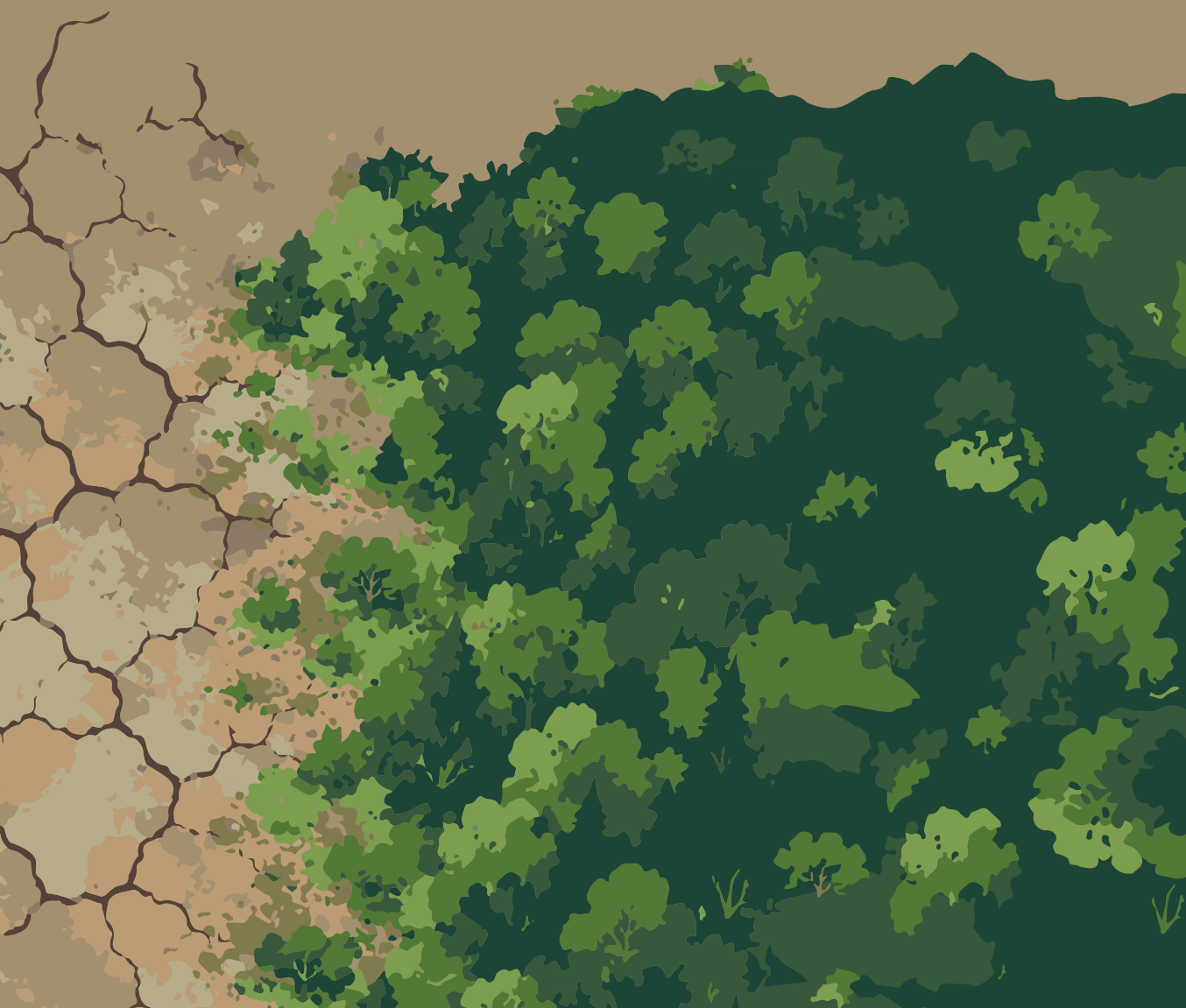


VELYKYI LUH IN THE FORMER KAKHOVKA RESERVOIR: PRESERVING EUROPE'S LARGEST FLOODPLAIN FOREST



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ABSTRACT



This brief examines the long-term consequences of the destruction of the Kakhovka Hydropower Plant by Russian forces for nature and the economy of southern Ukraine. It considers not only the consequences of the disaster, but also the history of the reservoir's construction during the Soviet period on the site of the unique floodplain forests of the Velykyi Luh.

The consequences for nature and the economy, as well as possible scenarios for the future management of the area, are presented in a concise overview based on the scientific publications *Destruction of the Kakhovka Reservoir: Environmental Consequences* and *Velykyi Luh or the Kakhovka Reservoir: A Modern Vision*.

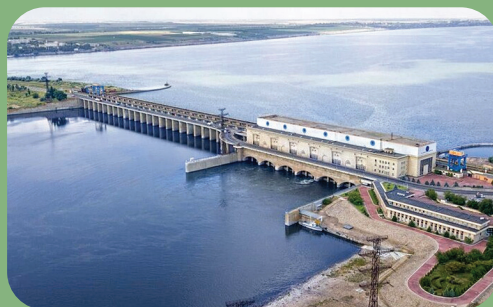
EXECUTIVE SUMMARY

In June 2023, Russian occupying forces destroyed the Kakhovka Dam on the Dnipro River, causing the Kakhovka Reservoir – Ukraine's largest artificial water body and one of the largest reservoirs in Europe – to drain. In the first days after the destruction, approximately 14 billion m³ of water flowed out of the reservoir, equivalent to 5.6 million Olympic-size swimming pools.

Downstream of the dam, catastrophic flooding affected 80 settlements in southern Ukraine and natural areas that provide habitat for dozens of rare animal and plant species. Most of these areas were part of national parks and biosphere reserves. At the same time, more than 2,000 km² of the former reservoir bed was exposed upstream of the destroyed dam. Before it was flooded, this area was known as the Velykyi Luh – a unique natural and historical-cultural landscape that had provided shelter for Ukrainian Cossacks for centuries.

Despite pessimistic predictions that the exposed reservoir bed and adjacent steppe areas would become desertified, the Velykyi Luh has begun to recover rapidly through natural processes. The former reservoir area is gradually developing into one of Europe's largest climate-resilient floodplain forest complexes.

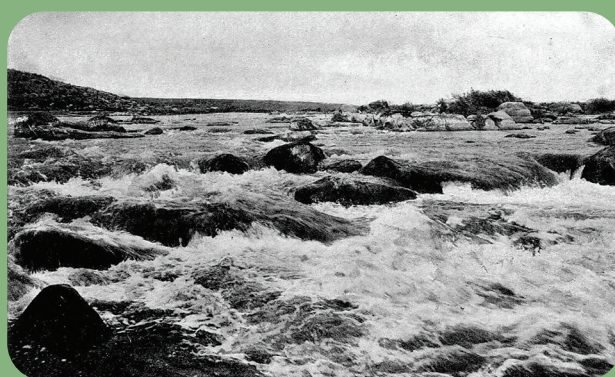
However, the loss of the reservoir has also caused significant economic damage to southern Ukraine. Approximately one million people and large areas of agricultural land used for irrigation depended on water from the Kakhovka Reservoir. Although the former reservoir area is currently a grey zone, effectively on the frontline, reconstruction of the Kakhovka Hydropower Plant is being considered once southern Ukraine is de-occupied, potentially with a higher generating capacity than before. An alternative approach proposed by researchers would preserve the Velykyi Luh and support a transition towards a more decentralised and climate-resilient regional economy.



Kakhovka Hydroelectric Power Plant (HPP)
before its destruction (2021)¹



The HPP after its destruction
by Russian forces (2022)²



Nenasytets Rapids — the most powerful rapids
on the Dnipro River⁵

1 Source: <https://uhe.gov.ua>.

2 Source: https://24tv.ua/tse-ekotsid-zelenskogo-pokazali-shokuyuche-video-pislya-pidrivu_n2328733.

3 The name *Velykyi Luh* derives from the historical meaning of the Ukrainian word *luh*, which originally referred to “a forest nourished by seasonal river flooding”.

4 Cossacks — free armed warriors who, from the late 15th century onwards, fought against the subjugation of Ukrainians by the Russian Empire.

5 Source: <https://voloske.com.ua/chasopis/85-71-jak-ce-bulo-do-budivnictva-dniprogesu.html>.

6 In 1775, Catherine II, Empress of the Russian Empire, ordered the destruction of the Zaporizhzhian Sich in an effort to suppress Cossack autonomy in the region. Following its destruction, the Velykyi Luh was gradually incorporated into the Russian Empire.

1

HISTORICAL AND ENVIRONMENTAL CONTEXT: CREATION OF THE KAKHOVKA RESERVOIR AND FLOODING OF THE VELKYI LUH

The Velykyi Luh is a historical and geographical region in the Dnipro River valley where the Soviet authorities built the Kakhovka Reservoir in the 1950s. Before the reservoir was created, it was the largest natural forest³ in Ukraine's Steppe Zone, covering an area approximately three times the size of New York City.

Rich in biodiversity, the area was also of exceptional historical importance to Ukrainians. Its favourable geographical location contributed to the establishment of six defensive fortifications of the Cossack⁴ community along the Velykyi Luh between 1386 and 1775. Known as Sich, these fortified settlements are regarded as key centres in the development of Ukrainian statehood. Ukrainian peasants seeking a life free from the rule of landlords and nobles of the Polish–Lithuanian Commonwealth, the Muscovite state and the Ottoman Empire settled here. Together, they formed a new social group — the Zaporizhzhian Cossacks. The Dnipro's meanders and granite rapids made river transport extremely difficult, creating a natural defence against raids by neighbouring peoples. The word *porohy* (“rapids”) is also reflected in the name of the Zaporizhzhian Sich.

Abundant opportunities for fishing, hunting, gathering and other traditional livelihoods, as well as livestock grazing for much of the year, provided settlers with far more favourable living conditions than the surrounding steppe areas, where a predominantly nomadic way of life prevailed. Thanks to these favourable natural conditions and their relatively free way of life, the population of the Velykyi Luh gradually grew, reaching more than 100,000 Cossacks⁶ by 1774.

During the Soviet period, in the 1930s, a substantial part of the Velykyi Luh's forested areas was converted into meadows for livestock grazing and haymaking for collective farms (*kolkhozes*). As a result, the Soviet regime caused the loss of 80% of the Velykyi Luh's forest cover, while the remaining 20% retained forest ecosystems and formed a complex landscape mosaic. Eventually, all of these lands were flooded by the waters of the Kakhovka Reservoir.

1.1. BACKGROUND TO THE FLOODING

Today, the protection of the Velykyi Luh is closely associated with the destruction of the Kakhovka Dam by Russian forces in 2023. Following the disaster, floodplain forest began to recover rapidly on the exposed bed of the former reservoir. Yet the need to protect the floodplain forests and steppes of southern Ukraine first became an acute issue in the mid-20th century, when the Soviet authorities embarked on a series of massive hydropower projects, including the construction of the Kakhovka Hydropower Plant and the creation of the Kakhovka Reservoir across the Velykyi Luh. The creation of the reservoir meant the complete destruction of all ecosystems within the area to be flooded. The decision was made by the political leadership of the USSR, without any consultation with local residents or experts.

MILITARY-INDUSTRIAL AND IDEOLOGICAL MOTIVES OF THE PROJECT

The construction of the Kakhovka Reservoir was part of the policy of the so-called “Great Construction Projects of Communism” and the “Great Plan for the Transformation of Nature”, initiatives conceived by Joseph Stalin, General Secretary of the Communist Party of the Soviet Union. The project’s primary stated purpose was to provide irrigation for the arid south of Ukraine, enabling cotton cultivation. At the time, cotton was used to produce gunpowder (nitrocellulose), a technology that had been widely used since before the Second World War. The project therefore had a primarily military purpose: to rebuild the Soviet Union’s defence capabilities in the aftermath of the Second World War.

The construction of the Kakhovka Reservoir was accompanied by extensive state propaganda that diverted attention from the project’s military purpose and the enormous cost of its construction during a period of difficult post-war recovery. Soviet media portrayed the project as a symbol of victory over drought and the transformation of the “wild” steppe into productive farmland, promising the development of new industries and unprecedented economic growth. The military purpose of the Kakhovka Hydropower Plant, meanwhile, was classified as a state secret.

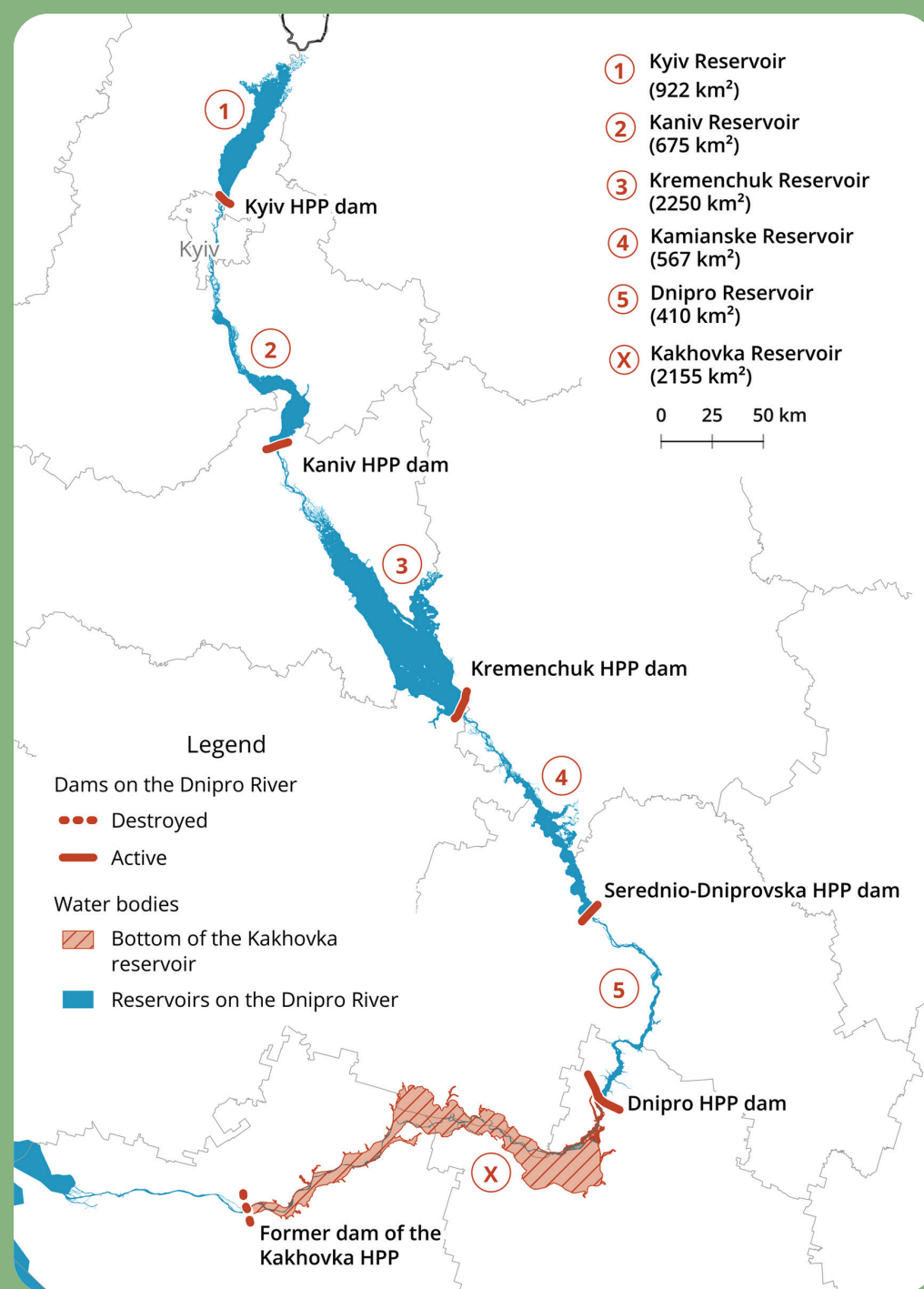
Archival materials also show that, as early as the design stage, some experts warned against flooding the Velykyi Luh and stressed its important economic and conservation value. At the same time, the Soviet authorities consistently sought to downplay the project’s potential environmental damage.

1.2. CONSTRUCTION PROCESS

Construction of the Kakhovka Reservoir took place between 1952 and 1955. It was the last reservoir in the Dnipro cascade, located in the lower reaches of the Dnipro River. Because of the small elevation difference and the distinctive topography of the lower Dnipro, the reservoir was designed to be relatively shallow: its average depth was 8.4 m, while its maximum depth reached 24 m. Its storage capacity therefore depended not on depth but on its vast surface area. As a result, the need to flood such an extensive area put as many as 93 settlements, as well as cemeteries, remnants of Cossack fortifications⁷, monasteries and churches, under water. All residents were forcibly resettled from lands where their families had lived for generations.

At the same time as the hydropower plant was being built, the city of Nova Kakhovka was constructed from scratch to accommodate those displaced by the project and house personnel responsible for operating the hydropower infrastructure. Construction was driven by intense haste and the “socialist competition” imposed on workers. As a result, in just two years the city was ready to accommodate up to 10,000 new residents.

⁷ By flooding the Velykyi Luh, the Soviet authorities completely destroyed a historic landscape that had come to symbolise Ukrainians’ struggle against Russia. Some historians consider the destruction of this landscape to have been one of Stalin’s intended objectives behind the project.



The cascade of Dnipro reservoirs stretching from north to south across Ukraine

ENGINEERING AND TECHNICAL PARAMETERS OF THE KAKHOVKA HYDROPOWER COMPLEX

From its construction until its destruction in 2023, the Kakhovka Reservoir remained the largest reservoir in Ukraine and one of the largest in Europe. It covered an area of 2,155 km², with a total storage capacity of 18.2 km³ and an active storage capacity of 6.8 km³.

The Kakhovka Hydropower Complex comprised a 193-metre-long hydropower plant structure, a concrete spillway dam with a total length of 435 metres, a 3.2-kilometre-long earthfill dam, and a single-chamber navigation lock measuring 320 × 18 metres. The hydropower plant was designed to handle a discharge of 4,962 m³/s, with an average annual electricity generation of 1,489 million kWh.

1.3. A CONTESTED DECISION: ENVIRONMENTAL AND SOCIAL RISKS

The environmental consequences of creating the reservoir became apparent within the first few years after it was filled. This is hardly surprising, given that the project represented one of the largest transformations of the Lower Dnipro's natural ecosystems in the 20th century. The construction also had profound social consequences. The loss of access to the Velykyi Luh's rich pastures and the Dnipro's natural resources significantly reduced the quality of life of local rural communities. This, in turn, accelerated the migration of resettled residents – particularly younger people – to cities and contributed to their assimilation. As a result, knowledge and memory of the Velykyi Luh, its natural ecosystems and history gradually faded, weakening people's connection to the landscape.

Most of the ecological changes caused by the creation of the reservoir were long-lasting and extended well beyond the area that was flooded, affecting adjacent steppe areas and the Dnipro Delta as well.

NATURAL HABITATS

One of the most significant environmental consequences of the construction was the flooding of more than 2,000 km² of the Velykyi Luh's natural floodplain. In an extremely short period of time, the area of open water increased by almost 770%, while terrestrial habitats were almost entirely replaced by aquatic ones.

Before the flooding in the 1950s, tree and shrub habitats covered approximately 550 km², wetlands around 920 km², wet meadows around 410 km², dry meadows around 400 km², and sandy spits and ridges around 60 km². These ecosystems provided habitat for a wide range of endemic plant and animal species. Had the Bern Convention on the Conservation of European Wildlife and Natural Habitats, adopted in 1979, been in force at the time, a substantial proportion of the Velykyi Luh's destroyed habitats would have fallen under its protection.

Although a significant increase in the numbers of some waterfowl species was recorded immediately after the reservoir was created, most of these populations had almost disappeared by the end of the 1950s. At the same time, populations of species associated with sandy shallows, dry meadows and steppe habitats declined substantially. Similar changes occurred among fish, invertebrates, planktonic organisms and benthic communities as a result of the loss of flowing water and high levels of oxygenation.

The reservoir also provided favourable conditions for the spread of non-native fish, plant and other aquatic species adapted to stagnant waters. The stagnant conditions were particularly favourable for the expansion of zebra mussels (*Dreissena polymorpha* and *D. bugensis*), whose biomass reached several kilograms per square metre of the reservoir bed in some areas.

RIVER FLOW REGULATION

It is hardly surprising that regulating the Dnipro's flow altered its natural hydrological regime. Before the river was regulated, the natural cycle of spring floods and summer low flows shaped the functioning of most aquatic and riparian ecosystems. The dam was designed to store spring floodwaters in the reservoir and release them during the dry summer season to meet irrigation needs. As a result, the free-flowing river's characteristic stretches with rocky and sandy riverbeds disappeared, depriving many migratory fish species of essential spawning grounds.

Changes to the hydrological regime also affected water availability in the lower Dnipro. In particular, after the Kakhovka Reservoir began operating, a trend towards reduced flow in the reservoir's downstream reach⁸ and increasing salinity⁹ of freshwater in the Lower Dnipro was observed. With less freshwater flowing from the Dnipro, saltwater from the Black Sea entered its delta through a deep-water navigation channel constructed to facilitate access by sea-going vessels to ports in the Dnipro–Buh estuary.

During the reservoir's design stage, scientists had already predicted that industrial and domestic pollutants would accumulate in the reservoir. These predictions were subsequently confirmed. By the time the dam was destroyed, wastewater from more than 400 industrial and agricultural facilities was entering the Kakhovka Reservoir, with a combined volume of approximately 6.1 million m³ per day. The accumulation of wastewater, combined with intensive evaporation, contributed to severe eutrophication. As a result, the reservoir water used for irrigation was classified as Class II, or "of limited suitability", and contributed to secondary soil salinisation.

Thus, Soviet engineers fundamentally transformed the natural system of the Lower Dnipro. The region subsequently experienced a second major environmental disaster: the destruction of the Kakhovka Reservoir by Russian forces in June 2023.

1.4. FORMATION OF THE SOUTHERN REGION'S ECONOMIC DEPENDENCE ON THE HYDROPOWER COMPLEX

From 1957 onwards, the Soviet leadership actively integrated the Kakhovka Hydropower Complex into the region's water management and energy systems. Water from the reservoir became essential for the supply needs of entire cities and industrial complexes, as well as for agriculture across southeastern Ukraine. The reservoir also supported parts of the transport infrastructure: in 2021, 43% of all cargo transported along the Dnipro passed through the Kakhovka navigation lock¹⁰. A significant share of this cargo consisted of grain destined for export.

However, both its logistical role and its irrigation and power-generation functions – the key purposes envisaged when the reservoir was constructed – gradually became less relevant over time.

⁸ A section of a river or water body located downstream of a hydraulic structure.

⁹ The intrusion of a "saltwater wedge" not only increased the water's mineralisation but also reduced dissolved oxygen concentrations, adversely affecting aquatic life.

¹⁰ River transport played a relatively minor role in Ukraine's logistics system before the destruction of the dam, accounting for only 0.15% of total freight transport.

WATER SUPPLY AS THE BASIS OF ECONOMIC DEPENDENCE

Three major trunk canals originated from the reservoir – the North Crimean Canal, the Main Kakhovka Canal and the Dnipro–Kryvyi Rih Canal – supplying water to approximately 493,000 people¹¹. Major users of reservoir water also included metallurgical enterprises in Kryvyi Rih and Zaporizhzhia, as well as the mining industries of Nikopol, Pokrov and Marhanets. The reservoir also supplied the cooling pond of the Zaporizhzhia Nuclear Power Plant, which required approximately 300 million m³ of water annually.



Canals connected to the Kakhovka Reservoir

The Kakhovka Reservoir served as a seasonal water storage facility. During the spring flood, it stored approximately 3–5 km³ of water, which was gradually used throughout the year, primarily to meet irrigation needs. This seasonal regulation of river flow ensured the stable operation of the entire water management system in the southern region. Before this transformation, the region's economy was predominantly pastoral, while irrigation and the cultivation of water-intensive crops were imposed on local pastoral communities. In this way, the region's economic model became part of the Soviet colonisation of Ukraine.

The rapid expansion of irrigation during the Soviet period became one of the key factors behind southern Ukraine's economic dependence on the Kakhovka Reservoir. The natural climate of the Steppe region is too dry to support high crop yields without irrigation. The creation of the Kakhovka Hydropower Complex made intensive commercial agriculture possible, gradually increasing the dependence of farms in the southern regions on reservoir water. In Kherson Region, for example, which has no natural outflow to the sea, 94% of total water use was allocated to irrigation. At the same time, despite the dependence of some farms – particularly those specialising in vegetable production – Ukraine as a whole experienced a trend towards a decline in the area of irrigated land¹².

ENERGY GENERATION AND ITS ROLE IN THE REGIONAL ECONOMY

Another planned function of the Kakhovka Hydropower Plant was electricity generation. In practice, however, a substantial share of the electricity it generated was used to power pumping stations that supplied water to the trunk irrigation canals. On average, these pumps consumed around 15% of the plant's total annual electricity generation, while during the hottest summer period, their share reached at least 89.5%. This effectively subordinated electricity generation at the Kakhovka Hydropower Plant to the agricultural sector's irrigation needs.

11 As of the period before the full-scale invasion.

12 The planned area of irrigated land expected to depend on the Kakhovka Reservoir was approximately 1.5 million hectares. By 2021, the actual irrigated area had fallen to less than one-quarter of that figure, at 329,000 hectares.

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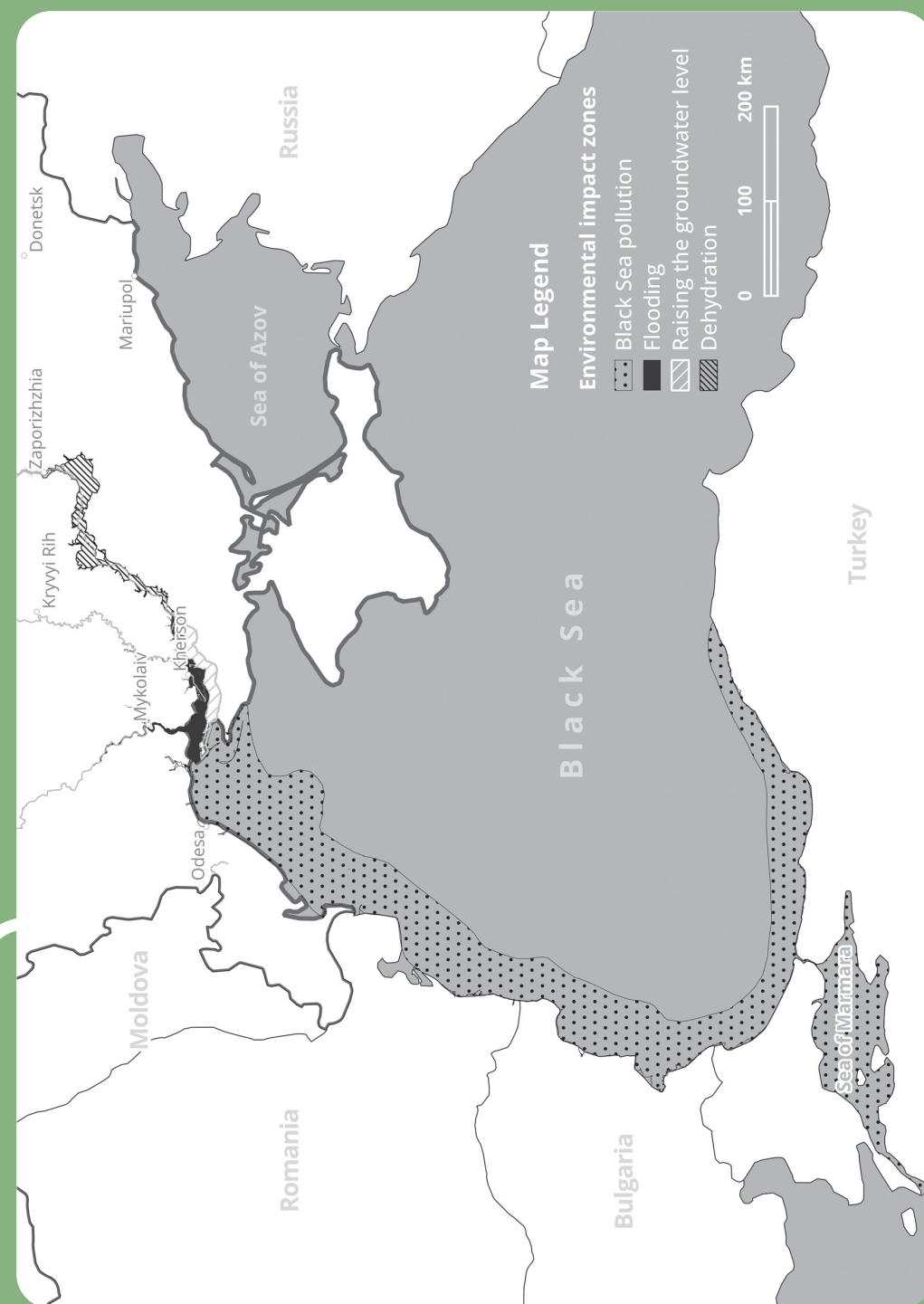
2023 KAKHOVKA DISASTER

The Kakhovka disaster should be understood as the deliberate destruction of the Kakhovka Hydropower Plant's infrastructure by russian forces. The plant had been under russian control since 24 February 2022, the first day of russia's full-scale invasion of Ukraine. In the early hours of 6 June 2023, russian forces detonated explosives inside the Kakhovka Hydropower Plant, apparently in an attempt to halt the advance of Ukrainian forces. Explosives were placed in a tunnel within the concrete dam and in the plant's turbine hall, while seismic monitoring stations recorded explosions at 02:35 and 02:54.

The destruction of the dam caused catastrophic flooding across the lower Dnipro within a matter of hours and almost completely drained the largest reservoir in the Dnipro cascade by volume. Ukraine has classified the destruction of the hydropower plant as an act of terrorism and ecocide. Representatives of the United Nations, the Council of Europe and the European Commission have likewise described the Kakhovka disaster as ecocide.

Before destroying the dam, russian forces had manipulated its gates to raise the reservoir to a record-high level, thereby increasing the potential scale of the resulting damage. At the time of the destruction, the Kakhovka Reservoir held a record 19.9 billion m³ of water, 72% of which flowed out during the first six days after the dam was destroyed. Because the Kakhovka Hydropower Complex is located in the lower reaches of the Dnipro, just 90 km from where the river enters the estuary, much of the surrounding area consists of low-lying land. These areas suffered the most severe flooding. Water from the Kakhovka Reservoir eventually reached the streets of around 80 settlements¹³, which were home to approximately 40,000 people at the time. Numerous sites posing technological and environmental hazards – including industrial facilities, farms, and fertiliser and pesticide storage facilities – were also affected by the flooding.

¹³ Water levels in settlements downstream rose by 5 metres, and in some places by as much as 12 metres, and remained elevated for several days



Areas affected by the disaster

2.1. 'ECONOMY AFTER THE 'DESTRUCTION OF THE 'HYDROPOWER 'PLANT

The destruction of the Kakhovka Hydropower Plant dam meant not only the loss of a single hydraulic structure, but the destruction of an integrated water management system that the Soviet Union had deliberately created as the basis for the economic development of southern Ukraine.

The destruction of the Kakhovka Hydropower Plant left 94% of irrigation systems in Kherson Region, 74% in Zaporizhzhia Region and 30% in Dnipropetrovsk Region without water. This does not mean that agricultural activity came to a halt at that point. The area under crops in these regions had already declined significantly¹⁴ after the start of Russia's full-scale invasion in 2022, as Russian occupying forces advanced through these territories. Both at the time of the dam's destruction and as of mid-2026, the vast majority of the former irrigation systems are either in active combat zones or in territories temporarily occupied by Russia. Until hostilities end and these territories are de-occupied, it is impossible to assess what proportion of these systems will remain suitable for agricultural use. At the same time, because irrigation was the main reason for creating the Kakhovka Hydropower Complex, the restoration of irrigation infrastructure in Ukraine is often cited as the main argument for rebuilding the reservoir.

Many resource-intensive enterprises located far from the Kakhovka Reservoir relied on it for industrial water supply and therefore suffered losses after its destruction. Ukraine's Ministry of Economy estimated the losses incurred by industrial enterprises at USD 105 million. The Kakhovka disaster also led to a decline in the production of pig iron, steel and rolled steel products in Ukraine, affecting export volumes. At the same time, metallurgical products have historically played a significant role in Ukrainian exports, accounting for 42% of total exports before the war. The Kakhovka disaster therefore directly affected the decline in Ukraine's GDP in 2023.

Around 140 settlements, with a total population of approximately one million people, used water from the Kakhovka Reservoir for drinking purposes. After the reservoir drained, water intake facilities were left on dry land, in some places tens of metres from the river channel. The loss of the reservoir also affected people who relied on groundwater, as groundwater levels in the surrounding regions fell in its absence¹⁵. This forced cities to switch to alternative sources of drinking water, including pipelines drawing water directly from the Dnipro or using water from other reservoirs in the cascade. Water pipelines supplying

Kryvyi Rih, Marhanets, Nikopol and Pokrov were fully completed in the years immediately following the disaster.

After the destruction of the dam, Ukraine lost a source of electricity generation with a capacity of 334.8 MW. However, the Kakhovka Hydropower Plant had ceased to operate as part of Ukraine's power system not because of its destruction by Russian forces, but because of the occupation, in October 2022. Before that, it played an important role in regulating renewable energy generation. Its complete loss did not cause a collapse of Ukraine's power system, as the plant itself was relatively inefficient compared with other hydropower plants in the Dnipro cascade¹⁶. In addition, during the dry summer months, a significant share of the electricity generated was used to power pumps supplying water to the canals. Therefore, in the energy sector, the Kakhovka Hydropower Plant was important primarily for supporting irrigation in southern Ukraine.

River navigation was also significantly affected by the loss of the Kakhovka Hydropower Plant dam. The reservoir was part of Ukraine's inland waterway network, while its navigation lock was the last and southernmost lock in the Dnipro cascade. All vessels travelling along the Dnipro to load or unload cargo passed through it¹⁸.

2.2. 'NATURE AFTER THE 'DRAINAGE OF THE 'RESERVOIR

The destruction of the Kakhovka Reservoir dam was one of the largest environmental events in Europe's modern history, setting in motion a long-term transformation of the natural system of the Lower Dnipro. Changes in the hydrological regime, soil conditions, natural habitat structure and biodiversity will shape the development of the region's ecosystems for many years to come.

14 In Kherson Region alone, the area under crops fell by 92% in 2022 compared with the pre-war level in 2021.

15 For example, a decline in groundwater levels of 5–8 metres was recorded on the right bank of Dnipropetrovsk Region, 7.6 km from the shoreline of the former reservoir.

16 In terms of land-use efficiency, the Kakhovka Hydropower Plant ranked last among the hydropower plants in the Dnipro cascade, generating only 6,590 kWh per hectare of reservoir area.

17 For example, in 2021, 43% of all cargo transported along the Dnipro – 14.4 million tonnes – passed through the Kakhovka navigation lock.



View of the Kakhovka Reservoir after the water was drained in June 2023¹⁸

TRANSFORMATION OF THE HYDROLOGICAL SYSTEM OF THE LOWER DNIPRO AND THE BLACK SEA

One of the most important long-term consequences of the Kakhovka disaster has been the transformation of the hydrological system of the Lower Dnipro. The destruction of the dam restored the natural direction of water flow, the seasonal functioning of branches and channels, and the conditions for periodic flooding of the floodplain during the spring high-water period. This marked a transition from the regime of a large artificial water body to that of a river valley closer to its natural state. In effect, the destruction of the reservoir initiated the restoration of the historic Dnipro riverbed along approximately 250 km. However, river flow along this stretch remains partly regulated by the upstream cascade of hydropower plants.

The Kakhovka disaster also had a significant impact on the northwestern part of the Black Sea, causing large-scale short-term freshening of coastal waters. The inflow of more polluted freshwater from the former reservoir, with a salinity of around 8‰ compared with the approximately 15‰ typical of the Black Sea, caused mass mortality among marine organisms, particularly attached and less mobile species such as mussels.

Huge quantities of organic silt, bottom sediments, and pollutants accumulated in the reservoir over decades from industrial and municipal sources were also carried into the estuary and the sea with the reservoir water. The prolonged decomposition of animal and plant organic matter in the aquatic environment means that these materials can remain a source of pollutants for an extended period.

DEGRADATION OF SOIL COVER AND THE FORMATION OF NEW SOILS

Alongside the transformation of the Dnipro's water regime, the Kakhovka disaster caused profound changes to soil cover both upstream and downstream of the destroyed dam. While the flooding itself was short-lived, changes in soil conditions will determine the capacity of ecosystems to recover naturally for many years to come.

¹⁸ Source: <https://www.061.ua/news/3625333/poblizu-zaporizza-kahovske-vodoshovise-peretvoruetsa-na-pustelu-fotoreportaz>.

¹⁹ The highest concentrations were detected for arsenic (As), lead (Pb), strontium (Sr) and zinc (Zn), while for several other metals, mean concentrations exceeded maximum permissible levels by 7–17 times.

During the Kakhovka Reservoir's less than 70 years of operation, a substantial layer of silt (bottom sediment) accumulated on its bed, averaging 17.6 cm in thickness and reaching up to 1 m in some places. Following the destruction of the dam, a significant portion of these sediments was redeposited downstream, in some places reaching a thickness of 70 cm. However, the truly concerning factor is not the redistribution of the silt itself, but the fact that these sediments contain large amounts of toxic substances originating from industrial enterprises in Zaporizhzhia, Dnipro, Kamianske, Nikopol, Marhanets and Pokrov.

RESULTS OF SOIL SAMPLE ANALYSIS



In summer 2023, scientists collected and analysed 119 soil samples from the former reservoir area. The results showed that 94% of the samples exceeded maximum permissible or natural concentrations of toxic substances, including heavy metals¹⁹. Over time, heavy metals may become more mobile, enter groundwater and surface water, and accumulate in animal and human organisms. In addition, there is a risk that sediments could be carried back into the aquatic environment during storms, creating a mechanism for secondary pollution even after the main phase of the disaster has ended.

Some of the sediments remained on the bed of the Kakhovka Reservoir and became the basis for the formation of floodplain soils. Soil formation is still at an early stage, but there are already grounds to believe that a complex mosaic of soil types will develop across the area in the future, shaping the subsequent development of vegetation.

MICROCLIMATIC CHANGES

Before the destruction of the dam, the reservoir moderated temperature contrasts and generated local breezes, particularly during the warm summer months. The drainage of the reservoir disrupted these microclimatic conditions, while the Land Surface Temperature (LST) of the surrounding landscape increased by at least 1.0°C. As a result, the microclimate of southern Ukraine has moved closer to its natural state – the conditions that existed before the reservoir was created.

Under the new conditions, water temperatures in the Lower Dnipro are expected to be higher in spring than they were when the reservoir existed, and lower in autumn. These changes may contribute to increased precipitation during the spring–summer period, which could have an overall positive effect on agriculture, as rainfall during this period can provide the greatest benefit to crops.

Although the exact scale of these microclimatic changes requires further research, they may have long-term implications for temperature patterns, air humidity and the functioning of adjacent natural ecosystems.

IMPACTS ON NATURAL HABITATS AND RARE-SPECIES POPULATIONS

The long-term consequences of the Kakhovka disaster for biodiversity are determined not primarily by the number of organisms that died in June 2023, but by the large-scale transformation of habitats. The former Kakhovka Reservoir area and almost the entire zone affected by catastrophic flooding were part of the Emerald Network – a system of sites established to protect habitats and species recognised as rare at the European level.

PROTECTED AREAS AFFECTED BY THE DISASTER



According to expert estimates, 47 protected areas and sites within Ukraine's Protected Areas Network were affected to varying degrees by the flooding, including the Black Sea Biosphere Reserve (protected since 1927 and included in UNESCO's World Network of Biosphere Reserves)²⁰, four national nature parks and the Kinburn Spit Regional Landscape Park.

Virtually the entire flooded area, as well as the area of the former reservoir, belonged to the European Emerald Network – an analogue of the Natura 2000 network operating in European Union countries²¹. Overall, two Emerald Network sites upstream of the hydropower plant dam and 11 downstream were affected by the Kakhovka disaster. These sites protected 21 types of valuable habitats identified under Resolution No. 4 of the Bern Convention, ranging from steppe and forest habitats to aquatic ecosystems.

Of the total area of the flooded territories, more than 80% is occupied by protected areas of national and international importance, including a UNESCO biosphere reserve. In the area exposed after the water receded, two Wetlands of International Importance (Ramsar Sites) were mainly affected – “Sim Maiakiv Floodplain” and “Archipelago Velyki and Mali Kuchuhury” – key sites for bird migration in southern Ukraine.

A significant proportion of the aquatic vegetation downstream of the dam was washed away by the powerful flow into the Dnipro–Buh estuary and the Black Sea, where it died in the saltwater. Species associated with highly specialised habitats of the Lower Dnipro – floodplain wetlands, shallow waters, sandy areas and steppe ecosystems – proved particularly vulnerable.

On the one hand, the disaster destroyed a significant proportion of natural habitats within the reservoir area. On the other hand, it simultaneously led to a sharp increase in the area of waterlogged coastal habitats through the restoration of the Dnipro floodplain, its branches and channels.

20 The administration of the Black Sea Biosphere Reserve was also affected by the flooding. The flow of water destroyed administrative buildings and the museum. As a result, in addition to natural heritage, a century of scientific work was lost forever, including research journals, observation records, the exhibition of the environmental education centre, herbarium collections, the photographic archive, educational materials and a library containing 3,480 publications.

21 In Ukraine and other European countries outside the European Union, Emerald sites form part of the pan-European ecological network, extending the biodiversity protection principles of Natura 2000 beyond the EU.

THREATS TO THE UNIQUE BIODIVERSITY OF THE VELKYI LUH



The Lower Dnipro region was of crucial importance for a number of species with restricted ranges and endemic species. It contains virtually the entire global range of *Spalax arenarius* (Mammalia), while *Stylodipus telum falzfeini* (Mammalia) is exclusively associated with the sands of the Lower Dnipro. For *Sicista loriger* (Mammalia), the region accounted for up to 70% of the known global population. The area affected by the disaster was also home to local endemics including *Centaurea breviceps*, *Jurinea laxa*, *Thymus borysthenticus*, *Alyssum savranicum*, *Crataegus alutacea*, *Crataegus helenolae*, *Agropyron dasyanthum* and *Goniolimon graminifolium*, as well as *Betula borysthénica*.

The fauna of the Lower Dnipro was particularly unique. *Iphigenella andrussowi* and *Iphigenella shablensis* (Malacostraca) are associated with the affected floodplain wetlands; *Laevicaspia lincta* (Gastropoda), *Hirudo verbana* and *Trocheta danastrica* (Clitellata) are characteristic of the Lower Dnipro floodplains; and recent records of *Hypanis plicata* (Bivalvia) are known only from the Dnipro estuary. Following the change in salinity and increased siltation, it is unknown whether this species has survived.

The disaster also affected species that already have a global conservation status under the IUCN Red List: *Sicista loriger* (Mammalia) – CR; *Spalax arenarius*, *Spalax zemni*, *Stylodipus telum* (Mammalia) and *Aldrovanda vesiculosa* (Magnoliopsida) – EN; and *Allactaga major* and *Nothocricetulus migratorius* (Mammalia) – NT. The scale of the impact is particularly striking in the case of *Triturus dobrogicus* (Amphibia): following the disaster, hundreds of individuals, most of them dead, were found washed ashore along the Black Sea coast, and losses may have affected more than half of the local population.

Following the destruction of the Kakhovka Hydropower Plant and the flooding of parts of their habitats, the conservation status of several rare mammal species on the IUCN Red List became more threatened: *Spalax arenarius* and *Spalax zemni* moved from Vulnerable (VU) to Endangered (EN), while *Sicista loriger* moved from Vulnerable (VU) to Critically Endangered (CR).

Thus, the affected area was not simply a centre of high biodiversity. For some species, it represented a substantial or critical share of their global range or population; for others, it was a key habitat for species already threatened with extinction at the global level.

TABLE 1.
RARE, ENDEMIC AND THREATENED SPECIES
IN THE KAKHOVKA DISASTER IMPACT ZONE

Name	IUCN Category*	Endemism / Restricted Range
PLANTAE		
MAGNOLIOPSIDA		
<i>Aldrovanda vesiculosa</i>	EN	
<i>Centaurea breviceps</i>		Endemic to the Lower Dnipro sands
<i>Centaurea paczoskii</i>		Endemic to the sands of the lower Inhulets River
<i>Centaurea appendicata</i>		Super-endemic to Kherson Region
<i>Jurinea laxa</i>		Endemic to the Lower Dnipro sands
<i>Thymus borysthenticus</i>		Endemic to the Lower Dnipro sands
<i>Alyssum savranicum</i>		Buh–Dnipro endemic
<i>Crataegus alutacea</i>		Buh–Dnipro endemic
<i>Crataegus helenolae</i>		Buh–Dnipro endemic
<i>Goniolimon graminifolium</i>		Buh–Dnipro endemic
<i>Betula borysthénica</i>		Subendemic
LILIOPSIDA		
<i>Agropyron dasyanthum</i>		Buh–Dnipro endemic
ANIMALIA		
CLITELLATA		
<i>Hirudo verbana</i>		Characteristic of the Lower Dnipro floodplains
<i>Trocheta danastrica</i>		Characteristic of the Lower Dnipro floodplains
GASTROPODA		
<i>Laevicaspia lincta</i>		Characteristic of the Lower Dnipro floodplains

MAXILLOPODA		
<i>Colpocyclops dulcis</i>		Rare species with a restricted range
<i>Colpocyclops longispinosus</i>		Rare species with a restricted range
MALACOSTRACA		
<i>Iphigenella andrussowi</i>		Characteristic of the Lower Dnipro flood-plains affected by catastrophic flooding
<i>Iphigenella shablensis</i>		Characteristic of the Lower Dnipro flood-plains affected by catastrophic flooding
<i>Lanceogammarus andrussowi</i>		Endemic to the Ponto-Caspian region; very rare species
<i>Shablogammarus shablensis</i>		Endemic to the Ponto-Caspian region; very rare species
<i>Pontastacus pachypus</i>		The entire known population outside the Caspian Sea is concentrated in the disaster zone
BIVALVIA		
<i>Hypanis plicata relictá</i>		Recent records are known only from the Dnipro estuary
AMPHIBIA		
<i>Triturus dobrogicus</i>		The disaster may have destroyed >50% of the local population
MAMMALIA		
<i>Stylodipus telum falzfeini</i>	EN	Endemic subspecies of the Lower Dnipro sands
<i>Sicista loriger</i>	CR	Up to 70% of the known global population was concentrated in the disaster impact zone
<i>Spalax arenarius</i>	EN	Endemic to the Lower Dnipro lowlands
<i>Spalax zemni</i>	EN	
<i>Allactaga major</i>	NT	
<i>Nothocricetulus migratorius</i>	NT	

* A significant proportion of Ukraine’s endemic species with restricted ranges are not included in the IUCN lists, partly because Ukraine is still not a state member of the IUCN.

THE VELKYI LUH

EUROPE'S LARGEST FLOODPLAIN FOREST

Before the Kakhovka Reservoir was created, the lower Dnipro was known as the Velykyi Luh. After the dam was destroyed in 2023, its unique natural and cultural landscape re-emerged from beneath the water.

Photo: Ukrhydroenergo



93

SETTLEMENTS

were flooded by the water. All residents were **forcibly evacuated** from areas where their families had lived for generations.

Construction of the Kakhovka Hydroelectric Complex.

2026

RESTORATION

1955

FLOODING

The Soviet authorities flooded the Velykyi Luh to create the reservoir.

2023

DRAINING

Russian forces blew up the Kakhovka Dam after the reservoir reached a **record water level**.

2023

2024

2026

Date

Willow trees on the drained reservoir bottom grow taller each year.

m
18
9

water level the day before

5,6

BILLION OLYMPIC-SIZED SWIMMING POOLS

that's the equivalent of the water that flowed out of the reservoir **in the first few days** after the dam was blown up.

water level 3 days after the disaster

Date

1M

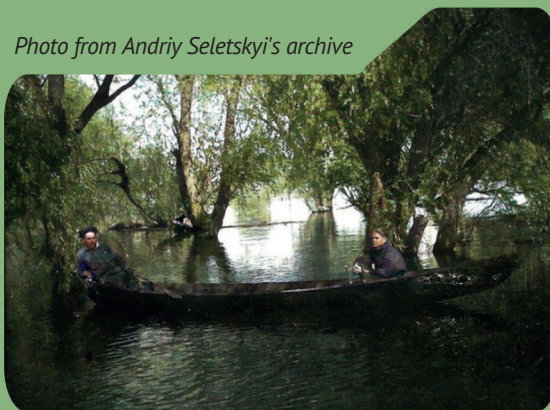
maximum **crack depth** on the drained bottom first mounthes after the disaster.



The site of the disaster is located about **90 km** from the mouth of the Dnipro River.

The dam of the Kakhovka Hydroelectric Power Plant

Photo from Andriy Seletskyi's archive



Natural floodplains of the lower Dnipro River in the 1940s-1950s.

Photo: Oleksandr Khodosovtsev



3

NATURAL RECOVERY AND CULTURAL HERITAGE OF THE VELYKYI LUH

The outflow of water from the Kakhovka Reservoir created conditions for the recovery of the Velykyi Luh almost immediately after the acute phase of the disaster had ended. The timing of the dam's destruction in early June coincided with the ripening of willow and poplar seeds, which began to germinate on a massive scale. The simultaneous dispersal of seeds and retreat of the water from the flooded areas resulted in mass tree regeneration, with 60–90 seedlings per m². At the same time, native species gained an advantage and became more competitive than non-native plant species²². **This creates a precedent for the spontaneous recovery of natural habitats over an area of more than 2,000 km². Today, the young willow–poplar forest growing on the bed of the former reservoir is the largest floodplain forest in Europe.**

The most important change following the disaster was the restoration of free-flowing conditions along approximately 250 km of the Dnipro. Water once again began to move through the natural network of river channels, branches and floodplain depressions that existed before the reservoir was created. Within the former reservoir area, the spatial structure of the floodplain is also gradually being restored – a system of branches, shallow waters, wetlands and periodically flooded areas characteristic of the historic Velykyi Luh.

One of the most striking consequences of this process has been the dramatic increase in the area of natural habitats of international importance. Before the destruction of the Kakhovka Reservoir, the Kakhovske Reservoir Emerald Network site (UA0000106) contained only 27.5 km² of protected habitats. Following the drainage of the reservoir, their area increased to at least 930 km² – approximately 34 times larger. In other words, the natural area of the Velykyi Luh already has significantly greater conservation value than the former reservoir's open water surface.

²² The proportion of invasive species recorded at the study sites remained relatively low in 2023 and has declined each year since. This may be partly explained by the fact that most invasive plant species in the region are drought-tolerant, making the moist floodplain conditions unfavourable for their spread.

²³ Photo by O. Khodosovtsev.

3.1. THE VELYKYI LUH THEN AND NOW: WHAT HAS CHANGED?

The exposed bed of the former reservoir is now located on the line of contact and is therefore under constant fire from Russian forces. Despite this, Ukrainian scientists regularly conduct expeditions to monitor the development of the Velykyi Luh – today's willow–poplar forest in the Dnipro floodplain.

Based on field research, it can be confidently stated that natural recovery processes are taking place much faster than expected. This is supported by the high moisture content of the substrate, as well as the presence in adjacent areas of plants that disperse their seeds by wind or water. The rapid recovery of vegetation stabilises the soil structure, reducing the risk of wind erosion and heavy-metal contamination.

By the end of June 2023, the studied sections of the reservoir bed were already densely covered with willow seedlings. The height of the willows increased rapidly: it averaged 190 cm in 2023 and reached 4.66 m in 2024. The structure of the willow stands also became considerably more complex. During their first year, the stands consisted of a single vegetation layer; by the second year, they had developed distinct layers of tree regeneration, shrubs, herbaceous vegetation and mosses. As of 2026, the trees had already exceeded 7 metres in height.



General view of the bottom of the former Kakhovka Reservoir in a drained bay, 30 June (a) and 19 October (b), 2023 ²³



Dreissenid colonies on the reservoir bottom and on submerged trees²⁴

Despite the rapid development of vegetation across the former reservoir area, the present-day floodplain forests do not fully replicate the habitats of the historic Velykyi Luh. Today's vegetation consists predominantly of young willow and willow–poplar stands that formed after the reservoir was drained. By contrast, when the Kakhovka Reservoir was created, the Velykyi Luh's tree and shrub communities consisted primarily of poplar forests, riparian willow forests, alder forests in depressions near the terrace, and floodplain oak forests on the highest parts of the floodplain. A significant proportion of the forests were gallery forests, meaning that they were associated with the channels of the Dnipro and its branches. This characteristic is also found in the present-day young willow–poplar forest on the bed of the former reservoir.

On the exposed reservoir bed, wetland habitats are the second most widespread habitat type by area after forests. By the end of 2023, reed stands covered 13% of the reservoir bed. The third and fourth groups of newly formed habitats are sparsely vegetated silt deposits and communities that have developed on shell and sandy sediments. These areas formed primarily in the central part of the former reservoir and in the highest sections of its former bed, where the largest colonies of zebra mussels had been concentrated. These areas now present the most extreme conditions for plant growth and are therefore becoming vegetated most slowly, currently supporting only sparse vegetation.

CONSERVATION STATUS OF NEWLY FORMED HABITATS



The dominant natural habitat type currently undergoing recovery corresponds to G1.11 Riverine Salix woodland under Resolution No. 4 of the Bern Convention, as well as to habitat types 91E0 "Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)" and 92A0 "*Salix alba* and *Populus alba* galleries" listed in Annex I to the EU Habitats Directive. Reed stands form the wetland habitat C3.2 "Water-fringing reedbeds and tall helophytes other than canes", which is protected under Resolution No. 4 of the Bern Convention. This habitat is also included in the European Red List of Habitats as C5.1a "Tall-helophyte bed".

Thus, the recovering riparian willow–poplar forests and wetland habitats belong to habitat types that are of priority importance for the European nature conservation network.

²⁴ Photos by S. Skoryk and I. Moisiienko, respectively, 2023.

The historic meadows, wetlands and forests of the Velykyi Luh developed under conditions of regular spring flooding, accompanied by the deposition of alluvial sediments and supporting the high productivity of these ecosystems. The present-day Velykyi Luh is also flooded during spring high-water periods, but its hydrological regime is not yet fully natural: it depends on the operation of the Dnipro Hydroelectric Power Plant and other reservoirs in the cascade located upstream. Despite this, by the end of 2024, waterlogged riparian habitats already covered around 60% of the former reservoir bed – almost as much as they did before it was flooded.

CLIMATE RESILIENCE AND ECOSYSTEM SERVICES



The recovery of the Velykyi Luh is also important for the region's climate resilience. The value of these willow forests lies in their ability to structure and purify soil and water by filtering nitrogen and phosphorus compounds and petroleum products, as well as adsorbing toxic heavy metals. This habitat is also the most climate-resilient forest type in Ukraine's Steppe Zone. In the coming years, the floodplain forest will cool and humidify the air during periods of extreme heat, functioning as a natural regulator of the microclimate in the surrounding areas.

3.2. NATURAL AND CULTURAL HERITAGE OF THE PRESENT-DAY VELYKYI LUH

As the reservoir bed drained, the cultural layer of the Velykyi Luh also emerged. Archaeologists and historians have discovered numerous artefacts dating from the Stone Age to the 20th century, including pottery, tools and even remains of wooden structures.

²⁵ The proposed site is titled "Velykyi Luh of the Lower Dnipro: Cultural and Natural Landscape of the Zaporizhzhian Sichs". The text of the appeal is available at: <https://uncg.org.ua/en/unesco-recognition-for-the-velykyi-luh/>.

²⁶ Джерело: <https://www.radiosvoboda.org/a/pidryv-kakhovskoyi-hes-povernennya-velykoho-lukhu-arkheolohichni-skarby/32487603.html>.

The inseparable connection between the natural landscape and its history has become the basis for a current initiative to seek international recognition for the Velykyi Luh. In 2026, researchers from the NGO Ukrainian Nature Conservation Group and the UWEC Work Group secured the support of around 100 organisations and 300 experts and proposed adding the Velykyi Luh²⁵ to the UNESCO Tentative List of World Heritage. Rather than treating the Velykyi Luh as a collection of separate historical monuments or natural areas, the proposal puts forward the territory as a single cultural and natural landscape. This is because the area combines two exceptional features: its historical role in the formation of the Zaporizhzhian Sichs and the large-scale natural recovery of the floodplain ecosystem following the disappearance of the Kakhovka Reservoir – a phenomenon without global precedent. Potential international recognition of the Velykyi Luh could become an important argument for preserving the restored natural landscape of the Lower Dnipro, while also creating conditions for further archaeological research in the area.



A dugout canoe carved from a single tree trunk, almost 7 metres long, found in a previously flooded section of the Dnipro. Scientists estimate that it is 300–500 years old²⁶

4

STRATEGIC SCENARIOS FOR MANAGING THE FORMER RESERVOIR AREA

Following the destruction of the Kakhovka Hydropower Plant, the question of long-term management of the former reservoir area arose. In addition, Ukraine has publicly committed²⁷ to its partner countries to conduct a transparent assessment of plans for the possible restoration of the Kakhovka Hydropower Plant.

Several possible management scenarios are being considered on Ukrainian and international platforms. They differ in their environmental consequences, as well as in the model of economic development for the region, weighing different approaches to the use of land and water resources for agriculture, energy generation and water supply for both the population and the region's industrial complexes.

4.1. SCENARIO A: FULL RECONSTRUCTION OF THE HYDROPOWER COMPLEX

The first scenario envisages the construction of a new dam, restoration of the Kakhovka Reservoir, reconstruction of the trunk canal system and a return to the centralised water-use model that existed from 1958 to 2023.

Implementing this approach would establish a model for the region's development at least until the end of the 21st century, as the hydropower complex has an expected service life of around 100 years. Ukrainian engineers are considering the construction of the Kakhovka-2 Hydropower Plant with an installed capacity of 550–600 MW – almost twice the capacity of the destroyed plant (335 MW). In addition, constructing a new dam would require the reconstruction of the entire hydropower complex, including the irrigation system.

The main advantage of this option is the restoration of the functions provided by the Kakhovka Reservoir: centralised irrigation, continued operation of the trunk canals, water supply for industry and settlements, hydropower generation, power-system balancing and traditional logistics infrastructure.

Financing is a serious obstacle to implementing this scenario. According to calculations by the National Bank of Ukraine, restoring the complex of hydraulic structures and irrigation systems would cost approximately USD 1.5 billion for each component. In addition, implementation of the scenario would have to be preceded by demining the bed of the Kakhovka Reservoir, which has been under constant shelling since 2023, as it lies along the front line. This would not only increase the project's cost, but also substantially extend its preparation period.

High cost is not the only challenge to implementing this scenario: climate change also raises questions about its long-term viability. Scientists project that over the next 100 years, the region's average annual temperature will increase by 2.68–2.98°C, compared with an increase of 1.2–1.4°C over the previous 100 years, while precipitation could decrease by 13 mm. Restoring the electricity-generation function of the Kakhovka Hydropower Complex amid growing water scarcity raises concerns. As early as 2021, Dnipro river flow was insufficient for the Kakhovka Hydropower Plant to operate at full capacity, while the proposed project envisages a plant with twice the capacity, which would require greater water releases. Creating a new reservoir would also increase water losses through evaporation from its surface and infiltration. Under conditions of climate change and increasing drought frequency, this could exacerbate water scarcity in the lower reaches of the Dnipro.

Implementing this scenario would also mean flooding the area where the natural ecosystems of the Velykyi Luh have been actively recovering since 2023. According to scientists, by the time construction might begin, a fully developed floodplain forest with around 40 billion trees could have formed here. Its flooding could therefore become the largest deliberate destruction of forests in the history of Ukraine. Even if there were the political will to restore the reservoir and flood the Velykyi Luh again, construction of a new hydropower complex could only be considered after the liberation of southern Ukraine and the reconstruction of the surrounding settlements. In light of these conditions, the economic feasibility of the project remains questionable.

²⁷ This is stated in the Environmental Compact for Ukraine, a strategic document developed in February 2024 by the International Working Group on the Environmental Consequences of War at the initiative of the Office of the President of Ukraine.

4.2. SCENARIO B:

PRESERVING THE VELYKYI LUH AND TRANSFORMING THE REGIONAL ECONOMY

Under a scenario of natural recovery of the Velykyi Luh, it is important not only to preserve the process of natural renaturalisation of the former reservoir area, but also to ensure the transformation of the economic model of southern Ukraine. Key tasks include reducing the region's dependence on centralised water infrastructure, replacing lost electricity generation capacity and restoring river navigation.

WATER SUPPLY

Abandoning the reservoir could lead to a shortage of water resources for monoculture agriculture. Instead of centralised irrigation, a model of sustainable agriculture could be introduced that combines a range of local solutions: drip irrigation, changes in crop structure with a focus on drought-tolerant crops, the use of local water sources, and the development of pasture-based livestock farming.

The development of pasture-based livestock farming would also create broad opportunities for developing the light industry sector. Before the full-scale invasion, Ukraine focused on growing grain crops and exporting agricultural products at low prices. By improving water-use efficiency and expanding its own meat and dairy production, Ukraine could potentially make the rural economy more resilient and reduce the cost of livestock products on both domestic and international markets. Current climatic conditions also favour the restoration of pastures in the Velykyi Luh, as natural grazing in the Steppe Zone can be maintained for up to 10 months of the year.

Water pipelines drawing directly from the Dnipro, local reservoirs and ponds, and the conversion of existing water intake facilities could provide options for addressing municipal water supply needs. In response to the water crisis, industrial enterprises could introduce closed-loop water use in their production processes, along with modern wastewater treatment and reuse technologies.

Consumption could also be regulated through differentiated tariffs: the lowest tariff during the spring high-water period and the highest during the low-water period, with different tariffs for businesses and household consumers. At the same time, abandoning a reservoir of such a large area would reduce water losses through evaporation from its surface and increase the annual flow of the Lower Dnipro.

ELECTRICITY GENERATION



The electricity generation capacity lost with the Kakhovka Hydropower Plant could be replaced through distributed renewable energy, such as solar panels. Calculations show that this type of land use is more efficient than hydropower generation²⁸. Solar panels installed on just 1/100 of the former reservoir area would generate as much electricity as the Kakhovka Hydropower Plant.

The new model should take into account the full range of functions previously provided by the Kakhovka Hydropower Plant, meaning not only electricity generation, but also balancing the power system during peak demand. As early as July 2023, the Cabinet of Ministers of Ukraine instructed that construction begin on a retaining structure downstream of the Dnipro Hydroelectric Power Plant. The structure was intended to address significant fluctuations in water levels – of up to 3 metres – downstream of the Dnipro Hydroelectric Power Plant, the next plant in the Dnipro reservoir cascade. Its construction could be complemented by other technologies: large-scale electrochemical batteries, redistribution of energy to points of consumption, and biogas power plants using energy willow. In particular, biogas facilities can operate independently of weather conditions and the time of day by storing biogas and burning it during periods of electricity shortages.

Thus, under a scenario of natural ecosystem recovery, electricity generation would only be possible in a decentralised form, with a much greater emphasis on distributed renewable energy than before.

NAVIGATION

Restoring navigation on the Dnipro does not require rebuilding the hydropower plant either. The absence of large-scale water abstraction for irrigation will ensure stable river flow for most of the year (except during the spring high-water period), supported by the other reservoirs in the cascade. This will create conditions for water transport navigation in the area of the Dnipro ports.

²⁸ When comparing energy generation with the amount of land used, the Kakhovka Hydropower Plant was the least efficient of all hydropower plants in the Dnipro cascade, generating 6,590 kWh per hectare.

The new river logistics model could potentially be even more efficient than it was when the reservoir existed. The problem of queues at navigation locks and the interruption of navigation in winter due to the reservoir freezing would disappear. For river transport to operate along the free-flowing Dnipro, only periodic dredging of the riverbed along the fairway would be required – a much cheaper and less environmentally damaging method than constructing a new reservoir. The use of modern, manoeuvrable vessels, potentially including unmanned vessels, could also be promising under the new conditions.

RESTORATION OF NATURAL ECOSYSTEMS AND IMPLEMENTATION OF INTERNATIONAL AGREEMENTS

An important advantage of this scenario is the restoration of the natural ecosystems of the Velykyi Luh and the ecosystem services associated with them. The rapid formation of willow–poplar forests contributes to carbon sequestration, air purification, microclimate regulation and the creation of habitats for a large number of animal species. The restoration of the Dnipro's free flow improves water quality and creates opportunities for the return of migratory fish species. However, to ensure the implementation of this scenario, the Velykyi Luh needs to be integrated into the nature conservation network through international mechanisms.

The entire former Kakhovka Reservoir already has Emerald Network site status, while a small part of it is also protected as a wetland of international importance (Ramsar Site). Under current conditions, a significant part of the former reservoir area has become a single wetland complex, and the status of a wetland of international importance could potentially be extended to the entire Velykyi Luh.

The restoration of the Velykyi Luh ecosystem could become Ukraine's decisive contribution to the restoration of ecosystems in the European Union. Abandoning the construction of a new reservoir would allow up to 1,800 km² of natural ecosystems to be restored, of which at least 1,000 km² would consist of climate-resilient forests, along with approximately 250 km of free-flowing Dnipro. Thus, protecting the Velykyi Luh could contribute to meeting a number of European and international nature conservation commitments concerning the protection of intact ecosystems, the restoration of degraded natural areas, the expansion of protected areas and the restoration of river ecosystems.

²⁹ Photo by V. Hubarieva.



A floodplain willow-poplar forest on the former bottom of the Kakhovka Reservoir that could become a Ramsar Site²⁹

In particular, this scenario is consistent with:

- the UN Decade on Ecosystem Restoration (2021–2030), which provides for the restoration of degraded ecosystems and the protection of intact ecosystems;
- the EU Biodiversity Strategy for 2030, which provides for increasing the area of protected areas, restoring natural ecosystems on part of agricultural land, and restoring at least 25,000 km of rivers to free-flowing condition;
- the Kunming–Montreal Global Biodiversity Framework, which aims to halt the loss of areas of high importance for biodiversity and restore at least 30% of degraded ecosystems by 2030;
- the EU Nature Restoration Law, which requires Member States to implement effective ecosystem restoration measures covering at least 20% of land and 20% of sea areas by 2030, followed by the restoration of all ecosystems in need of restoration by 2050.

Thus, the natural recovery of the Velykyi Luh creates the conditions for one of the largest-scale environmental restoration projects in Europe – without the need for large-scale human intervention or substantial financial expenditure. This scenario is already beginning to take practical shape: funding for the region's post-war reconstruction is increasingly being directed towards adapting to the new conditions rather than restoring the functions of the Kakhovka Hydropower Complex.

4.3. ALTERNATIVE MANAGEMENT OPTIONS

Between the scenarios of fully restoring the reservoir and allowing nature to recover, there are many so-called balancing or alternative management options that seek to compensate for the economic functions of the Kakhovka Reservoir while minimising environmental damage. These include creating a smaller reservoir, constructing a cascade of low-head hydropower plants, developing a combination of wind and solar power plants on the bed of the former reservoir, or growing energy crops to compensate for lost electricity generation capacity in the region.

Creating a reservoir that is smaller in area but deeper is an attempt to retain some of the functions of the former reservoir without flooding large areas. However, the protective dam surrounding the reservoir could potentially be around 35 km

long, and its construction would require approximately 16 million m³ of soil. An additional problem with this scenario is that the reduced reservoir volume may not be sufficient to ensure both efficient hydropower generation and irrigation needs, particularly given the lower flow of the Dnipro today.

Creating a cascade of small or floating low-head hydropower plants (LHPs) along the section of the Dnipro previously occupied by the reservoir would provide only electricity generation. At the same time, irrigation, water supply and other functions previously provided by the reservoir would remain unresolved. Although such facilities have a smaller impact on the morphology of the river, their efficiency depends directly on natural fluctuations in water levels.

One of the most promising compromise scenarios could be a **combination of solar and wind power plants** on the former reservoir bed. The idea is fully consistent with current legislation, under which contaminated soils may be used for the construction of such facilities. Moreover, to achieve electricity generation comparable to that of the Kakhovka Hydropower Plant, a combination of solar and wind power plants with a total capacity of 1,000–1,100 MW would be sufficient, occupying only 1–2% of the former reservoir area (approximately 4,000 ha). However, spring high-water periods could pose a major challenge when developing such a project, as more than half of the former reservoir area is flooded during this period. This significantly complicates the placement of energy infrastructure on the reservoir bed.

Among the scenarios proposed by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) for using the former reservoir bed is planting energy crops on up to 20% of its area, primarily energy willow. Such crops do not require fertile soils and can also contribute to land reclamation and phytoremediation by removing heavy metals from the soil. The risk of this scenario is that the accumulated heavy metals and toxic substances could be released into the air during combustion, meaning that the safety of this approach still requires further research.

Of all the management options for the Velykyi Luh known at present, it is difficult to identify a single option that would be most beneficial both for local residents and for the country's economy. This is primarily because they are designed for different implementation timeframes. For example, restoring the Velykyi Luh would bring benefits in the short term, but taking advantage of them would require changes to the region's economic structure. By contrast, building a reservoir would not in itself require such changes, but it would take considerable time to assess the risks, plan and implement the project.

RECOMMENDATIONS

The destruction of the Kakhovka Reservoir presents an opportunity not simply to replace lost infrastructure, but to reconsider the development model of southern Ukraine. Decisions about the future of the hydropower complex should not be driven by the objective of restoring the infrastructure that was lost. Instead, they should be based on how well each scenario can meet the needs of local communities, the environment and the region's key economic sectors. The following steps should therefore be prioritised:

1. CONDUCT A COMPREHENSIVE ASSESSMENT OF THE SCENARIOS

Before any irreversible decisions are made, the main scenarios – from restoring the reservoir to preserving the Velykyi Luh and transforming the region's economic model – should be assessed comprehensively in terms of their benefits, costs and long-term risks. The assessment should account for projected climate change, water availability, the needs of agriculture, water supply and energy, environmental impacts, and the costs of restoring and maintaining the necessary infrastructure.

Research should also continue into the contamination of bottom sediments and the mechanisms through which heavy metals migrate into soil, wood and other components of the ecosystem. Until sufficient scientific evidence is available, the use of wood and soils from the area for economic purposes should be approached with caution.

2. KEEP THE PRESERVATION OF THE VELKYI LUH ON THE INTERNATIONAL AGENDA

The preservation of the Velykyi Luh should be considered not only a national nature conservation priority, but also part of the broader process of Ukraine's recovery and adaptation to climate change. The unique wetlands that have emerged on the site of the former reservoir have the potential to be designated as a Ramsar Site – a key

area for the migration and nesting of birds in southern Ukraine. At the same time, the Velykyi Luh merits consideration for UNESCO recognition as a single cultural and natural landscape, reflecting the historical role of the territory in the formation of Ukrainian identity during the era of the Zaporizhzhian Sichs.

3. DEVELOP MODELS FOR THE REGION'S ECONOMIC TRANSFORMATION

The economic recovery of southern Ukraine should not automatically entail a return to a model dependent on the Kakhovka Reservoir. The region's needs for water, food and energy should instead provide the basis for a more decentralised and resilient economic model.

Priority should be given to modern agricultural technologies, more efficient water use, reducing losses in water distribution, developing alternative water sources, improving energy efficiency and expanding renewable energy.

Implementing these steps would allow investments already being made in the recovery of southern Ukraine to support its long-term transformation rather than recreate an inefficient economic system designed during the Soviet era and maintained until 2023. Preserving the Velykyi Luh, by contrast, could provide a foundation for a regional development model that is more resilient to both climate change and geopolitical risks.

More detailed information on the topics covered in this brief can be found in the following publications (2026):



**Velykyi Luh or the Kakhovka Reservoir:
A Modern Vision**

<https://doi.org/10.67531/velykyi-luh>



**Destruction of the Kakhovka Reservoir:
Environmental Consequences**

<https://doi.org/10.67531/kakhovka-dam>



**Kakhovka Dam Destruction Aftermath.
Literature Review**

Valeriia Kolodezhna
Oleksii Vasyliuk

**Velykyi Luh
in the Former Kakhovka Reservoir:
Preserving Europe's Largest Floodplain Forest**

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