible and improving the level of navigability by removing bottlenecks on waterways).

2.6 Traffic substrates

A waterway (fairway) is an area of inland waters of a certain depth width and prescribed dimensions that are arranged, marked and open for safe navigation. It is defined by the navigable trough and the turning radius at low navigable water level (LNWL) and free gauges under bridges and overhead cables under high navigable water levels (HNWL).

- LNWL – is the water level determined based on a statistical calculation of the durability of the water level from a 30-year timeline on ice-free days, and it corresponds to the water level of 94% durability (defined by the Danube Commission).
- HNWL – is the water level determined based on the statistical calculation of the durability of the water level from a 30-year timeline on ice-free days, and it corresponds to the water level of 94% durability (defined by the Danube Commission)

Based on Article 135, Paragraph 6 of the Law of Navigation and Inland Water Ports OG No. 144/21) the Minister of the Sea, Transport and Infrastructure gave out the Rulebook on classification and opening of waterways on inland waters (OG 77/11, 66/14 and 081/15). This Ordinance classifies and opens the waterways on the internal waters of the Republic of Croatia according to the navigability standards determined by international agreements for international and interstate waterways and the standards established by the Regulation on determining the standards of waterways for determining the navigability on waterways.

Table 2.8. Class of the waterway of the Danube River (source: Rulebook on classification and opening of waterways on inland waters OG 77/11, 66/14 and 081/15):

River	**Type of waterway/river section**	**Length of the waterway (km)**	**Waterway class**
INTERNATIONAL WATERWAYS			
DANUBE	1295+500 (Ilok) - 1433+000 (Batina)	137,50	VI.c class

Level of Service (LOS)

The depth of waterway 2.5 m at low navigable water level, i.e. for 94% (343 days) of the year is determined based on a statistical calculation of the durability of the water level from a 30-

year timeline on ice-free days. The width of the waterway is between 80 and 100 m in Croatia, Serbia, Romania and Bulgaria (including border areas).

The level of service describes a certain depth and width of the waterway,

- Level of service 1 (LoS1): deep channel of the waterway for pushable composition, as provided by the corresponding class of the waterway, moving downstream in one-way traffic (Defined in the Master Plan for the Rehabilitation and Maintenance of the Danube River Waterway and its Navigable Tributaries)
- Level of service 2 (LoS2): for a pushed composition, as provided by the appropriate class of waterway, moving downstream and passing one vessel moving upstream
- Level of Service 3 (LoS3): two pushed formations passing each other as provided by the appropriate waterway class

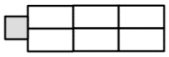
Table 2.9. Service levels and vessel schedule:

Service level	***Vessel schedule***	***Opis***
LOS 1		a pushed formation of 4 units moving downstream in one-way traffic
LOS 2		a pushed formation of 4 units moving downstream and passing one vessel moving upstream
LOS 3		two pushing formations of 4 units passing each other

The general definition of traffic elements of inland waterways in Europe is given by the UN/ECE classification of waterways from 1992 in the form of a recommendation of the Committee for Inland Transport, UN Economic Commission for Europe. The classification defines only the size of the vessel and the composition for each of the VII classes of waterways.

According to this classification, the following vessel characteristics are relevant for the Danube River:

Table 2.10. Vessel size and composition for VI.c class of waterway (source: UN/ECE classification of waterways, 1992):

Inland waterway class	Motorized vessels and barges (basic characteristics)				Push convoy (basic characteristics)					The space under the bridges
	max. length L (m)	max. width B (m)	draft d (m)	capacity T (t)	formation	max. length L (m)	max. width B (m)	draft d (m)	capacity T(t)	
VI c (Dunav)						270-280* 195-200*	22,80 33,00-34,20*	2,50-4,50	9800-18000 9600-18000	9,10**

**The first number reflects the current situation, while the second takes into account future developments as well as, in some cases, the current situation.*

***Based on the maximum permitted length of vessels and tug-barge combinations, some waterways may be classified as Class VI, although their maximum width is 11.40 m and maximum draft is 4.00 m.*

The following parameters are used to define the route of the waterway:

- waterway class,
- vessels and fleet,
- navigable dimensions and minimum radius:
  - the draft of the vessel and the depth of the waterway,
  - the width of the vessel and the waterway,
  - fairway bend radius.
  - navigable dimensions,
  - the height of the free profile under the bridges,
  - speed of navigation,
  - navigable water levels.

The relevant dimensions of the waterway were selected according to the recommendations of the Danube Commission from 1988 and the UN/ECE classification from 1992. and the AGN Agreement from 1996.

The minimum depth of the waterway on the section with free flow amounts is:

- d_{min} = 2.5 m,

, and on the section with deceleration

- d_{min} = 3.5 m.

The minimum width of the waterway on the section with the free flow is:

- on section with an unstable river bed B_{min} = 180 m

- on section with a stable river bed B_{min} = 100 m
- shallows with an unstable river bed B_{min} = 150 m
- on a section with an unstable river bed < 4000 m B_{min} = 200 m

  on the section with a slowdown
- with an increase of up to 200 m in the turn B_{min} = 180 m

The minimum radius of the waterway amounts to:

- R_{min} = 1000 m
- Exceptionally, it is allowed on morphologically unsuitable sections R_{min} = 750 m.

Annex III. The European Agreement on Main Inland Waterways of International Importance (AGN) stipulates that E-waterways must meet the most basic requirements of the prescribed class (IV.-VII.), which refer to: minimum vessel dimensions (length and width), minimum height under bridges, it is necessary to ensure the prescribed draft of the vessel, which is reached or exceeded for an average of 240 days a year (or 60% of the navigation period), to ensure the minimum water level. According to the same, each E-port must meet the prescribed technical and operational criteria.

The acceptance of the new classification of waterways in Europe in recent decades is caused by a change in the application of technologies in inland navigation, which is reflected in the switch from a towing system to a pushing system. In modern water traffic, propulsion technology prevails, based on propulsion assemblies that are created from modular units, i.e. from one or more tightly connected thrusters and one pusher. The principle for the new classification is the size of the rigid propulsion system, while for the old classification it was the carrying capacity of cargo vessels. In rigid push systems with a length of 100 to 300 m, the width of the waterway is significantly greater than in the towed system, which required the determination of new criteria for the evaluation of existing and the design of new waterways.

The new classification establishes the sizes of water systems, and designers are expected to, on the basis of knowledge and acceptance of the postulates of the profession, shape detailed parameters themselves, adapting them in a wide range to the local conditions of riverbeds and natural features of the route of water channels, i.e. internal waterways.

The new classification of inland waterways of international significance includes the following basic technical principles of European waterways:

- The class of the waterway will be determined according to the horizontal dimensions of motor vessels, barges and propulsion systems, and according to standardized dimensions, i.e. their greatest width.
- Only waterways that meet at least the most basic Class IV requirements (minimum dimensions of the vessel 85 m x 9,5 m) can be considered European waterways.

- During the modernization of waterways of class IV (as well as smaller regional waterways), it is recommended to satisfy at least class Va (or higher category, if possible).
- However, new European waterways must meet the requirements of class Vb. In this sense, it is necessary to provide the smallest draft of 2,80 m.
- When modernizing current waterways and/or building new ones, one should always take into account the size of the vessels and the compositions of larger sizes.
- To ensure more efficient container traffic, the free heights under the bridges must be foreseen with 5,25 m for 2 rows of containers, 7 m for 3 rows of containers and 9.10 m for 4 rows of containers.
- On free-flowing waterways, the recommended draft value should correspond to the draft that is reached or exceeded during an average of 240 days per year.
- The same grade, draft and height under bridges should be ensured either along the entire waterway or at least on its most important parts.
- The biggest draft of the vessel (4,50 m) and the smallest free height under the bridges (9,10 m) should be provided on all parts of the network that are directly connected to the coastal routes
- At least 7 m of free height under bridges must be ensured on waterways that connect important seaports with the hinterland., which are suitable for container traffic and river-sea traffic.

According to the Economic Commission for Europe of the United Nations, the inland waterways of Europe are classified into seven classes depending on the dimensions and carrying capacity of the vessels and pushable compositions that can navigate unhindered. It should be noted that in Europe pushers do not have standard dimensions, but pushers are standardized and there are two types:

- Europe I (capacity 1000 - 1500 t depending on draft),
- Europa II (load capacity 1500 – 3000 t depending on draft),

with classes A and B. For the composition of thruster with a pusher, the specified dimensions are not standardized, but it is accepted as a relatively standardized dimension - the length of the composition of pushers with a pusher (presser assembly).

Waterways of regional or national importance include 3 classes:

1. Class I waterway – these waterways are used by motor vessels with a carrying capacity between 250-400 t, a length of up to 38,5 m and a width of up to 5 m and a draft of up to 2,2 m,
2. Class II waterways - these waterways are used by motor vessels with a carrying capacity between 400 - 650 t, a length of up to 57 m, a width of up to 9 m and a draft of up to 2,5 m,

3. **Class III waterway – these waterways are used by motor vessels and pusher systems with a composition of two pushers with a capacity between 650-1000 t, a length of up to 90 m and a draft of up to 2.5 m.**

Waterways of international importance include classes (from IV to VII) whereby Class V waterways are classified into Va, Vb, and Class VI into VIa, VIb and VIc.

The classification of Europe's waterways of international importance distinguishes the following:

1. Class IV waterway – it is used by motor vessels with a length of 80-85 m, a width of up to 9.5 m and a draft of up to 2.5 m, and a composition of one thruster and a thruster of a length of up to 85 m, a width of up to 9.5 m and a draft of 2.5 - 2.8 m;
2. Class Va waterway - it is used by motor vessels with a length between 95 - 110 m, a width of up to 11.4 m, a draft of 2.5 - 2.8 m, a load capacity of 1000 - 1500 t and a composition of one thruster and a thruster, length 95 - 110, width 11.4 m, draft 2.5 to 4.5 m and carrying capacity 1600 - 3000 t;
3. Class Vb waterway – it is used by formations of two pushers in line and a pusher with dimensions of length 172-185 m, width 11.4 m, draft 2.5-4.5 m and load capacity 3200-6000 t;
4. Class VIa waterway – it is used by container or Ro-Ro motor tugs with a length of 140 m, a width of 15 m and a draft of up to 3.9 m, as well as a combination of two thrusters and a pusher with a length of 95 - 110 m, a width of 22.8 m, a draft of 2.5 - 4.5 m
5. Carrying capacity 3200 - 6000 t;
6. Class VIb waterway – it is used by sets of thrusters with pusher P+2+2, length 185 - 195 m, width 22.8, draft 2.5 - 4.5 m and carrying capacity 6400 - 12,000 t;
7. **Class VIc waterway – it is used by pusher assemblies with a pusher in the arrangement P+2+2+2, length 270 - 280 m, width 22.8 m, draft 2.5 - 4.5 m and carrying capacity 9,600 - 18,000 t, as well as assemblies of thrusters in the arrangement P+3 +3 length 195 - 200 m, width 33 - 34.2 m, draft 2.5 - 4.5 m and carrying capacity 9,600 - 18,000 t.**
8. Class VII waterway – it is used by pusher assemblies with a pusher in the arrangement P+3+3+3, length 275-285 m, width 33-34.2 m, draft 2.5-4.5 m, and carrying capacity 14,500-27,000 t.

2.7 Analysis of the navigable water levels of the Danube (project area)

A waterway is a strip of inland waters of a certain depth, width and prescribed dimensions that is arranged, marked and open for safe navigation. It is defined by the navigable bed and radius of bend at low navigable water level (LNWL), and by free dimensions under bridges and aerial cables below high navigable water level (HNWL).

- LNWL - is determined based on the statistical calculation of the durability of the water level from the 25-year observation period and corresponds to a water level of 94% durability.
- HNWL – is determined on the basis of a statistical calculation of water level durability from a 25-year observation period and corresponds to a water level of 1% durability.

The low navigable water level is defined by the Danube Commission as a water level of 94% of flow durability, i.e. 343 days per year, which is calculated by processing data of the past time period of 30 years without taking into account periods of ice formation. According to the Ordinance on the classification and opening of waterways on inland waters (Official Gazette 77/11, 66/14 and 81/15), the Danube River in the section in question is an international waterway VI.c. class, and for the same it is necessary to provide a minimum depth of the used road of 2,5 m.

Low navigable water levels for analysis within this project were obtained by the Client and the same was adopted by the Interstate Commission between the Republic of Croatia and the Republic of Serbia.

The goal of this analysis is to determine the condition of navigability, in terms of available depths for navigation about the low navigable water level (LNWL) and different waterway widths.

Below (

Table 2.11.), a calculation of dredging quantities is given for all critical sections, to achieve the appropriate dimensions of the waterway. The calculation is given for depth 2,5 m and widths of 200 m, 150 m, 120 m and 100 m, as defined by the Critical Sectors Prioritization Methodology.

Additional analyzes were carried out for a depth of 2,8 m and a width of 150 m and 100 m, and a depth of 3,0 m with a width of 150 m and 100 m in accordance with the recommendations of the Danube Commission and the Client's requirements (

Table 2.12.).

The critical threshold was determined in agreement with the Client:

- Critical sections are those for which the amount of material for cleaning (excavation) to reach the appropriate gauges of the waterway exceeds 10.000,00 m^3.
- Non-critical sections are those for which the amount of cleaning (excavation) of material to reach the appropriate dimensions of the waterway is below 10.000,00 m^3.

Table 2.11 Quantities for cleaning (excavation) of materials to reach the appropriate gauges of the waterway defined by the Methodology of prioritizing critical sectors:

Legend

-	0,00
0,01	10.000,00
10.000,01	25.000,00
25.000,01	75.000,00
75.000,01	

CS	Critical sector name	from rkm	to rkm	h	200	150	120	100	80
1	Batina / Bezdan	1429,00	1425,00	2,5	1.664,97	0,00	0,00	0,00	0,00
2	Siga-Kazuk	1424,20	1414,40	2,5	9,27	0,00	0,00	0,00	0,00
3	Apatin	1408,20	1400,00	2,5	58.570,39	23.756,93	11.552,41	5.683,05	1.815,91
4	Židovski/Čivutski rukavac	1397,20	1389,00	2,5	83.865,61	17.152,05	4.727,27	1.566,69	334,72
5	Ušće Drave	1383,40	1381,60	2,5	42.927,77	6.308,26	496,86	5,13	0,00
6	Aljmaš	1381,40	1378,20	2,5	0,00	0,00	0,00	0,00	0,00
7	Staklar	1376,80	1373,40	2,5	10.166,37	873,55	2,30	0,00	0,00
8	Erdut	1371,40	1366,40	2,5	436,33	208,19	53,07	10,92	3,90
9	Bogojevo	1366,20	1361,40	2,5	1.283,23	0,00	0,00	0,00	0,00
10	Dalj	1357,00	1351,00	2,5	9.202,99	881,11	37,74	0,00	0,00
11	Borovo I	1348,40	1343,60	2,5	85.065,32	21.329,90	5.260,87	654,74	0,00
12	Borovo II	1340,60	1338,00	2,5	51.804,63	11.962,06	2.731,01	0,00	0,00
13	Vukovar	1332,00	1325,00	2,5	843,86	0,00	0,00	0,00	0,00
14	Sotin	1324,00	1320,00	2,5	8.013,52	1.634,22	838,31	482,65	281,18
15	Opatovac	1315,40	1314,60	2,5	9,72	9,72	9,72	9,72	9,72
16	Mohovo	1311,40	1307,60	2,5	3.914,10	1.640,41	688,00	226,50	0,00
17	Ilok	1302,00	1300,00	2,5	0,00	0,00	0,00	0,00	0,00

Table 2.12. Quantities for cleaning (excavation) of materials to achieve the appropriate gauges of the waterway per the recommendations of the Danube Commission and the requirements of the Client:

Legend

-		0,00
0,01		10.000,00
10.000,01		25.000,00
25.000,01		75.000,00
75.000,01		

CS	Critical sector name	from rkm	to rkm	h	150		100
1	Batina / Bezdan	1429,00	1425,00	2,8	106,56	0,00	0,00
2	Siga-Kazuk	1424,20	1414,40	2,8	0,00	0,00	0,00
3	Apatin	1408,20	1400,00	2,8	32.202,92	0,00	8.039,65
4	Židovski/Čivutski rukavac	1397,20	1389,00	2,8	30.074,57	0,00	4.438,88
5	Ušće Drave	1383,40	1381,60	2,8	11.566,54	0,00	234,24
6	Aljmaš	1381,40	1378,20	2,8	0,00	0,00	0,00
7	Staklar	1376,80	1373,40	2,8	3.159,83	0,00	144,16
8	Erdut	1371,40	1366,40	2,8	1.670,06	0,00	494,81
9	Bogojevo	1366,20	1361,40	2,8	0,00	0,00	0,00
10	Dalj	1357,00	1351,00	2,8	2.435,89	0,00	5,51
11	Borovo I	1348,40	1343,60	2,8	29.407,74	0,00	1.088,84
12	Borovo II	1340,60	1338,00	2,8	19.463,89	0,00	1.348,45
13	Vukovar	1332,00	1325,00	2,8	2,00	0,00	0,00
14	Sotin	1324,00	1320,00	2,8	8.129,69	0,00	3.469,91
15	Opatovac	1315,40	1314,60	2,8	174,46	0,00	174,46
16	Mohovo	1311,40	1307,60	2,8	5.169,06	0,00	657,79
17	Ilok	1302,00	1300,00	2,8	0,00	0,00	0,00

Legend

-		0,00
0,01		10.000,00
10.000,01		25.000,00
25.000,01		75.000,00
75.000,01		

CS	Critical sector name	from rkm	to rkm	h	150		100
1	Batina / Bezdan	1429,00	1425,00	3,0	1.305,36	0,00	58,70
2	Siga-Kazuk	1424,20	1414,40	3,0	0,00	0,00	0,00
3	Apatin	1408,20	1400,00	3,0	40.128,41	0,00	10.192,22
4	Židovski/Čivutski rukavac	1397,20	1389,00	3,0	43.897,39	0,00	8.759,94
5	Ušće Drave	1383,40	1381,60	3,0	16.132,15	0,00	739,70
6	Aljmaš	1381,40	1378,20	3,0	0,00	0,00	0,00
7	Staklar	1376,80	1373,40	3,0	6.426,15	0,00	976,79
8	Erdut	1371,40	1366,40	3,0	4.555,23	0,00	2.052,87
9	Bogojevo	1366,20	1361,40	3,0	12,16	0,00	0,00
10	Dalj	1357,00	1351,00	3,0	3.907,22	0,00	93,39
11	Borovo I	1348,40	1343,60	3,0	38.846,33	0,00	1.898,49
12	Borovo II	1340,60	1338,00	3,0	25.837,91	0,00	2.648,48
13	Vukovar	1332,00	1325,00	3,0	464,32	0,00	0,00
14	Sotin	1324,00	1320,00	3,0	18.824,14	0,00	9.153,14
15	Opatovac	1315,40	1314,60	3,0	529,48	0,00	529,48
16	Mohovo	1311,40	1307,60	3,0	10.532,17	0,00	1.962,50
17	Ilok	1302,00	1300,00	3,0	8,56	0,00	0,00

For the purposes of a complete assessment (analysis) of navigable water levels (LNWL and HNWL) and the location of the necessary cleaning on 17 critical sections, a description of each individual location (critical section) is given below. On the graphic displays, the data is presented through several graphic and textual contents. In the following, a description will be given on one of the attachments in order to make it easier to understand the analysis carried out.

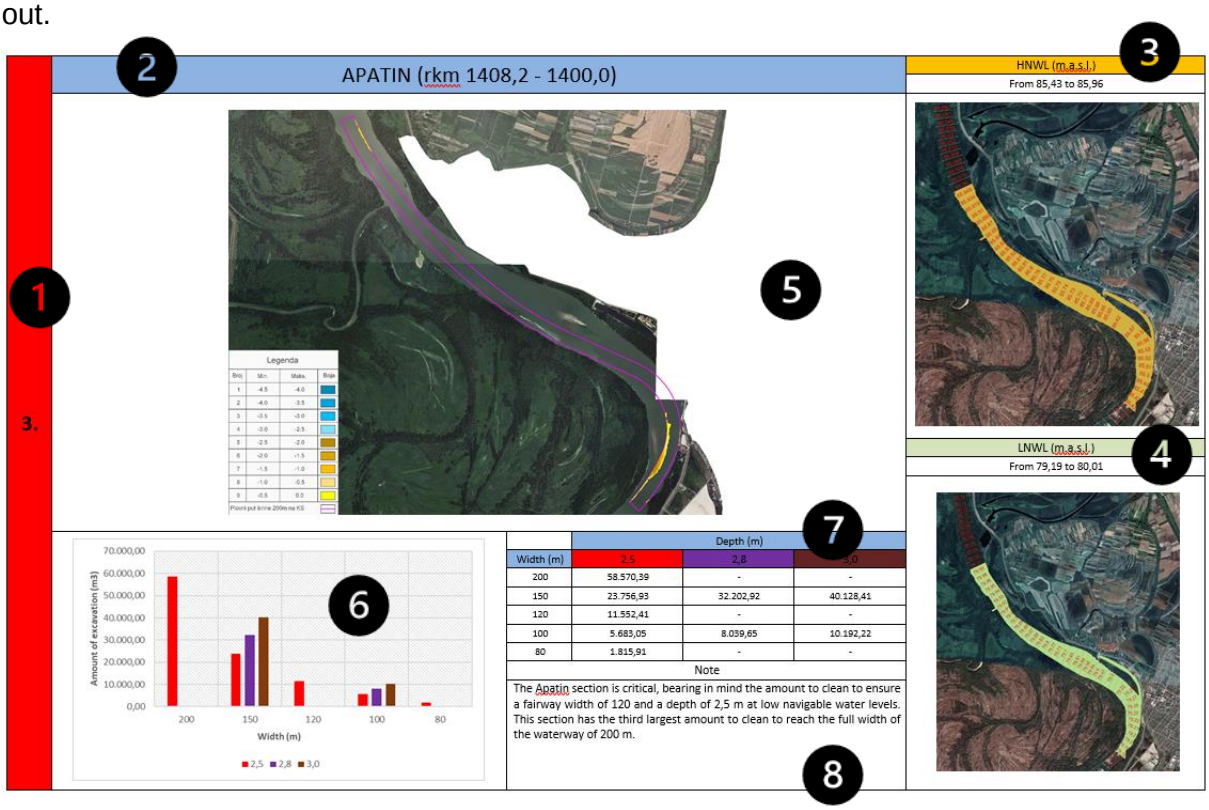


Figure 2.68. Description of graphic attachments of analysis of navigable water levels.

The description of the graphic attachments of the analysis of navigable water levels is given below:

Serial number of the critical section. The critical section is marked (categorized) by colour. The colours correspond to the legends in the tables above (

Table 2.11 and

1. Table 2.12).
2. Name of the critical section with associated river kilometres.
3. Display of the critical section overlaid with HNWL (high navigable water level) with associated HNWL values

4. Display of the critical section overlaid with LNWL (low navigable water level) with associated LNWL values.

5. Graphic representation on the location of dredging for the width of the waterway of 200.0 m and the depth of 2.5 m

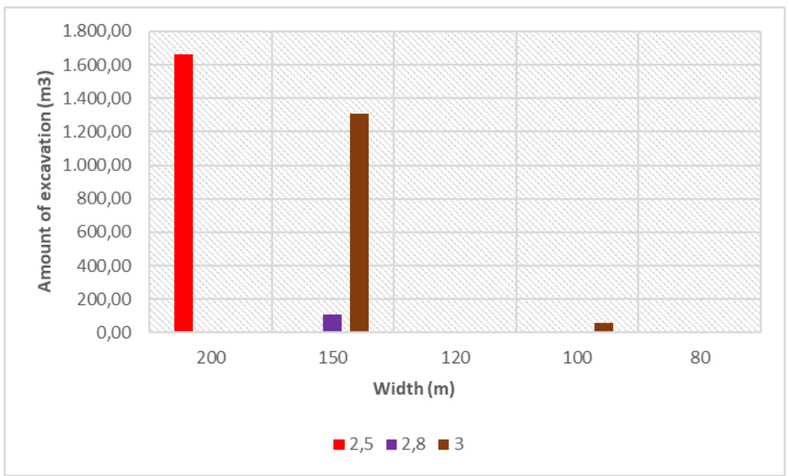
6. Diagram of the quantity for dredging (excavation) of material to reach the appropriate dimensions of the waterway (criteria: width: 200 m, 150 m, 120 m, 100 m and 80 m and depth 2.5 m, 2.0 m, 3.0 m).

7. Tabular representation for dredging (excavation) of material to reach the appropriate dimensions of the waterway (criteria: width: 200 m, 150 m, 120 m, 100 m and 80 m and depth 2.5 m, 2.0 m, 3.0 m).

8. Notes for the critical section in question and a review of the conducted analyses.

1.

BATINA/BEZDAN (rkm 1429,0 - 1425,0)



	Depth (m)		
Width (m)	2,5	2,8	3,0
200	1.664,67	0,00	0,00
150	0,00	106,56	1.305,36
120	0,00	-	-
100	0,00	0,00	58,70
80	0,00	-	-

Note

The Batina/Bezdan section is not a critical section. This section is ranked 10 as a critical section with a negligible cleaning amount of 1,664.67 m^3 in order to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

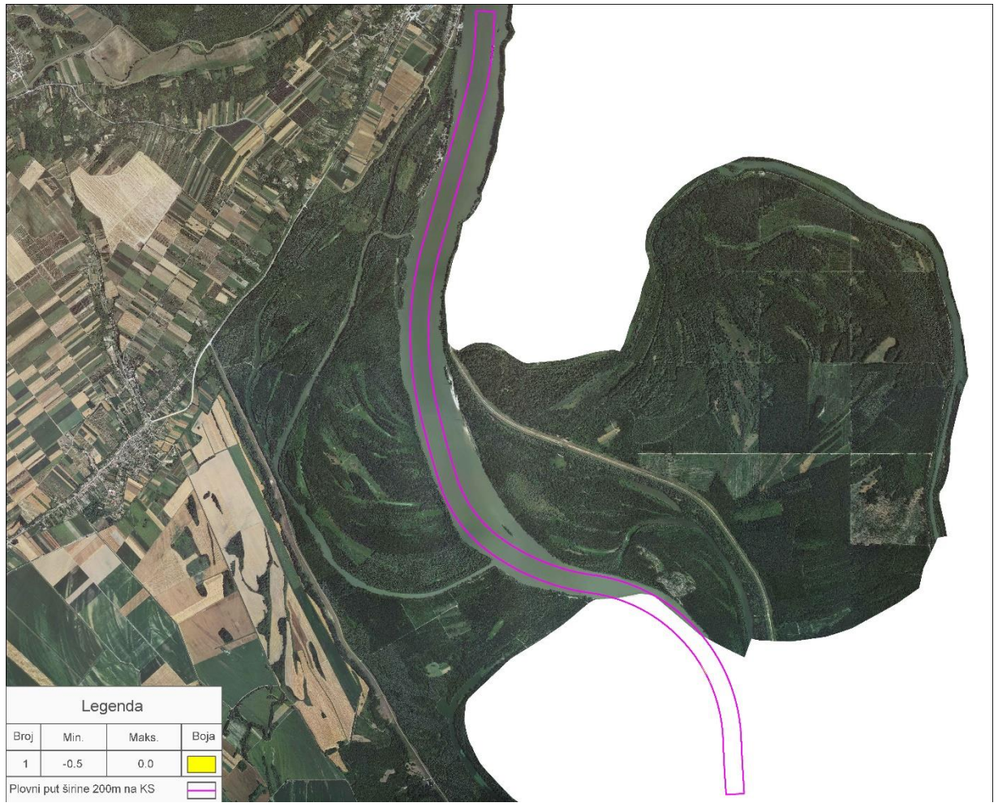
From 86,64 to 86,78

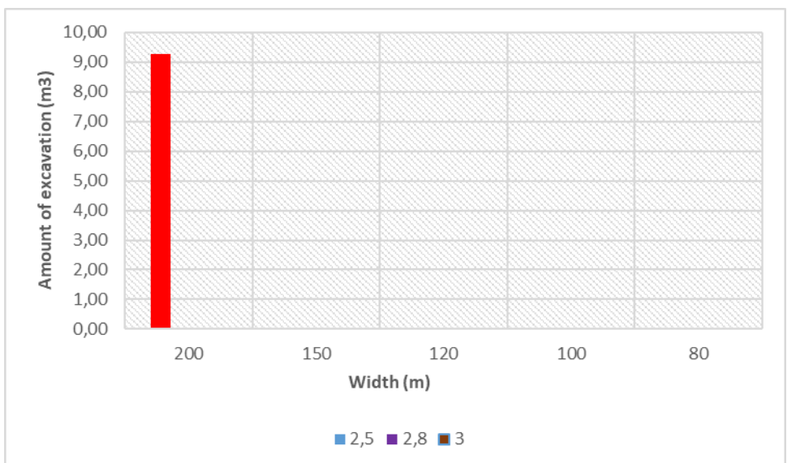
LNWL (m.a.s.l.)

From 80,54 to 80,60

2.

SIGA - KAZUK (rkm 1424,0 - 1414,0)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	9,27	-	-
150	0,00	0,00	0,00
120	0,00	-	-
100	0,00	0,00	0,00
80	0,00	-	-

Note

The Batina/Bezdan section is not a critical section. This section is ranked as the 15th critical section with a negligible cleaning amount of 9,27 m^3 to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

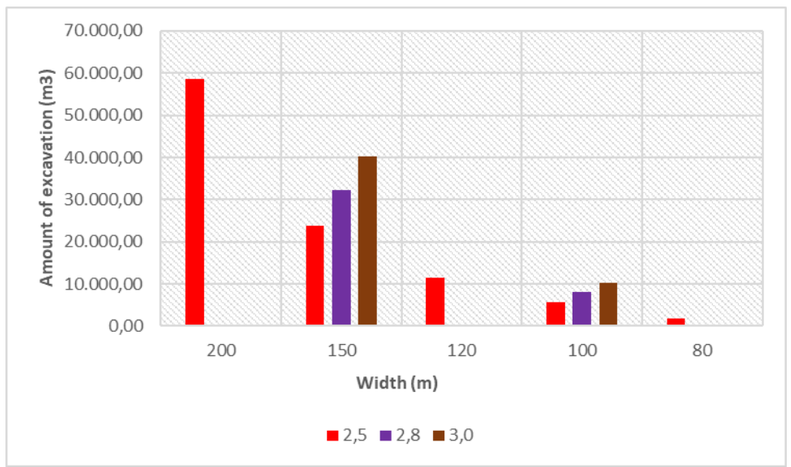
From 86,23 to 86,64

LNWL (m.a.s.l.)

From 80,27 to 80,51

3.

APATIN (rkm 1408,2 - 1400,0)



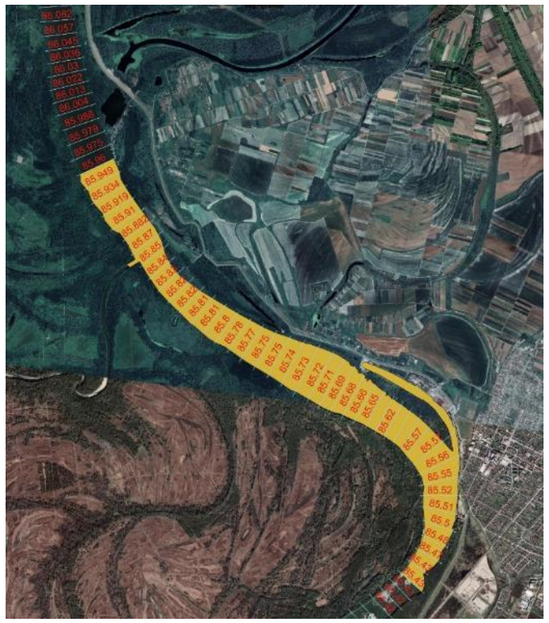
	Depth (m)		
Width (m)	2,5	2,8	3,0
200	58.570,39	-	-
150	23.756,93	32.202,92	40.128,41
120	11.552,41	-	-
100	5.683,05	8.039,65	10.192,22
80	1.815,91	-	-

Note

The Apatin section is critical, bearing in mind the amount to clean to ensure a fairway width of 120 and a depth of 2,5 m at low navigable water levels. This section has the third largest amount to clean to reach the full width of the waterway of 200 m.

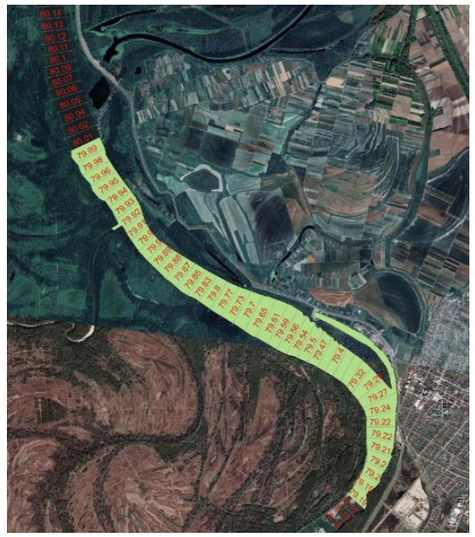
HNWL (m.a.s.l.)

From 85,43 to 85,96



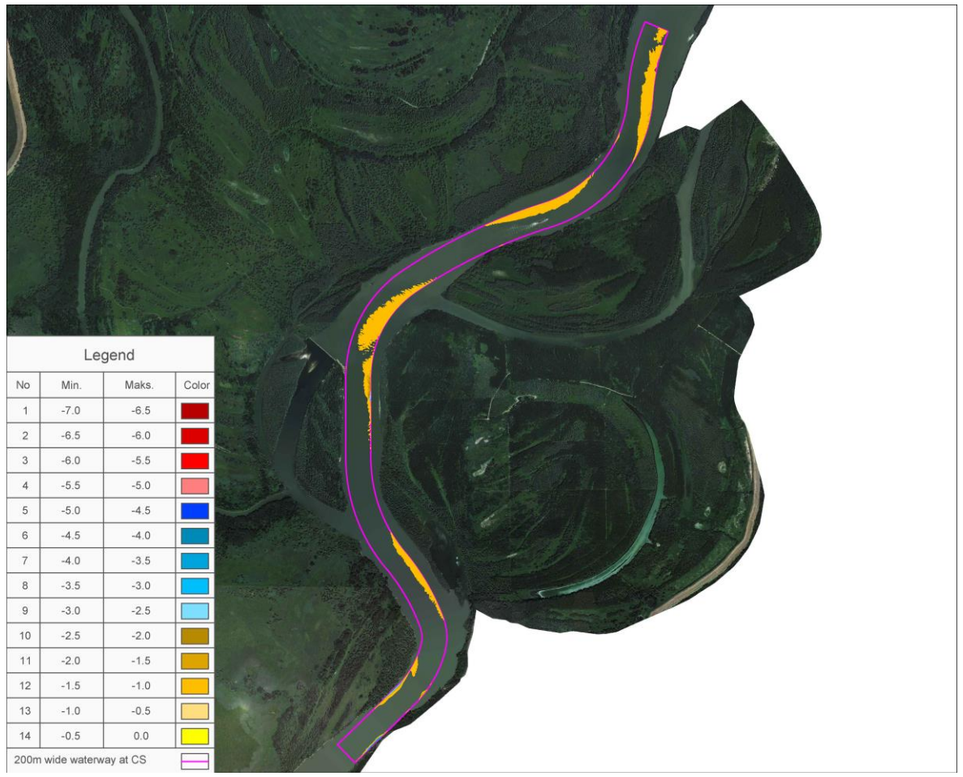
LNWL (m.a.s.l.)

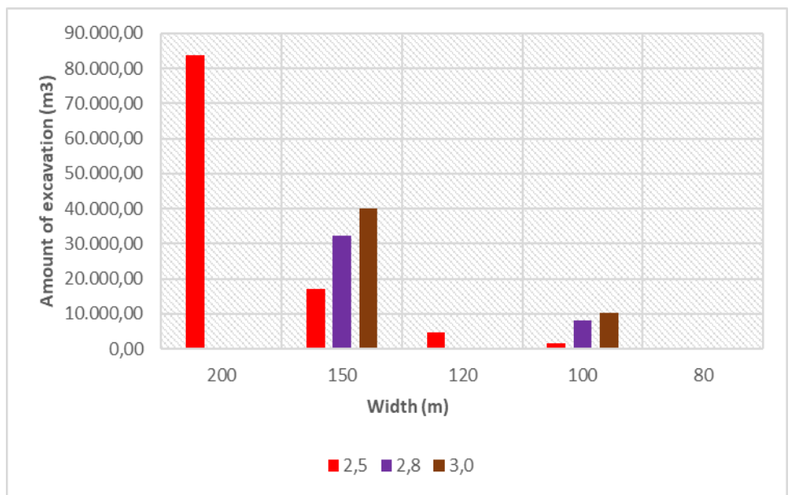
From 79,19 to 80,01



4.

ŽIDOVSKI/ČIVUTSKI RUKAVAC (rkm 1397,2 - 1389,0)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	83.865,61	-	-
150	17.152,05	32.202,92	40.128,41
120	4.727,27	-	-
100	1.566,69	8.039,65	10.192,22
80	334,72	-	-

Note

The section Židovski/čivutski rukavac is a critical section, bearing in mind the amount to clean to ensure a fairway width of 150 and a depth of 2,5 m at a low navigable water level. This section has the second largest amount to clean to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

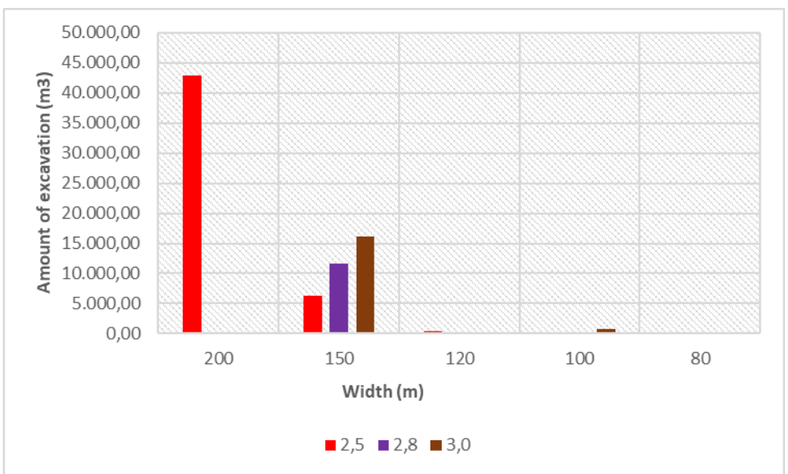
From 84,73 to 85,29

LNWL (m.a.s.l.)

From 78,60 to 78,98

5.

UŠĆE DRAVE (rkm 1383,4 - 1381,6)



	Depth (m)		
Width (m)	2,5	2,8	3,0
200	42.927,77	-	-
150	6.308,26	11.566,54	16.132,15
120	496,86	-	-
100	5,13	234,24	739,70
80	0,00	-	-

Note

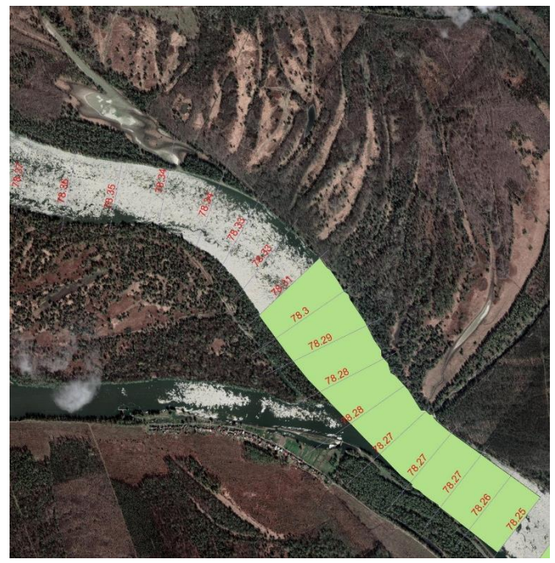
The section of the confluence of the Drava is critical, taking into account the amount to be cleaned to ensure a width of the waterway of 150 and a depth of 2,5 m at a low navigable water level. On this section, the fifth largest amount to be cleaned to reach the full width of the fairway of 200 m. The total amount to be cleaned is on the right side of the fairway, i.e. the fairway enters formed bank upstream and downstream of the confluence.

HNWL (m.a.s.l.)

From 84,24 to 84,07

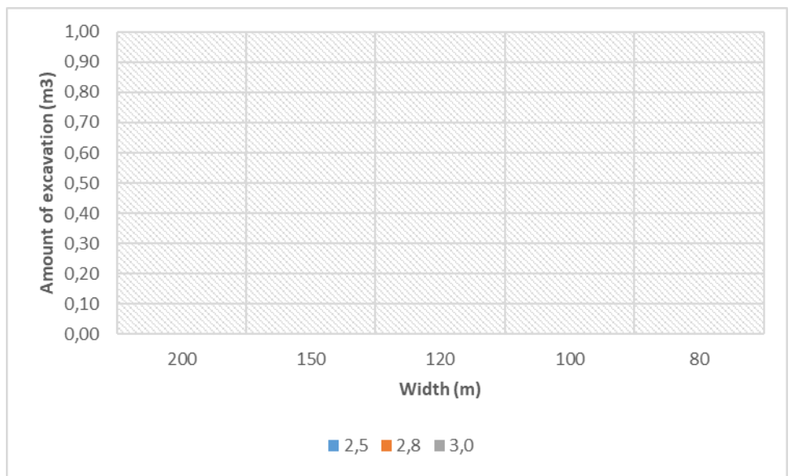
LNWL (m.a.s.l.)

From 78,07 to 78,24



6.

ALJMAŠ (rkm 1424,0 - 1414,0)



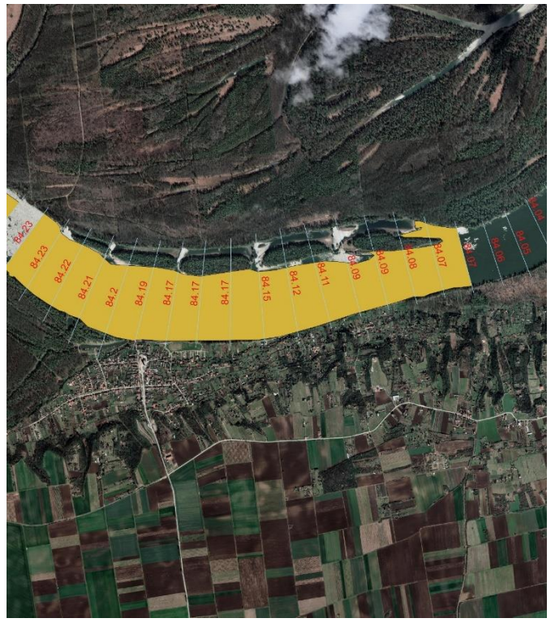
	Depth (m)		
Width (m)	2,5	2,8	3,0
200	0,00	-	-
150	0,00	0,00	0,00
120	0,00	-	-
100	0,00	0,00	0,00
80	0,00	-	-

Note

The Aljmaš section is not a critical section. This section is ranked as the 17th critical section. On this critical section, there are no quantities for cleaning by analyzing the dimensions of the waterway (criteria: width: 200 m, 150 m, 120 m, 100 m and 80 m and depth 2,5 m, 2,0 m, 3,0 m).

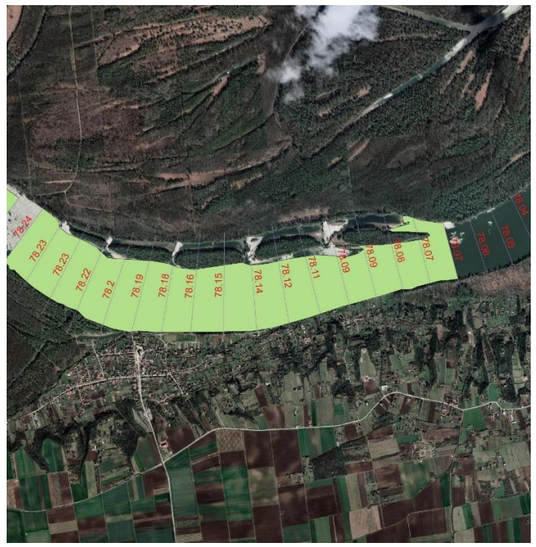
HNWL (m.a.s.l.)

From 84,24 to 84,07



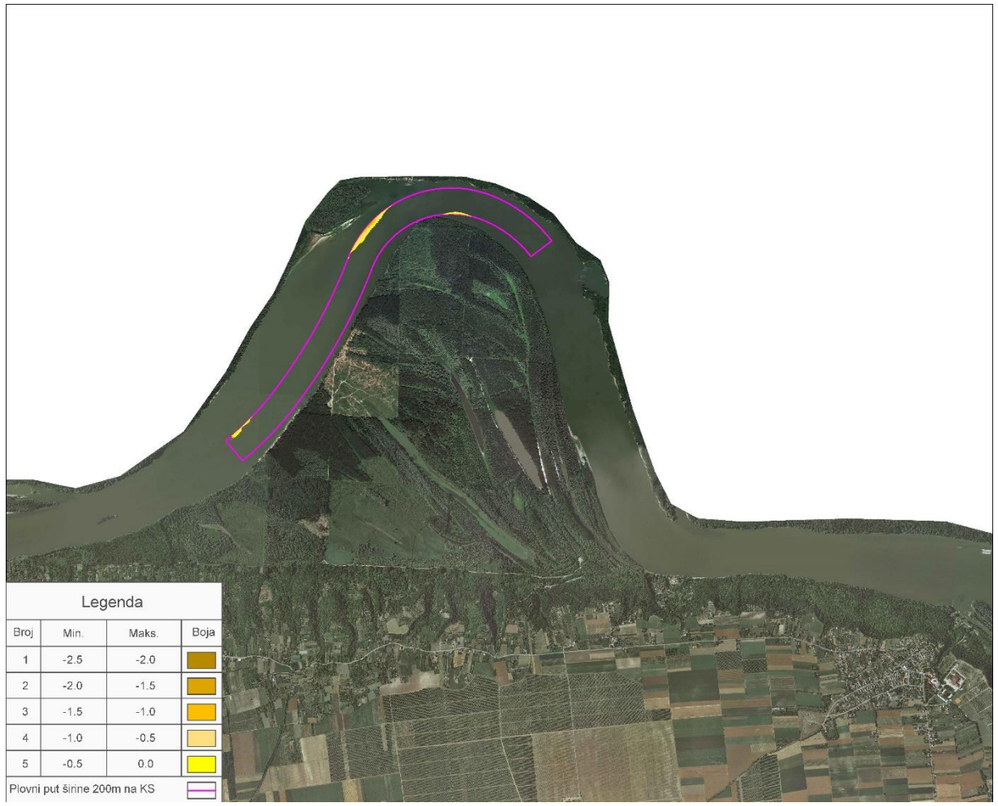
LNWL (m.a.s.l.)

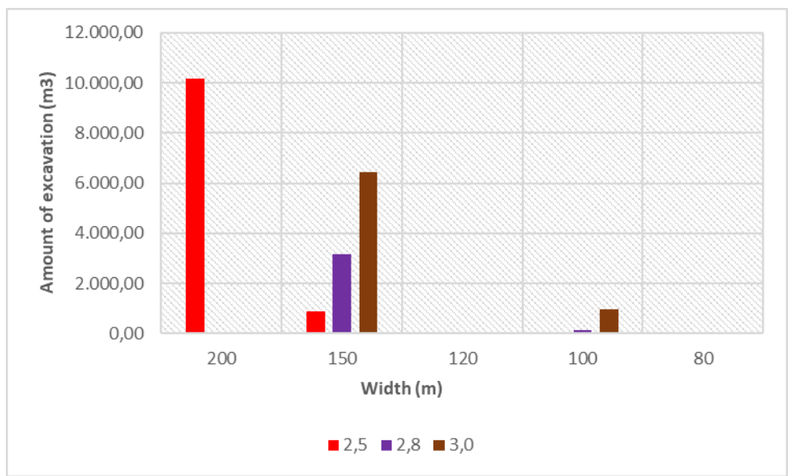
From 78,07 to 78,24



7.

STAKLAR (rkm 1376,80 – 1373,40)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	10.166,37	-	-
150	873,55	3.159,83	6.426,15
120	2,30	-	-
100	0,00	144,16	976,79
80	0,00	-	-

Note

The Staklar section is a borderline critical section. This section is ranked 6 as a critical section with a cleaning volume of 10,166.37 m^3 in order to reach the full width of the waterway of 200 m. Considering that the critical section limit for ranking sections is above 10,000.00 m^3, this section falls under the category of critical.

HNWL (m.a.s.l.)

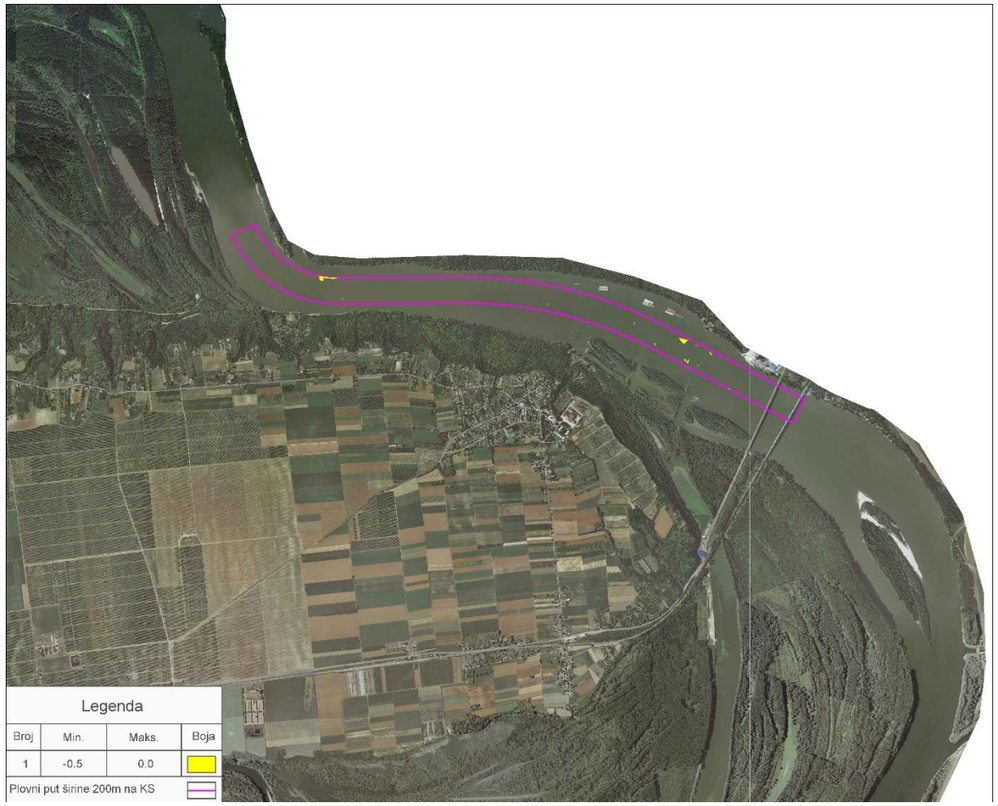
From 83,80 to 83,98

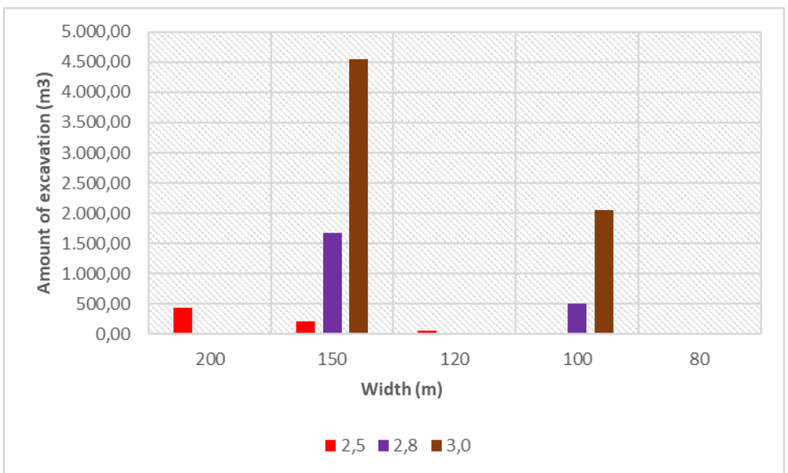
LNWL (m.a.s.l.)

From 77,86 to 77,99

8.

ERDUT (rkm 1371,4 – 1366,4)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	436,33	-	-
150	208,19	1.670,06	4.555,23
120	53,07	-	-
100	10,92	494,81	2.052,87
80	3,90	-	-

Note

The Erdut section is not a critical section. This section is ranked as the 13th critical section with a negligible cleaning amount of 436,33 m^3 to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

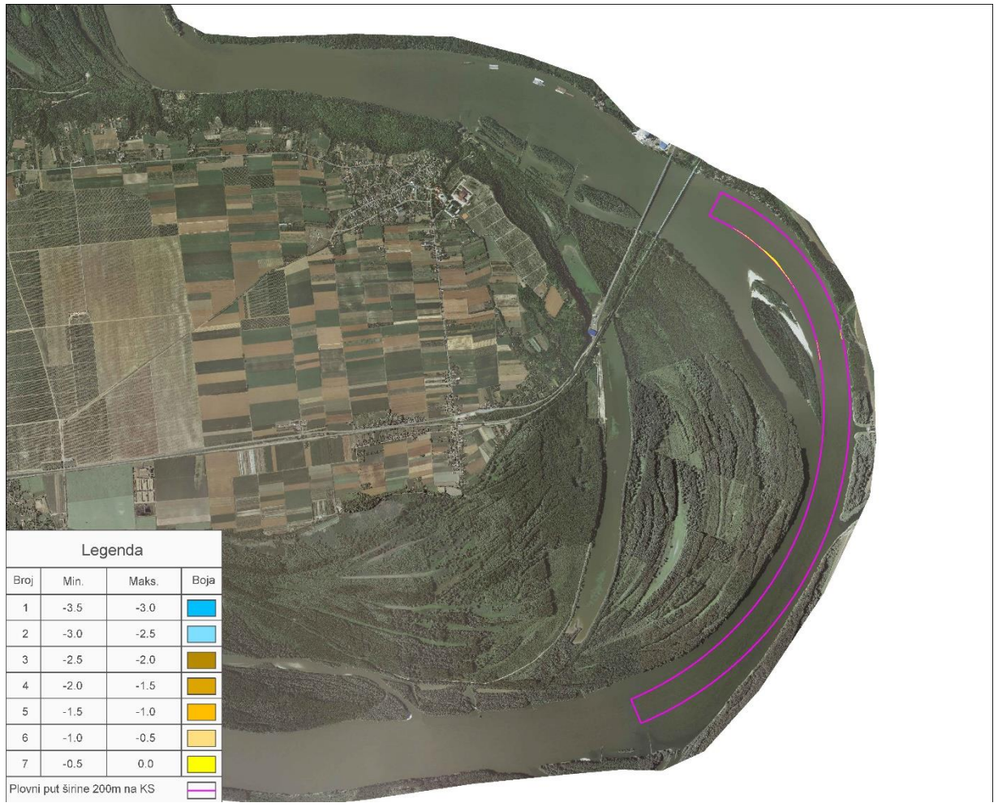
From 83,40 to 86,656

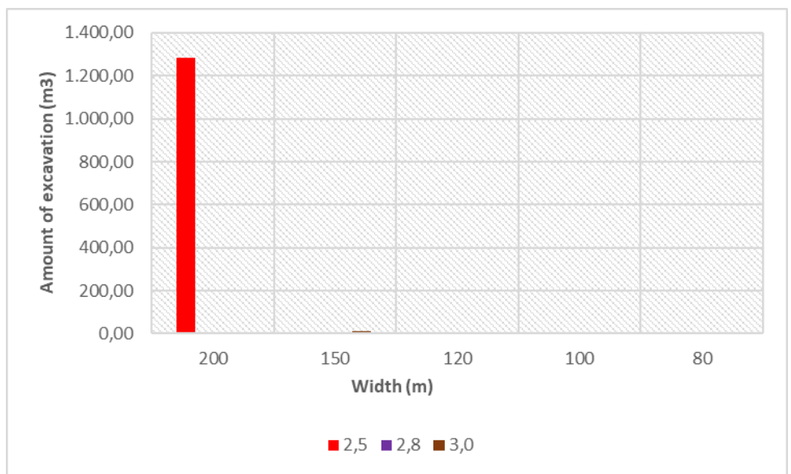
LNWL (m.a.s.l.)

From 77,54 to 77,77

9.

BOGOJEVO (rkm 1366,2 – 1361,4)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	1.283,23	-	-
150	0,00	0,00	12,16
120	0,00	-	-
100	0,00	0,00	0,00
80	0,00	-	-

Note

The Bogovjevo section is not a critical section. This section is ranked as the 11th critical section with a negligible cleaning amount of 1,283.23 m^3 to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

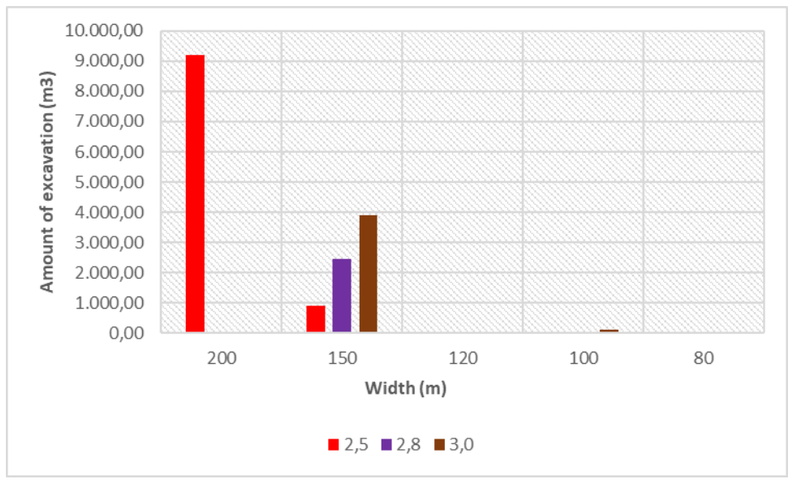
From 83,17 to 83,397

LNWL (m.a.s.l.)

From 77,37 to 77,52

10.

DALJ (rkm 1357,0 – 1351,0)



	Depth (m)		
Width (m)	2,5	2,8	3,0
200	9.202,99	-	-
150	881,11	2.435,89	3.907,22
120	37,74	-	-
100	0,00	5,51	93,39
80	0,00	-	-

Note

The Dalj section is not a critical section. According to the ranking, this section is a critical section with an amount to be cleaned of 9,202.99 m^3 in order to reach the full width of the waterway of 200 m. Given that for the ranking of the criticality of sections, the limit of a non-critical section is below 10,000.00 m^3, this section does not fall under category critical.

HNWL (m.a.s.l.)

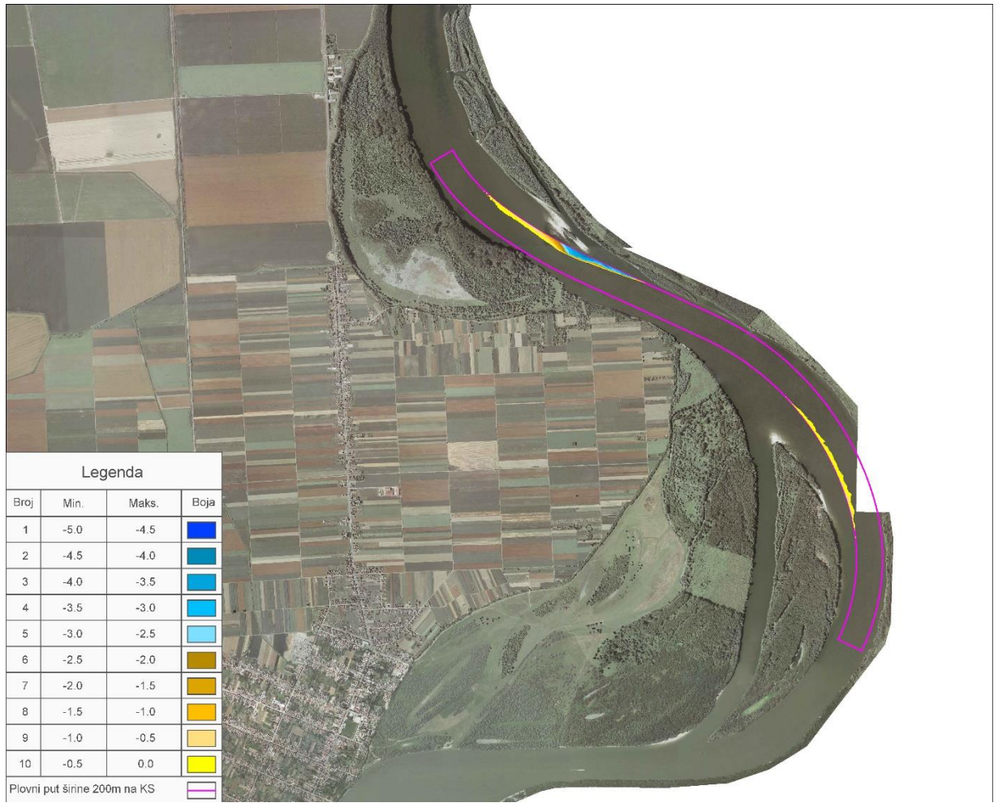
From 82,631 to 82,922

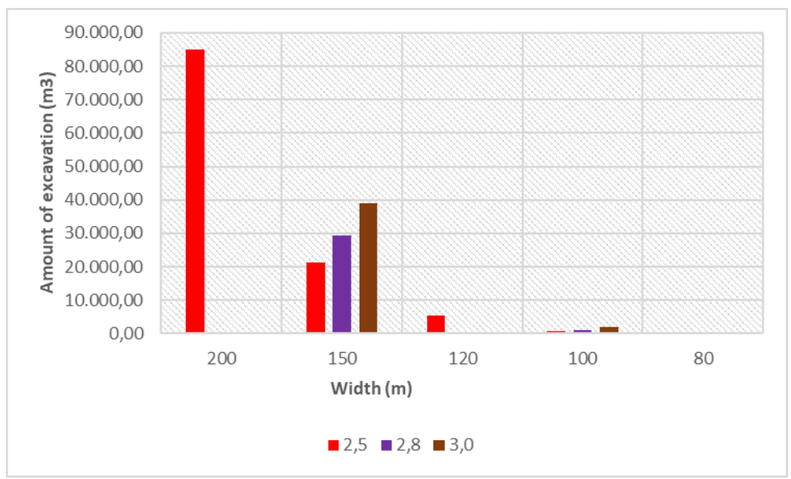
LNWL (m.a.s.l.)

From 76,92 to 77,16

11.

BOROVO I (rkm 1348,4 - 1343,6)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	85.065,32	-	-
150	21.329,90	29.407,74	38.846,33
120	5.260,87	-	-
100	654,74	1.088,84	1.898,49
80	0,00	-	-

Note

The Borovo I section is the most critical section, taking into account the amount to be cleaned to ensure a fairway width of 120 and a depth of 2,5 m at a low navigable water level. This section has the largest amount to clean to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

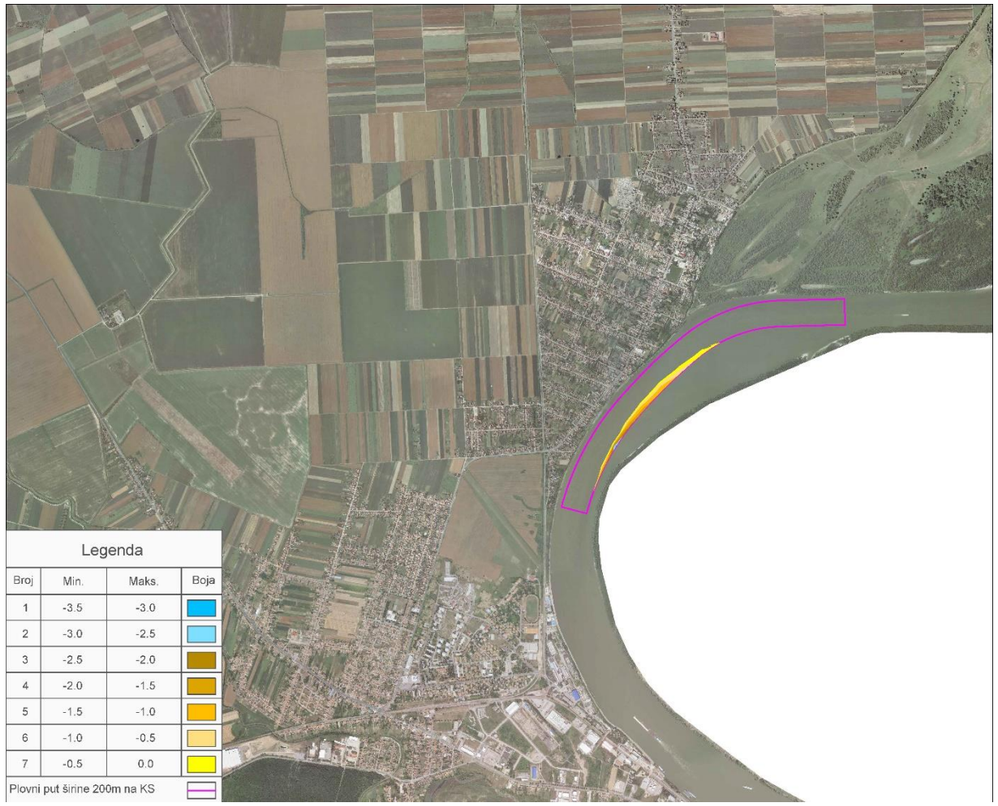
From 82,17 to 82,47

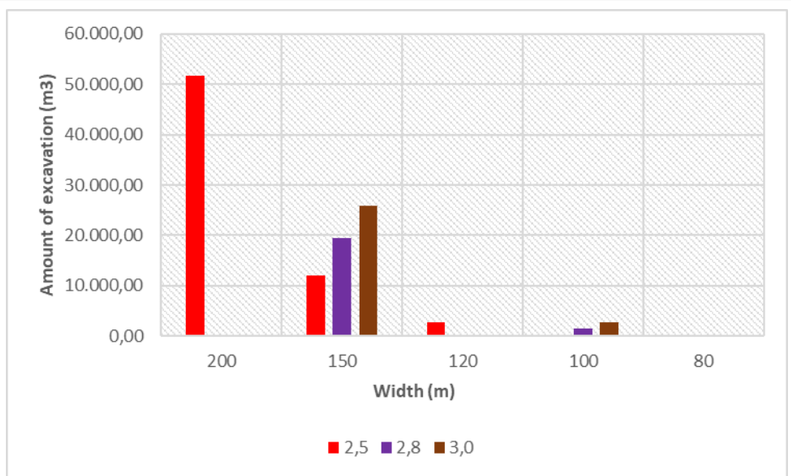
LNWL (m.a.s.l.)

From 76,71 to 76,85

12.

BOROVO II (rkm 1340,6 - 1338,0)





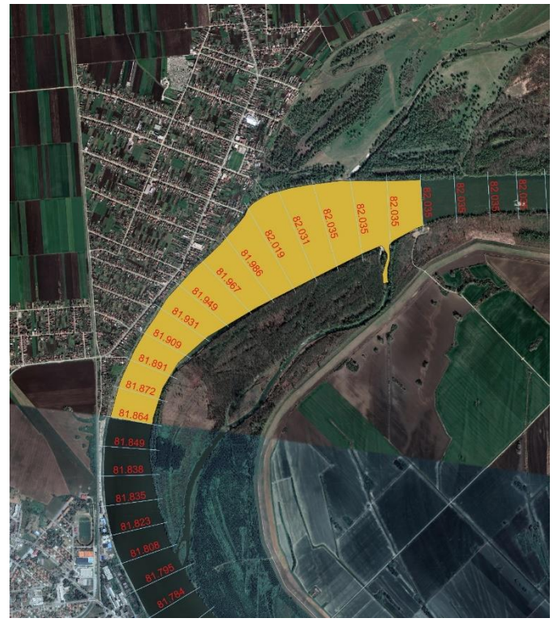
	Depth (m)		
Width (m)	2,5	2,8	3,0
200	51.804,63	-	-
150	11.962,06	19.463,89	25.837,91
120	2.731,01	-	-
100	0,00	1.348,45	2.648,48
80	0,00	-	-

Note

The Borovo II section is critical, considering the amount to clean to ensure a fairway width of 120 and a depth of 2,5 m at a low navigable water level. In this section, the fourth largest amount to be cleaned is to reach the full width of the fairway of 200 m. The total amount to be cleaned is on the left side of the fairway, i.e. the fairway enters the formed bank along the left bank.

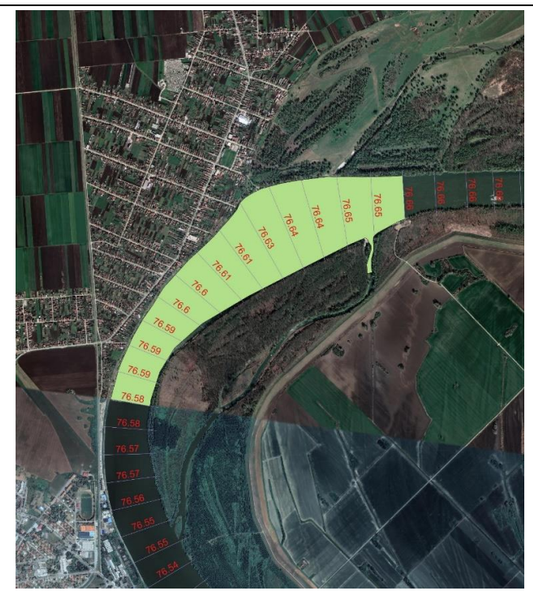
HNWL (m.a.s.l.)

From 81,864 to 82,035



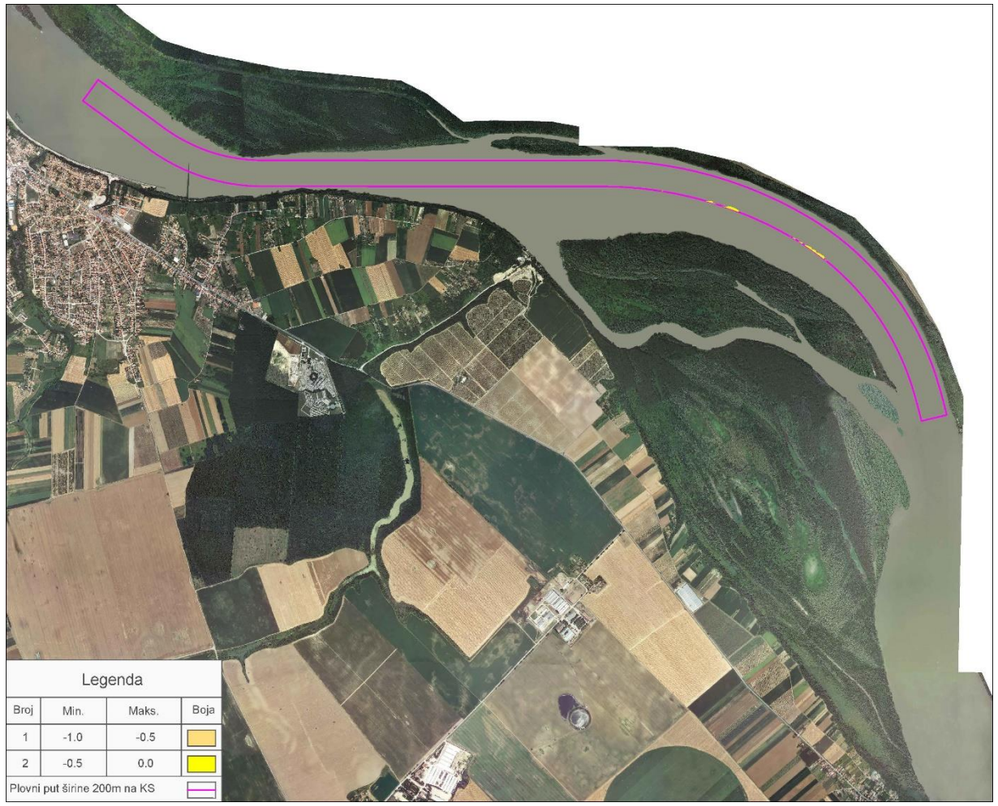
LNWL (m.a.s.l.)

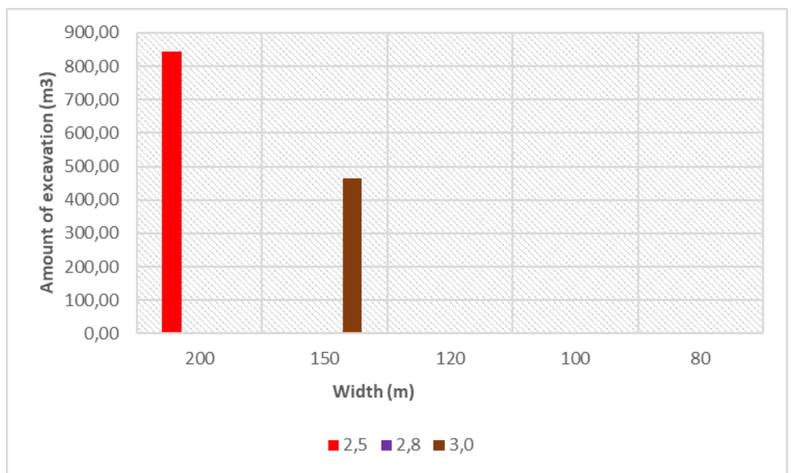
From 76,58 to 76,65



13.

VUKOVAR (rkm 1322,0 – 1325,0)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	843,86	-	-
150	0,00	2,00	464,32
120	0,00	-	-
100	0,00	0,00	0,00
80	0,00	-	-

Note

The Vukovar section is not a critical section. This section is ranked 12 as a critical section with a negligible cleaning amount of 843,86 m^3 in order to reach the full width of the waterway of 200 m.

HNWL (m.a.s.l.)

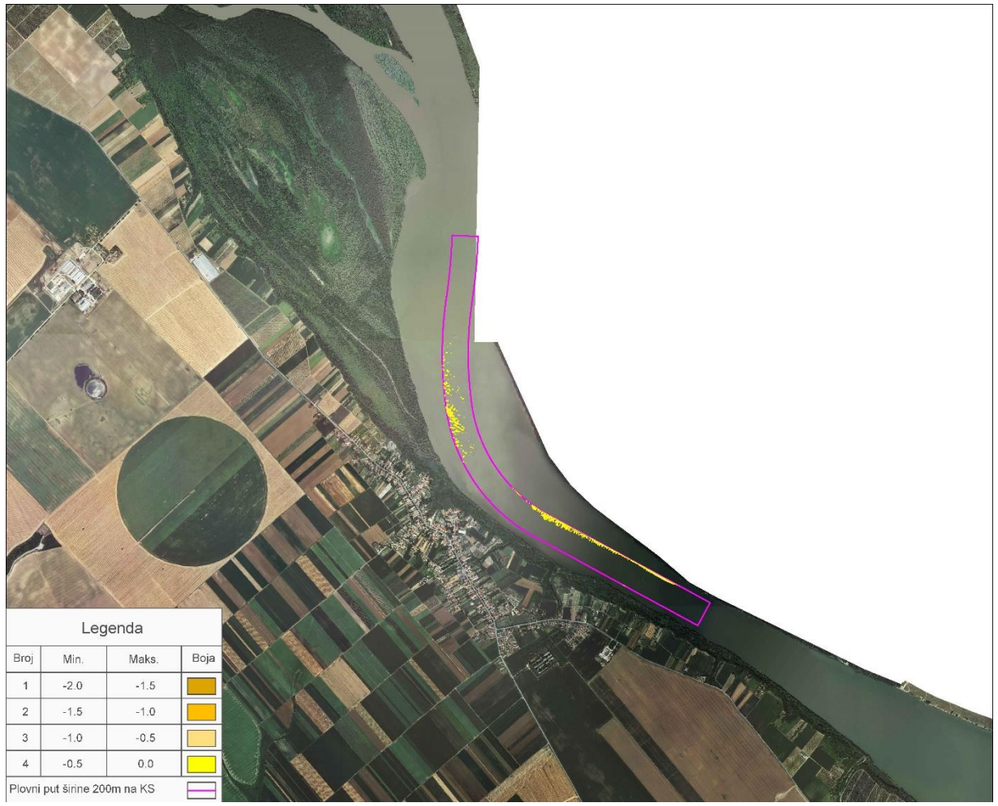
From 81,15 to 81,573

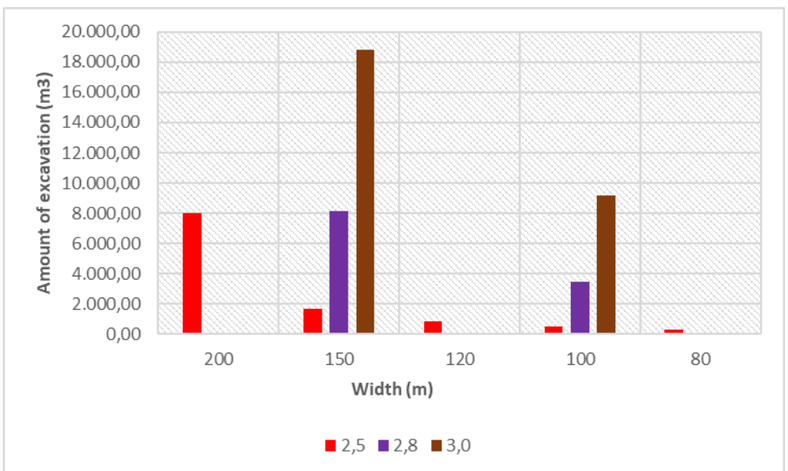
LNWL (m.a.s.l.)

From 75,93 to 76,26

14.

SOTIN (rkm 1324,0 – 1320,0)





	Depth (m)		
Width (m)	2,5	2,8	3,0
200	8.013,52	-	-
150	1.634,22	8.129,69	18.824,14
120	838,31	-	-
100	482,65	3.469,91	9.153,14
80	281,18	-	-

Note

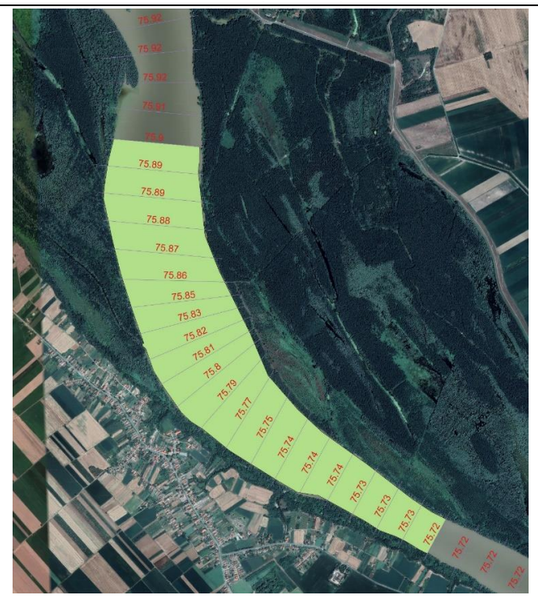
The Sotin section is not a critical section. According to the ranking, this section is the 9th critical section with a cleaning volume of 8,013.52 m^3 in order to reach the full width of the waterway of 200 m.
Since the construction of regulatory buildings is in progress on the section in question and it is known that the condition of the waterway on the section in question has already improved, it can be concluded that the Sotin section is not a critical section.

HNWL (m.a.s.l.)

From 80,895 to 81,128

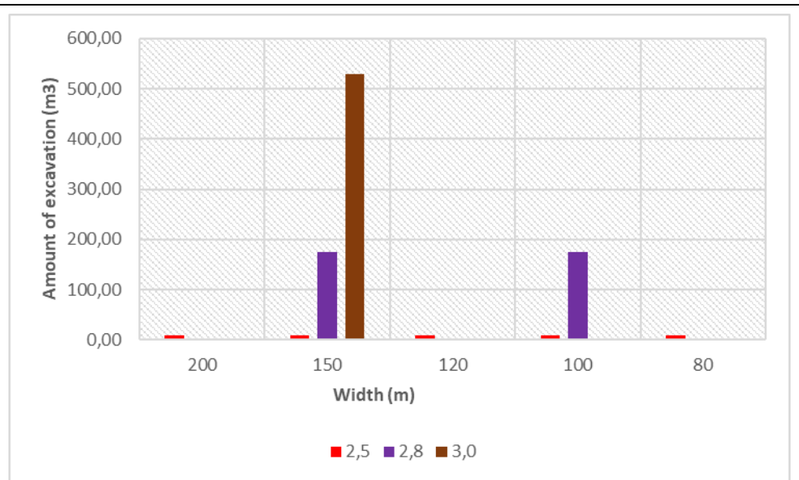
LNWL (m.a.s.l.)

From 75,72 to 75,90



15.

OPATOVAC (rkm 1315,4 – 1314,6)



	Depth (m)		
Width (m)	2,5	2,8	3,0
200	9,72	-	-
150	9,72	174,46	529,48
120	9,72	-	-
100	9,72	174,46	0,00
80	9,72	-	-

Note

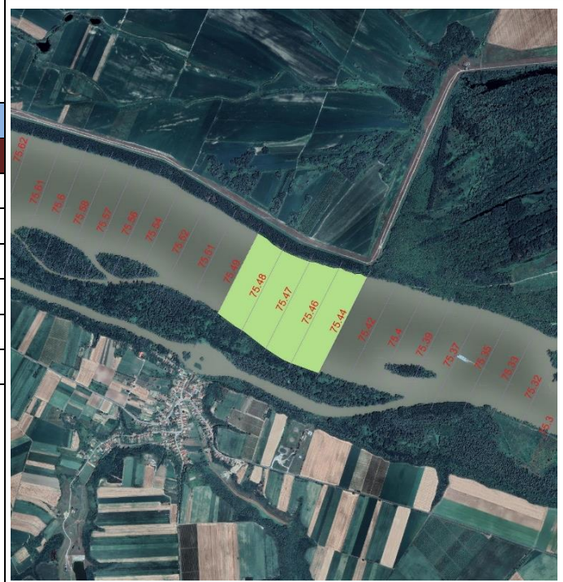
The Opatovac section is not a critical section. This section is ranked 14th critical section with a negligible cleaning amount of 9,72 m^3 to reach the full width of the waterway of 200 m.
It is interesting that the amount of 9,72 m^3 is repeated for all analyzed dimensions of the waterway (criteria: width: 200 m, 150 m, 120 m, 100 m and 80 m and depth 2,5 m), which means that the amount in question is located in the middle waterway.

HNWL (m.a.s.l.)

From 80,881 to 80,842

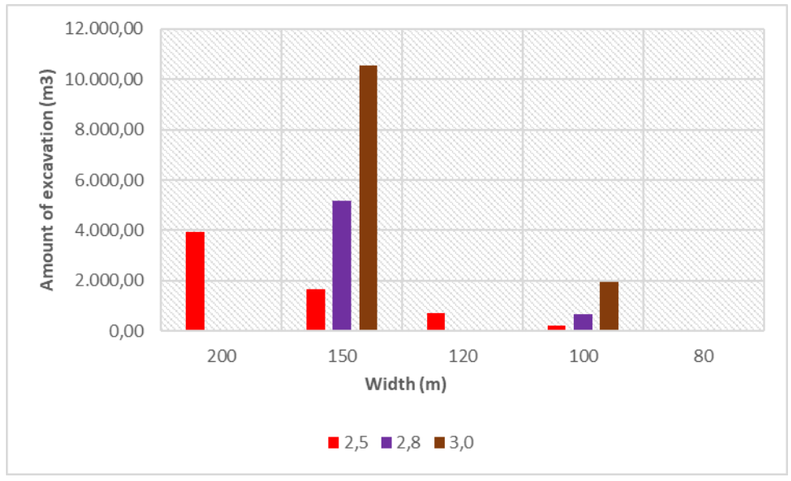
LNWL (m.a.s.l.)

From 75,44 to 75,49



16.

MOHOVO(rkm 1311,4 – 1307,6)



	Depth (m)		
Width (m)	2,5	2,8	3,0
200	3.914,10	-	23.788,79
150	1.640,41	5.169,06	10.532,17
120	688,00	-	-
100	226,50	657,79	1.962,50
80	0,00	-	-

Note

The Mohovo section is a critical section considering the amount to be cleaned to ensure a fairway width of 200 and a depth of 3,0 m at a low navigable water level. On this section, there are not large quantities to clean, but they are spread over the entire width of the waterway. The bottom is solid, and disturbances are created by underwater rocky elevations.

HNWL (m.a.s.l.)

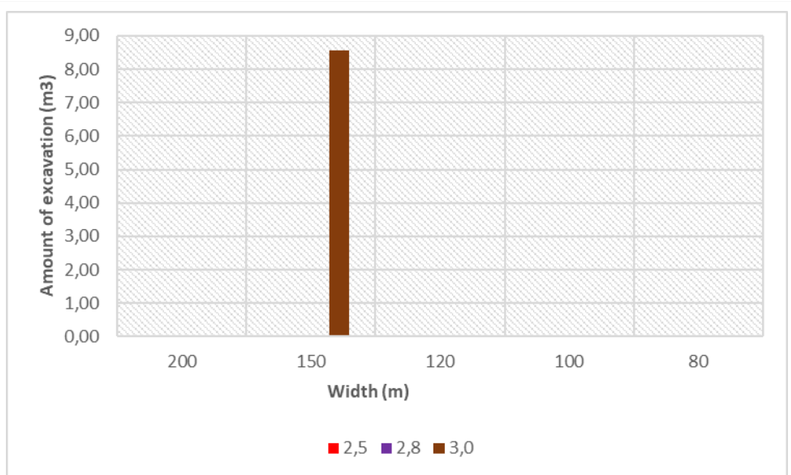
From 80,183 to 80,459

LNWL (m.a.s.l.)

From 74,9 to 75,25

7.

ILOK (rkm 1302,0 - 1300,0)



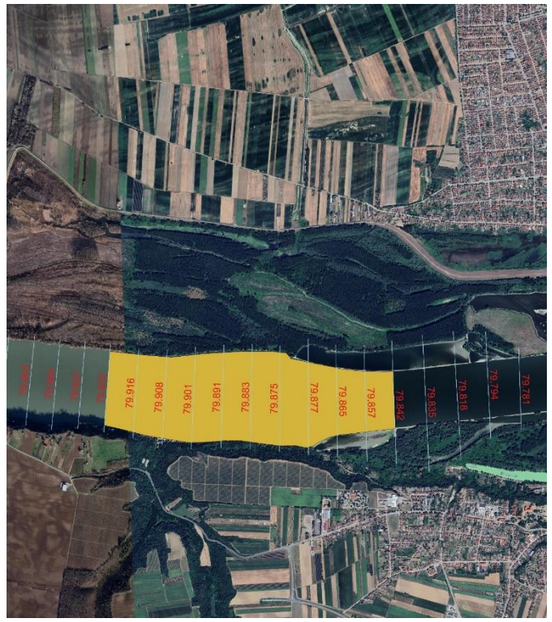
	Depth (m)		
Width (m)	2,5	2,8	3,0
200	0,00	-	-
150	0,00	0,00	8,56
120	0,00	-	-
100	0,00	0,00	0,00
80	0,00	-	-

Note

The Ilok section is not a critical section. This section is ranked 16th critical section. On this critical section, there are no quantities for cleaning by analyzing the dimensions of the waterway (criteria: width: 200 m, 150 m, 120 m, 100 m and 80 m and depth 2,5 m, 2,0 m, 3,0 m).

HNWL (m.a.s.l.)

From 79,842 to 79,922



LNWL (m.a.s.l.)

From 74,51 to 74,60

The obtained critical sectors and the necessary amounts of river sediment for cleaning (excavation) were compared with data from 2014, taken from: Application of the critical sector prioritization methodology on the joint SRB-CRO section of the Danube River, Plovput and Waterways Agency, 7/2014.

Table 2.13 Comparison of critical sections and the required amount of river sediment for cleaning in 2014 and 2021:

Legenda

-	0,00
0,01	10.000,00
10.000,01	25.000,00
25.000,01	75.000,00
75.000,01	

KS	Naziv	od rkm	do rkm	h	2021	2014
1	Batina / Bezdan	1429,00	1425,00	2,5	1.664,97	10.966,00
2	Siga-Kazuk	1424,20	1414,40	2,5	9,27	8.680,00
3	Apatin	1408,20	1400,00	2,5	58.570,39	79.979,00
4	Židovski/Čivutski rukavac	1397,20	1389,00	2,5	83.865,61	82.369,00
5	Ušće Drave	1383,40	1381,60	2,5	42.927,77	34.086,00
6	Aljmaš	1381,40	1378,20	2,5	0,00	0,00
7	Staklar	1376,80	1373,40	2,5	10.166,37	115.815,00
8	Erdut	1371,40	1366,40	2,5	436,33	1.831,00
9	Bogojevo	1366,20	1361,40	2,5	1.283,23	25.071,00
10	Dalj	1357,00	1351,00	2,5	9.202,99	17.844,00
11	Borovo I	1348,40	1343,60	2,5	85.065,32	126.841,00
12	Borovo II	1340,60	1338,00	2,5	51.804,63	9.890,00
13	Vukovar	1332,00	1325,00	2,5	843,86	54.700,00
14	Sotin	1324,00	1320,00	2,5	8.013,52	1.780,00
15	Opatovac	1315,40	1314,60	2,5	9,72	209,00
16	Mohovo	1311,40	1307,60	2,5	3.914,10	7.768,00
17	Ilok	1302,00	1300,00	2,5	0,00	0,00

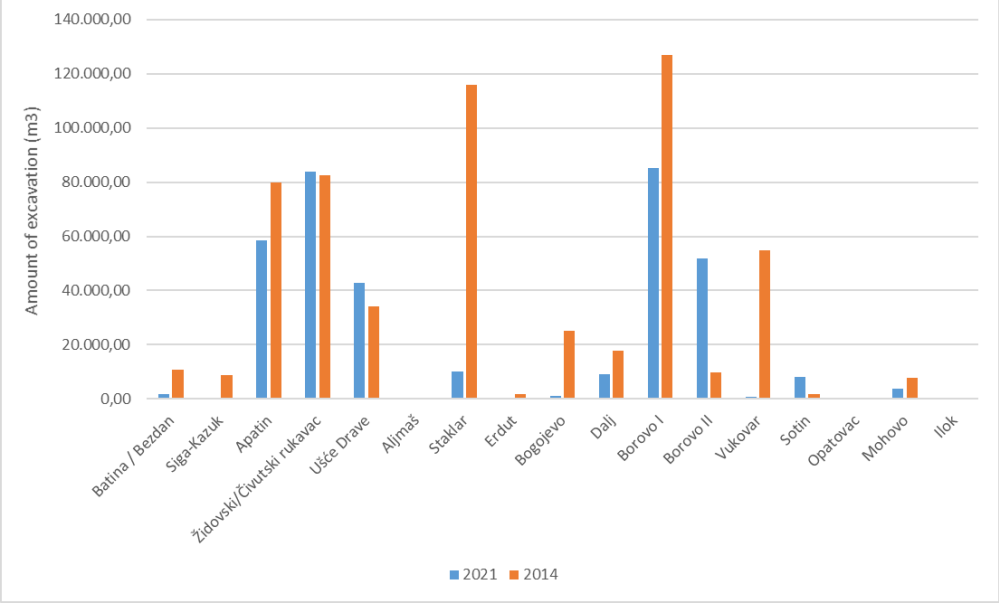


Figure 2.69. Comparison of quantities for cleaning (excavation) of materials to reach the appropriate dimensions of the waterway in 2014 and 2021.

2.8 Data on the ship movements in the project area

The effectiveness of the existing waterway was analyzed on the basis of logs of ships sailing on the relevant section of the Danube River. Data on the movement of ships in the subject area were obtained from the Client.

River Information Services (RIS) is an information group of related information, communication and navigation services to support the management of traffic and the transport of goods in inland navigation, including connections with other types of transport. The implementation of the system is important considering that inland navigation also takes place outside the borders of individual countries, and therefore it is necessary to ensure unhindered traffic, and equally important, to enable the integration of inland navigation.

The task of RIS is to improve the safety and efficiency of traffic on inland waterways, which contributes to their more intensive use, and to a reduced number and consequences of navigational accidents.

The main goals of RIS are, above all, safe transport on inland waterways with as few accidents and consequences of accidents as possible, and then efficient transport with reduced travel time, transport costs and fuel consumption. Using the river information system ensures safe, efficient and environmentally friendly transport.

Data on ship movements were analyzed for the month of August from August 15, 2022. until August 20, 2022, due to the fact that at that time it was the lowest recorded water level at the water measuring station Vukovar (-30 cm).

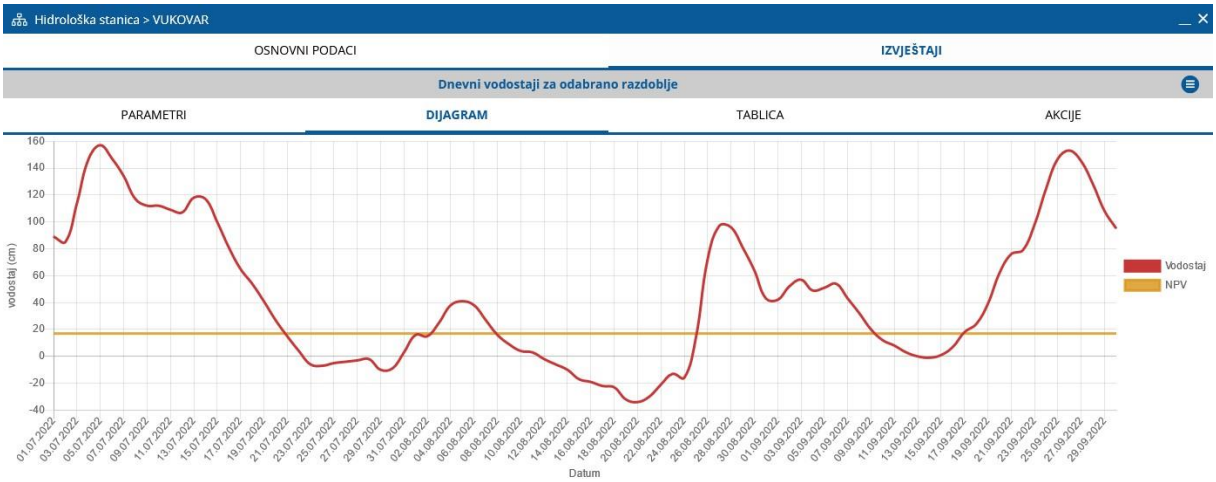


Figure 2.70. Display of the water level of the Danube River at the water measuring station Vukovar in the period from July to September 2022.

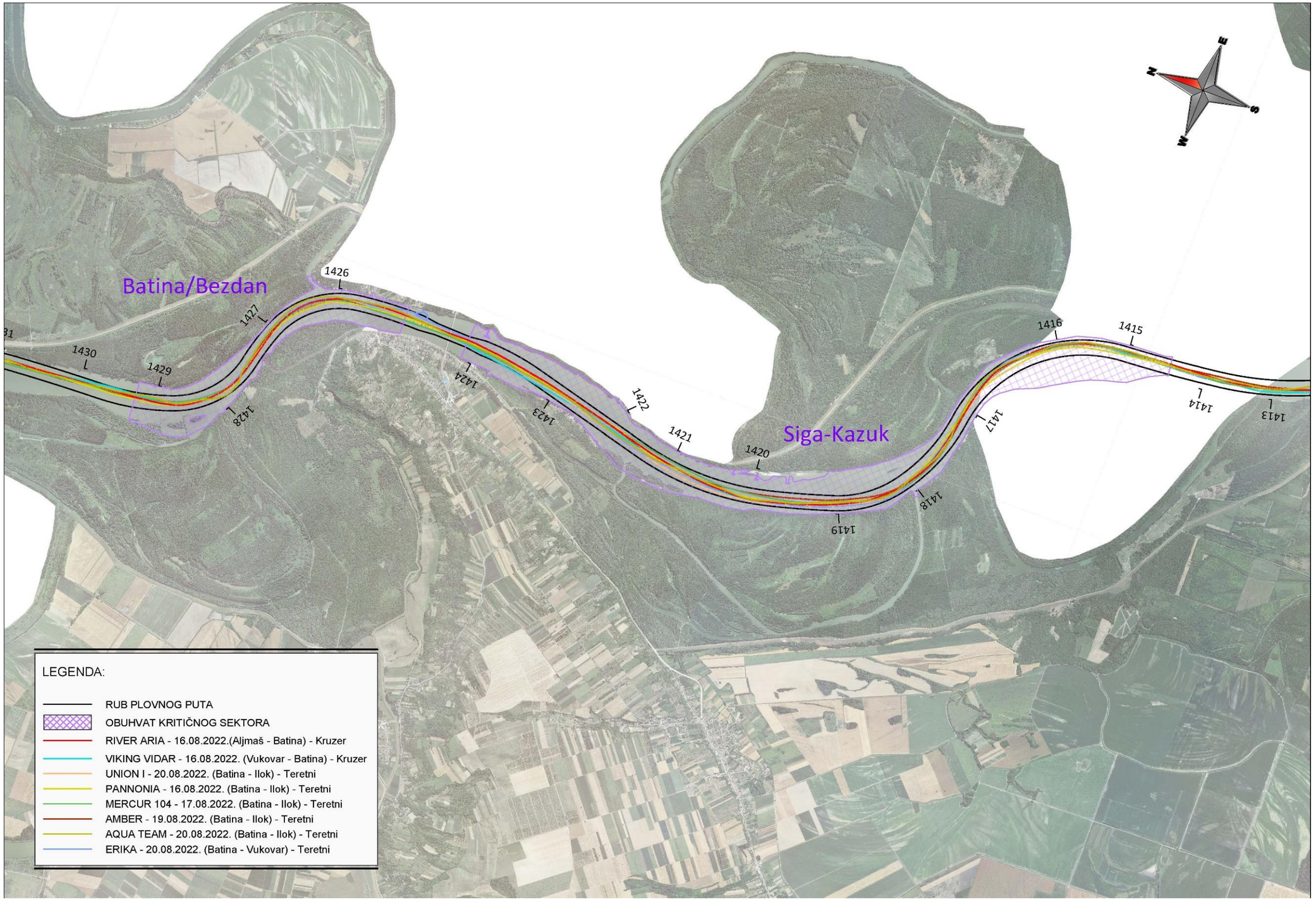
Further, the table (*Table 2.14*.) provides detailed information related to the obtained data.

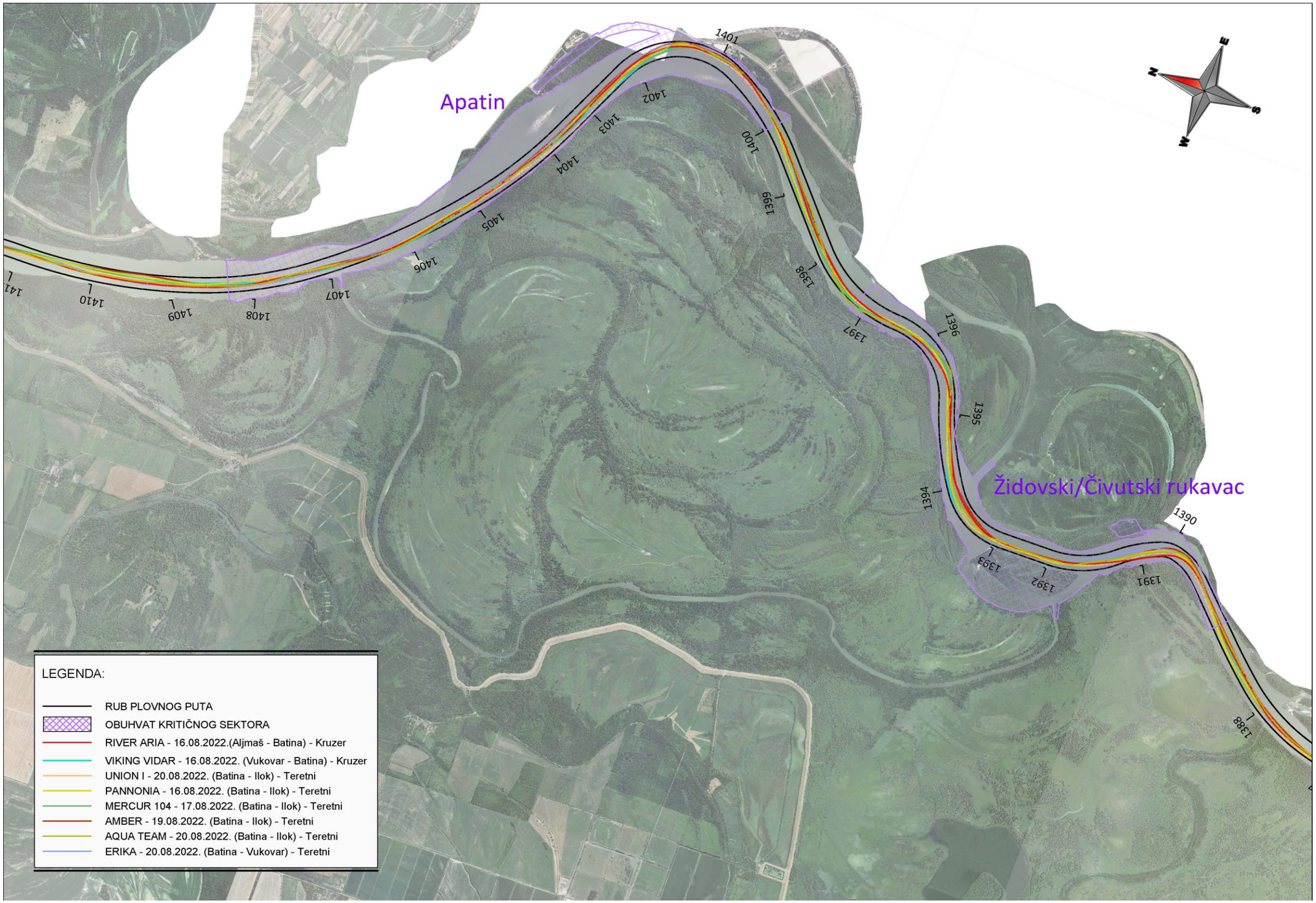
Table 2.14. Overview of received data on ship movements (Source: River Information Service, MMPI, Internal Navigation Administration):

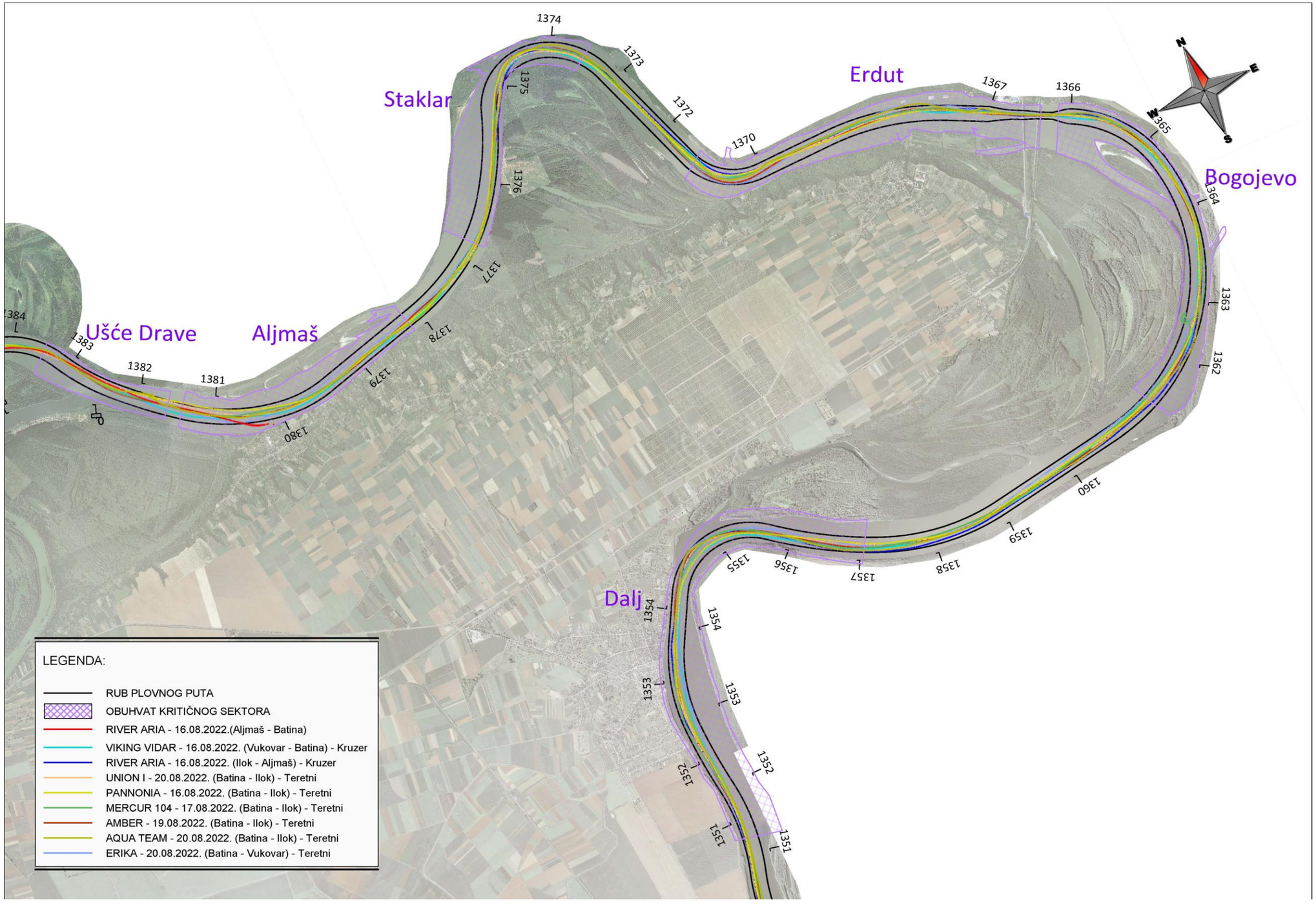
No.	Ship	Type of ship	Date	Information about the ship's voyage	
				From	To
1	AMBER	CARGO	19.8.2022	Batina	Ilok
2	AQUA	CARGO	20.8.2022	Ilok	Batina
3	ERIKA	CARGO	20.8.2022	Batina	Vukovar
4	MERCUR 104	CARGO	17.8.2022	Batina	Ilok
5	ORAŠAC	CARGO	15.8.2022	Vukovar	Ilok
6	PANNONIA	CARGO	16.8.2022	Batina	Ilok
7	RIVER ARIA	CRUISER	16.8.2022	Aljmaš	Batina
8	RIVER ARIA	CRUISER	16.8.2022	Ilok	Aljmaš
9	UNITON I	CARGO	20.8.2022	Batina	Ilok
10	VIKING VIDAR	CRUISER	15.8.2022	Ilok	Vukovar
11	VIKING VIDAR	CRUISER	16.8.2022	Vukovar	Batina

Data on the movement of ships on the subject stretch are systematized and shown in the attachments below. The attachments indicate the existing waterway, the river station and data on the movement of ships on the section in question.

It is evident from the navigation logs that the trajectories of the ships are mostly within the dimensions of the 200 m wide waterway at low water levels. There are locations where shippers use the marginal parts of the waterway, such as Apatin, Židovski/Čivutski ruvac, Staklar, Erdut, Borovo 1, Sotin, Opatovac and Mohovo.


Batina/Bezdan
Siga-Kazuk
1426
1427
1430
1429
1428
1424
1423
1422
1421
1420
1419
1418
1417
1416
1415
1414
1413
LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
RIVER ARIA - 16.08.2022.(Aljmaš - Batina) - Kruzer
VIKING VIDAR - 16.08.2022. (Vukovar - Batina) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
MERCUR 104 - 17.08.2022. (Batina - Ilok) - Teretni
AMBER - 19.08.2022. (Batina - Ilok) - Teretni
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ERIKA - 20.08.2022. (Batina - Vukovar) - Teretni


Apatin
Židovski/Čivutski rukavac
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1400
1399
1398
1397
1396
1395
1394
1390
1393
1392
1391
1388
N
E
S
W
LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
RIVER ARIA - 16.08.2022.(Aljmaš - Batina) - Kruzer
VIKING VIDAR - 16.08.2022. (Vukovar - Batina) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
MERCUR 104 - 17.08.2022. (Batina - Ilok) - Teretni
AMBER - 19.08.2022. (Batina - Ilok) - Teretni
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ERIKA - 20.08.2022. (Batina - Vukovar) - Teretni


Staklar
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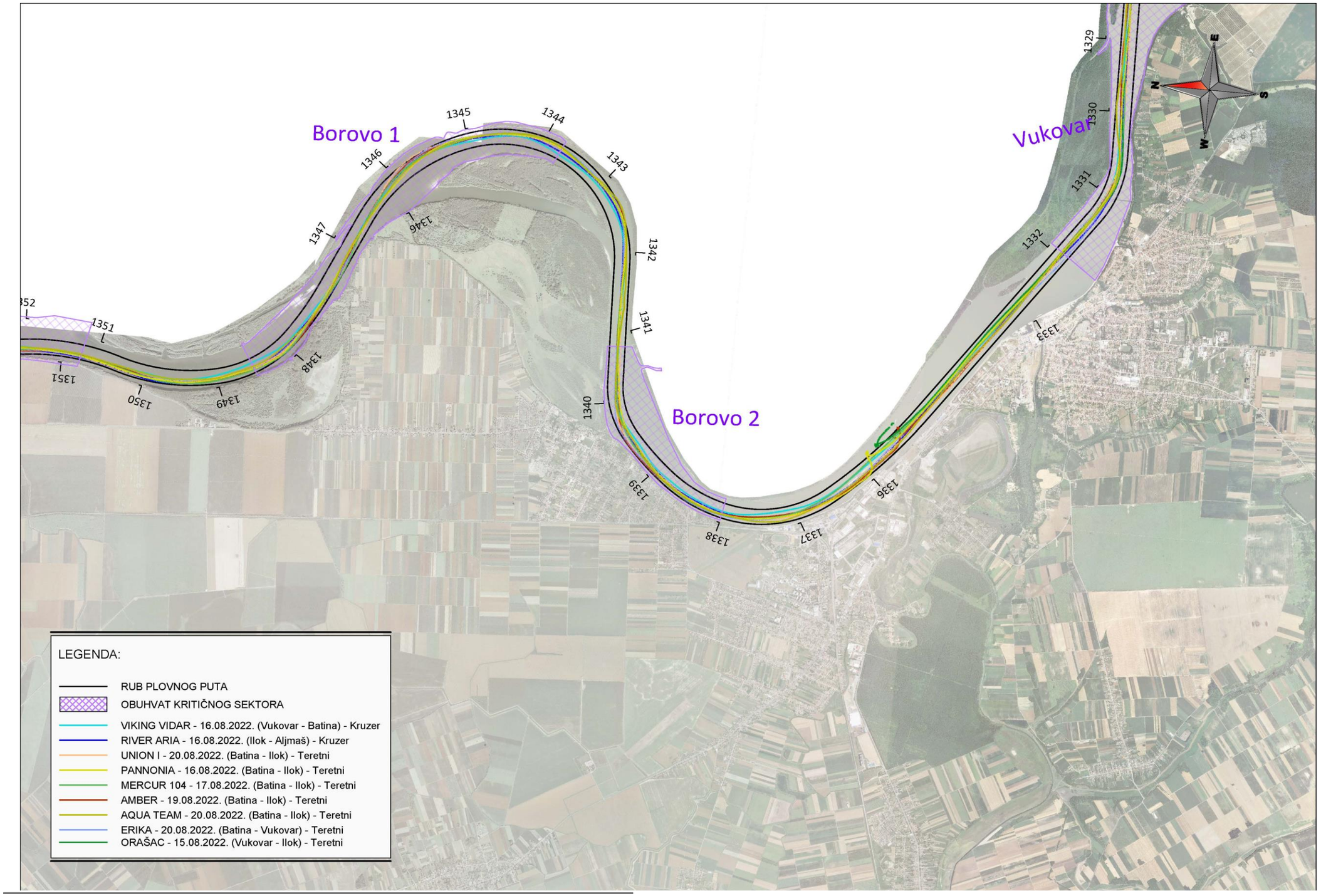
LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
RIVER ARIA - 16.08.2022.(Aljmaš - Batina)
VIKING VIDAR - 16.08.2022. (Vukovar - Batina) - Kruzer
RIVER ARIA - 16.08.2022. (Ilok - Aljmaš) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
MERCUR 104 - 17.08.2022. (Batina - Ilok) - Teretni
AMBER - 19.08.2022. (Batina - Ilok) - Teretni
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ERIKA - 20.08.2022. (Batina - Vukovar) - Teretni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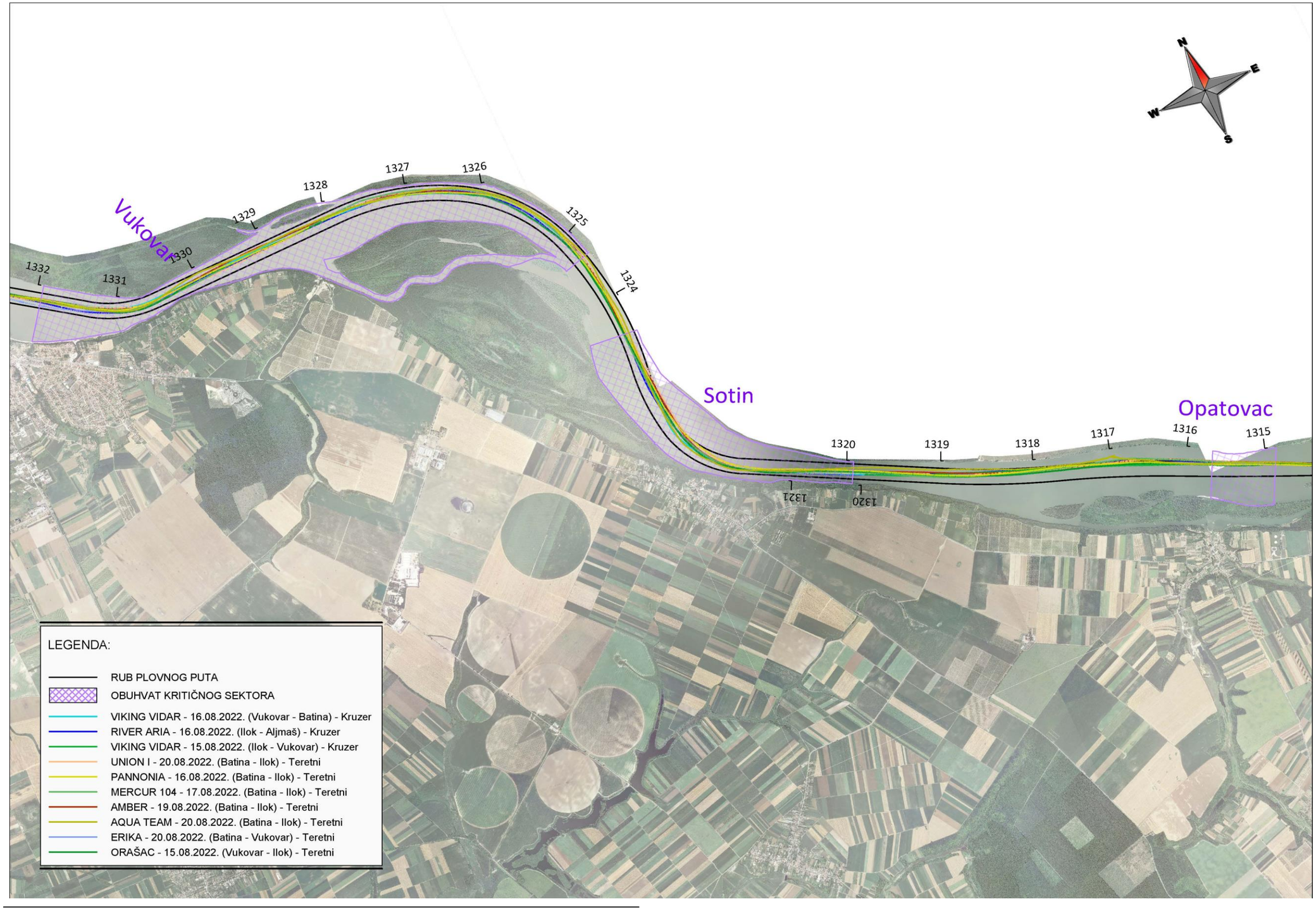
LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
VIKING VIDAR - 16.08.2022. (Vukovar - Batina) - Kruzer
RIVER ARIA - 16.08.2022. (Ilok - Aljmaš) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
MERCUR 104 - 17.08.2022. (Batina - Ilok) - Teretni
AMBER - 19.08.2022. (Batina - Ilok) - Teretni
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ERIKA - 20.08.2022. (Batina - Vukovar) - Teretni
ORAŠAC - 15.08.2022. (Vukovar - Ilok) - Teretni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LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
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RIVER ARIA - 16.08.2022. (Ilok - Aljmaš) - Kruzer
VIKING VIDAR - 15.08.2022. (Ilok - Vukovar) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
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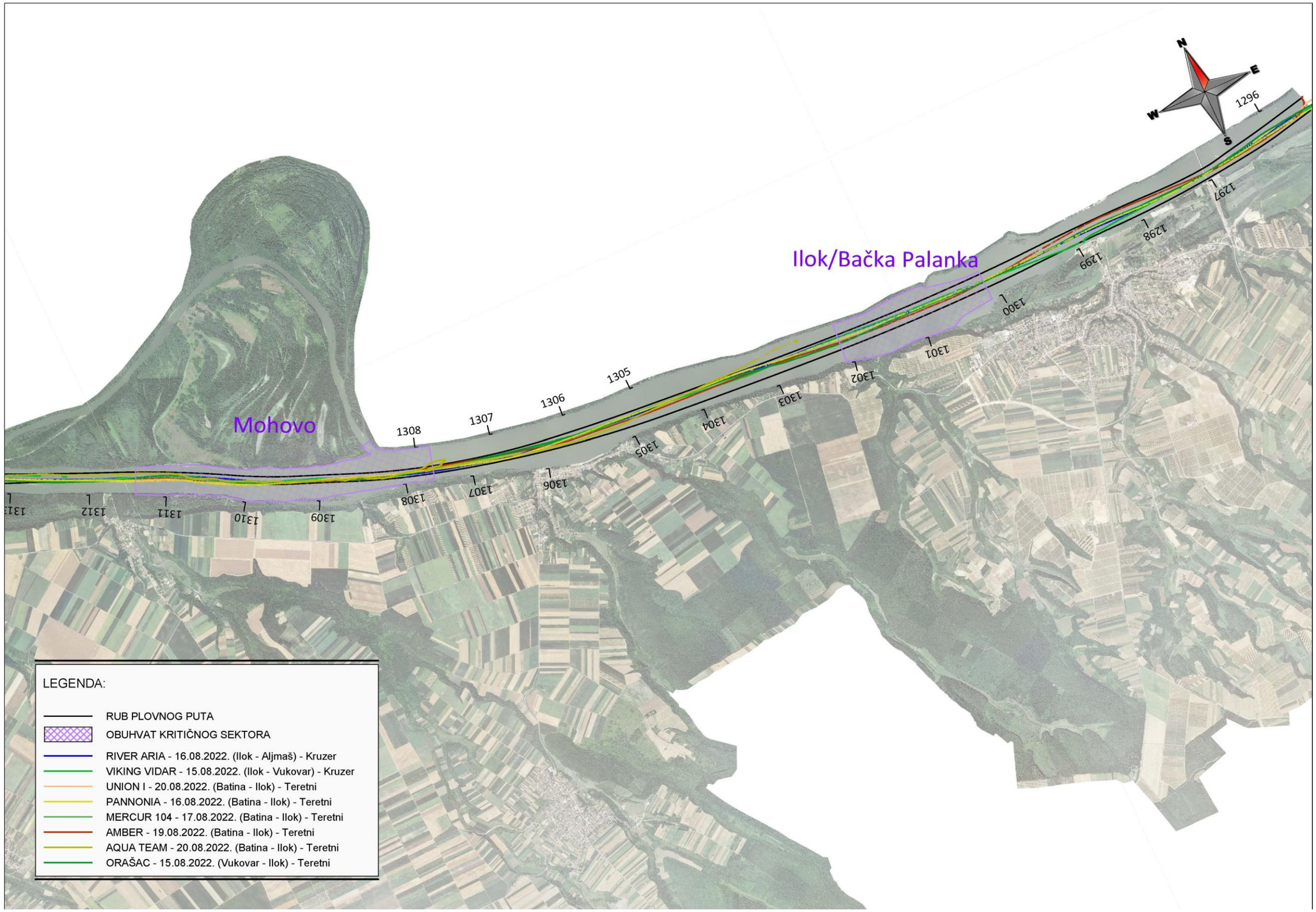
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ERIKA - 20.08.2022. (Batina - Vukovar) - Teretni
ORAŠAC - 15.08.2022. (Vukovar - Ilok) - Teretni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Mohovo
Ilok/Bačka Palanka
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LEGENDA:
RUB PLOVNOG PUTA
OBUHVAT KRITIČNOG SEKTORA
RIVER ARIA - 16.08.2022. (Ilok - Aljmaš) - Kruzer
VIKING VIDAR - 15.08.2022. (Ilok - Vukovar) - Kruzer
UNION I - 20.08.2022. (Batina - Ilok) - Teretni
PANNONIA - 16.08.2022. (Batina - Ilok) - Teretni
MERCUR 104 - 17.08.2022. (Batina - Ilok) - Teretni
AMBER - 19.08.2022. (Batina - Ilok) - Teretni
AQUA TEAM - 20.08.2022. (Batina - Ilok) - Teretni
ORAŠAC - 15.08.2022. (Vukovar - Ilok) - Teretni

2.9 Analysis of existing traffic volumes on the Danube River

To analyze the existing volumes of traffic, available data on river traffic in the relevant sections of the Danube River were collected. The data was received from the Client, which included all traffic on the relevant sections, namely:

- cargo transport of all purposes (division by composition or vessel and amount of cargo in tons) and
- passenger traffic (number of dockings and number of passengers).

Cargo traffic on the Danube River is exclusively related to the functioning of the port of Vukovar. The port of Vukovar is located 1335 km from the Danube River in the area of the so-called middle Danube. It is located at the intersection of the west-south trade flows between Croatia and Bosnia and Herzegovina, as well as the northeast between Hungary, Serbia and Romania.

There are four passenger wharfs along the waterway of the Danube River in the Republic of Croatia: Ilok (km 1299+000), Vukovar (km 1333+000), Aljmaš (km 1380+000) and Batina (km 1425+500). Passenger wharfs on the Danube River are managed by the Port Authority of Vukovar.

2.9.1 Analysis of the current state of freight traffic on the Danube River in ports on the territory of the Republic of Croatia

The port of Vukovar has the best position of all Croatian river ports for river navigation between Croatia and the European Union as well as the countries around the Black Sea. Due to its location on the Danube River, Vukovar is almost completely outside the influence of shallow waters, which allows the port a high rate of productivity. Due to the proximity of Osijek and Vinkovci, the port is well connected with national and international railway systems and the Pan-European Corridor Vc.

The table and graphic below shows the number of vessel arrivals for the period from 2015 to 2021.

Table 2.15 The number of dockings in the port of Vukovar

	Port of Vukovar						
Year	2015	2016	2017	2018	2019	2020	2021
The number of dockings	-	243	289	376	450	517	331

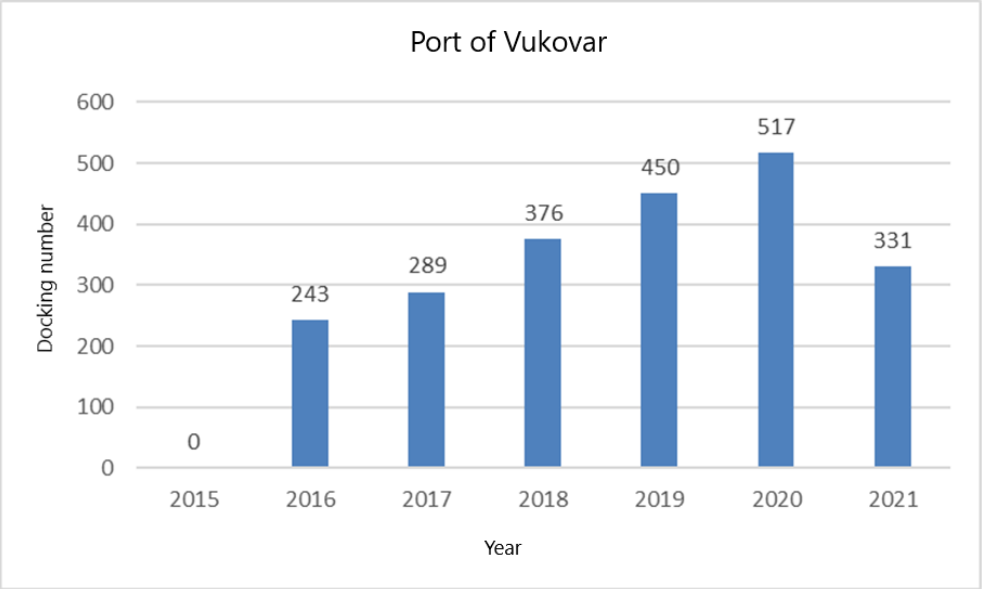


Figure 2.71. Number of dockings - Vukovar port.

Vukovar is a river port that can serve class 5 ships (classes of ships are described in the previous chapter), and the navigability category and reliability of navigation on the Danube 365 days a year put it ahead of other river ports in Croatia. The installed capacities of the port enable transshipment of up to 2,000,000 t per year. The port of Vukovar is extremely conveniently located, considering that it is integrated into the Rhine-Main-Danube navigation system, which connects the North and Black Seas.

The table below shows received data on freight traffic in tons [t] for the port of Vukovar in the period from 2015 to 2019.

Table 2.16 Data of cargo traffic in the port of Vukovar:

	Number of freight traffic by vessel type		**The volume of cargo traffic**
Year	**Composition**	**Vessels**	**[t]**
2015	0	0	424.304
2016	171	72	332.941
2017	213	76	319.467
2018	309	67	418.708
2019	290	160	483.929
2020	454	63	557.534

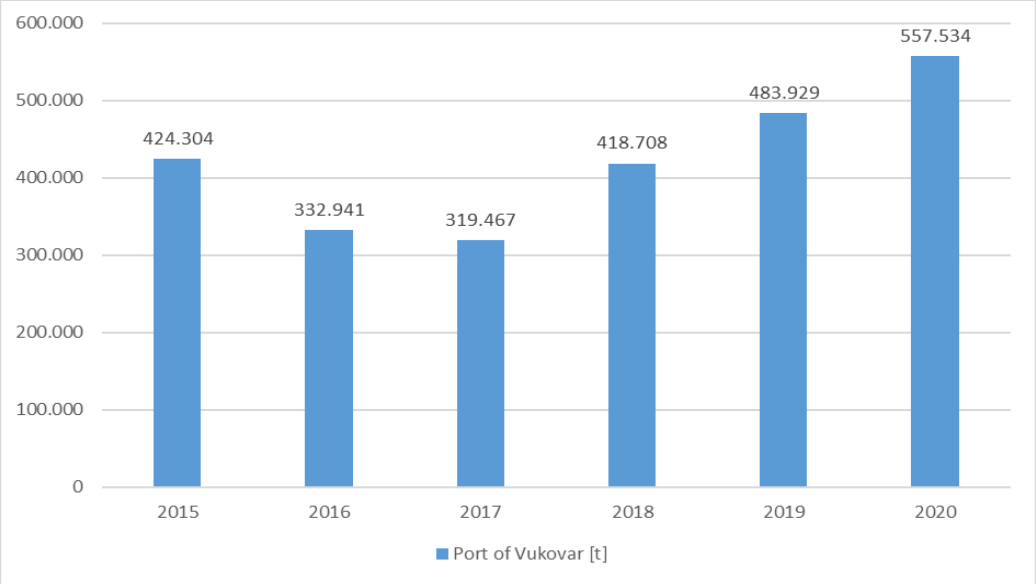


Figure 2.72. Data on cargo traffic (tons/year) in the port of Vukovar.

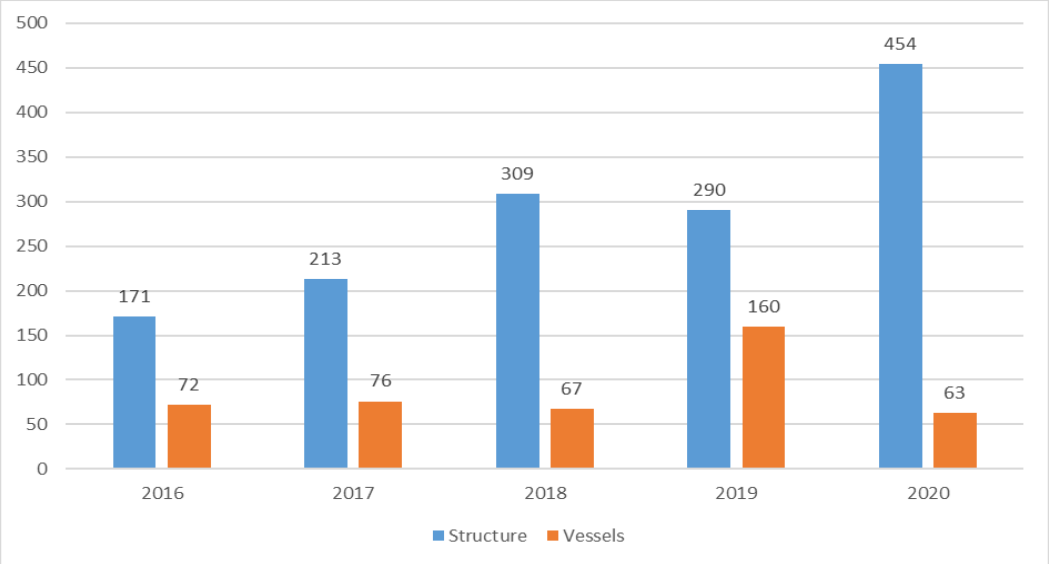


Figure 2.73. Number of freight traffic by vessel type.

The structure of transshipped cargo in the port of Vukovar for the period 2017-2020 is shown in the graphic attachments below.

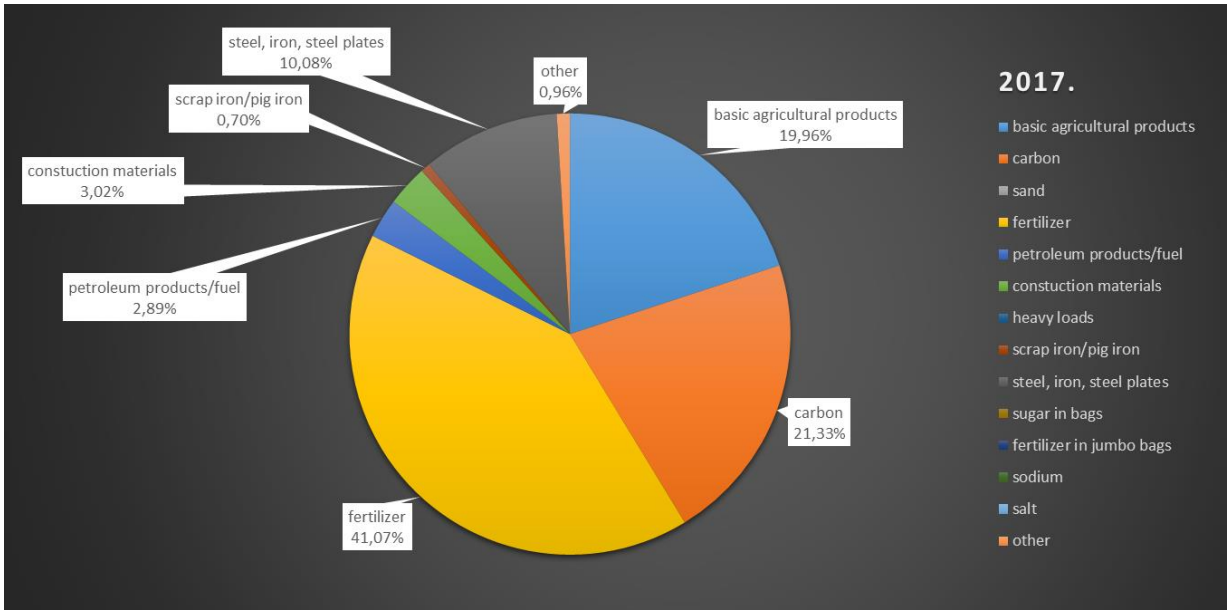


Figure 2.74. Cargo structure in the port of Vukovar for 2017.

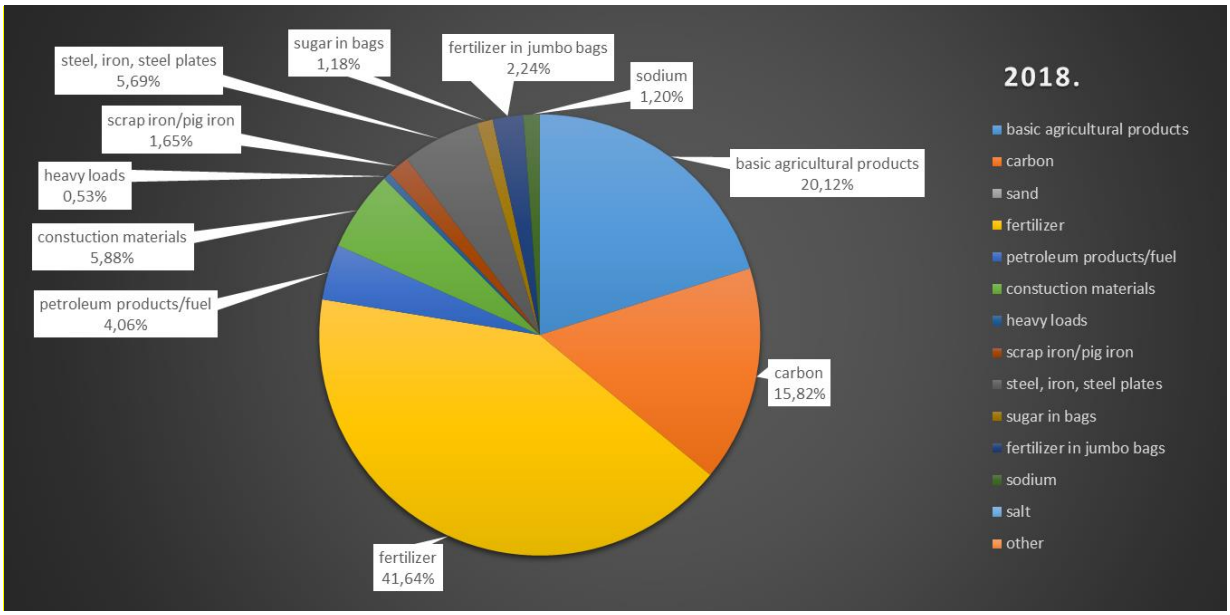


Figure 2.75. Cargo structure in the port of Vukovar for 2018.

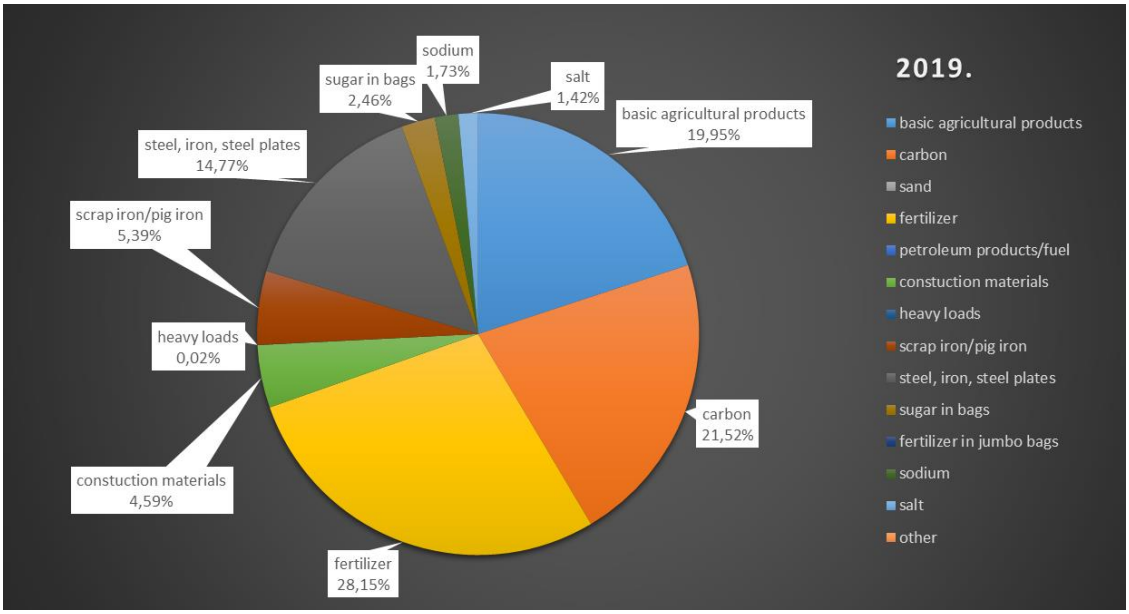


Figure 2.76. Cargo structure in the port of Vukovar for 2019.

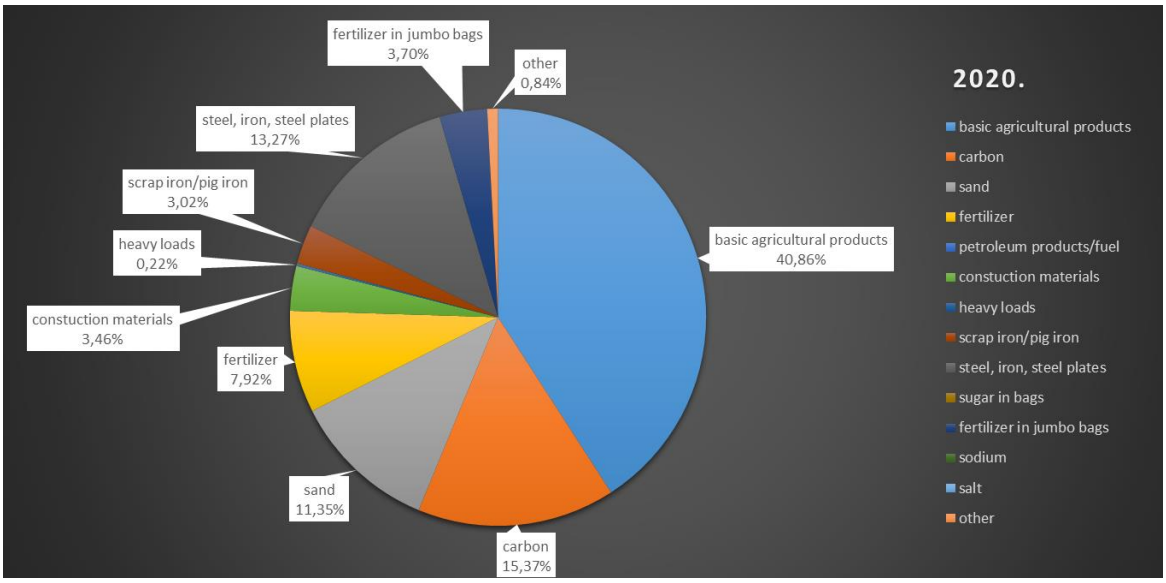


Figure 2.77. Cargo structure in the port of Vukovar for 2020.

By analyzing the structure of transshipped cargo in the port of Vukovar for the period from 2017-2020, we conclude that in the port of Vukovar mostly bulk cargo is transshipped (basic agricultural products, coal, sand, fertilizer), while a smaller part is liquid (petroleum products/fuel) and general cargo (construction materials, heavy loads, scrap / pig iron, steel, iron, steel plates, powdered sugar, fertilizer in jumbo bags, sodium, salt and others).

2.9.1 Analysis of the current state of passenger traffic on the Danube River in ports on the territory of the Republic of Croatia

The table below shows the received data on the traffic of passenger ships for the passenger ports of Ilok, Vukovar, Aljmaš and Batina in the period from 2015 to 2020.

Table 2.17. Data on the traffic of passenger ships at the locations of Ilok, Vukovar, Aljmaš and Batina:

	Passenger wharf Ilok		Passenger wharf Vukovar		Passenger wharf Aljmaš		Passenger wharf Batina	
Year	No. of docking instances	Number of passengers registered	No. of docking instances	Number of passengers registered	No. of docking instances	Number of passengers registered	No. of docking instances	Number of passengers registered
2015	22	2.822	221	29.207	0	0	36	4.485
2016	31	4.168	224	27.122	0	0	41	4.710
2017	37	5.326	205	27.162	4	557	33	4.734
2018	40	6.079	231	31.972	28	4.175	32	4.285
2019	71	11.327	351	49.114	86	12.650	49	7.122
2020	1	83	14	1.277	0	0	9	974

From data for the period 2015-2020. year, there is a visible trend of growth in the number of passengers from 2017 to 2019 and an extremely significant drop in 2020 caused by the pandemic (COVID-19). From the available data, we can see that for the Aljmaš passenger wharf (in 2020) there were about 50 arrivals in the announcement, but all arrivals were cancelled. Another example is the Ilok wharf, where out of the 86 announced dockings in 2020, only one ship arrived.

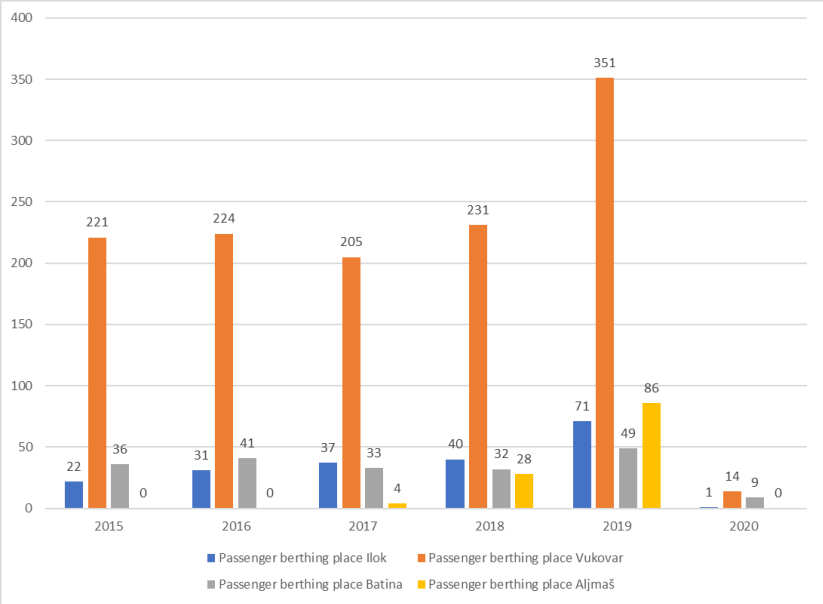


Figure 2.78. Data on the number of passenger ship landings on the Danube River.

Out of a total of 4 wharfs on the Danube River, more than 70% of the number of landings took place at the Vukovar passenger wharf.

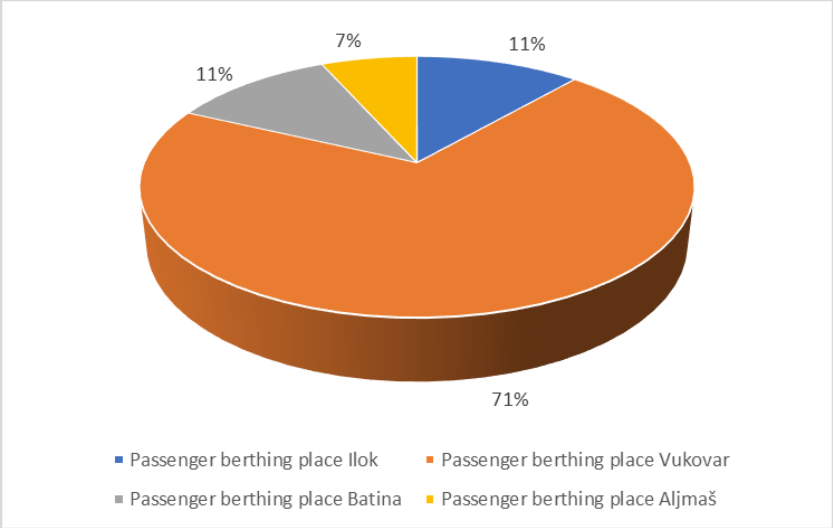


Figure 2.79. Comparative presentation of passenger traffic on the Danube River.

Following on from the presented analysis, it should be noted that the preparation of project documentation for the modernization and expansion of the existing wharf for passenger ships on the right bank of the Danube River in Vukovar is underway (completion is expected in 2023).

2.10 Evaluation conditions of the existing waterway

Waterway depth

The depth analysis on the subject critical sections was made for the existing route of the VI.c class waterway. An analysis was made of critical sections and transverse profiles where, at LNWL=$V_{94\%}$, the depth of the 200 m wide waterway is less than 2,5 m.

From the analysis of the depths of the existing waterway for VI.c. class, it can be seen that out of a total of 17 critical sections, 7 of them are critical, i.e. 44% of the sections in question are critical.

Therefore, it can be concluded that, if a waterway depth of 2,5 m is to be achieved on the entire section of the Drava River at a 94% duration of water level and a defined width of the waterway of 200 m, it is necessary to carry out regulatory works and/or technical maintenance works on 41% of the section, i.e. in a length of approx. 32,80 km (out of a total of 79,40 km).

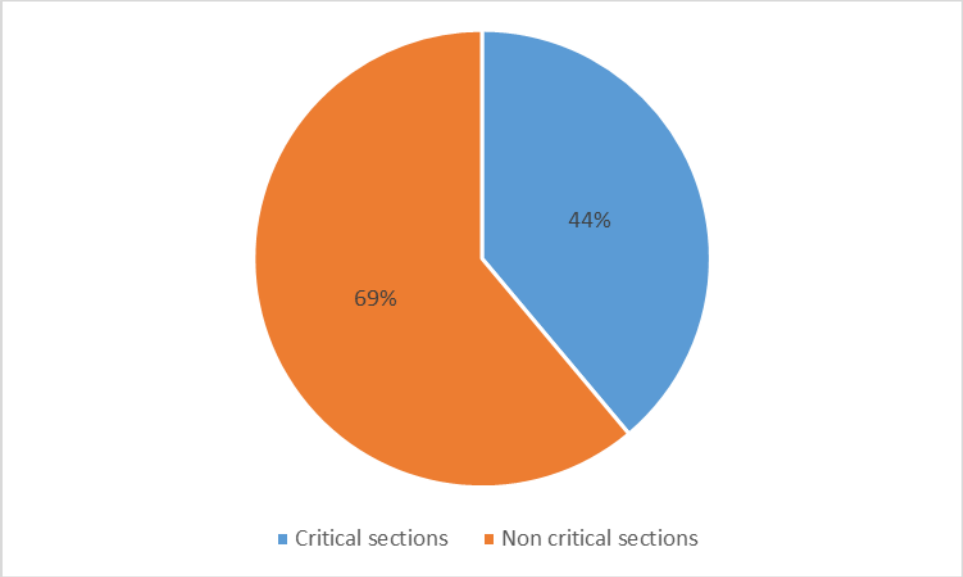


Figure 2.80. Analysis of the criticality of sections in dependence on the depth of the waterway

Critical sections are Borovo I, Židovski/Čivutski rukavac, Apatin, Borovo II, Ušće Drave and Staklar and Mohovo bearing in mind that in this section the bottom is rocky/firm and the obstacles are created by underwater solid structures.

Sections that are not critical are: Dalj, Sotin, Batina / Bezdan, Bogojevo, Vukovar, Erdut, Opatovac, Siga-Kazuk, Ilok and Aljmaš.

The width of the waterway

The analysis depending on the width of the waterway in the section in question was made for widths of 200, 150, 120, 100 and 80 m.

From the analysis of the widths, it is evident that out of a total of 17 critical sectors:

- 6 sectors are critical for the width of 200 m (Apatin, Židovski/Čivutski rukavac, Ušće Drave, Staklar, Borovo I and Borovo II),
- 4 sectors are critical for a width of 150 m (Apatin, Židovski/Čivutski rukavac, Borovo I and Borovo II),
- 1 sector is critical for a width of 120 m (Apatin) and
- no section is critical for widths 100 and 80 m.

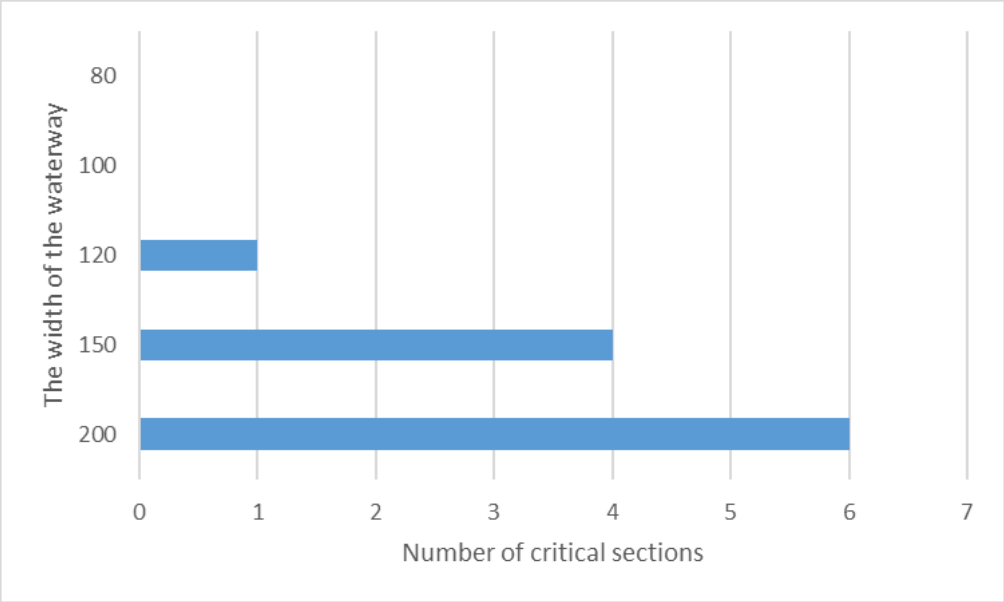


Figure 2.81. Analysis of the criticality of sections in dependence on the width of the waterway.

- Section Mohovo is critical for all widths of the waterway except for the width of 80 m because of underwater underwater solid structures and obstacles created.

Waterway bend radius

For the purposes of this analysis, the minimum radius of the waterway is Rmin=1000m. On morphologically inappropriate sections, Rmin = 800 m is exceptionally permitted.

In the entire subject area, the axis of the existing waterway consists of 101 bends and 34 intermediate routes. Out of a total of 101 bends, 10 of them have a smaller radius than Rmin=1000m and 1 bend has a smaller radius than Rmin=750 m (at rkm 1390 with a length of approx. 200m, i.e. on the critical section Židovski/Čivutski rukavac).

According to the analyzes carried out, it is evident that almost 100% of the section meets the minimum radius Rmin = 750 m.

The width of the waterway and the height of the free profile under the bridges

Required criteria:

- minimum free width under the bridges 50 m
- minimum clearance under bridges 9,10 m

There are four bridges in the subject section shown in the following table.

The bridge	Stationary [rkm]	B_{pl} [m]	H_{vpl} [m]	HNWL [m.a.s.l.]	ELBS [m.a.s.l.]
Road bridge Batina - Bezdan	1424+425	120,00	**9,30**	86,64	95,94
Road bridge Erdut - Bogojevo	1366+625	125,00	**9,61**	83,41	93,02
Railway bridge Erdut - Bogojevo	1366+443	80,00	**8,59**	83,40	91,99

Road bridge Ilok - Bačka Palanka	1297+050	120,00	**10,13**	79,67	89,80

where are:

- *B_{pl} (m) is the horizontal distance between the endpoints that limit the waterway*
- *H_{vpl} (m) – the vertical distance between the high navigable water level and the lower bridge structure*
- *HNWL – the high navigable water level in the bridge profile*
- *ELBS – the lowest elevation of the lower edge of the bridge structure*

Out of a total of 4 bridges on the Danube River section from Batina to Ilok only the road and railway bridge Erdut – Bogojevo are located within the critical sections defined by the project. It is evident from the analysis that only the railway bridge Erdut - Bogojevo does not meet the required minimum clearance height of 9,10 m.

Sections where the waterway located adjacent to the bank potentially threatens the stability of the bank and the safety of navigation (side erosion of the banks).

On the section in question, 6 sections were observed that do not meet the criteria, i.e. the waterway is located right next to the coast, thus jeopardizing the stability of the coast (erosion) and the safety of navigation.

The sections located directly along the coast are: Apatin, Židovski/Čivutski rukavac, Staklar, Borovo I, Vukovar and Sotin.

Overall evaluation of the state of the existing waterway

The assessment of the state of the existing VI.c waterway was based on previously conducted analyses. According to the conducted analyses:

- depth of the fairway — partially satisfies (10/17)
- width of the fairway — partially satisfies (10/17)
- fairway bend radii — satisfies (16/17)
- waterway width and height
  free profile under bridges — partially satisfies (3/4)
- sections where the waterway is located
  right next to the coast, which endangers it
  coastal stability and navigation safety — partially satisfies (11/17)

In the current conditions, disturbances due to insufficient depth and/or width and the small radius of bends do not cause delays in navigation on any critical section, because these are short sections and one-way navigation is always possible, for which there is sufficient width at any time if you sail in prescribed compositions.

2.11 The list of existing river regulation structures

According to the data from the document "*Cadastre - Schematic Form of Buildings*" ("*Katastar – shematski oblik građevina")* and "*Cadastre - Tables*" („*Katastar – tablice*"), as well as the data available to the Executor, the following regulatory buildings are located on the relevant section of the Danube River from rkm 1433.1 to rkm 1295.5:

In total, there are 181 regulatory buildings on the subject section, of which 92 are on the right bank, and 89 are on the left bank.

The list of existing regulatory buildings also includes regulatory buildings (1321-1, 1322-1, 1323-1) near Sotin, which are currently under construction.

Table 2.18. List of regulatory buildings on the right bank of the Danube River:

Desna obala				
No.	***Name***	***Type of building***	***Chainage***	***Date of construction***
1	1432-2			
2	1432-1	GROYNE 1a	1432+200	1972
3	1431-2			
4	1431-1	GROYNE 2a	1431+350	1972
5	1428-4	PARALLEL CONSTRUCTION WITH TRAVERSES	1428+500-1429+500	1942-1948
6	1428-3	T-GROYNE	1428+900	1972
7	1428-2	T-GROYNE	1428+650	1972
8	1428-1	T-GROYNE	1428+425	1971
9	1427-2	PARALLEL CONSTRUCTION	1427+700	1975
10	1427-1	REVETMENT	1427+400-1429+400	1893-1913
11	1426-4	REVETMENT	1427+300-1426+500	1908-1909
12	1426-3	PARALLEL CONSTRUCTION	1426+500	1908-1909
13	1426-2	GROYNE	1426+300	1908-1909
14	1426-1	GROYNE	1426+100	1908-1909
15	1425-2	REVETMENT	1425+800	1908-1909
16	1424-3	TRAVERSE	1424+100	1897-1898
17	1424-2	TRAVERSE	1424+200	1897-1898
18	1424-1	REVETMENT	1424+150-1426+000	
19	1423-4	REVETMENT	1423+250-1422+750	1897-1898
20	1423-3	PARALLEL CONSTRUCTION	1424+200-1423+250	1897-1898
21	1423-2	BARRIER	1423+300	1961-1965
22	1423-1	BARRIER "ZELENI OTOK"	1423+200	
23	1422-1	GROYNE	1422+100	1970-1972
24	1421-3	GROYNE	1421+700	1970-1972
25	1421-2	GROYNE	1421+400	1970-1972
26	1421-1	GROYNE	1421+100	1970-1972
27	1420-1	GROYNE	1420+800	1970-1972

Desna obala				
No.	**Name**	**Type of building**	**Chainage**	**Date of construction**
28	1418-1	REVETMENT	1420+650-1418+200	1973-1979
29	1417-2	REVETMENT	1418+150-1416+950	1976
30	1417-1	GROYNE	1417+960	1976
31	1412-1	REVETMENT	1412+000	1937-1938
32	1409-2	GROYNE	1409+000	1909-1910
33	1409-1	GROYNE	1409+300	1909-1910
34	1408-3	GROYNE	1408+700	1909-1910
35	1408-2	GROYNE	1408+500	1909-1910
36	1408-1	GROYNE	1408+100	1909-1910
37	1407-1	REVETMENT	1407+900-1407-000	1909-1910
38	1406-2	BARRIER	1406+900	1893-1899
39	1406-1	REVETMENT	1406+900-1406+500	1893-1894
40	1406-4	PARALLEL CONSTRUCTION	1406+7-1406+815	
41	1406-3	PARALLEL CONSTRUCTION	1406+6-1406+655	
42	1406-1	GROYNE	1406+22	
43	1405-2	GROYNE	1405+625	
44	1397-1	REVETMENT	1398+400-1396+800	1967
45	1395-1	LANDFILL	1396+400-1395+600	1976
46	1393-4	LANDFILL	1393+855-1394+124	1976
47	1393-3	PARALLEL CONSTRUCTION	1393+650-1393+856	1976
48	1393-2	TRAVERSE	1393+704	1976
49	1393-1	BARRIER	1393+000	1972
50	1392-4	REVETMENT	1393+000	1972
51	1392-3	REVETMENT	1393+000-1392+100	1973
52	1392-2	PARALLEL CONSTRUCTION	1391+900	1972
53	1392-1	THRESHOLD	1391+500	1972
54	1387-1	BARRIER	1387+650	1973
55	1386-1	REVETMENT	1388+000-1384+700	1974-1976
56	1384-1	REVETMENT	1384+000-1386+040	1974
57	1382-2	TRAVERSE	1382+400	1973
58	1382-1	PARALLEL CONSTRUCTION	1382+150-1382+500	1973
59	1381-2	T-GROYNE	1381+950	1973
60	1381-1	T-GROYNE	1381+450	1974
61	1380-2	T-GROYNE	1380+850	1974
62	1380-1	REVETMENT	1380+480-1380+300	1979
63	1379-1	REVETMENT	1379+300-1378+870	
64	1378-1	REVETMENT	1378+850-1377+950	1976
65	1377-1	REVETMENT	1377+360-1378+230	1975
66	1368-1	GROYNE	1368+380	1982
67	1367-2	GROYNE	1367+800	1983

Desna obala				
No.	**Name**	**Type of building**	**Chainage**	**Date of construction**
68	1367-1	GROYNE	1367+080	1982
69	1361-1	GROYNE	1361+100	1978-1981
70	1360-2	GROYNE	1360+700	1978-1979-1980
71	1360-1	GROYNE	1360+300	1978-1979-1980
72	1359-2	GROYNE	1359+850	1978
73	1359-1	BARRIER	1359+000	1979
74	1355-2	GROYNE	1355+300	1979
75	1355-1	GROYNE	1355+100	1979
76	1354-1	GROYNE	1354+900	1979
77	1353-1	REVETMENT	1352+350-1355+050	1957-1963
78	1348-1	REVETMENT	1349+380-1347+700	1983
79	1338-1	REVETMENT	1337+676-1339+800	1974
80	1336-1	REVETMENT	1337+643-1335+241	
81	1333-1	REVETMENT	1332+400-1334+750	1957;1957-1961;1962-1963
82	1331-1	REVETMENT	1332+400	
83	1327-1	REVETMENT	1327+625-1327+800	
84	1323-1	PARALLEL CONSTRUCTION	1322+725-1323+870	2022
85	1322-1	GROYNE	1322+015	2022
86	1321-1	GROYNE	1321+53	2022
87	1315-1			
88	1309-1			
89	1306-1			
90	1300-2			
91	1300-1			
92	1296-1	PARALLEL CONSTRUCTION	1296+900-1296+700	1976

Table 2.19. List of regulatory buildings on the left bank of the Danube River:

Left bank				
No.	**Name**	**Type of building**	**Chainage**	**Date of construction**
1	1432-13	BARRIER	1432+650	1971
2	1432-12	GROYNE	1432+350	1971
3	1430-12	REVETMENT	1430+200-1432+180	1927-1934
4	1430-11	PARALLEL CONSTRUCTION	1430+100	1971-1976
5	1430-00	T-GROYNE	1430+000	1971-1976
6	1429-12	T-GROYNE	1430+900	1971
7	1429-11	REVETMENT	1429+300-1429+850	1978
8	1426-11	REVETMENT	1426+300-1425+650	
9	1425-15	REVETMENT	1425+650-1425+550	1961-1965

Left bank				
No.	***Name***	***Type of building***	***Chainage***	***Date of construction***
10	1425-14	REVETMENT	1425+550-1425+470	1961-1965
11	1425-13	REVETMENT	1425+350-1425+470	1961-1965
12	1425-12	REVETMENT	1425+310-1425+350	1961-1965
13	1425-11	REVETMENT	1425+310-1424+990	
14	1424-13	REVETMENT	1424+990-1424+900	
15	1424-12	GROYNE	1424+700	1901-1902
16	1424-11	GROYNE	1424+400	1901-1902
17	1423-11	GROYNE	1423+500	1901-1902
18	1422-13	GROYNE	1422+900	1891-1892
19	1422-12	GROYNE	1422+300	1901-1902
20	1421-11	REVETMENT	1421+800-1420+600	1905-1907;1935-1938
21	1420-12	GROYNE	1420+250	1970-1972
22	1420-11	GROYNE	1420+000	1970-1972
23	1419-11	GROYNE	1419+500	1970-1972
24	1415-11	REVETMENT	1414+450-1416+295	1974-1976
25	1410-11	REVETMENT	1410+150-1409+650	1909-1910
26	1405-11	REVETMENT	1406+250-1404+450	1904-1908
27	1403-12	BARRIER	1403+550	1966
28	1403-11	REVETMENT	1401+230-1404+000	1929-1931-1955
29	1402-11	REVETMENT	1401+800-1402+500	1965-1970
30	1401-11	REVETMENT	1401+700	1957-1960
31	1400-12	REVETMENT	1400+500-1399+600	1912-1913
32	1400-11	REVETMENT	1400+500-1400+800	1912-1913
33	1399-11	REVETMENT	1399+100-1399+570	1979
34	1398-12	PARALLEL CONSTRUCTION	1398+800	1979
35	1398-11	GROYNE	1398+250	1979-1983
36	1397-12	GROYNE	1398+000	1979-1983
37	1397-11	GROYNE	1397+700	1979-1983
38	1396-12	GROYNE	1396+900	1976
39	1396-11	LANDFILL	1396+200-1396+800	1978
40	1395-14	BARRIER	1396+000	1965-1967
41	1395-13	REVETMENT	1396+000-1394+600	1965-1967
42	1395-12	THRESHOLD	1395+390	1977
43	1395-11	THRESHOLD	1395+400	1977
44	1394-11	REVETMENT	1394+400-1395+000	1972-1973
45	1390-11	REVETMENT	1388+600-1390+900	1898-1906
46	1388-12			
47	1388-11	GROYNE	1388+250	1979-1983
48	1387-12	T-GROYNE	1387+700	1977
49	1387-11	BARRIER	1387+250	1977

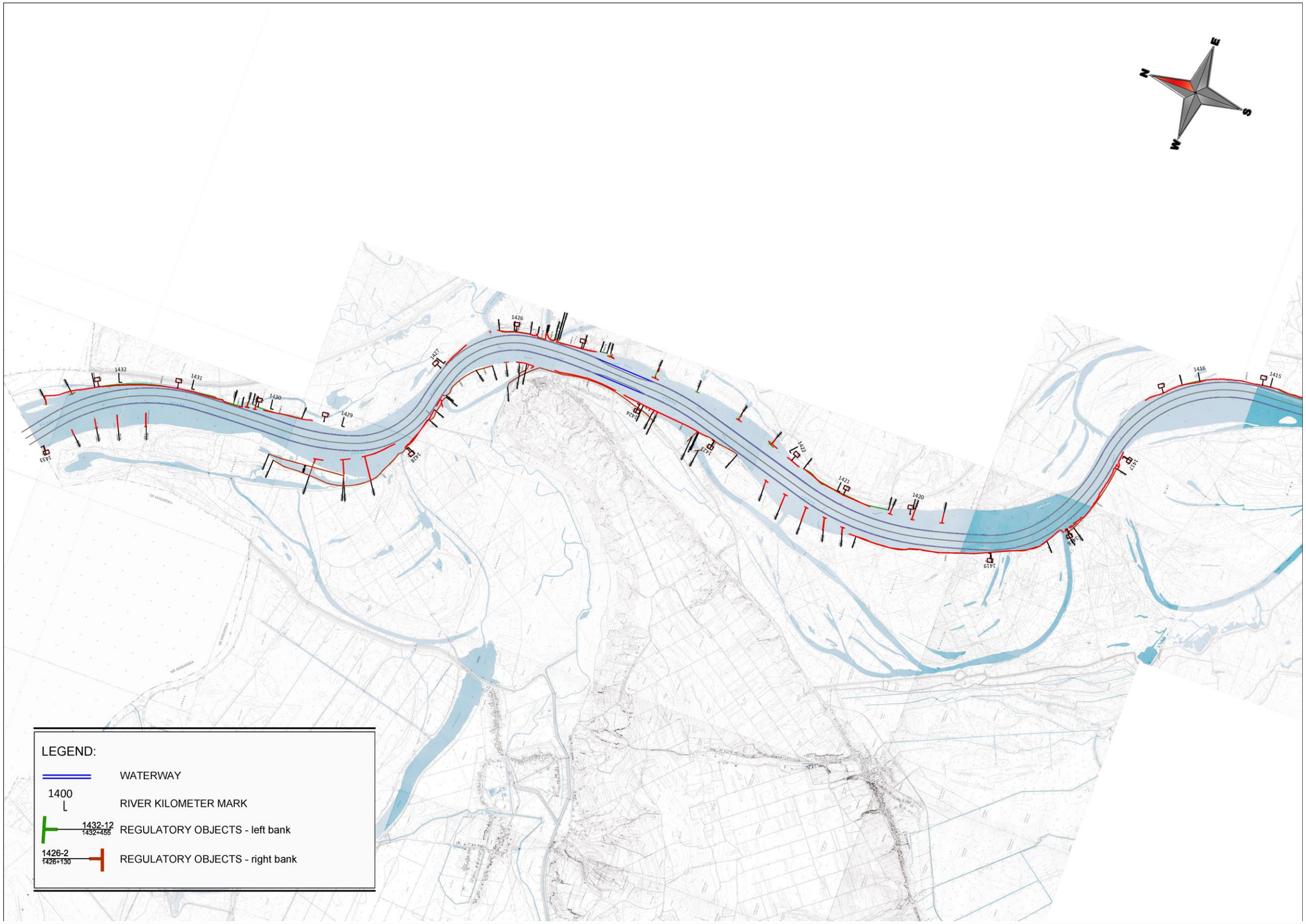
Left bank				
No.	***Name***	***Type of building***	***Chainage***	***Date of construction***
50	1386-11	BARRIER	1386+700	1977-1978
51	1383-12	REVETMENT	1384+400-1383+500	1894-1895;1971-1972
52	1383-11	REVETMENT	1383+500-1382+800	1971
53	1381-11	T-GROYNE	1381+100	1973-1974
54	1380-12	T-GROYNE	1380+800	1974
55	1380-11	T-GROYNE	1380+200	1976
56	1379-12	T-GROYNE	1379+640	1976
57	1379-11	T-GROYNE	1379+100	1974
58	1378-11	T-GROYNE	1378+500	1974
59	1375-11	REVETMENT	1375+800-1373+750	1910-1917;1933-1964
60	1373-14	THRESHOLD	1373+800	1975
61	1373-13	THRESHOLD	1373+980	1975
62	1373-12	THRESHOLD	1373+880	1975
63	1373-11	THRESHOLD	1373+780	1975
64	1373-10	BARRIER	1373+000	1910-1914
65	1372-11	REVETMENT	1372+600-1373+000	1910-1914
66	1367-11	REVETMENT	1367+000-1368+000	1937-1940
67	1366-12	REVETMENT	1366+500-1367+400	1887-1893
68	1365-11	REVETMENT	1361+500-1366+500	1893-1908
69	1361-12	GROYNE	1361+500	1978
70	1361-11	GROYNE	1361+000	1978
71	1360-12	BARRIER	1360+700	
72	1358-13	PARALLEL CONSTRUCTION	1359+370	1981
73	1358-12	THRESHOLD	1358+180	1981
74	1358-11	THRESHOLD	1358+000	1981
75	1357-11	THRESHOLD	1357+800	1981
76	1350-11			
77	1349-12	GROYNE	1349+830	1983
78	1349-11	GROYNE	1349+300	1983
79	1342-11	REVETMENT	1340+500-1345+580	1918-1923;1938-1939;1947
80	1319-11			
81	1307-11			
82	1300-13			
83	1300-12			
84	1300-11			
85	1297-13	GROYNE	1297+780	1976
86	1297-12	GROYNE	1297+400	1976
87	1297-11	GROYNE	1297+040	1976
88	1296-12	GROYNE	1296+700	1979

Left bank				
No.	**Name**	**Type of building**	**Chainage**	**Date of construction**
89	1296-11	GROYNE	1296+340	1979

**Regulatory facilities in engineering practice are named in such a way that the facility has a river kilometer mark in its name, a mark for the right or left bank of the river and its serial number on the specified river kilometer.*

Regulatory objects are systematized and shown in the attachments below. The attachments show the existing waterway, river station and regulatory facilities on the left and right banks of the Danube.

Detailed overview of river regulation infrastructure is given in a separate document "M*onitoring of hydrological, hydraulic and morphological characteristics of the Danube river and inventory of biodiversity components on the joint croatian-serbian sector of the Danube river - Inventory of river regulation infrastructure related to navigation*", I-2206/24; Hidroing Ltd. Osijek) based on conducted field surveying.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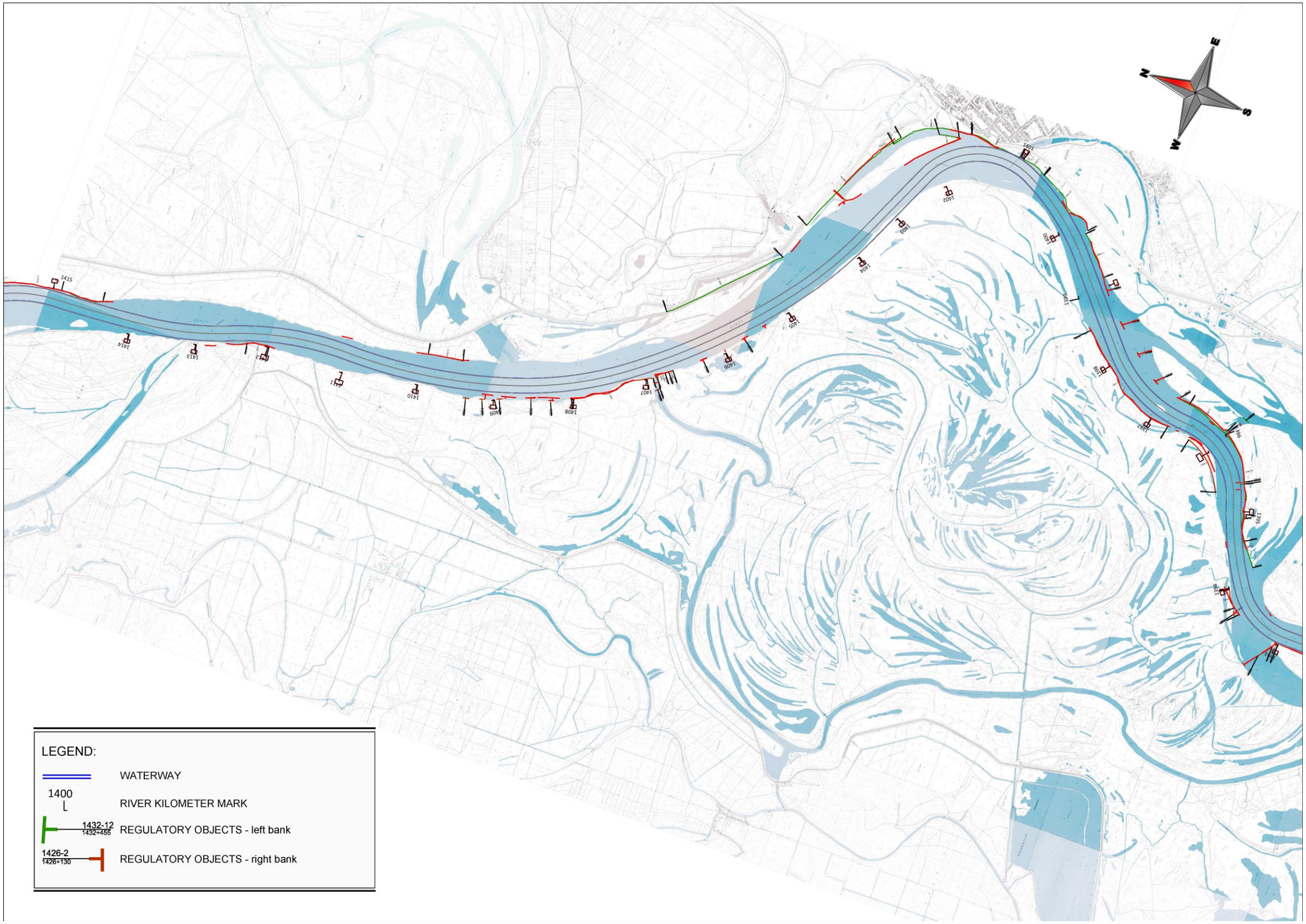
1416
1415
LEGEND:
WATERWAY
1400
L
RIVER KILOMETER MARK
1432-12
1432+455
REGULATORY OBJECTS - left bank
1426-2
1426+130
REGULATORY OBJECTS - right bank


LEGEND:
WATERWAY
1400
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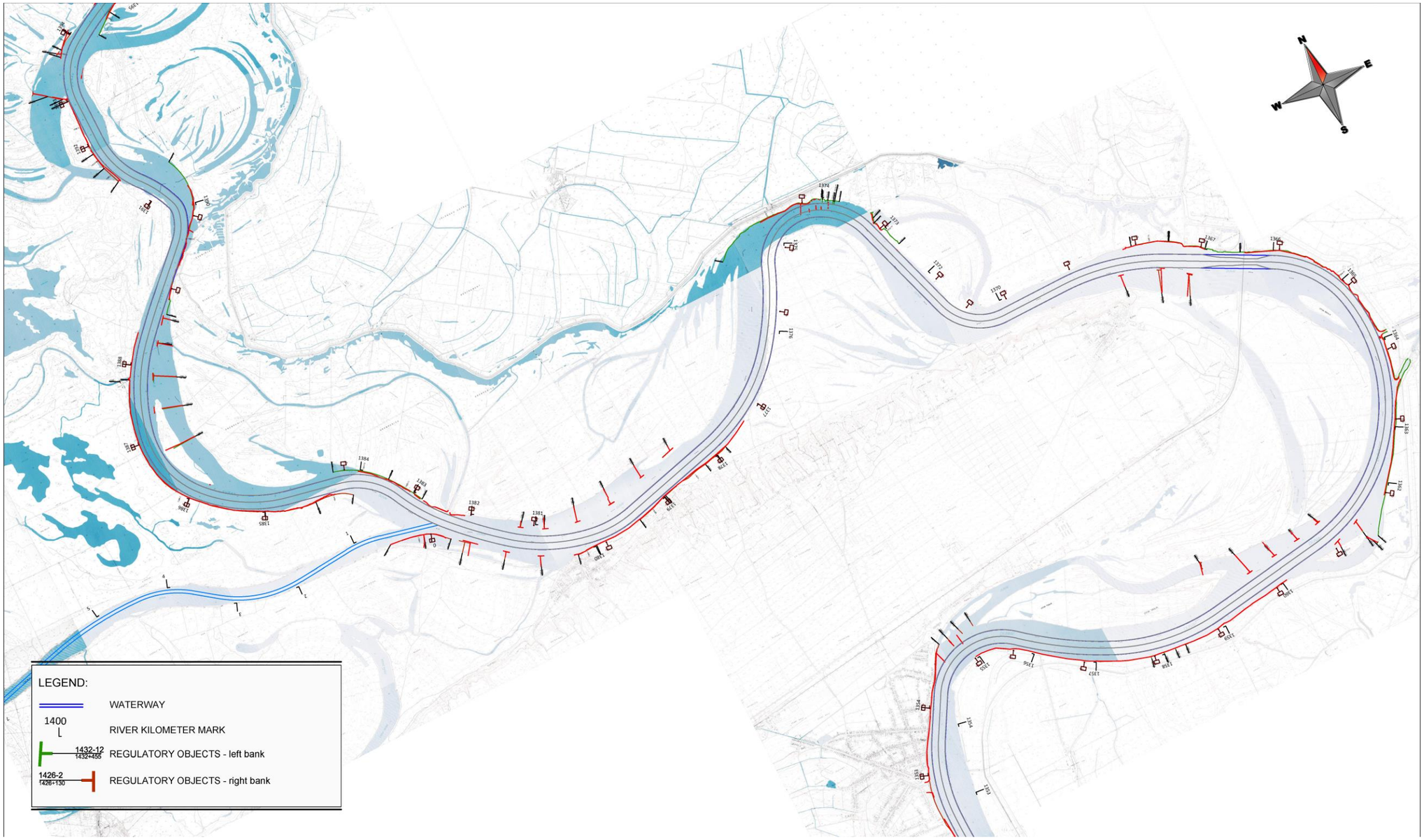
RIVER KILOMETER MARK
1432-12
1432+455
REGULATORY OBJECTS - left bank
1426-2
1426+130
REGULATORY OBJECTS - right bank


N
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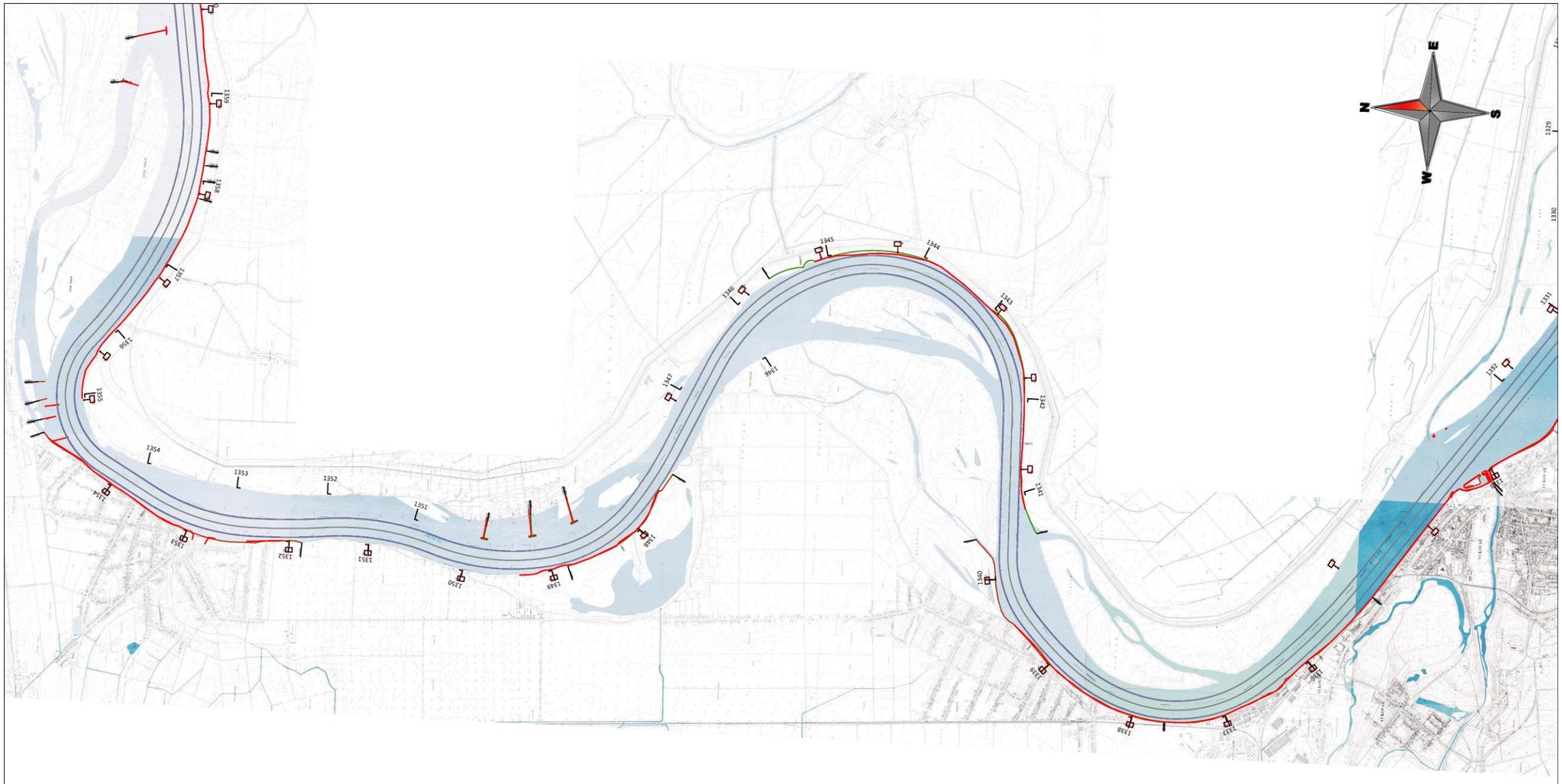
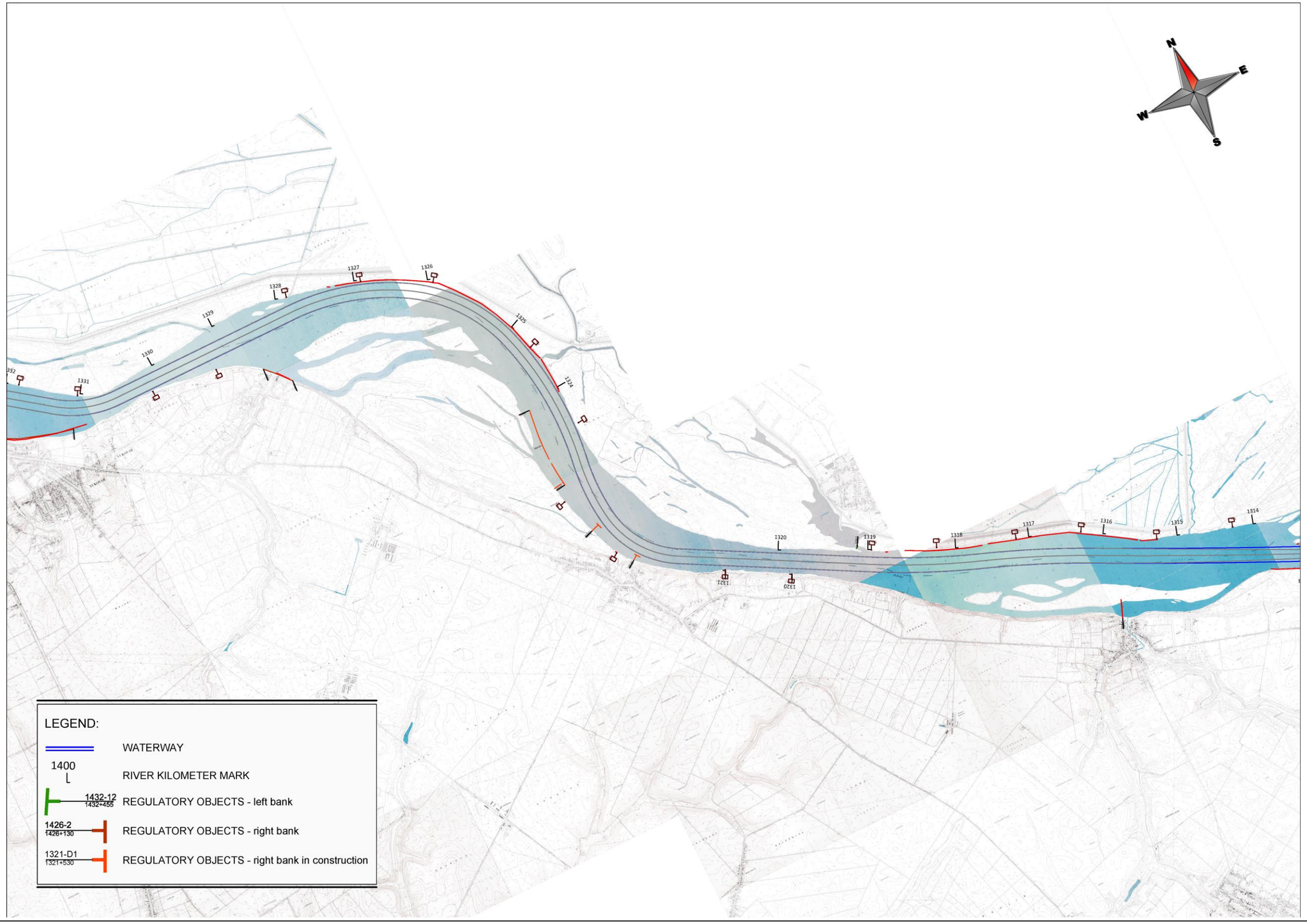
LEGEND:
WATERWAY
1400
RIVER KILOMETER MARK
1432-12
1432+455
REGULATORY OBJECTS - left bank
1426-2
1426+130
REGULATORY OBJECTS - right bank



LEGEND:

- WATERWAY
- 1400 — RIVER KILOMETER MARK
- 1432-12 / 1432+455 — REGULATORY OBJECTS - left bank
- 1426-2 / 1426+130 — REGULATORY OBJECTS - right bank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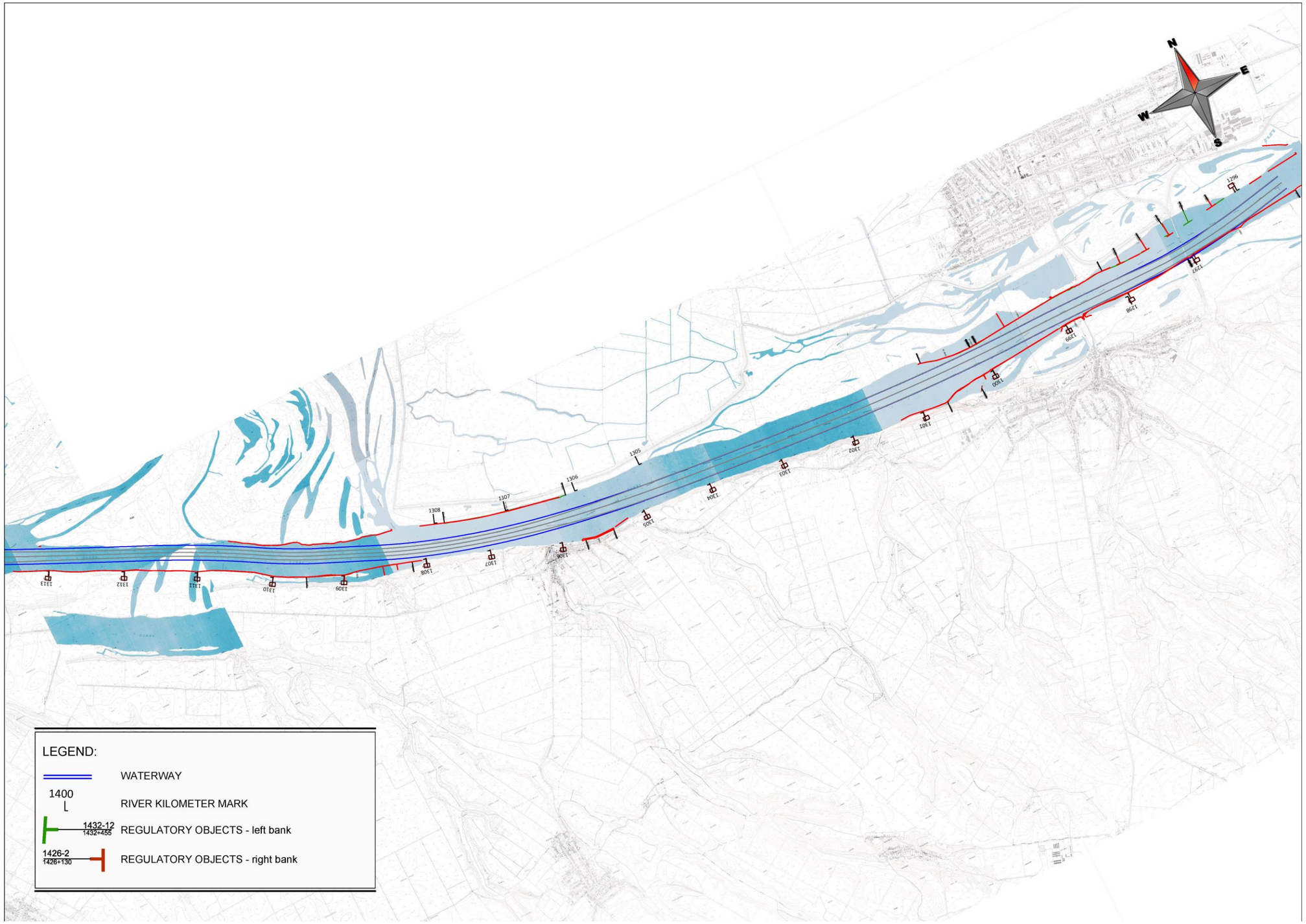
1315
1314
LEGEND:
WATERWAY
1400
RIVER KILOMETER MARK
1432-12
1432+455
REGULATORY OBJECTS - left bank
1426-2
1426+130
REGULATORY OBJECTS - right bank
1321-D1
1321+530
REGULATORY OBJECTS - right bank in construction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1311
1312
1313
LEGEND:
WATERWAY
1400
RIVER KILOMETER MARK
1432-12
1432+455
REGULATORY OBJECTS - left bank
1426-2
1426+130
REGULATORY OBJECTS - right bank

2.12 Metodology

In this chapter, the methodology for monitoring the parameters relevant to the maintenance of the waterway is given, namely:

- Inventory of all regulatory buildings related to navigation,
- Speed and flow measurement,
- Measurement of the transfer of suspended and dragged sediment,
- Installation of piezometers.

2.12.1 Inventory of regulatory buildings

For the purposes of inventorying all regulatory buildings related to navigation, all buildings will be needed on the ground:

- geodetic recording (i.e. plan and height recording of the elevation of the crown of the building) namely:
  - revetments (beginning and end of the building, and visible damage if necessary)
  - groynes and parallel construction (beginning and end of construction and rooting in the shore)
- photograph and document at water levels that allow a visual inspection:
  - photos must contain location data (GPS coordinates) so that they can be displayed in the space within the interactive map of the subject area
  - buildings should be photographed from several sides for the purpose of a detailed visual impression

After the field work, the buildings will be analyzed and processed in several textual and graphic forms:

- textual (table):
  - building designation,
  - name and type of building,
  - about the location of the building,
  - length and elevation of the crown of the building,
  - condition of the building
- graphically:
  - the situation of regulatory buildings with a display of the building designation: the content of the plan will be the regulatory buildings recorded during the field visit, aligned with records from the cadastre of buildings

- buildings will be marked according to the following description:

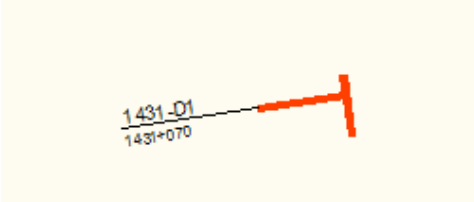


Figure 2.82. Display of the regulatory building.

where:

- *1431 – river kilometer of the building*
- *D1 - right bank first object (L = left bank)*
- *1431+070 – exact river kilometer of the building*

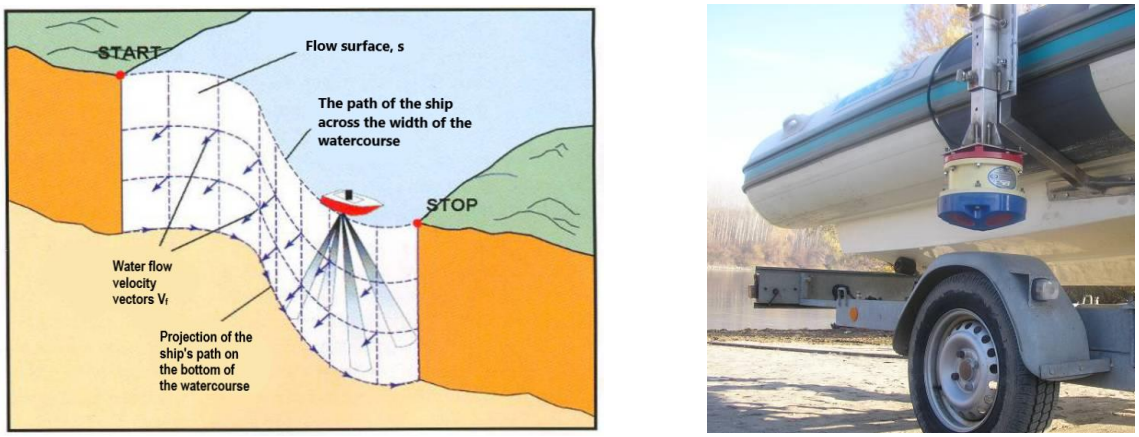
An example of a table view is given below:

Right bank						
No.	***Building designation***	***Name and type of building***	***Location of the building rkm or from rkm to rkm***	***Length of the building m***	***Elevation of the crown of the building m.a.s.l.***	***Condition of the building***
1	1431-D1	T-groyne	1431	206	82,95	Good

2.12.2 Flow and velocity field measurement

An acoustic current meter based on the Doppler effect, Acoustic Doppler Current Profiler (ADCP) type RDI Workhorse Rio Grande, frequency 1200 kHz, will be used to measure the flow and current image. This acoustic current meter is used to measure the spatial direction and speed of the flow. The current meter is connected to the boat on its side. A GPS-RTK positioning system is used to locate the boat in plan, which coordinates the measurement with the selected profile measurement positions and also records the position of the bathymetric points. The acoustic current meter enables the instantaneous recording of a three-dimensional current image of open watercourses and the sea, as well as the simultaneous recording of the bottom profile. The ADCP device works on the principle of the Doppler effect, that is, it perceives a change in the frequency of the initial sound signal. By reflecting the initial sound signal from small particles or plankton in the water, a return sound image is obtained, the frequency of which is proportional to the speed of the particles. The particles are assumed to travel at the same speed as the water. By recording the current image transversely to the flow direction, the entire three-dimensional current image of the profile is obtained, and by integrating the current image along the transverse profile, the flow is obtained. The device tracks its absolute orientation via a built-in compass and tilt sensor. To determine the rotation of the instrument around its axes, an internal compass with a resolution of 0.01° with an accuracy of ±2° is used to determine the direction angle, and a tilt sensor with a resolution of 0.01° and an accuracy of ±0.5° to determine the rocking and

stumbling of the boat. The measurement of these angles during data collection, combined with the use of a GPS device to track the absolute E, N coordinates of the position, enables the transformation of the recorded flow vectors in the beam direction to a Cartesian coordinate system in the plane referenced by the true north position. For height positioning, it is necessary to know the level of the water surface, which is determined directly using the RTK GPS device.



a) Schematic representation of current image recording *b) Electricity meter on the boat*

Figure 2.83. Recording of current image with ADCP device.

The measured values from the current meter can be read directly in real time and stored on the computer. The cross-profile flow is calculated over the average velocity in each cell. The vertical column of water is divided into a series of equally wide layers. The unit flow in a cell is obtained by multiplying the area of one cell and the associated average velocity in the cell. The flow in one column is obtained by summing the unit flows in the vertical. By traversing the entire width of the river, the total flow is recorded on the measuring profile. By recording the current image transversely to the flow direction, the entire three-dimensional current image of the profile is obtained, and by integrating the current image over the surface, the flow on the measuring profile is obtained.

Measured data on speeds, the boat's route, the depth of the bed and other data can be directly controlled on the computer during the measurement and stored for later processing. The computer program WinRiver will be used during the measurement. After recording on the river, the collected data will be processed using a computer program developed at the Institute of Hydrotechnics, which enables the display of a three-dimensional velocity profile by velocity components (u, v, w).

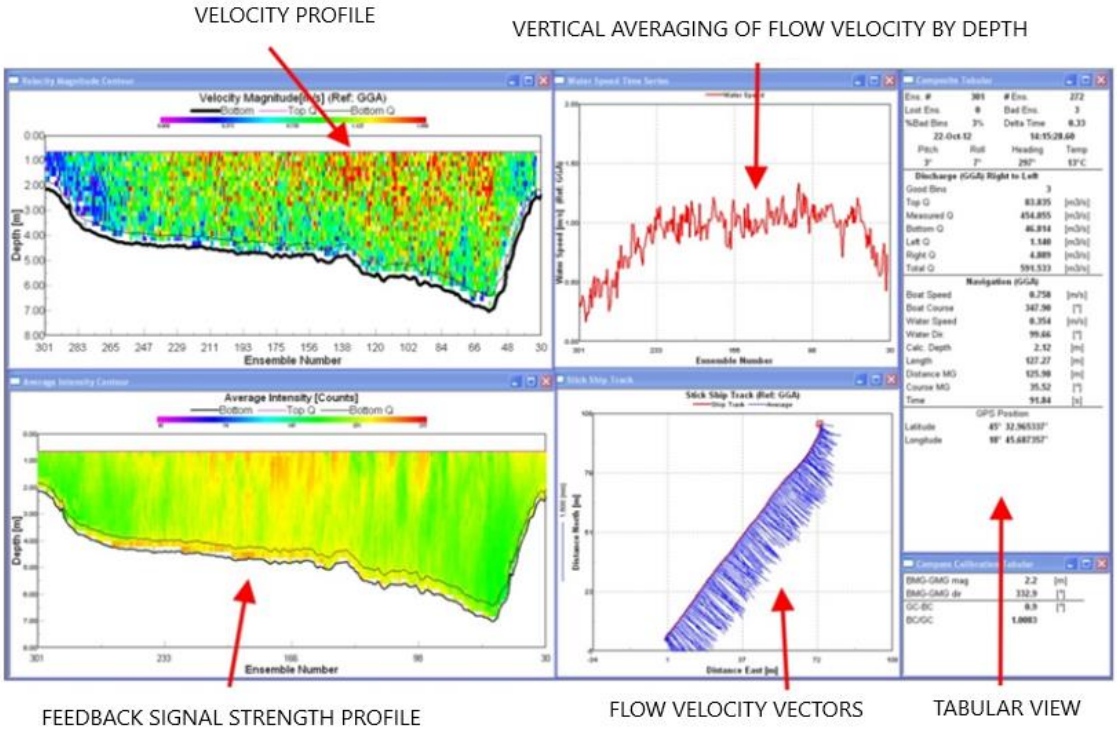


Figure 2.84. WinRiver user interface for a single profile.

When measuring the velocity profile along the transverse profile, it is common to average the vector over space for graphical display. Spatial averaging will be performed in such a way that several vertical units are averaged into one vertical profile. In this way, the spatially averaged components u, v, w of raw velocities suitable for further analysis will be obtained.

2.12.3 Measurement of the transfer of suspended and dragged sediment

For the sampling of suspended sediment, the so-called multi-point measurement method in the verticals of the water column of the river profile. For this purpose, the control profile is divided into three segments: left, middle and right. Measuring verticals are located in the middle of each segment. One control profile will be selected for the stakeholders in question, usually the most upstream profile. Sampling will be performed at several vertical points. The number of verticals for sampling suspended sediment will depend on the depth of the flow, but it should not be less than 3 points per vertical, usually every 0.5 m or 1 m per depth, depending on the existing depths. A schematic representation of suspended sediment sampling is shown in the diagram below:

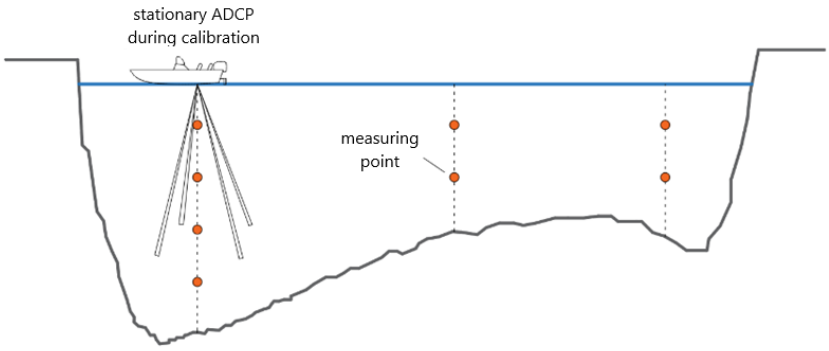


Figure 2.85. Scheme of verticals on the control profiles with the position of the measurement points where the suspended sediment was sampled.

An isokinetic sediment trap DH-59 was used for physical sampling of suspended sediment (*Figure 2.86.*). The inlet nozzle of the catcher is shaped in such a way as to ensure the continuity of the velocity, i.e. the velocity in the nozzle itself is equal to the flow velocity at the same point under undisturbed conditions, i.e. when the catcher does not represent an obstacle to the flow. The volume of the measuring vessel for deposit sampling is 0.5 l. The samples are stored in bottles and taken to the laboratory for further analysis.

Figure 2.86. Isokinetic physical drift catcher DH-59.

The water samples collected by the isokinetic trap will be analyzed in the laboratory. The concentration of suspended solids was determined using the filtration method. First, the exact sample of the water is VV in the bottle was read. Before filtering, the filter paper is dried at 105°C for an hour and weighed with an analytical balance (m_p). Water samples were filtered with filter paper with a pore size of 3-5 µm. After filtering, the filter papers will be dried at 105°C for an hour and then weighed (m_{p+u}). The concentration of suspended sediment is calculated by the following equation:

$$SSC\left[\frac{mg}{l}\right] = \frac{m_{p+u} - m_p}{V_V}\left[\frac{mg}{l}\right]$$

In addition to physical sampling, a non-invasive, acoustic sensor, LISST-ABS, was used at the same time, an instrument that allows the user to determine the local concentration of suspended sediment (SSC) without taking physical water samples. LISST-ABS uses an audio signal to record the backscatter signal to determine the SSC at the sensor head. The instrument measures continuously at a sampling frequency of 1 Hz and provides sediment

concentration values in real time. However, raw values must be moderated (calibrated) against physical samples to obtain accurate concentration data. The results of physical samples will be used for calibration purposes. The sensor will be fixed above the isokinetic catcher so the drift is measured at the same point where it enters the physical catcher.

Figure 2.87. Acoustic sensor LISST-ABS.

Data on the concentration of suspended sediment measured by LISST-ABS will be used to determine the transport of suspended sediment, and the acoustic sensor will be calibrated based on the data collected by the physical sediment catcher. Using a large number of concentrations simultaneously measured by physical and indirect sampling, a calibration curve was established. During suspended sediment sampling, the vertical velocity field will be measured in all verticals with a stationary ADCP device, i.e. a series of velocity time series will be available for each point. Based on these time series of velocities, the average time profiles of the velocities at the point will be calculated, which will then be used to calculate the unit sediment transport.

The method of calculating suspended sediment transfer approximates the concentration of suspended sediment in a cross profile based on the concentration measured at the points of one vertical and the flow velocity measurement. The product of speed and concentration gives the unit transfer of sediment (g/cm^2) in the vicinity of the measuring points. The total sediment load per profile results from the integration of the unit sediment transport over the entire width and depth of the river profile (kg/s) or (t/year). Interpolation of such discrete data means summing the areas of triangular, rectangular and trapezoidal surfaces to approximate sediment concentration.

Since the development of acoustic measurement techniques enabled the measurement of the flow velocity continuously along the entire transverse profile of the river, the estimation of the suspended sediment transport was also adapted to such a sampling method. In order to measure the spatial distribution of suspended sediment over the entire cross-section, the data on backscattering of the acoustic signal recorded by the ADCP device during the measurement of the flow velocity field along the cross-sections will be used. By applying the sediment concentration estimation procedure proposed by Baranya and Józsa (2003), the measured values of acoustic signal backscatter recorded by ADCP can be converted into local values of suspended sediment concentration.

For the purpose of calibrating the ADCP device, the average values of the relative dispersion of the acoustic signal from the stationary ADCP measurements from the same points where the suspended sediment sampling was carried out will be used. In this way, the simultaneous

signal from ADCP and sediment concentration from physical measurements can be connected. Since both LISST-ABS and ADCP are acoustic devices, the results of these devices can be made dependent on the data on backscattering of the acoustic signal, and the concentration measured by the LISST-ABS device can be applied to all cells in which the ADCP measures velocity. In the described way, it is possible to calculate the spatial distribution of the concentration of suspended sediment along the entire profile.

Some of the traditional standard methods will be used for the purpose of measuring towed sediment, i.e. determining the second flow of towed sediment.

A Helley-Smith type mechanical towed sediment catcher will be used to measure the amount and transfer of towed sediment. The mechanical catcher is hydraulically shaped with an opening on the upstream side through which sediment enters and is retained in a porous bag (*Figure 2.88.).* The sediment collection process begins when the catcher is lowered to the bottom of the watercourse. After a certain period, which is measured with a stopwatch, the catcher is removed from the watercourse, and a sample of the dragged sediment that is caught in the net is prepared. On one vertical, the drift is measured at least 3 times.

Figure 2.88. Helley-Smith type trailed sediment catcher.

After drying, by weighing, the total mass of sediment that was caught in the total duration of capture is determined for each vertical. Then, for each vertical, the specific drift is calculated using the following expression:

$$q_v = \frac{G_v}{b \cdot t}$$

where:

- *qv – elemental flow of dragged sediment [kg/m/s],*
- *Gv – mass of the total affected towed sediment [kg],*
- *b – width of the entrance to the crate in [m]*
- *t – the time it took to capture the sample in [s].*

From the calculation, a diagram of the distribution of the specific transport of dragged sediment is drawn along the bottom of the bed, and the total transport is obtained by planimetry of the area of the diagram below the curve.

2.12.4 Installation of piezometers

Drilling of three piezometer boreholes, sealing with a PVC construction made of full pipes and a sieve (predictable) diameter of 3", installation of gravel backfill and clay-bentonite buffer, cleaning and securing and securing of the piezometer are planned.

Below is a brief technical description.

Drilling and installation

The drilling of the piezometer borehole will be carried out by a machine (predictably) using a direct rotary method with flushing the borehole with water. The swollen material is taken from the outpouring liquid, laid on a flat surface and mapped by geological determination of the samples.

For the installation of the piezometer construction, high-pressure solid (blind) PVC pipes and mesh perforations (predictably) of 1 mm with additionally wound dense PVC mesh ("filter plastic") will be prepared.

Overview of piezometer construction

At the bottom of the structure will be placed a conical PVC cap wound on the opening, i.e. the bottom of the full PVC pipe that makes up the settling tank.

In the free annular space around the borehole structure, a granular backfill of double-washed quartz gravel with a grain size of 1-3 mm will be installed. After backfilling and conquering the piezometer, the remaining free ring space of 10,0 m to the ground surface is filled with clayey material with the addition of bentonite (clay buffer), in order to protect the entry of surface water into the piezometer well and underground water.

Cleaning, capturing and securing the piezometer

Upon completion of the installation of the technical structure, backfill and buffer, the piezometer will be conquered (cleaned). Conquest will be carried out by the "air-lift" method using a compressor. A compressor rubber hose will be installed in the piezometer, through which air will be pressed, first at a depth of 20 m, and then it will gradually rise to the zone with the sieve.

Cleaning will be carried out until the water is completely clear.

The construction of the piezometer will contain the bottom of the precipitator (PVC cap) and a steel protective tube with a cover and padlock. The protective pipe near the ground will be secured with a massive concrete block (approx. 0,5 x 0,5 x 0,3 m), and will also contain a signal rod.