v. 24 n. 1 2024

cadernospós
cadernos de pós-graduação
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Urban fluvial infrastructure, from streets to rivers: watershed as a planning, design, and management unit

Infraestrutura urbana fluvial, das ruas aos rios: bacia hidrográfica como unidade de planejamento, projeto e gestão

Infraestructura fluvial urbana, desde calles hasta ríos: la cuenca como unidad de planificación, diseño y gestión

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How to cite this paper: IKEDA, Eloísa B.; DELIJAICOV, Alexandre. Urban fluvial infrastructure, from streets to rivers: watershed as a planning, design, and management unit. *Cadernos de Pós-Graduação em Arquitetura e Urbanismo*, São Paulo, v. 24, n. 1, p. 28-44, 2024.

DOI 10.5935/cadernospos.v24n1p28-44

Submitted: 2024-03-25
Accepted: 2024-03-29

Abstract

This article proposes and conceptualizes meta-designs for urban fluvial infrastructure in public architecture, and consists of two parts: "concepts" and "design". The former discusses relevant concepts to understanding the built environment of cities, developed in conversations and projects carried out by the Grupo Metrópole Fluvial,

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FAU USP, coordinated by Professor Alexandre Delijaicov. It includes considerations on constitutive elements of the urban fluvial infrastructure, such as rivers, canals, bridges, streets, galleries, piers, and ports. After reflecting on the relationship between these constructions and the environment and human needs, the second part presents, through diagrams, meta-designs for watersheds in their various scales. These meta-designs propose ideas for structuring places taking rivers as axes for environmental and urban development, which consider the watershed as the planning, design, and management unit. Delimiting this drainage area is key for understanding the site and how its nature can be or was built. This methodology on studies about cities allows to construct urban infrastructure elements which guarantee basic and environmental sanitation conditions throughout the inhabited area.

Keywords: Urban fluvial infrastructure; Public Architecture; Built Nature; Architectural design methodology; Urban Rivers.

Resumo

Este artigo tem caráter propositivo de desenho e conceituação de metaprojetos para arquitetura pública de infraestrutura urbana fluvial. Está dividido em duas partes: “conceito” e “projeto”. A primeira parte é um ensaio sobre conceitos relevantes para a compreensão do ambiente construído das cidades, desenvolvidos pelo Grupo Metrópole Fluvial, da FAU USP, coordenado pelo professor Alexandre Delijaicov. Para isso, foram feitas considerações sobre elementos que compõem a infraestrutura urbana fluvial, rios, canais, pontes, ruas, galerias, cais e portos. A partir de uma reflexão sobre a relação dessas construções com o meio ambiente e as necessidades humanas, busca-se, na segunda parte do artigo, apresentar, por meio de diagramas, um estudo de metaprojeto para bacias hidrográficas nas suas diversas escalas. Esses diagramas contêm ideias para a estruturação de lugares tendo os rios como eixos de desenvolvimento ambiental e urbano. A unidade de planejamento, projeto e gestão considerada nesses estudos é a própria bacia hidrográfica. A delimitação dessa área de drenagem é a base para a compreensão do lugar e a forma como sua natureza pode ser ou foi construída. O objetivo dessa metodologia para se pensar as cidades é viabilizar a construção de elementos de infraestrutura urbana que garantam condições de saneamento básico e ambientais para toda a população, em toda a área habitada.

Palavras-chave: Infraestrutura urbana fluvial; Arquitetura Pública; Natureza Construída; Metodologia de projeto de arquitetura; Rios Urbanos.

Resumen

Este artículo tiene carácter propositivo de diseño y concepción de meta proyectos para arquitectura pública de infraestructura urbana fluvial. Está dividido en dos partes: “concepto” y “proyecto”. La primera parte es un mensaje sobre conceptos relevantes para comprender el ambiente construido por las ciudades, desarrollado por el Grupo

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"Metrópole Fluvial", de la FAU USP, coordinado por el profesor Alexandre Delijaicov. Para esto, se estableceran consideraciones sobre elementos que componen una infraestructura urbana fluvial, ríos, canales, puentes, calles, galerías, molles y puertos. A partir de una reflexión sobre la relación de las construcciones con el medio ambiente y las necesidades humanas, busca-se, en la segunda parte del artículo, presentar, a través de diagramas, un estudio de meta proyecto para cuencas hidrográficas en sus diversas escalas. Estos diagramas contienen ideas para la estructura de lugares que tienen como fin los ríos como ejes de desarrollo ambiental y urbano. La unidad de planeamiento, proyecto y gestión considerados como estudios es una cuenca hidrográfica propia. La delimitación de esta área de drenaje es una base para comprender el lugar y una forma como su naturaleza puede ser o haber sido construida. El objetivo de esta metodología para pensar en ciudades es viabilizar la construcción de elementos de infraestructura urbana que garanticen condiciones de salud básica y ambiental para toda la población, en toda el área habitada.

Palabras clave: Infraestructura urbana fluvial; Arquitectura Pública; Naturaleza Construida; Metodología de diseño arquitectónico; Ríos Urbanos.

Introduction

The purpose of this article is to justify the consideration of the watershed as a unit for planning, design, and management. The micro-watershed, sub-watershed, and watershed, referring to small streams and larger rivers, can serve as a basis for thinking about the best ways to build or rebuild cities. In this way, project scales can be addressed, from the neighborhood to the metropolis. The urban interpretation starts from the largest unit, the main river that flows through settlements, to the small tributaries that feed this river. The relationship between the scales of watersheds is essential to understanding the whole, the general context of occupations and the reasons that justify the way they have been developed.

As an introduction to the topic, we begin with a proposed definition of infrastructure. Then the street is conceptualized as a precursor element in the occupation of a site and in its secondary but fundamental role as an urban drainage channel, the street canal. Thus, the construction of cities and street networks is related to the watercourses that irrigate them.

As a conclusion to this analysis, metaproject studies are presented for neighborhoods, cities, and metropolises based on their watersheds. In short, a metaproject is understood as a set of guiding ideas, concepts, and parameters. The diagrams function as guides that could orient the design of urban fluvial infrastructure projects. If public architecture has as one of its principles the pursuit of equity in the treatment of each user, the conception of the metaproject is also a way to achieve project results with the same degree of quality, regardless of whether the site is central or peripheral and who it serves. Public architecture

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should embrace the entire occupied area with a uniform quality and allow for the proper use of space.

1. Concepts

1.1 Infrastructure

Infrastructure may be understood as the set of constructions that allow for the occupation of a place under adequate conditions of existence: health, comfort, safety, efficiency, and beauty. These constructions must function in a systematic, coordinated way, aiming at adapting the natural environment to the built preexistences and the available resources to the basic needs of the community they serve.

Sometimes infrastructure is an invisible structure, noticed only when it fails to serve its purpose. For example, when you trip on a broken sidewalk, when a polluted stream emits a foul odor, or when you board an overcrowded bus that does not get close enough to your destination.

Occupying a place can mean establishing a permanent or temporary stay through the actions of dwelling, being, or passing through. To illustrate this concept, herein is an image (Figure 1) and a dialogue excerpt from the 1990 film Dreams, directed by Akira Kurosawa, in which a passing man converses with an older resident who is setting up a water mill in a village. Below is a transcription of part of their dialogue:

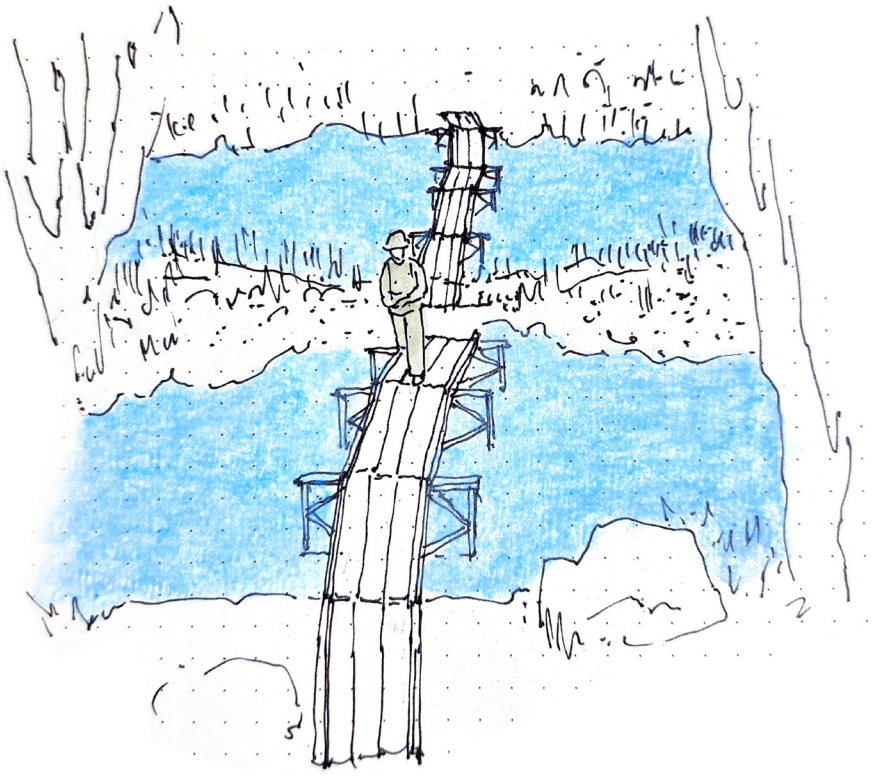

Figure 1: Scene from the episode of the village of the water mills. Film Dreams by Akira Kurosawa (1990). Redrawn by the author.

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Visitor: Good morning.
Villager: Good morning.
V: What is the name of this village?
A: It doesn't have one. We just call it "the village". Some people call it the village of the water mill.
V: Do all the villagers live here?
A: No, they live elsewhere.
V: There's no electricity here?
A: No. We don't need it. People get too used to comfort. They believe that comfort is better. They despise what's really good.
V: But what about light?
A: We have candles and linseed oil.
V: But the nights are very dark.
A: Yes. That's how the night should be. Why should the night shine like the day? I wouldn't like nights so clear that you can't see the stars.
V: You have fields, but no tractors to cultivate them?
A: We don't need them. We have cows and horses.
V: What do you use for fuel?
A: Mainly firewood. We don't feel good when we destroy trees, but enough of them fall on their own. We cut it down and then use it for firewood. And if you make charcoal, a few trees can give as much heat as a whole forest. And cow dung is good fuel too. We try to live like the men of old. It's the natural way of life. People today have forgotten that in reality they are just part of nature. Yet they destroy the nature on which our lives depend. They always think they can do something better. Especially scientists. They may be intelligent, but most of them don't understand the heart of nature. They only invent things that make people unhappy in the end. And they still feel proud of their inventions. What's worse, most people are also proud. They look at them as if they were miracles. They worship them. They don't know it, but they are destroying nature. They don't see that they're going to die. The most important things for humans are clean air, clean water and the trees and grass that produce them. Everything is getting dirty, polluted forever. Dirty air, dirty water dirtying the hearts of men.

The village has no name; it is like a metaproject, a synthesis of the essence of what infrastructure should be and provide. The infrastructure should not impose itself on the nature of the place. Instead, infrastructure should emphasize, valorize, and keep intact as much as possible its characteristics, terrains, rivers, and vegetation, so that the environmental consciousness is not lost or obscured for future generations.

The village is formed by a bridge over the river that crosses this natural obstacle, the mills that use the power of the water flow to generate energy or motion, the

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mill houses, and the road along the river. The bridge is located where there is a river island, so the span of the river is divided into two smaller spans, reducing the bending moment of the structure. The existing natural features in this case suggest the design solutions.

Infrastructure is in harmony with the environment, as if it had always been there. They are proportional and on a human scale. They are neither monumental nor do they express subjectivities. They are the minimum necessary for the collective, respecting the diversity of conditions of each individual, and they are executed with techniques that have been proven by repetition in previous civilizations and that have proven to be efficient with a minimum of maintenance.

However, this does not mean that new technologies are not welcome. Quite the opposite, innovative technologies should be incorporated to optimize buildings without losing their essence and harmony with their surroundings.

1.2 Street channel

The path, the consolidation of a route between origin and destination, seems to be the precursor infrastructure element in the occupation of a place. It is a passage that can also promote encounters. This observation can be analyzed on the map of Lutetia, ancient Paris (Figure 2). The foundation of the city is indicated at the

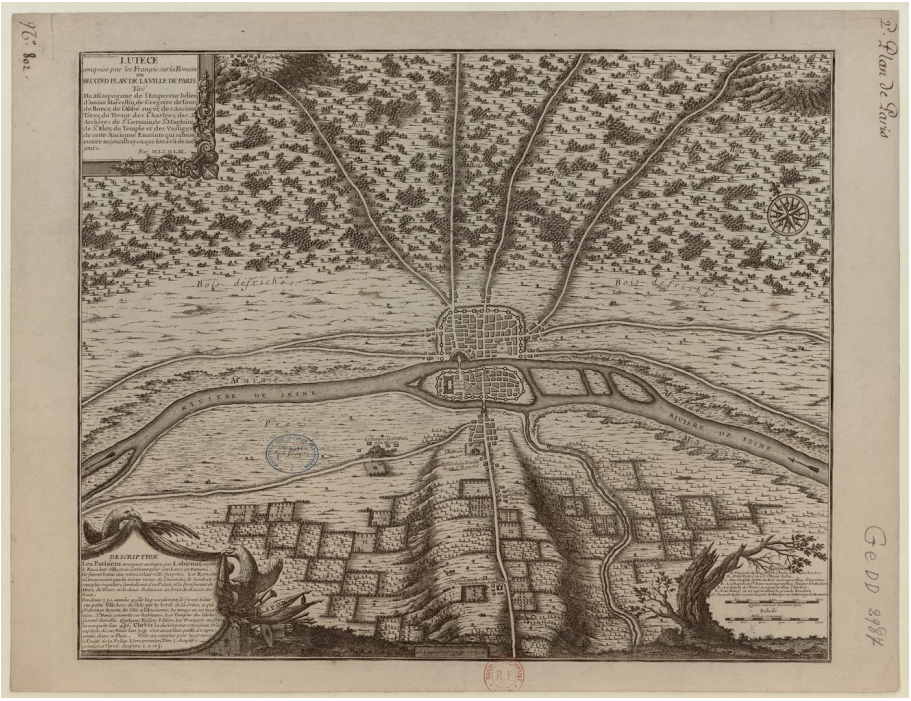

Figure 2: Lutetia conquered by the Romans, on the second plan of the city of Paris. Nicolas de la Mare (1705). Source: Bibliothèque National de France. Available at: https://gallica.bnf.fr/ark:/12148/btv1b8593323r/f1.item.r=plan%20lutece.zoom#. Access on: June 1, 2022.

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crossroads of roads leading to neighboring settlements. The origin of the city is located at the intersection of the Seine and a path that crosses the hills, bordering the Buttes aux Callais and north of the Seine, between the hills of Montmartre and Belleville. The path follows the plains, avoiding these reliefs; and the river crossing, as in the village in Dreams, takes place where there is a river island.

The street, which is the main element that allows the realization of a path, facilitates the drainage, in addition to the passage of people and/or vehicles, and becomes an artificial channel through which rainwater and also used water flow.

In the streets of ancient Roman cities, the crosswalk was in relief. The raised level of the roadway at the height of a step imitates a stream crossing, where one chooses the best path among the emerging stones. People could cross the streets without getting their feet wet in the used or rainwater carried by the street channel.

An alternative for draining water was to divert it to the sides of the roadway, leaving that space clear for people or vehicles to pass. Figure 3, below, represents a typical situation of the old part of the urbanization of Japanese cities.

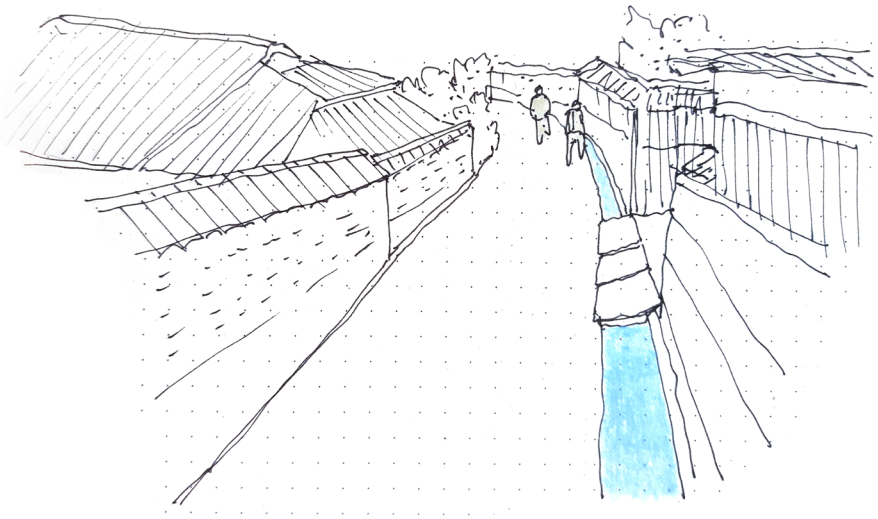

Figure 3: Hagi canal, Japan. Redrawn by the author from a Google Street View image at the address: 2 Chome 37. Gofukumachi, Hagi, Yamaguchi.

The contrasting images show the Jardim Gaivotas neighborhood in São Paulo (Figure 4) and the cities of Hagi and Shimabara in Japan (Figure 3). The small side channels in the streets of Japan are common in neighborhood streets. Clear water and carp often flow through them. In the streets depicted in São Paulo, along the edge of the Billings Reservoir, the elements are the same: a canal at the edge of the roadway; above it, a bridge leading to the entrance of the house. However, the water flowing in these indentations, which appear to be the result of small erosions, is sewage.

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Figure 4: Drainage in the streets of Jardim Gaivotas, São Paulo. Used water flows into eroded cracks in the open. Source: João Gabriel de Oliveira (2022).

Another possible cross section, especially common in pedestrian streets, is to drain the water in the central part of the street. In this case, the cross-section of the street has its lowest point on its longitudinal axis, equidistant between the sidewalks on both sides.

In the evolution of these streets, which form the lines of the urban fabric, the street becomes a bundle of infrastructures distributed on two levels. On the surface, a roadway is the axis of the street, flanked by sidewalks; rows of trees, streetlamps, and urban furniture such as benches and litter bins modulate the sidewalks. Underground: tunnels or galleries carry drinking water, sewage, electricity, telephone, Internet, gas, and other services. Railroad and road tunnels also cross under streets, but not necessarily along their axes.

The underground infrastructure bundle frees the surface of the streets for people to move around in conditions conducive to healthy, hygienic living, where sewage does not flow on the same surface. Therefore, the tunnels or channels that carry sewage and drinking water are fundamental in creating the conditions for the proper occupation of a place. Drainage, which takes place in gutters or ditches in the middle of the streets, is established on the basis of the road network. This would be the most decentralized (distributed, branched) type of urban drainage. Figures 5 to 7 illustrate the Paris galleries, photo, map and cross section, respectively.

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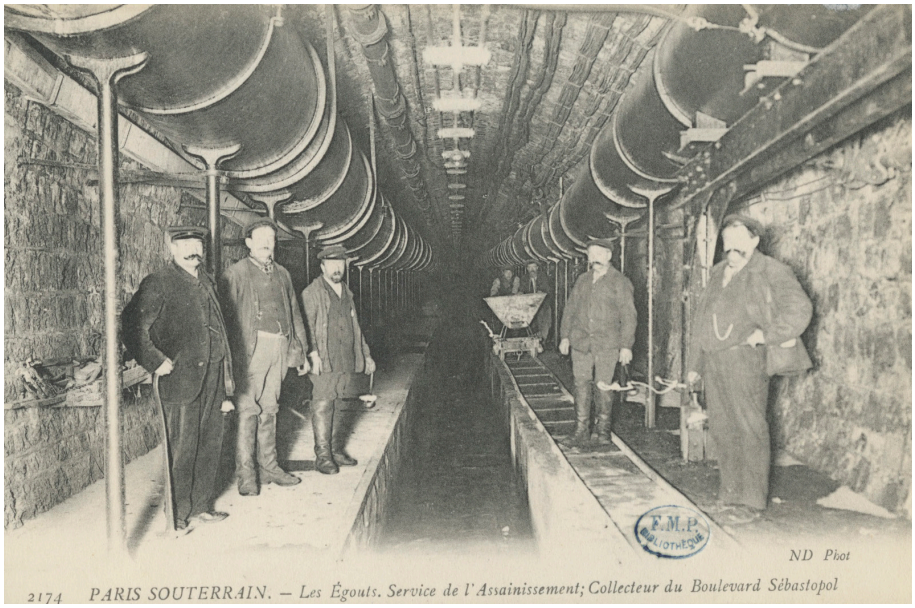

Figure 5: Paris sanitation service. Underground collectors in the Sébastopol Boulevard. Source: Bibliothèques d'Université Paris Cité. Available at: https://www.biusante.parisdescartes.fr/histoire/images/index.php?refphot=CISB0059. Access on: June 1, 2022.

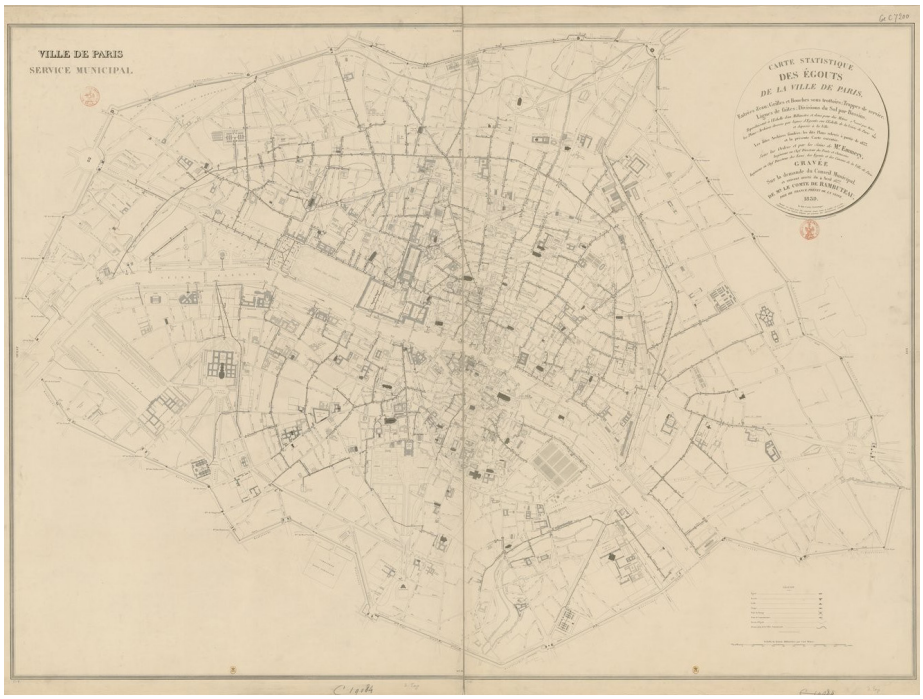

Figure 6: Map of the Paris sewage system. Source: Bibliothèque National de Paris. Available at: https://gallica.bnf.fr/ark:/12148/btv1b53085591g.r=paris%20egouts?rk=171674;4. Access on: June 1, 2022.

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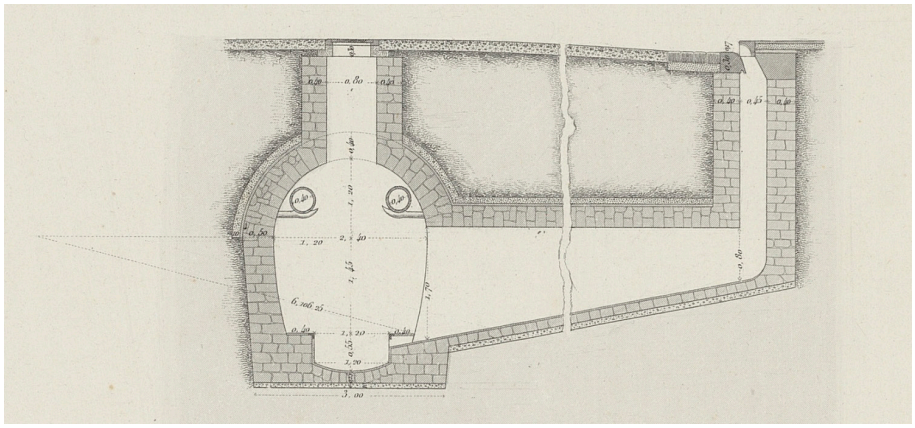

Figure 7: Cross-sections of underground galleries in Paris. Design variations are shown; all of them have sufficient headroom to accommodate a standing person. Source: Printed by Avril frères, Paris (approx. 1858). Paris Specialized Libraries. Available at: https://bibliotheques-specialisees.paris.fr/ark:/73873/pf0000855559/v0001.simple.selectedTab=record. Access on: June 2, 2022.

The network of streets forms a grid that overlaps with the topography of the place, which may or may not follow the paths suggested by the terrain: along riverbanks, on ridges, and on crossings that ascend and descend slopes, crossing these longitudinal lines in valleys and crossing rivers on bridges. In the map of Alexandria, the layout of the modern city streets overlaps with the ancient one (Figure 8). The designs are quite different. The modern layout has orthogonal lines on a Cartesian base that overlays the terrain. The ancient layout has more organic streets, located in flat areas and away from floodplains. The designs of the streets are defined by variable parameters, resulting in two very different urban fabrics constructed in the same place.

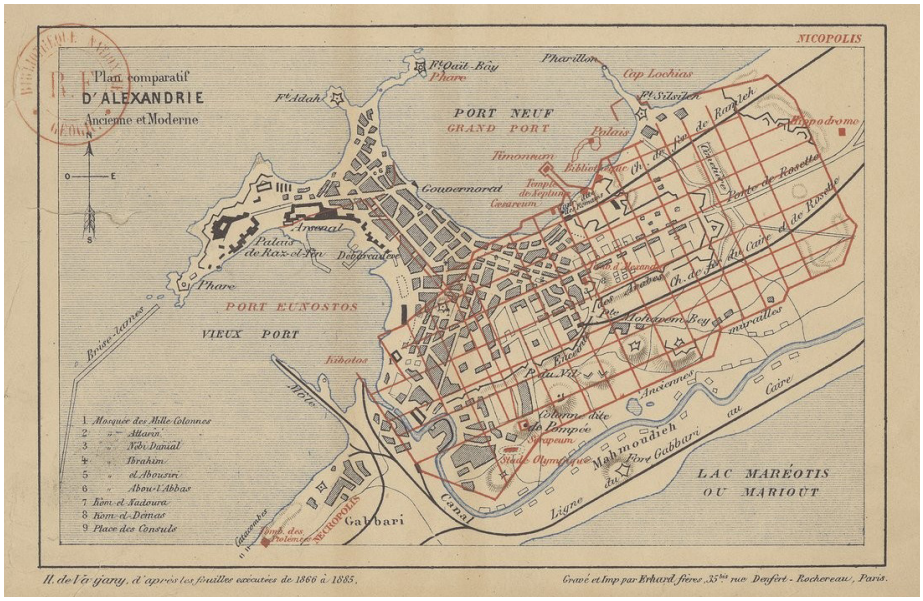

Figure 8: Comparative map of modern and ancient Alexandria, H. de Vaujany, from excavations carried out between 1866 and 1885. Source: Bibliothèque National de France. Available at: https://gallica.bnf.fr/ark:/12148/btv1b550111606. Access on: June 2, 2022.

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The streets, understood as drainage channels, have rivers as their axes, a natural element. The road network consolidates the urban occupation and marks an urbanized area by its design. This network of roads carries rainwater and sewage, by the force of gravity, to a natural axis, the rivers, at the bottom of the valleys. Thus, watercourses are natural axes of urban infrastructure.

2. Project

Meta-project for micro-basins, sub-basins, and river basins

For Grupo Metrópole Fluvial, the possibility of the water network to play a role in urban development with environmental quality is studied. In this proposal, the watersheds are the units to understand a place and its geographical context, starting from the scale of the nano- or micro-watershed, in proportion to the neighborhoods, referring to the tributary of the tributary of the main river passing through a city. The boundaries of the watershed are the water dividers that circumscribe the drainage area, which converges on a single axis at the bottom of the valley. Within this space, all water that falls or emerges from the ground follows the same course, passing through streets and galleries. Thus, planning, design and management are attributed to a unit defined by geography. This proposal contrasts with current practice, where river axes sometimes represent political-administrative boundaries at all scales, from neighborhood to nation.

The following set of diagrams (Figures 9 to 11) illustrates ideas for the metaproject of a watershed. Drainage is conceived as a combination of two elements: channels and lakes formed by dams. Artificial or natural channels are represented by rivers and streams, the streets themselves, and the tunnel channels that drain wastewater and rainwater. In this system, each natural watercourse is represented by a bundle of canals: the main canal, open, and the lateral canals on both sides to collect and collect the sewage and rainwater drained in the street galleries. Diversion channels can also be considered distributing the flow of water, for example in the construction of an artificial delta. Lakes, on the other hand, are hydraulic structures formed by dams that retain water at the headwaters, near the sources of rivers, and at the confluences between tributaries where water may accumulate during rainy seasons.

The first diagram presents a system of canals, lakes and parks at the headwaters and along the river axes, with water controlled by movable dams, at the scale of a larger urban watershed. The use of navigation is considered at this scale, and the harbors that modulate the banks of the urban waterways become places of encounter between water and land, squares framed by public facilities open to the water and connected to the city by intermodal transportation.

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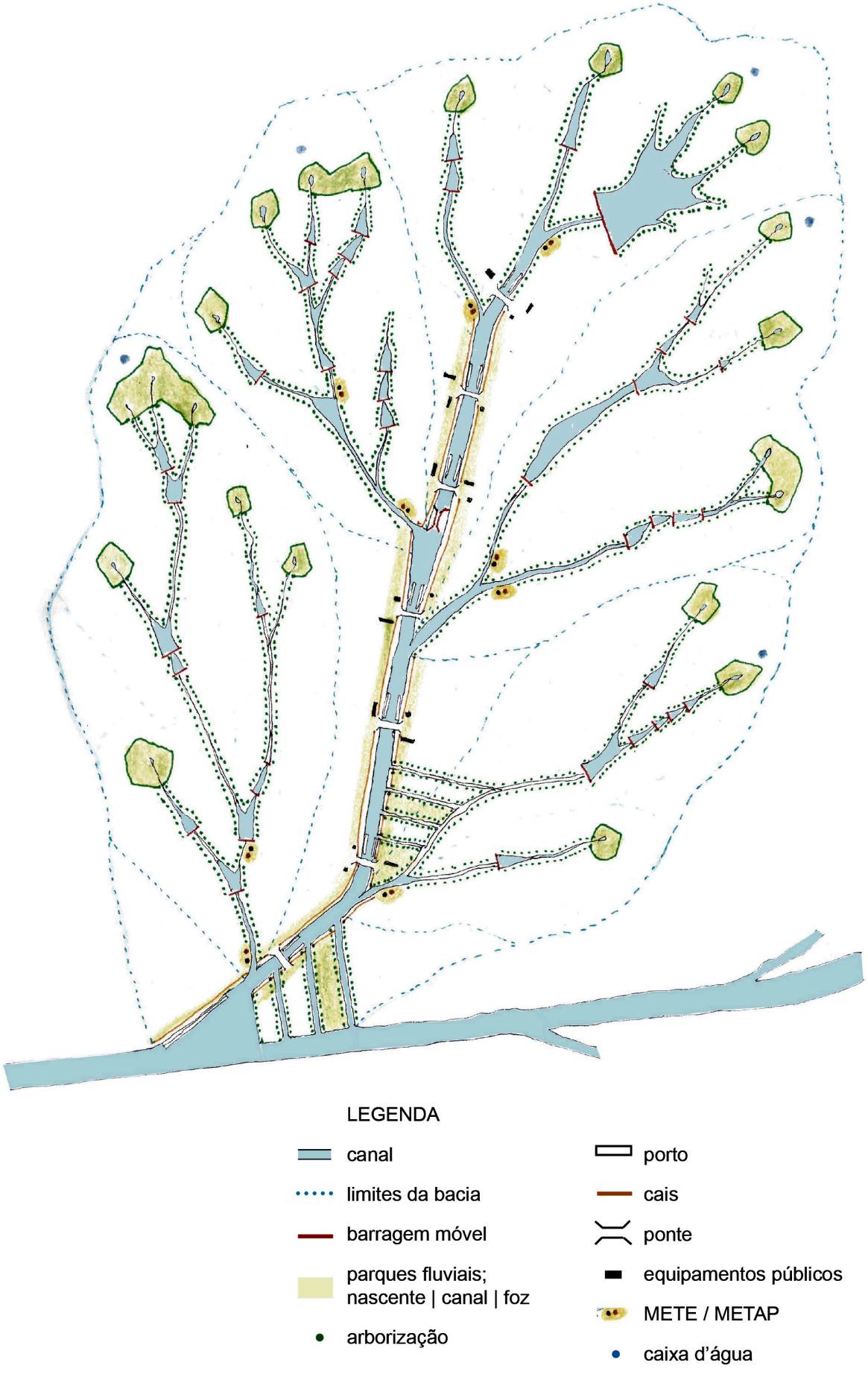

Figure 9: Metaproject for urban watersheds. Source: Ikeda (2023).

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The second diagram represents a smaller scale, that of the nano- or micro-watershed. Each micro-watershed has a set of micro-stations for treating rainwater and wastewater (MetaP and MetaE). In this way, water treatment can be decentralized. The treated water can either feed the streams themselves or be pumped to neighborhood water tanks for local consumption. Some water will be treated to where it can be used to irrigate gardens and orchards in the same watershed, as well as for street cleaning. Lakes with aquatic plants and fish can contribute to the treatment process while providing a landscape function.

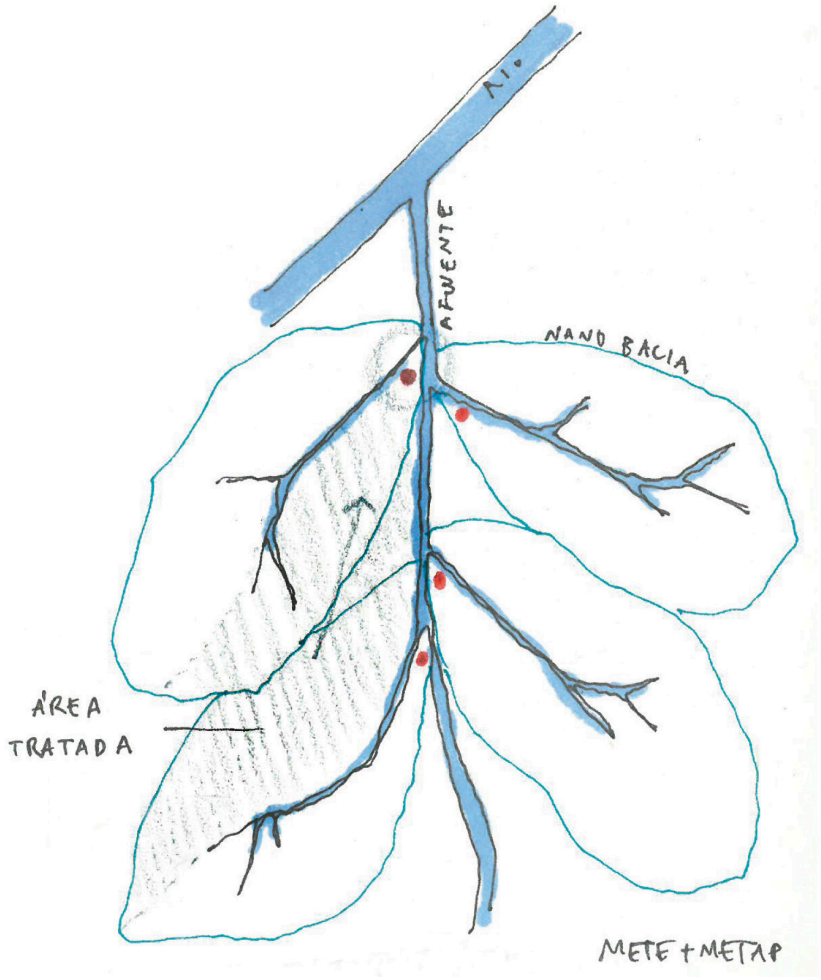

Figure 10: Metaproject for urban watersheds. Each Mete and Metap addresses the upstream slope of the watershed in which it is located and the downstream slope of the neighboring upstream watershed. Source: Ikeda (2023).

The third diagram illustrates the capillary collection of water, from the street gutters to the network of tunnel canals that border the river parks and flow by gravity to the treatment plants.

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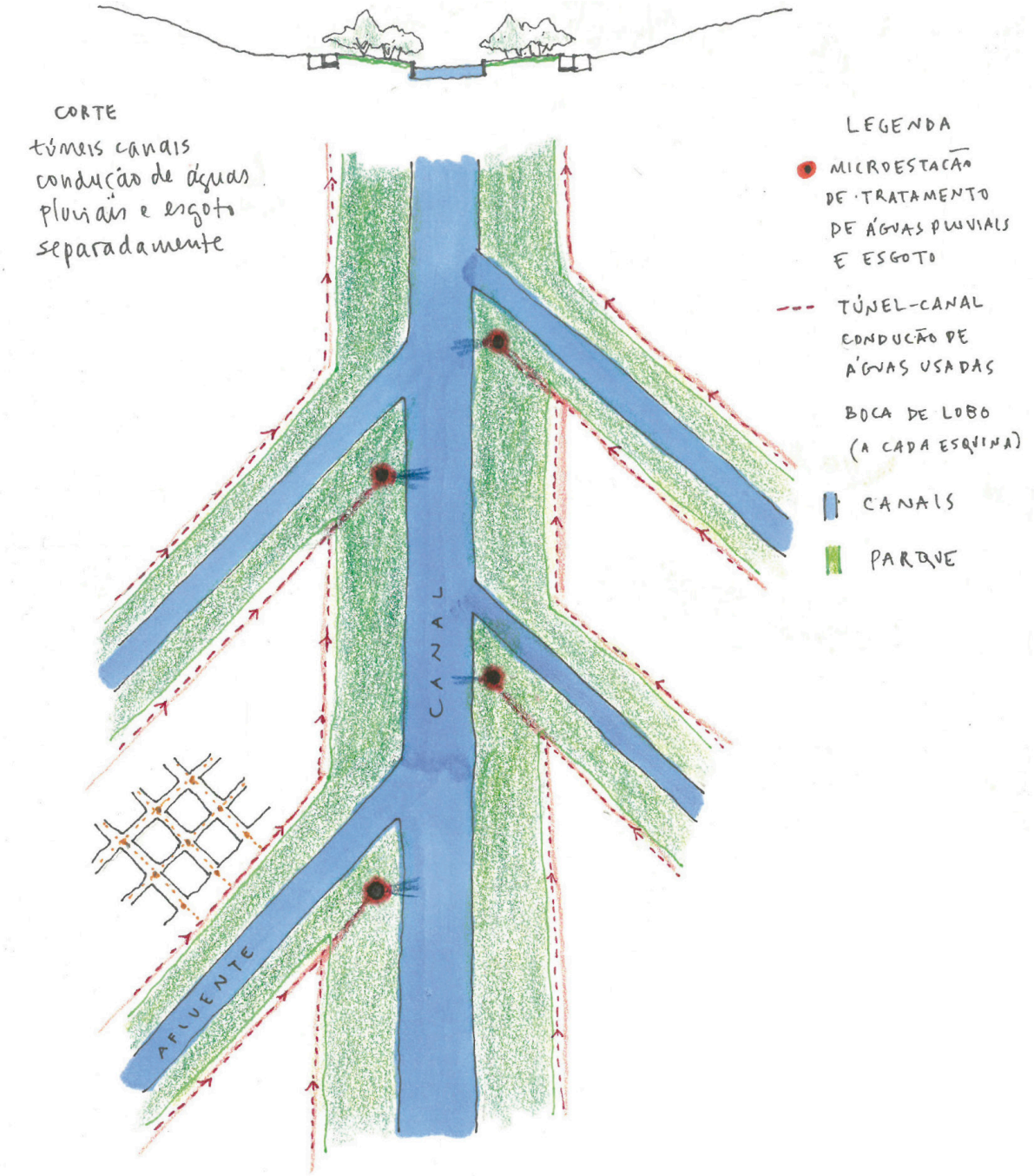

Figure 11: Metaproject for urban watersheds. Location of Metes and Metaps at the mouth of small tributaries, on the upstream bank. Source: Ikeda (2023).

This proposal contrasts with centralized treatment systems that require pumping dirty water. The idea is to treat water upstream of the watersheds at the mouths of small tributaries. The intention is to avoid the accumulation of sewage at the bottom of large valleys, in the lowest parts of cities. The multiplication of small wastewater and stormwater treatment structures can divide the problem and solve

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it at the local level, rehabilitating each micro-watershed within its own perimeter. The challenge of this proposal is to identify available or expropriable areas in the urbanized area for the implementation of Metes and Metaps stations. Ideally located near watercourses, at confluences, by environmental law these areas for water conservation can be free of construction. However, irregular settlements are often located within these perimeters, just above the larger riverbed.

From watercourses to large rivers, rivers are the axis for river parks along their banks. River boulevards line larger rivers. They are wide tree-lined avenues shared by multiple modes of transportation: pedestrians, bicycles, rail vehicles, and public and private motorized vehicles. Parks at river mouths ensure water conservation. Estuary parks mark the confluence of rivers.

Navigation can take place on rivers, canals, and lakes. Waterways are modulated by bridges and harbors, the meeting point between aquatic and terrestrial. They are synonymous with urban structures that give rise to settlements. Bridges span the water and connect the two banks of the river. The harbor dock occurs on two levels, the one closest to the water and the higher dock at street level.

The construction of lateral canals along main rivers can be an alternative to allow navigation. In this case, the riverbed is maintained for drainage, while the lateral canal has its water controlled by dams and locks. The interest in separating navigation and drainage uses through the implementation of a waterway parallel to the river is to promote the consistency of water levels regardless of rainfall occurrences.

Diagrams are based on the concept of multiple water uses. Supply, macro-drainage, navigation, recreation, irrigation, and energy are the uses that guide the proposed projects for urban rivers.

This metaproject for an urban hydraulic machine can be understood as a system of environmental compensations for the effects of human settlement practices. Lakes, diversion channels, parks, tree plantings, gardens and orchards form a system of interconnected containers with vegetated edges that compensate for the paved surfaces of streets, squares, and buildings.

Final considerations

Diagrams presented herein outline a proposed methodology for public architecture design for urban river infrastructure. These are the elements that make up this infrastructure at the scale presented: canals, lakes, bridges, towers (structures that overcome the difference in level between low and high docks), river parks, river streets and boulevards, tunnel canals, micro stations for water and sewage treatment, docks, ports, and moorings.

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Approaching the place through the watershed, which can be defined for an intermittent watercourse of the Amazon River, allows for flexibility in the delineation of the study areas. This way of understanding the place supports it to be broken down into the small parts that make it up, the micro-watershed of a small tributary, without losing the sense of context. The design approach is characterized by successive approximations of the place, always anchored in the larger scales. The goal is to design the part and/or the whole in a systemic way, where the human use of a place is in harmony with nature.

The Brazilian Federal Law No. 9.433 of January 8, 1997, defines the watershed as "the territorial unit for the implementation of the National Water Resources Policy and the operation of the National Water Resources Management System". In its article 3, the law defines the general guidelines for the implementation of the National Water Resources Policy:

I - the systematic management of water resources, without dissociating the aspects of quantity and quality;

II - the adaptation of water resources management to the physical, biotic, demographic, economic, social and cultural diversity of the different regions of the country;

III - the integration of water resources management with environmental management;

IV - the articulation of water resources planning with user sectors and with regional, state and national planning;

V - the articulation of water resources management with land use management;

VI - the integration of watershed management with estuarine systems and coastal zone management.

The project methodology presented herein advocates the addition of a seventh guideline, which could be defined as

VII - the integration of watershed management with the planning, design, and management of public architecture for urban river infrastructures at the scales of neighborhood, city, metropolis, state, country, and continent.

This guideline aims to articulate environmental issues, including rivers, green spaces, urban biota, and microclimate, with the construction of the city, understanding them through what they have in common: the place.

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