



# Unveiling Milan’s Navigli and Underground Water Heritage through Integrated Urban (Water) Design

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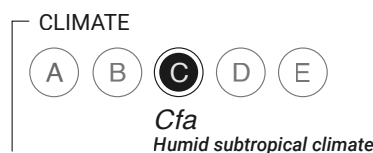
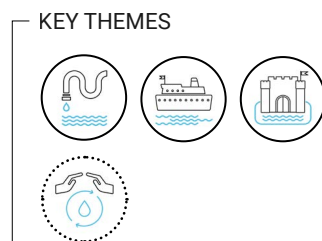
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Historic water systems have become iconic features of cities like Venice and Amsterdam. The Navigli of Milan were constructed to channel groundwater for various purposes and a consequence was the desiccation of the surrounding marshy land. As the city faced new water challenges amid imminent water needs, its water identity was affected by the covering of the historic water system. Climate change poses new challenges to preservation and planning in this historical water city. This article highlights the importance of history and water heritage for future interventions by evoking the Navigli vistas that were once the cityscape of Milan. It discusses the current challenges of the hydrographic network, including more frequent and severe floods, and proposes the daylighting of the canals to inspire the adaptation of modern and future water systems to climate impact. The goal is to reclaim Milan’s identity as a “city of water” through a deliberate design methodology informed by the city’s history.

**Keywords:** Navigli, Milan, urbanization, floods, sustainable drainage systems (SUDs)



< Fig. 1 Snowfall in the Navigli, Milan. Painting: January 1852 (Source: Angelo Inganni, Public domain, via Wikimedia Commons).



## Introduction

Cities involve social, economic and cultural features and activities that continually shape their character and identity. Water has played a pivotal role in this process. Its significance in the establishment and governance of ancient civilizations has transcended consumption and livelihood. Control over water supply has long symbolized power and authority (Adeyemi 2023). Historic water infrastructures, such as aqueducts, irrigation systems and canals, have added character to territorial landscapes, creating “uniqueness” through the combination of multiple modular elements. Transformations like those brought about by the automobile have sometimes altered this character when they have not erased it completely. As the world is rapidly urbanizing, cities are at the forefront of suffering the impacts of climate change, and thus require mitigating measures (Adeyemi 2023).

The Navigli of Milan are an example of an ancient water system that contributed to the city's original identity as a “city of water” (fig. 1). Although not widely known today, this identity is being remembered in two exhibitions: *The Waterways in Mediolanum* (held from 2023 and still ongoing) and *Milan City of Water* (held in 2015). To add to this “water” identity, the presence of a natural hydrographic network makes the city of Milan particularly vulnerable to floods, especially during periods of intense rainfall (Spano et al. 2021). As a result and as a potential solution to the problem, some citizens and the municipality of Milan have called for daylighting the Navigli (Boatti et al. 2013, 16; Boatti and Prusicki 2019). Yet, in designing and planning for sustainable urban futures, there remains a disconnect between the analysis of physical characteristics of terrains and historical studies of water systems and events (Hein et al. 2023).

This article discusses the water heritage of Milan, natural and cultural, tangible and intangible, manifested in and through the hydrological system of Navigli, which has long been modified, if not forgotten. By proposing an integrated heritage-inclusive urban design for the city, our aim is to use historical interpretation to recover and reestablish the city's intimate connection with water.

## Milan's Water Heritage

Milan, located at the center of Northern Italy, depends, like all cities, on the presence of water sources for sustenance and economic activity. Despite its land-locked position, the geography, geology and history of Milan indicate that the city's origins and prosperity are inextricably linked to water (Gattinoni and Scesi 2017), which brought both natural and cultural water heritage. Unlike other ancient cities, Mediolanum (later called Milan) was not built where it was because of proximity to surface water bodies. When the first Roman settlers founded this new fortress, they observed that the soil was particularly marshy, suggesting an underlying groundwater reservoir. The Romans explored the navigational and water supply potential of the area by digging interconnected channels that were filled by the aquifer, creating through the centuries a water system (Navigli) for the city of Milan (fig. 2). Navigli comprised canals, locks and other water management works to direct and redirect water to various parts of the city. The hydrological net was completed with the creation of the Fossa Interna: a Circular Naviglio connecting all other Navigli and canals and connecting different parts of the city.

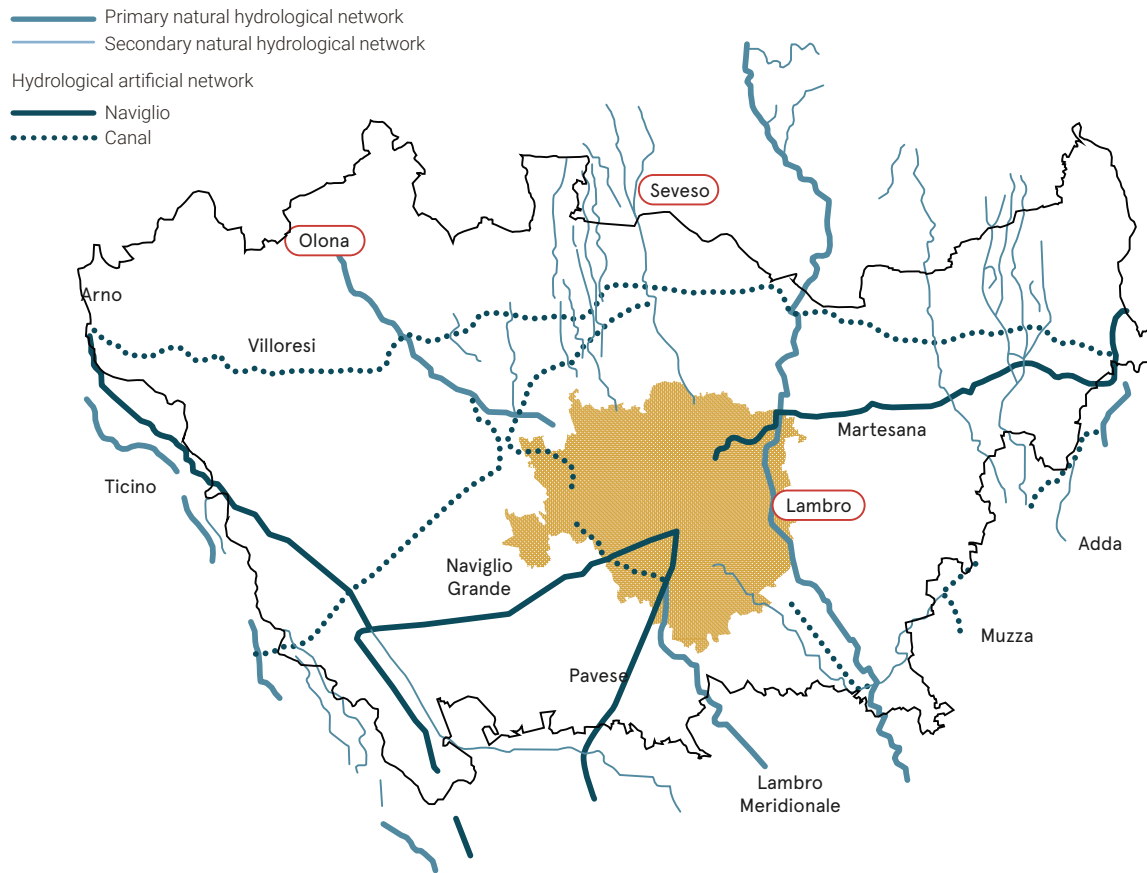


^ Fig. 2 Map of Milan's historic water system (Source: Stanqiweb, n.d.).

### Natural Water Heritage

The city's name Mediolanum has been interpreted in several different ways, including "medium-lanum" - *medio e (p)lanum*, meaning "in the middle of the plain," "place between watercourses" and "fertile land" (Ruggini 1990, 17). The city is at the confluence of some important rivers (fig. 3): the Olona, the Lambro and the Seveso. The Lombardy region itself, positioned just below the Alps, is a natural collector of waterways and water bodies, one of the most fluvial regions

in Italy, with more rivers, lakes and natural water heritage sites than any other. Milan's hydrography, especially underground, reflects this natural condition, although some natural waterways have been buried. The covering of these rivers puts certain areas at greater risk of flooding. For example, the Niguardia District, which is also a densely populated residential area, has the Seveso River flowing underneath. Urban development has disregarded the natural variation of the river's flow and failed to provide adequate space for its discharge or drainage (Aprea et al. 2018).



^ Fig. 3 Map of surface hydrography (Source: Aprea et al., 2018, adapted from image by Legambiente).

### Cultural Water Heritage

The Navigli were dug as early as 1179 for defensive purposes, as private irrigation channels, and later as lines of trade and business, and became a part of everyday Milanese life (Aprea et al. 2018). In the past, these artificial rivers were the only source of running water for domestic use; for instance there were many old washing houses along the Navigli like the one in Vicolo dei Lavandai (Ministry of Tourism n.d.). They were even used to transport materials to the Duomo (Milan's main cathedral) during construction (Tyson 2021; Global Site Plans n.d.). The Navigli system reached its peak during the

Renaissance, when Leonardo da Vinci worked on the improvement and expansion of the canals (Tramonti 2014).

In 1929 most of the canals, especially the Fossa Interna (which is also known as the Cerchia dei Navigli and the Cerchia Interna) were covered up. It was thought that the canals should be turned into roads to develop a more effective transport system trains and cars replaced boats (fig. 4). Also, the canals were perceived as sources of disease and odor, and as health and hygiene needs of the growing city became alarming, initiatives to conceal them were desirable (Cesàri n.d.; Global Site Plans n.d.). Today





^ Fig. 4 Via Fatebenefratelli ca. 1930 (left) and 1960 (right) (Source: Civico Archivio fotografico Milano, modified by authors).

only three sections of the Navigli are visible: Naviglio Grande, Naviglio Pavese and Naviglio Martesana (Tramonti 2014).

### The Modern Water System of Milan

The modernist approach to water management, framed as a purely technical endeavor, has disconnected residents' lifestyles from direct interaction with the water system. Despite its historical significance, water is no longer one of Milan's defining features. The city, now renowned as Italy's and the world's fashion capital, has turned away from its water heritage, relegating it to underground infrastructure (Tyson 2021). The remaining Navigli have become almost an aesthetic feature and the area known as the Navigli District in the southwestern part of the city is famous for its nightlife, fine dining and vintage markets (Tyson 2021, Global Site Plans n.d.).

Through the decades, the changes that have occurred have given rise to a different city, where water courses and infrastructures are no longer its most impressive landmarks. This urban re-configuration also disrupted the operation and

efficiency of its water systems, resulting in the occurrence of frequent and extreme floods (Spano et al. 2021). The modern water system and integrated water service (that is the supply and distribution of drinking water and the treatment of wastewater) is managed by Metropolitana Milanese (MM) SpA (2022), the same entity that operates the underground metro lines. The Navigli is currently managed by various entities – public, private and NGOs, such as the Ministry of Tourism, L'Associazione Naviglio Grande and the Institute for the Navigli. However, there is no collaboration among these nor a joint management framework with MM SpA, highlighting the need for integrated water management efforts. In the words of Dr. Stefano Cetti of MM, "The management of the subsoil and its history, in [...] Milan, deserves further study, as heritage [...], and technological innovation, [and] systemic approaches between entities, especially in water management" (Aprea et al. 2018, 205). From 2008 to 2010, Boatti and colleagues (2013), under the commission of the Municipality of Milan, worked on proposals for a Navigli reopening project, in which the daylighting of the Fossa Interna restores the hydraulic connection between the Naviglio della Martesana and the old dock, Darsena (Cesàri n.d.). It was voted for by 94

per cent of Milan's residents in 2011 (Aprea et al. 2018), supporting the proposal's claim that it could revive a water heritage element recognized by the older generations as a lost, or original, urban identity. After a public debate (Beltrame et al. 2018), which included a critique of the vision as being confined to the Fossa Interna, excluding what is beyond, and also as irrelevant to the attenuation of the floods of the Seveso River, the project has remained under consideration.

Although Milan is a national icon of excellence in water management and hydraulic works (Ministry of Tourism n.d.) from the historical structures by Leonardo da Vinci to the most modern water collectors, it has experienced more emergency flood situations over the last fifty years (Spano et al. 2021). This has occurred particularly in vulnerable areas such as the Niguardia and Isola Districts where the Seveso River overflowed in 1976 and in 2014 respectively (Aprea et al. 2018) and more recently during the rainstorms of 2023 (Ruffino and AP 2023). Most of the metropolitan city's aquifer is less than 10 m below ground level and continues to rise due to a decrease in groundwater consumption – the economic transformation that the city has undergone led to manufacturing industries being increasingly replaced by service industries, as well as to changes in demographic patterns (Gattinoni and Scesi 2017; Aprea et al. 2018). In addition, the groundwater, when rising, was contaminated by chemical compounds discharged in the soil by industrial, artisanal and agricultural activities, rendering much of it unsafe for consumption. Between 1994 and 1999, 51 wells were abandoned, as a result of this pollution (Aprea et al. 2018). The water table is predicted to continue rising, leading to setbacks, especially on underground structures and infrastructures. To mitigate these risks effectively, a multifaceted approach tailored to different city areas is necessary (Gattinoni and Scesi 2017).

## **Waterland Milan**

A need for combined research and analysis regarding the history, hydrology, morphology and other characteristics of specific urban enclaves guided the urban design proposal Waterland Milan (Aprea et al. 2018). Waterland Milan is an MSc. Architecture graduation project which proposes a heritage-inclusive urban water vision for Milan that not only restores the city's water identity but also manages floods and associated risks. By responding to the critiques of Beltrame et al. (2018) regarding the Navigli reopening project, the project also preemptively responds to Marco Granelli's statement on Milan's flood preparedness (Ruffino and AP 2023). The methodology used, which is informed by history, proposes a water system designed to suit the specific temporal and spatial needs of Milan's various districts.

## **Historical Interpretation: A Base for Envisioning a Future Water System**

According to Hein and colleagues (2023), "History and heritage can serve as a mirror for water-system thinking, the past has to be recognized as the foundation for future development, and specific spaces and practices can be identified and protected as heritage." By studying the three historical events listed below, we came to understand that they were not only the outcomes of urbanistic responses to past phenomena but were also temporally and spatially connected in a cause-effect cycle (see table 1).

The project by Aprea and colleagues (2018) sought to reconstruct the broken relationship between Milan's residents and water, making it something like it was in Roman times, and to preserve this memory in the long term. By re-integrating the city's hidden historic waterways

with a modern water system, Waterland Milan restored Milan’s identity as a “city of water” while tackling the hydrological emergency the city experiences annually. Diverse aspects and elements of Milan’s hydrological system (aqueduct, potable water supply, sewage system, pumping stations, wells, etc.) and its natural characteristics and historical evolution were explored across the different areas of the city (Aprea et al. 2018). Secondly, it was found that Milan is 59.5 per cent permeable and 40.5 per cent impermeable. While zoning can illuminate Milan’s urban evolution, the abandoned railway yards were identified as potential hotspots for the project. An analysis of water conditions and flood risks according to specific areas revealed the eastern riverbanks as well as the northern Niguardia and Isola Districts to be the most vulnerable.

This landscape project looked into the past and present water infrastructure, both surface and underground. It considered technological solutions for collecting, absorbing, filtering and purifying rainwater. On one hand, these solutions check the fragmented soil permeability, preventing the risk of flooding and improving the

surface water management system with an adaptable and variable program over time. On the other hand, the proposal enhances the architectural and engineering heritage in the Milanese underground, making citizens aware of this richness and showing that historical elements can inspire the future (Aprea et al. 2018, 96). Water could be moved from more vulnerable areas to less vulnerable ones, and abandoned areas could serve new water management and urban functions.

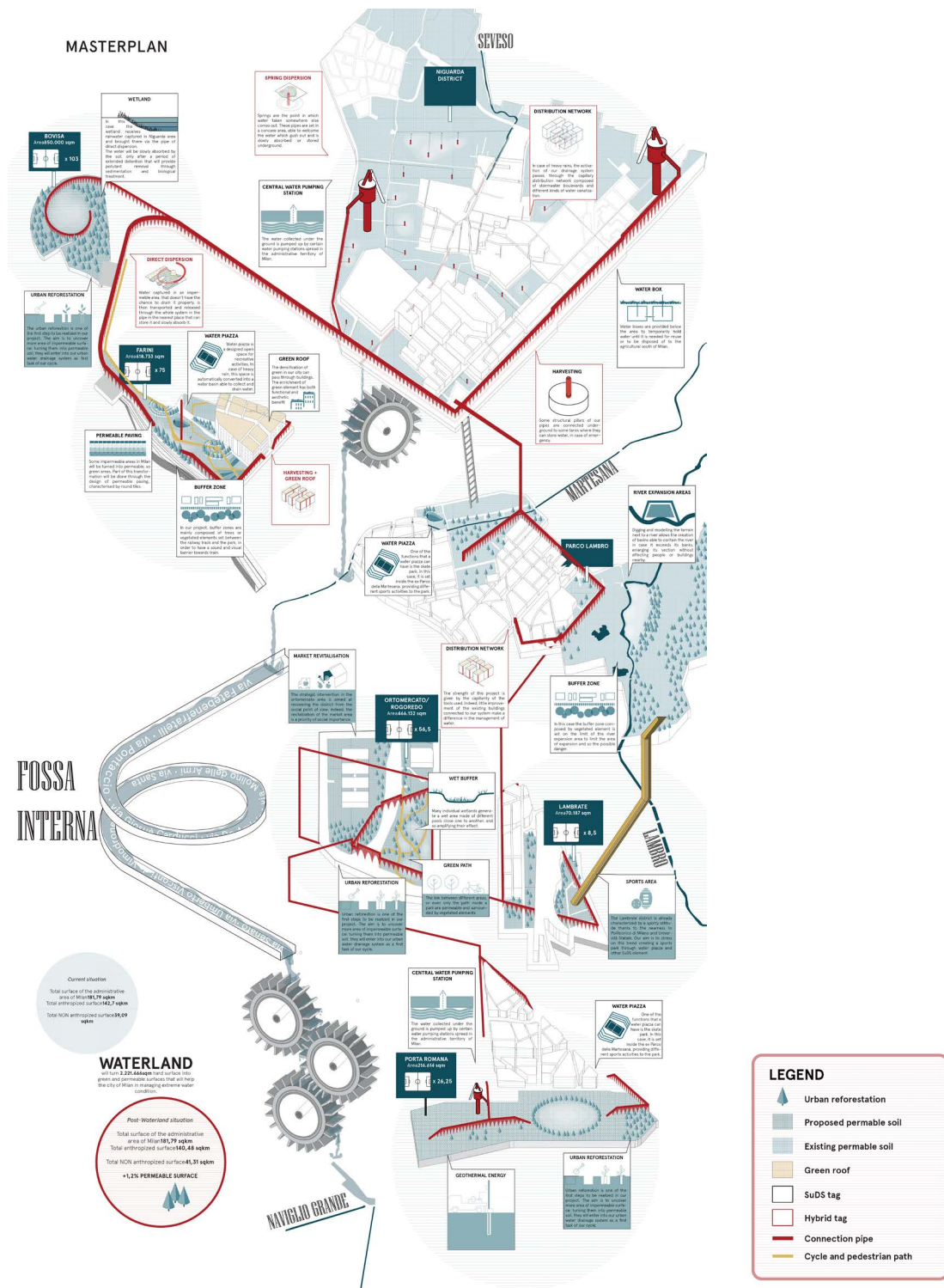
### Design Strategy

The primary objective was to enhance current aspects of the Milanese urban morphology, with a critical eye toward the past, by designing not only for technical efficiency but also for the beauty of the city’s natural and architectural heritage (Aprea et al. 2018, 29). The priority was to tackle flood risks by monitoring groundwater levels and the functionality of the existing sewage system. By restoring water and ecological continuity through a green-blue system, the city’s biodiversity (insects and birds) were

Historical event	Emerging necessity	Immediate consequence	Long-term effect	Resulting analyses
1) New mobility, shift to cars and trains	Urban expansion and asphalt road diffusion	Waterways are buried, urban transformation	Flooding	Urban voids and flood risk analysis
2) Industrialization, higher demand for labor, immigration	Rapid urbanization without a regulation plan	Lack or reduction of green areas	Heat island	Precipitation analysis
		Inability of soil to absorb water	Soil consumption	Permeable and impermeable terrain analysis
3) Indiscriminate environmental pollution, rise of chemical industry and factories	Regulation of industrial waste disposal and pollution levels	Fall of industrialization and closure of water pump factories	Rising level of the aquifer	Aquifer morphology

^ Table 1. Using historical interpretation to understand Milan’s hydrological risk (Source: Carlien Donkor, Agnese Bavuso Marone and Allegra Aprea, 2024).





^ Fig. 5 Waterland Milan master plan showing the hydraulic continuity of the project to the Fossa Interna as well as the three Navigli (Source: Carlien Donkor, Agnese Bavuso Marone and Allegra Aprea, 2018).

protected. The project also integrated interventions to minimize traffic by promoting soft mobility. Finally, a plan that establishes intervention phases suggested the project would be extended to the metropolitan area by the year 2030.

## Project

The outcome of the project was a water system parallel to the existing one combining soft elements of sustainable drainage systems (SUDs) (Detroit Future City 2012, 411–16) with technical pipes, to manage stormwater, connect new urban features and finally restore the water identity of Milan (fig. 5). The SUDs, since they are mainly landscape elements, were designed as biodiversity hotspots, providing additional ecological benefits. Zero energy principles of gravity, dispersion and suction enabled the project to be cost effective. Temporality offered relevant responses to different levels of emergency and risks, while also accommodating the possibility of different scenarios: for instance, a skate park in the dry season could function as a collector in the rainy season.

## Conclusion

Failure to recognize hydraulic works as national heritage is common around the world. The responsibility is not that of governance alone. Today, water is treated exclusively as a sector of supply and distribution (Ovink 2022) and considered in economic and technical terms without acknowledging past and present cultural significance. As Ovink (2022) argues, “Exploring past practices can and must have positive meaning for today”; the water management sector needs to complement their technical expertise with a knowledge of historical hydrological interventions, including their successes

and shortcomings, and an understanding of the types of water heritage, tangible and intangible, to appreciate what the past means for citizens in terms of fostering and keeping an identity, or simply upholding their values (Hein et al. 2023). This is necessary to be able to predict and design for tomorrow’s water systems and cities.

For older Milanese, water in Milan evokes a deep nostalgia for the disappeared aquatic city symbolized by the countless depictions in art of the Navigli. The Navigli brought water to the people and people to the water. In the same way, Waterland Milan would do the same. While the call to reopen the canals is good, it should be noted that their water management function is for a different scale of city; this should be translated in a contemporary intervention. At the same time the question of why Milan’s Navigli is not among the 10 UNESCO sites in the Lombardy region nor an official national heritage landmark remains unanswered.

## Policy Recommendations

- Conduct historical analysis of cities to find disused elements that can be integrated into technical hydraulic proposals.

## Acknowledgment

The text is adapted from “Waterland. Unveiling the Lost Memoirs of a City through Integrated Urban Water Design. The Case of Milan,” by Allegra Aprea, Agnese Bavuso Marone and Carlien Donkor (2018) and does not reflect entirely the extensive work outlined therein. This contribution was peer-reviewed. It was edited by members of the editorial team of the UNESCO Chair Water, Ports and Historic Cities: Carola Hein, Julia Korpicka and Kaiyi Zhu.

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*lan Capital of the Roman Empire*] (286–402 d.C.), curated by Gemma Sena Chiesa.

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