



HAL
open science

The Place of Water in Urban Projects Two European Examples *

Gilles Hubert

► **To cite this version:**

Gilles Hubert. The Place of Water in Urban Projects Two European Examples *. Water & City - Hydraulic Systems & Urban Structures, 2020. hal-03931564

HAL Id: hal-03931564

<https://hal.science/hal-03931564v1>

Submitted on 9 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

The Place of Water in Urban Projects

Two European Examples*

Gilles Hubert, *Urban Engineering School- Lab'Urba,*

University of Paris-Est Marne-la-Vallée, Paris, France.

gilles.hubert@univ-paris-est.fr

Introduction

Cities have maintained close relations with the rivers that cross their territories. Originally, their presence in cities was a sign of prosperity. Their qualitative and quantitative characteristics determine the functions and uses of water that favour the development of cities. Over the centuries, these relationships have evolved. As scientific and technological progress evolved, cities have moved away from the immediate proximity of water. In the 19th century Europe, the development of network technology (for drinking water supply and sanitation) allowed this distance. At the same time, the trend of hygienic thinking led city engineers and technicians to eliminate stagnant water, to bury the smallest rivers. Only larger rivers were kept but enclosed between high docks to avoid overflows.

In Europe, at the end of the 19th century and during the first half of the 20th century, urban rivers were first considered as technical objects that had to be controlled. But from the second half of the 20th century, new relationships between water and the city appeared. They are mainly linked to two factors that follow one another over time and which, today, combine.

The first factor of transformation is related to the environment and the living environment. These challenges lead cities to enhance their watercourses. New linear public spaces are thus created thanks to the development of the riverbanks. A green and blue grid system is being set up. In France, the city of Lyon is a perfect example of this dynamic.

The second transformation factor is related to urban development in flood-prone areas. It is a major challenge for European cities which, in the name of sustainable development, seek to combat urban sprawl by densifying their territory. Flood-prone areas are ideal areas for this purpose. For a long time, they were not urbanized because of the risk of flooding. They were then very useful flood expansion areas to protect cities. But the confidence placed in structural measures (dams, dikes,...) leads to the urbanization of floodplain. The occurrence of catastrophic floods is shaking up certainties, which are now also being questioned by the issue of climate change¹. In Holland, the city of Rotterdam is a case study to show these paradigm shifts.

This article is therefore based on the presentation of two European examples, each chosen to illustrate a specific transformation factor. These two cases show the importance and role of planning actions in time and space in order to hopefully conduct coherent projects.

* In Ayda ALEHASHEMI, Jean-François COULAIS & Gilles HUBERT (Editors) - *WATER & CITY – Hydraulic systems and urban structures (2020)* ; L'œil d'or – Essais et entretiens ; 2020 ; pp 185 – 198.

The metropolis of Lyon and the development of the river banks.

The territory of Lyon is marked by water. The valley is crossed by two major rivers (the Rhône and Saône) which meet south of the city (Fig1). Various groundwater aquifers occupy the eastern part of the plain, including an alluvial aquifer used for drinking water supply. The hills are crossed by an important network of small rivers and streams.



Figure 1: Lyon, a city crossed by two water courses: Saône river (left) & Rhône river (right)

Source: <https://earth.google.com/>

Historically, the urban area has been structured along the Rhône and Saône rivers. These two rivers have always been important communication routes. They have also enabled the development of industrial and port activities. Their regime has set the pace for urban development. The historic floods of the Saône (1840) and Rhône (1856) are thus at the origin of important protection works, but also of a law promulgated by the State in 1858 which makes the flood expansion fields upstream of the major cities unbuildable².

The greatest protection works were carried out in the 19th century with the construction of dike lines and high platforms. In the city centre, access to the river is provided in some places (stairs, ramps, low harbours) in order to carry out river activities.

During the 20th century, commercial activities left the city centre to be gathered around ports (north of Lyon along the Saône and south of Lyon on the Rhône). The appearance of the banks was then radically altered, in particular with the creation of traffic lanes and parking areas. Gradually, the city has been cutting off its links with the waterways of the entire agglomeration.

A change in attitude began in the 1980s with the emergence of issues to preserve the living and local environment. Other factors have accompanied this change and promoted the structuring of a global policy for the river banks.

Let us mention the fact that in 1969, the Lyon conurbation was organized into an urban community with 58 municipalities. From that time on, some urban policies were part of a cooperation vision. This has taken shape over the years and has enabled the urban area to build innovative public policies, some of which have been developed in partnership with the Lyon university community (for example in the field of water, sanitation and the environment). A new step was taken in 2015 when the urban community and the Rhône department (on the

territory of the 59 municipalities that make up the agglomeration's territory) merged to form the Metropolis of Lyon (1.3 million inhabitants).

The development of a strategic document

A reflection on the reconquest of the banks was initiated in 1981 with the establishment of an internal commission "Lyon, fluvial city" within the Urban Community, which drafted a strategic document in 1991: the Blue Plan. It defines the objectives and lays down principles for banks development, combining often divergent interests: promoting public access to the river, preserving the environment, integrating nature in the city and developing economic activities (ports and tourism). The second version of the 1998 Blue Plan reflects this culture of compromise more than the previous version. It explicitly highlights to keep port activities in Lyon and proposes the implementation of a landscape integration plan³.

An essential prerequisite

Before being able to take action, the urban community must first consider the legal status of the Rhône and Saône. In the case of watercourses connected to the public domain, it is up to the State to decide on the right of use of the water and the banks. An agreement is therefore signed between the two actors to define the modalities of action for the enhancement of the banks throughout the urban area.

However, the status of state ownership has a significant advantage in creating spatial continuity in shoreline development. Indeed, the State imposes an easement on residents that prohibits any action likely to block traffic on the banks (including a 7.80-metre wide towing easement).

The geography of the territory leads to the division of the Lyon urban area into several sectors, with each of the planning objectives and principles set out in the Blue Plan. Without establishing any programming, the Blue Plan constitutes the reference document for all the operations that will thus be implemented. Some examples are presented for illustrative purposes

First step: Rhône riverbanks (Fig 2)

River areas project entered operational phase in 2000 with the development of the banks of the Rhône over a length of 5.5 km between two districts: the *Cité Internationale* and *Gerland*.

The Cité Internationale is a tertiary district (office, museum, cinema, congress centre, and hotel) whose construction will lead to a profound transformation of the area⁴. It requires a recalibration of the riverbed, the construction of a dike against flood and the remodelling of the banks. The latter will be carried out using ecological engineering techniques, used on an experimental basis in urban areas⁵.

The most delicate operation of this first stage concerns the transformation of 15 hectares of parking space (1800 spaces) into a space open to the public. The process can be summarized as follows:

- 2000: Preparation phase with temporary actions on the banks (opening to the public during the weekend, organisation of festive events);
- 2004: Communication and consultation phase (presentation of the project to the public and organisation of debates);
- 2005: Works phase (including the search for alternative solutions for deleted parking spaces on the banks)
- 2007: Opening of the banks to the public.

The operation is a success that is reflected in increased public use of the banks; it will also require the rehabilitation of the cleaning and waste management service (creation of a specific service).



Fig 2: The banks of the Rhône in Lyon redeveloped in the mid-2000s to become public space

Source: https://commons.wikimedia.org/wiki/Category:Berges_du_Rh%C3%B4ne

Second step: The “blue ring” (Fig 3)

Upstream of the city Centre, the urban area has one of the largest peri-urban natural areas in Europe with more than 3000 hectares. It is bordered to the north by the channeled Rhône and to the south by a canal, originally dug to divert part of the river's flow and supply a hydroelectric plant. This space fulfils essential metropolitan functions: flood protection (flood expansion area), drinking water supply (catchment points)⁶, biodiversity (nature reserve area), leisure activities (Miribel-Jonage Park), power generation (hydroelectric plant). These functions are each carried out by different actors who have signed a charter of objectives to make them compatible.

This territory forms an island that is ultimately very poorly connected to the surrounding areas, including Lyon. One of the ambitions of the "Blue Ring" project is to fill this gap. The development of the banks of the canals surrounding this area is one of the means used to create functional links between natural and urban areas. But the "Blue Ring" project is much more than a simple operation to create riverside walks. It includes various heritage enhancement actions (natural, landscape, cultural,...).

Its implementation is ensured thanks to a partnership structure that brings together the State, local authorities (11 communes, the metropolis of Lyon, 2 departments, 1 region) and managers: those of the leisure Park (1 mixed syndicate and 1 local public company), that of the canals (Voies Navigables de France), that of the hydroelectric plant (Electricité de France,...). It aims to coordinate operations, organize their management and financing. The "blue ring" project is to be completed in 2015.

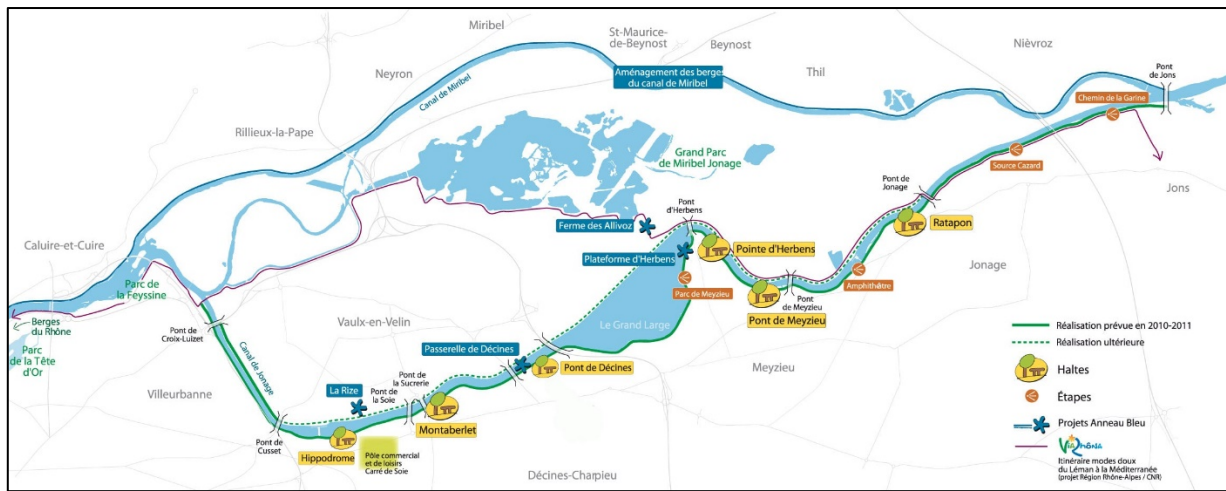


Fig 3: The blue ring

Source: <https://www.rue89lyon.fr/wp-content/uploads/2013/10/Plan-Anneau-Bleu-ok.jpg>

Third step: Saône riverbanks

The most recent operation concerns the banks of the Saône from the upstream part of Lyon (11 km north of the city centre) to a new urban area, called “Lyon Confluence” (4 km south of the city center)⁷. This project is presented by the Lyon Metropolitan Area as one of the largest urban redevelopment projects in Europe. It covers 15 municipalities, including the city of Lyon. It is organized in 8 sequences, the layout of which has been designed with international artists (sculptors, plastic artists, architects,...). Their works (23), installed along the river, punctuate a 15 km long walkway. The Saône riverbank project is due to be completed in 2022.

A temporal and spatial continuity project

The reconquest of the banks of the Saône and Rhône rivers is a long-term process. Despite the political changes at the head of the municipalities and the urban community, the initial strategy (set out in the Blue Plan) has remained a reference throughout the action that has been implemented in recent decades and will end in a few years.

Thanks to a solid experience in intermunicipal cooperation, the operation was carried out on the scale of the entire urban area. The actions have been adapted to take into account local characteristics (geographical, urban, landscape, hydrological, ecological). Shoreline development today constitutes a network whose nodes are formed by urban parks, natural spaces or structuring facilities (leisure base, museum,...).

This operation is part of the sustainable development policy of the Lyon metropolitan area. The enhancement of the banks is part of the actions of Greater Lyon's Agenda 21 and the Territorial Energy Climate Plan (promote nature in the city, soft mobility, coolness island,...).

Table. 1- Overview of key actions. Source: Author, 2018.

<i>Date</i>	<i>Actions</i>
1981	<i>Creation of the "Lyon, river city" commission within the Urban Community</i>
1991	<i>"Blue Plan" edition</i>
1992	<i>Drafting of an urban ecology charter</i>
1997	<i>Agreement between the State and the Urban Community for the Saone & Rhône river banks development</i>
1998	<i>Update of the "Blue Plan"</i>
2000	<i>Launch of the Rhône riverbank project - opening to the public in 2007</i>
2003	<i>First step of Eco-district project "Lyon Confluence"</i>
2005	<i>Launch of the "Blue Ring" project</i>
2005	<i>Approval of Agenda 21 of the Urban Community</i>
2007	<i>Approval of Territorial Climate Energy Plan</i>
2009	<i>Approval of the Eastern Lyon Water Development and Management Scheme (for groundwater resource)</i>
2013	<i>Launch of the Saône river banks project</i>
2015	<i>Creation of the Metropolis of Lyon</i>

Through this policy of enhancing the banks, the metropolis of Lyon has made it possible to connect spaces a few dozen kilometres apart. It is probably an exaggeration to speak here of a green framework..... In any case, it is discontinuous: sections of highly mineralized banks (heritage of the past) alternate with a few sectors where the shoreline is vegetated; traditional urban parks coexist with natural environments.

Can we talk about blue grid? This metropolitan policy focuses solely on the structuring rivers of the urban area, namely the Saône and the Rhône. The development operations, carried out by some of the city's municipalities on peri-urban rivers, remain isolated. There is currently no desire to create a connection between the two major rivers and their tributaries. On another level, the actions concerning the management of rainwater by the agglomeration (which make the reputation of its water management) are carried out separately.

To go beyond the simple question of public access to the banks and to move towards greater integration (between qualitative and quantitative aspects), we could imagine the implementation of a Metropolitan Water Development and Management Scheme⁸. There is such an approach, but it only concerns the aquifers of eastern Lyon, which are a major challenge for the urban area's drinking water supply⁹.

The metropolis of Rotterdam and the control of hydrological risks

In Europe, flooding is the most important major natural risk and Holland is probably the European country most affected by this phenomenon. Its territory extends over a vast delta formed by three rivers: the Rhine, the Scheldt and the Meuse. Much of the land is located below sea level.

Traditionally confronted with maritime storms and river overflows, Holland experienced dramatic floods in 1953, caused by a storm in the North Sea. This catastrophic event is at the origin of the *Delta Plan*¹⁰, which will allow the implementation of a vast system of land protection.

This action program is regularly revised, and its content evolves according to the challenges, particularly those of a climate change nature. Thus, the 2014 Delta Plan is based on an approach called "adaptive delta management" which proposes to adjust actions according to the evolution of knowledge and uncertainties related to climate change¹¹.

Although flood risk management policy in Holland remains dominated by structural measures (reflecting a strong technical culture), new modes of action are emerging under the influence of sustainable development issues and the emergence of the concept of resilience in the field of natural hazards. It is in this context that programs such as "room for the river", "building with nature", "flood proof housing" appear. In addition, despite the trust placed in the protective structures, the authorities are now studying the mechanisms of dam failure and their consequences (in terms of damage to property and persons, in terms of population evacuation)¹². The example of Rotterdam, with its flood risk management policy based on taking climate change into account in practices, is a perfect illustration of these recent transformations.



Figure 3: Rotterdam, a city where water plays an important role
 Source: http://gallery.spotimage.com/product_info.php?products_id=1228

Table.2- Simplified presentation of the distribution of competences between the actors of water management. Source: Author, 2018

Actors	Tasks
Central State	Definition of the natural risk management policy. Elaboration of Delta Plan and work planning.
Rijkwaterstaat	Government agency in charge of implementing the Delta Plan: construction and maintenance of structural measures.
Provinces (12)	Territorial subdivision at the level of which the national policy is applied Control and coordination of Waterschappen & Municipalities works.
Waterschappen (21)	Public authorities in charge of : <ul style="list-style-type: none"> - Construction and maintenance of local protection works (canals, dikes, locks, pumps) - Water quality monitoring and control - Construction and operation of wastewater treatment plants
Municipalities (355)	Drinking water supply Wastewater collection and transportation Organisation and implementation of urban planning
Citizens	Responsible for the implementation and maintenance of personal protection measures Responsible for stormwater management on their property

Some Characteristics of Rotterdam City

- Total area : 325 km²
- Aquatic area: 208 km²
- Land area: 117 km²
- Inhabitants: 629 078
- Density: 3012 inhab/km²

Rotterdam, the second largest city in the Netherlands in terms of population, is the largest port in Europe (40 km long).

It is also the lowest inhabited polder in the country. Its altitude is between 6.5 and 7 metres below sea level. The territory is protected through a series of structural measures implemented over the centuries.

A mobile dam (Maeslantkering)¹³, built on one of the delta's waterways, protects the city from North Sea storms. Its commissioning in 1997 contributed to the development of the city and its port area.

The urbanized polders are protected from flooding by a vast network of primary dikes, walls and locks. Within these urbanized polders, water levels are regulated by canals (400 km), basins, underground collectors and pumping stations (900) that drain, store and return excess water to the rivers.

The whole system is integrated into a larger and closed system of dikerings. Safety standards are assigned to these dikes based on their degree of resistance to storms and tides.

Part of the city (historic commercial district, port) remains vulnerable because it is located outside the ring dikes. In addition, the city centre is particularly sensitive to storm rainfall because the ground has been completely waterproofed and there is no possibility of creating storage capacity on public space¹⁴.



Figure 4: Bentheplein water square in Rotterdam created in 2013 for the rainwater management

Source : https://commons.wikimedia.org/wiki/File:Bentheplein_terrain_skate_gestion_eau.jpg?uselang=fr

Despite its sophisticated protection system (with some of the highest safety standards in the world), the city of Rotterdam takes the issue of flood risk and climate change very seriously. It is in this context that it has initiated a process of reflection and then action.

A first project "Rotterdam water city" is presented at the International Biennale of Architecture held in Rotterdam in 2005 (then at the Shanghai World Expo in 2010).

In the same year (2005), a plan was drawn up for the territory of Rotterdam. It determines zoning based on land use, the presence of water and the level of exposure to risk. Its objective is to imagine what the city could be like in 2035. It also makes it possible to reflect on the spatialization of actions to be carried out on the territory. This map divides the city into three areas:

- "Singel city" in the north: an area where the city can play the role of a sponge and where solutions for water storage, absorption and infiltration can be preferred;
- "River city" in the centre: an area where the city is subject to the play of the tides and where floating housing experiments can be carried out¹⁵;
- "Canal city" in the south: an area where the existence of a canal network must be mobilized to strengthen the links between water and residential areas (for example by using canals as a means of transport).

The planning perimeter was then expanded to include the upstream and downstream of Rotterdam and to imagine the creation of a green and blue grid.

A document entitled "Rotterdam climate proof" was produced by the city in 2008. It collects data and reviews available knowledge on the effects of climate change and possible solutions. This document highlights that the territory must simultaneously face risks related to sea level rise, heavy rainfall¹⁶, river regime (low and high water), periods of high heat and drought¹⁷.

This document leads to the definition of an adaptation strategy adopted by the city in 2013. Its objective is to make Rotterdam one of the first cities to be able to face the challenges of climate change in 2025 (Van Veelen P., 2014). The strategy is based on 4 fundamental principles:

- Optimize the existing protection system: schedule investments and maintenance;
- Continuously adapt: invest in researching many and diverse solutions on a small scale rather than one-off investments on a large scale;
- Make the link with urban dynamics: change land use in a targeted way by acting progressively through urban renewal and renovation operations (intervention also on existing land);
- Creating added value: the municipality intends to capitalize on climate change....

This strategy reflects a paradigm shift in risk management at the metropolitan level, which is expressed in several ways.

First, it leads to an evolution in the modalities of action in the field of protection. It is no longer systematically envisaged to give priority to large-scale structural measures (such as strengthening or raising dikes). On the contrary, it is envisaged to promote local measures. For rainwater management, this leads to the search for storage, infiltration or absorption possibilities in both public and private spaces (residents' gardens). As an example of a project, we can mention the creation in 2013 of a rainwater retention basin that also acts as a public square (Water Plaza Benthemplein), and the construction of green roofs with a surface area of 160,000 m² in 2014.

A "River as a tidal park" programme was adopted in 2014 jointly by the City of Rotterdam, the Port Authorities, the Province and the State. It is supported by WWF Netherlands. This action aims to experiment with the concept of "building with nature" by creating a park to preserve the 10% of the city's banks that are still "natural", i. e.

knowing the regular effects of the tides and still having tidal biotopes. The project also aims to raise awareness of this natural phenomenon among the inhabitants.

Secondly, it involves new actors alongside the community (and the State) in order to get them involved in the design, implementation and management of projects (experimentation, pilot operation, innovation, etc.): consultants, design offices (architects/urban planners/landscape planners/hydrologists/ecologists,...), engineering companies, nature protection associations, communities of inhabitants,... Concerning the inhabitants, the challenge is to go beyond information and awareness to make them commit to the action (voluntary adaptation of housing to floods, acceptance of the temporary presence of water on the property, solidarity and mutual aid within the district,...).

Since the strategy includes a "knowledge" component, the city works in partnership with universities and their research teams. Training has even been set up where students are taught about climate change and water management.

In the case of Rotterdam, water is considered an opportunity and not a threat. This example is undoubtedly a precursor to future action to address climate change. The inability of States to pursue a policy commensurate with the challenges requires local actors to implement actions at their level. The city of Rotterdam and its partners see climate change as a challenge. The adaptation strategy (and not mitigation) implemented gives priority to the methodological, technical (whether civil engineering, urban engineering or environmental engineering) and technological (digitisation) dimensions. Communication, even marketing, is not absent from this strategy. It is a question of acquiring exportable know-how and making it known.

Conclusion

The two cases presented in this article illustrate the problem of urban and seasonal aquosity¹⁸ (GUILLERME A. et al., 1991). Each having a different entry point, they have several aspects in common.

First, they show the importance of the spatial dimension and the interlocking of scales for water management. This dimension is expressed through actions that, depending on the case, can be implemented both at the scale of a plot and at the scale of a district, a city,..., a functional territory (the hydrographic basin for example).

They then highlight the question of the time scale, which is reflected in several ways: the consideration of history and heritage, the integration of uncertainties, the adaptability of actions, the duration of decision-making and action processes.

Finally, they show us that - given the diversity of water functions and uses, but also the complexity of the processes involved - all projects require compromises, negotiations and partnerships between stakeholders from design to operation management.

References

A. Guillerme, G. Hubert, Y. Tsuchiya, *Urban and seasonal aquosity: a comparison between Paris and Tokyo*. "Research report for French Ministry of Equipment and Housing", 1991.

A. Loos Nillesen, *A new vision for confronting flood risk: the Netherlands*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 60-75.

C. Gerardot, *Lyon's political figures and its rivers: regeneration in question*, "Géocarrefour", 2004, 79, 1, pp. 75-84.

G. Hubert, *The city and flooding : an uneasy cohabitation*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 218-233.

J. Bethemont, J. Pelletier, *Lyon and its rivers: from neglected riverbanks to a rejuvenated waterfront*, "Revue de Géographie de Lyon", 1990, 65, 4, pp. 300-307.

P. Van Veelen, *Climate adaptation Rotterdam*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 33-43.

¹ G. Hubert, *The city and flooding : an uneasy cohabitation*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 218-233.

² It is thanks to this law that the Rhone alluvial plain has been preserved upstream of Lyon: Miribel-Jonage (3000 hectares).

³ C. Gerardot, *Lyon's political figures and its rivers: regeneration in question*, "Géocarrefour", 2004, 79, 1, pp. 75-84.

⁴ The construction of the Cité Internationale took several decades to complete. The competition to designate the prime contractor took place in 1985. The operation was completed in 2006.

⁵ The use of ecological engineering techniques for shoreline reconstruction is essentially based on the mechanical and physical properties of plants, including their ability to root. Plant species are primarily selected for the quality of their root system which, by developing on large and deep surfaces in the soil, stabilizes the shoreline in a sustainable way.

⁶ The alluvial groundwater of the Rhône provides 90% of the drinking water of Greater Lyon (300 ha catchment area).

⁷ This is an eco-neighbourhood (housing and tertiary activities) created at the confluence of the Saône and Rhône on former industrial land. A first 41 ha phase was carried out between 2003 and 2008. The second 35 ha phase began in 2012 and is expected to be completed in 2025.

⁸ The Water Development and Management Scheme (SAGE) is a planning document drawn up on the scale of a coherent hydrographic unit (watershed, sub-watershed, aquifer, etc.). It sets general objectives for the use, development, quantity and quality protection of water resources. The scheme is developed by local actors (elected officials, users, associations, State representatives, etc.) within the local water commission (CLE). These local actors establish a project for a concerted and collective water management for a period of 10 years.

⁹ The SAGE of Eastern Lyon was approved in 2009. It aims to better understand the groundwater tables in order to define protection and management actions. The major challenge of drinking water supply requires the control of abstractions and pollution (agricultural, industrial, urban).

¹⁰ The Delta Plan has created a chain of dikes and dams to protect the delta from tides and storms.

¹¹ P. Van Veelen, *Climate adaptation Rotterdam*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 33-43.

¹² A. Loos Nillesen, *A new vision for confronting flood risk: the Netherlands*, in J.J. Terrin (ed.), *Cities and flooding*, Marseille, Parenthèses, Collection: la ville en train de se faire, 2014, pp. 60-75.

¹³ Maeslantkering is one of the largest mobile structures in the world. Its length is 420 metres and its height 20 metres.

¹⁴ From the second half of the 20th century, a large number of canals were filled to make boulevards, leading to a significant decrease in the possibilities of rainwater absorption.

¹⁵ The Dutch government considers floating houses as a necessity and not an architectural extravagance. Since the 2000s, it has been possible to acquire a plot of water to build a house.

¹⁶ Currently, heavy rains that cause damage occur on average every 5 years. According to experts, their return period could be annual in 2050.

¹⁷ Major droughts also represent a danger because the levees and docks are made up partly of peat and risk collapsing as they dry up.

¹⁸ A. Guillerme, G. Hubert, Y. Tsuchiya, *Urban and seasonal aquosity: a comparison between Paris and Tokyo*. "Research report for French Ministry of Equipment and Housing", 1991, p. 145.