

(in)visible rivers

creating a flooding resilient system and
new urban spaces in Curitiba - Brazil

Sonjaly Roncato Juraszek

Master Thesis in Sustainable Urban Design at Lund University

Author: Sonjaly Roncato Juraszek

Examiner: Peter Sjöström, assoc. Professor, Director of SUDes, LTH

Supervisor: Andreas Olsson, Architect, Lecturer SUDes LTH

Jury: Jenny B. Osuldsen, Partner and Senior Landscape Architect, Snøhetta and Professor in Landscape Architecture at the University of Life Sciences Ås, Norway

Pär Gustafsson, Professor Emeritus Landscape Architect SLU Alnarp

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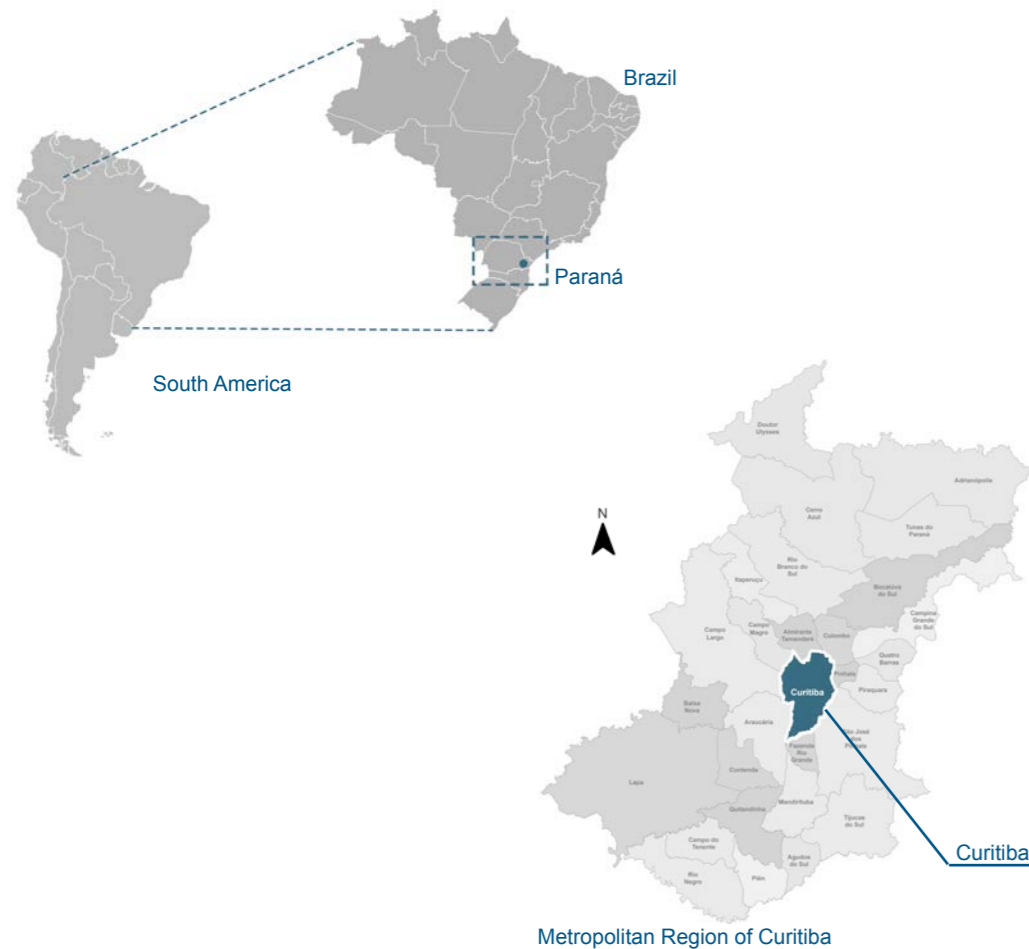
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1 introduction

- 1.1 Research question
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Map adapted from IPPUC.

Curitiba is the capital of the state of Paraná, in the south of Brazil. The city has approximately 1.910.000 inhabitants. Around the city there are 28 municipalities, which are part of the Metropolitan Region of Curitiba. It is the 8th metropolitan region with the most inhabitants of Brazil, with around 3.500.000 people.

Curitiba is mostly known for its urban planning solutions, such as its BRT system and more than 30 parks. Today, however, as many other Brazilian cities, Curitiba faces different environmental and social issues. The main environmental issue is related to flooding and cloudburst events. They are caused not only because of climate change, but also because of the piping of many rivers, the pollution on the water systems (caused by inefficient waste management and illegal sewer connections) and irregular settlements around the floodplains.

On a social aspect, the rivers that were once part of the culture and daily life of people, cannot be considered part of Curitiba anymore. They were the birthplace and the ground zero of the city, but today they are hidden under streets and infrastructure or treated as sewage. Many of them cross the entire city, passing through different neighborhoods, with various activities and communities. As such, working around the rivers could bring not only environmental benefits but also social ones, where the river is given back to all citizens, serving as a space of social gathering.

Considering all the aspects above, this thesis project works on two main layers: the environmental one - dealing with flooding and cloudburst events; and the social one - creating a new kind of gathering space which allows new connections between nature and people, as well as the recovery of the history and identity of the rivers.

1.1 Research question

The main focus of this thesis is dealing with flooding and cloudburst events in an existing dense urban context. This issue will be dealt with in two main layers: the environmental and the social layer.

Environmental layer

1a. How to deal with cloudburst events and flooding in an existing dense and impermeable city?

1b. How to create a system that is resilient to cloudburst?

Social layer

2a. How to create new relationships between the citizens and the river?

2b. How to create new relationships between people from different neighborhoods and social backgrounds?



1.2 Objectives

On a broad way, the thesis aim is to turn a “problem” – the rivers and heavy rain – into an opportunity, both environmentally and socially.

Specifically, the project aims to:

1. Create a resilient and responsive system to cloudburst events, which takes into account the existing urban tissue;
2. Use different design strategies to filter, retain and delay floodings, and at the same time support a wide range of activities;
3. Create new relationships between people and water, taking into consideration the existing cultural and social dynamics of the chosen area;
4. Encourage encounters between people of different backgrounds and the growth of a river related identity

1.3 Method of Work

This thesis report is divided into 2 main parts.

The first one is the Context and Background Research, in which a history of flooding and the context of the city is explained. It serves as a background to understand the importance of stormwater management in Curitiba.

Based on that, a basin in the city is chosen to work with, in which the project proposals will be implemented in three different scales.

The second part of the thesis is the Project, with proposal and detailing. In order to fully understand and respond to flooding events, the project is done in 3 different scales.

On the first scale, stormwater management strategies are outlined for the whole basin and river. The chosen basin is the Belém, the most dense in the city.

On the second scale, an area within the basin is chosen to show how the strategies created for the basin can work in a responsive system against flooding. In this scale, the design solutions can be detailed. The aim of these two first scales is to serve as a case study, with solutions which could be applied to other parts of the city as well.

Finally, on the third scale, one of the responsive system areas is chosen for detailing.



2 context and background research

- 2.1. Curitiba and its beginning: around rivers
- 2.2. A historical challenge: Swamps and Floodings
- 2.3. Current scenery: Floodings, pollution and climate change
- 2.4. The rivers and basins of Curitiba
- 2.5. An entirely Curitiba's river: Belém
- 2.6. Belém basin: Flooding risk analysis
- 2.7. Belém basin: Social aspects
- 2.8. Belém basin: Municipality's plans
- 2.9. Chosen project area

2.1 Curitiba and its beginning: around rivers

The history of Curitiba is characterized by water. The city started near the junction of two important rivers: the Ivo river and the Belém river. The ground zero of the city - where it first started - is located at the Tiradentes Square, in the city centre, represented by the n. 1 on the 1857 map.

The plan of the city in 1857 shows the ground zero, Tiradentes Square (1), the two main rivers (2- Ivo river; 3- Belém river), the “swamp” as it was named at the time, later converted into a park - Passeio Público (4) and the area where the two rivers meet (5).



Plan of Curitiba - 1857
From Retratos do Belem blogspot



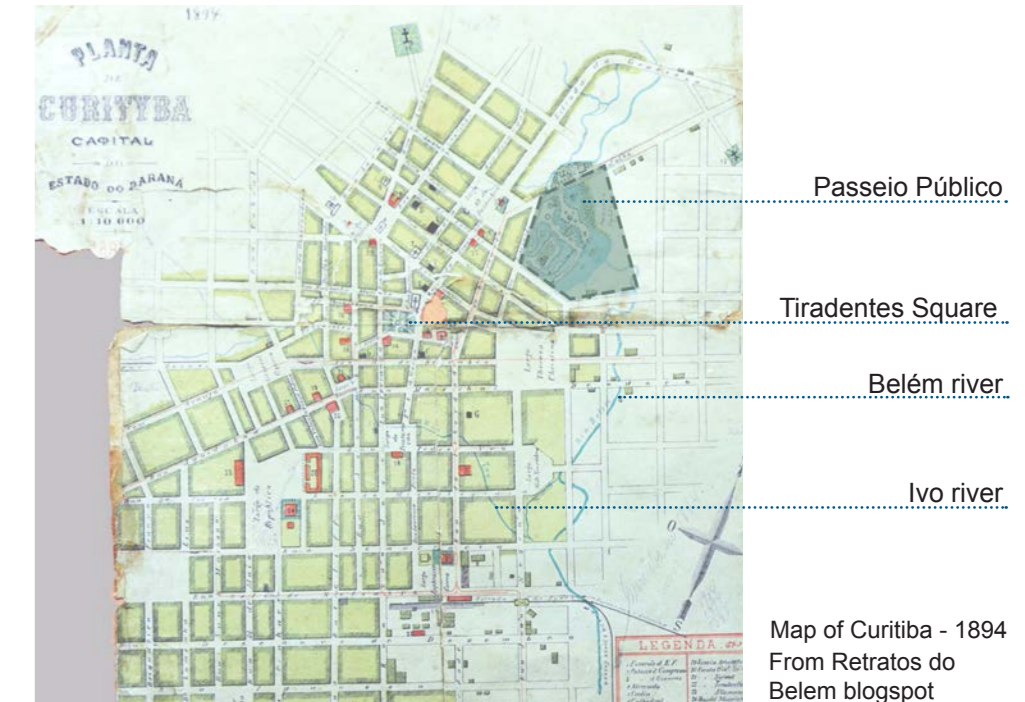
Curitiba in 1855
Painting by G. Schlichting

2.2 A historical challenge: Swamps and Floodings

Floodings were always a part of Curitiba's history. In spite of the municipality's efforts to always come up with new solutions for the problem, floodings are still an issue on the present day.



Flooding of the Ivo and Belém Rivers at João Negrão Street in 1911
Photo from Cid Destefani/Gazeta do Povo



Passeio Público

Tiradentes Square

Belém river

Ivo river

Map of Curitiba - 1894
From Retratos do Belem blogspot

The first signs of occupation of Curitiba show numerous ‘swamps’, which were frequently flooded. The main “swamp” at the time was called Bitencourt Swamp and in 1886 was transformed into a park: Passeio Público. It was the first park of the city, with a modern concept of transforming flooded areas into leisure spaces.



Passeio Publico n 1904 - Postcard collection from Tolanda Roberto

Around 1940, the French urban planner Alfred Agache was hired to do a Master Plan for the city. According to him, anyone who was interested in urban planning in Curitiba would face a big challenge: the rivers.

With the constant floodings, Agache suggested that these rivers should be straightened and around them “park-avenues” would be created. The two main rivers of the city were then modified to follow the

streets grid. The Ivo River corresponds to the Vicente Machado Street, while the Belém river goes along the Mariano Torres street.

However, still around 1960, the center of the city continued to suffer with many floodings. The municipality then decided to cover the Belém River on the whole perimeter of the center, until the intercity bus terminal. The river is until today underneath the Mariano Torres street.

Historic timeline of flooding and creation of parks

The Bitencourt Swamp is transformed into a park: Passeio Público in 1886.

Around 1960, the municipality covered the Belém river on the whole perimeter of the center.

In 1972, many other urban parks were created to try to solve the flooding problems, including Barigui Park.

Between 1960 and 1980 the population of the city grew three times. The actions to intensify the greenery of the streets and plots were more severe.



Barigui Park



Passeio Publico today



Mariano Torres street flooded before the covering of the Belém river

In 1972, inspired by Passeio Público, other urban parks were created to try to solve the flooding problems.

Around 1940, the French urban planner Alfred Agache was hired to do a Master Plan for the city. Agache suggested that the rivers should be straightened and the creation of “park-avenues”.



Flooding at the city center in 1943 SMOP-OCP

Many parks were created on the 90's and 00's. The idea of having parks which contain storm water was repeated several times around the city. Today, Curitiba has 21 municipal parks which contribute to the storm water drainage.



Tanguá Park

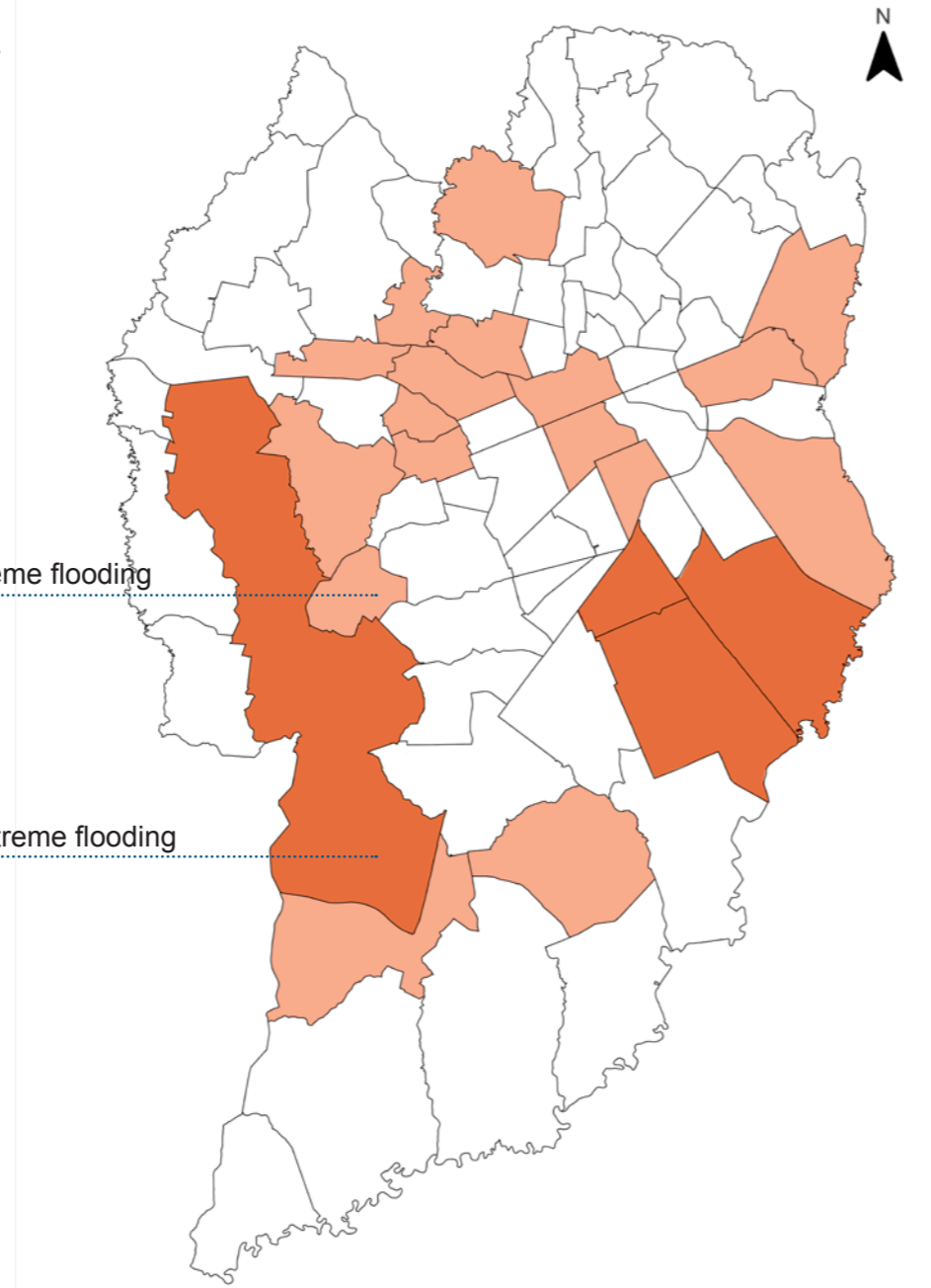
2.3 Current scenery: Floodings, pollution and climate change

Despite the urban planning efforts to minimize the occurrence of flooding and its consequences, Curitiba still suffers with it. In addition to the historic and geographic characteristics of the city, climate change has increased the frequency and intensity of extreme events of cloudburst and flooding, as well as heat waves.

A research conducted between 2005 and 2010, analyzing data from the civil defense Department of Curitiba revealed that flooding is the main problem of the city, with 45% of the incidences (Lohmann, 2013). The events are usually wide spread around the city and vary in its impact.

Medium frequency - 11 to 20 extreme flooding events in the last 30 years

High frequency - more than 20 extreme flooding events in the last 30 years



Extreme flooding events map from 1980-2010
Districts that have flooding most frequently
Information for map adapted from Goudard/Mendonça, 2017

Recent timeline of flooding in the city



(Information taken from various local news)

Causes for flooding are not only related to climate change.

The impermeability of the city and the pollution of the rivers are factors that increase the risks. In Curitiba flooding happens for three main reasons:

1. Urbanization

As mentioned before, the area where Curitiba is today had many rivers and swamp areas. When the city first started, it was not even considered a proper spot for a capital. In an attempt to fix this situation, many engineering techniques of the time were used to deal with floodings. The most common one was the channelling and covering of the rivers. The whole city center has covered rivers underneath.

The rapid urbanization of the city also brought a high soil impermeabilization of the land. The infrastructure once built to contain the rivers and the rainwater is, in many spots, insufficient today.



43% of the people that live around covered rivers have no idea of their existence



Channeling and covering of the rivers

| Basins | Green area (sq. km) | Total Area(sq. km) | Impermeable Area (sq. km) | % Impermeable |
|----------------|---------------------|--------------------|---------------------------|---------------|
| Atuba Basin | 8,64 | 63,70 | 55,06 | 86,43% |
| Barigui Basin | 27,99 | 140,8 | 112,81 | 80,12% |
| Belém Basin | 5,36 | 87,8 | 82,44 | 93,89% |
| Iguaçu Basin | 18,58 | 69,69 | 51,11 | 73,34% |
| Padilhas Basin | 2,86 | 32,28 | 29,42 | 91,14% |

Impermeable Areas per River Basin in Curitiba (PDD Curitiba - 2017)

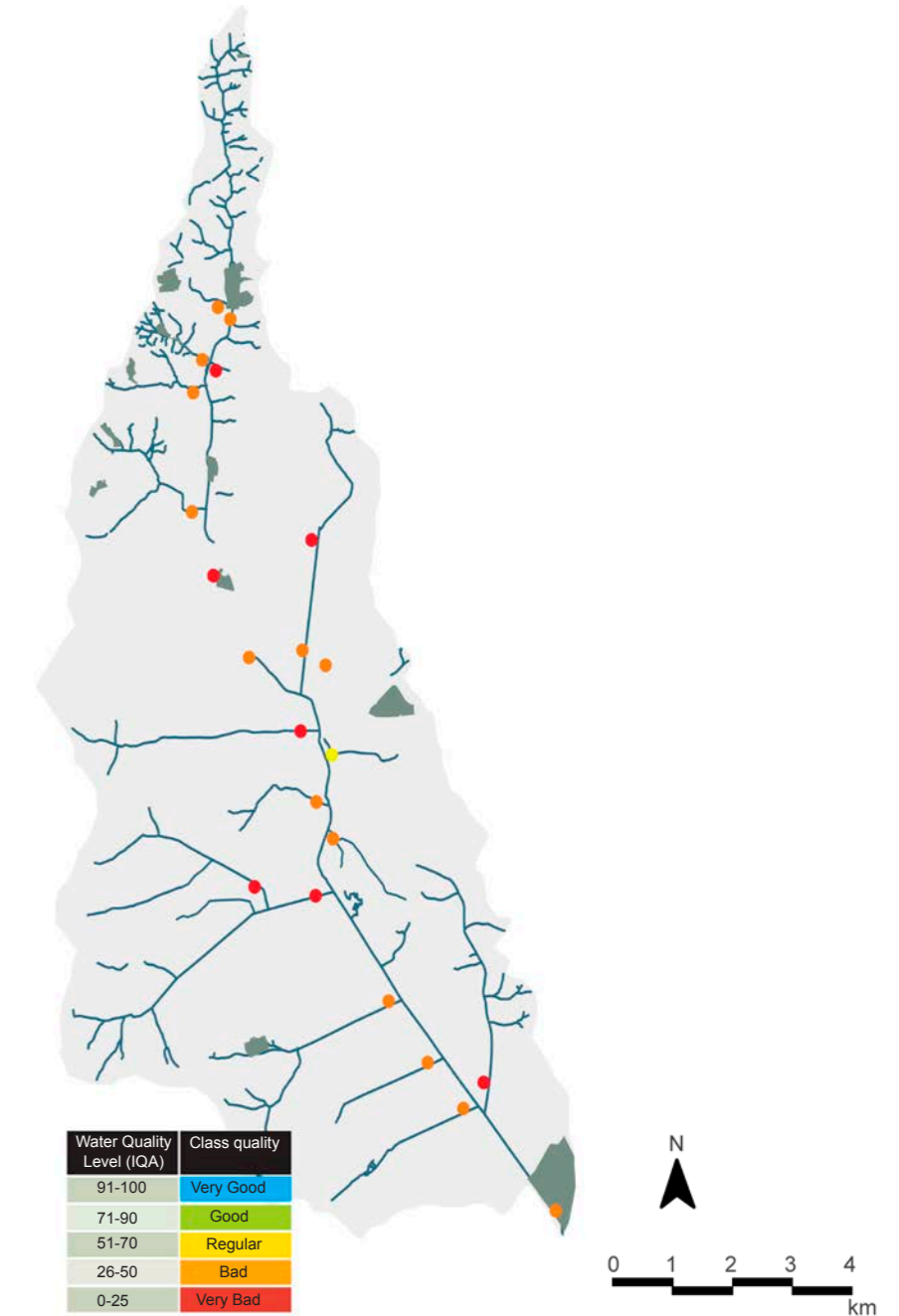


2. Pollution

Although the city has a program for recycling waste, less than 7% of it is actually recycled. A considerable amount of the waste is thrown in the rivers. However, the biggest challenge surrounding the river's pollution is actually sewage. Especially when the river is underneath the streets, there is less control over the illegal sewer connections. This means that when the river resurfaces, it is already at its highest level of pollution.

The map to the right shows a study made by the SMMA (Secretaria Municipal do Meio Ambiente) which analyzed 22 spots on the Belém basin. The method used was by analyzing the IQA - Water Quality Ratio, which takes into account 9 parameters, including dissolved oxygenation and levels of faecal coliforms. The levels reached were divided in 5: Very Good, Good, Regular, Bad and Very Bad.

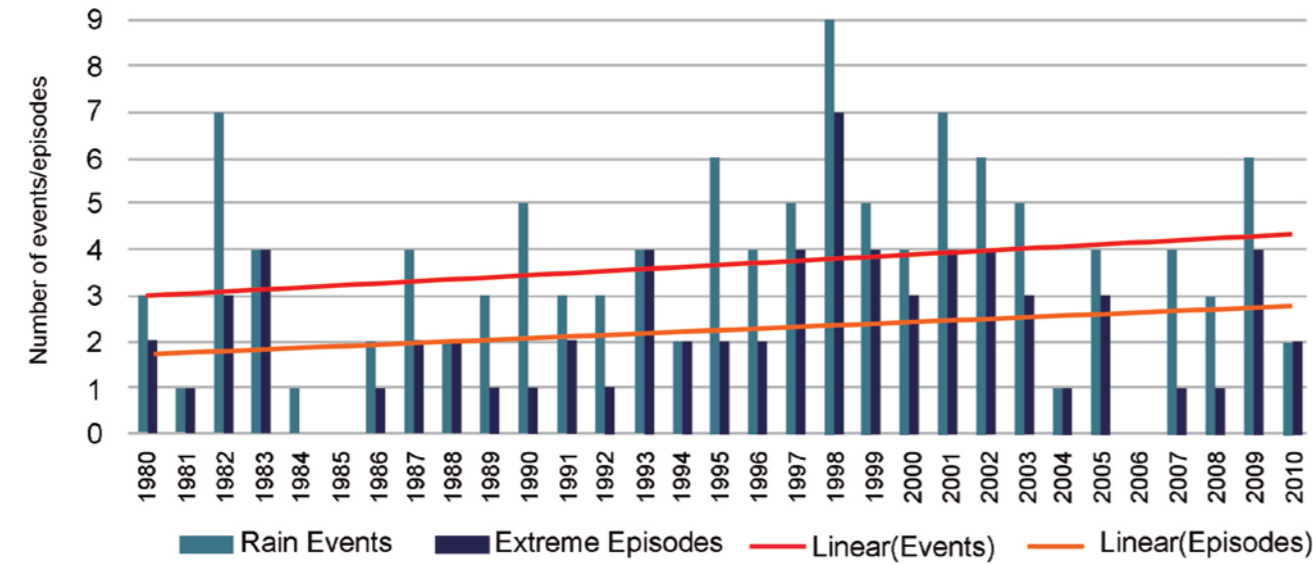
From the 22 spots analyzed, 14 were considered bad, 7 were very bad and only one 1 was regular. None of them was considered good or very good.



Example of levels of pollution in a Curitiba's basin: Belém Basin
Adapted map from IPPUC and Vamos dar vida ao Belém

3. Climate Change

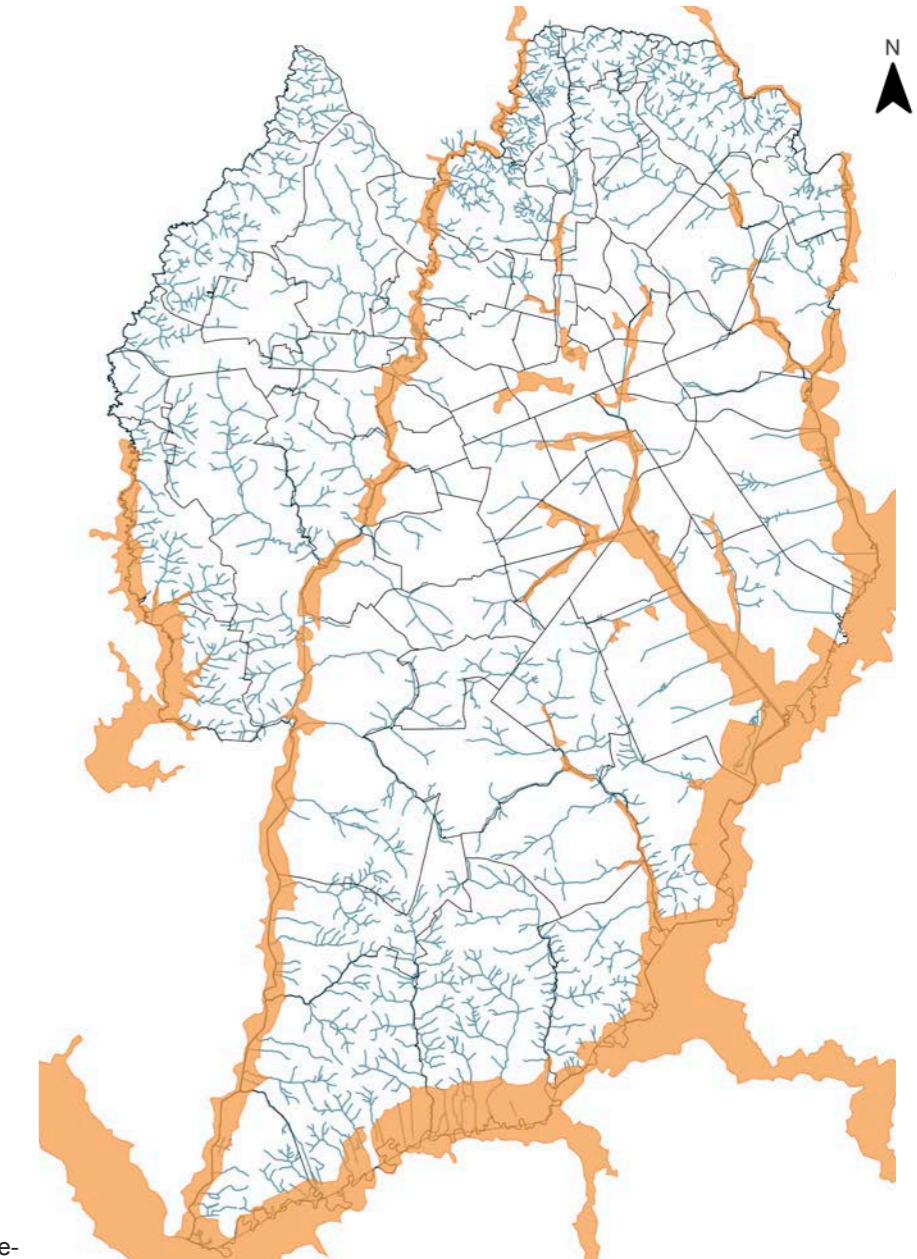
Meteorological observations from recent years, conducted by IPCC (Intergovernmental Panel on Climate Change), show that the regime of rain is changing and this change is quite perceptible in the south of Brazil. It has caused cloudbursts of high intensity during short periods of time, almost during all the 12 months of the year. The IPCC in 2014 predicted a raise of 20% on the seasonal rains for the south of Brazil, where Curitiba is located (PDD Curitiba, 2017).



Extreme flooding events map from 1980-2010 in Curitiba
Information adapted from Goudard/Mendonça, 2017

Recently, the subject of flooding is discussed frequently in the news and in the municipality. A new stormwater management plan was created, with measures to contain the floodings.

The map shows the most vulnerable areas in Curitiba - the ones that would flood in a 50 years flooding event.



50 years flooding event in Curitiba
Adapted map from IPPUC - Avaliação de vulnerabilidade ambiental e socioeconômica para o município de Curitiba

2.4 The rivers and basins of Curitiba

The 75 districts of Curitiba are built on top of 6 river basins, all part of the Iguaçu Basin.



Some districts are part of more than one basin.

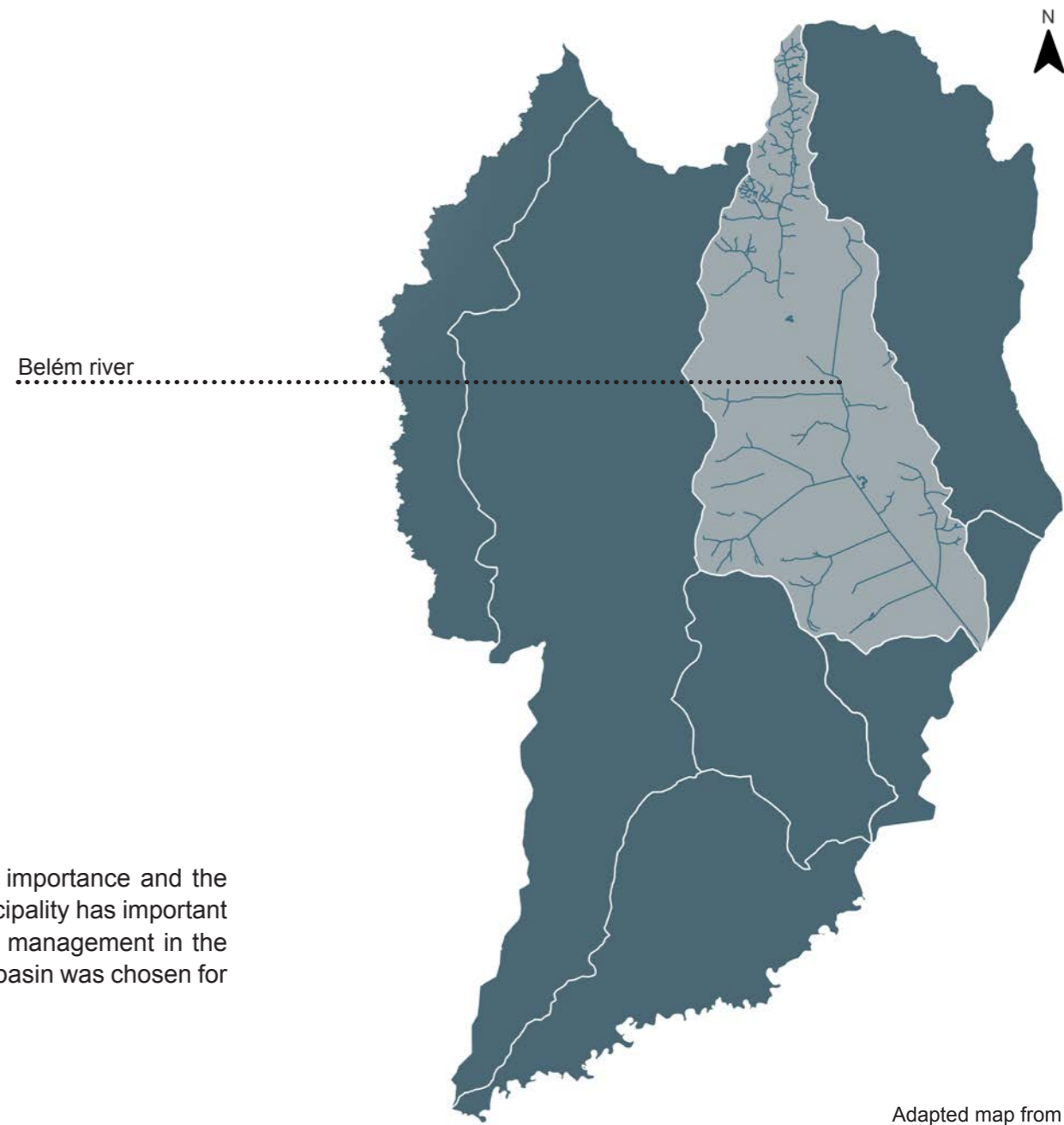
- 01- Passaúna Basin..... 08 districts
- 02- Barigui Basin..... 27 districts
- 03- Padilha Basin 07 districts
- 04- Belém Basin..... 38 districts
- 05- Atuba Basin..... 16 districts
- 06- Iguaçu Basin..... 06 districts



2.5 An entirely Curitiba's river: Belém

The Belém river has a special meaning and high importance for the city, since it is entirely located in Curitiba. It has 17,13km of extension, beginning on the North of the city, on the Cachoeira district and going all the way to the south, where it ends at the Iguaçu river, on the Boqueirão district. Its basin has 87,80km², which takes up 20,32% of the area of Curitiba.

Compared to the other basins of the city, the Belém Basin also has the highest population density, as well as the higher percentage of impermeable surface.

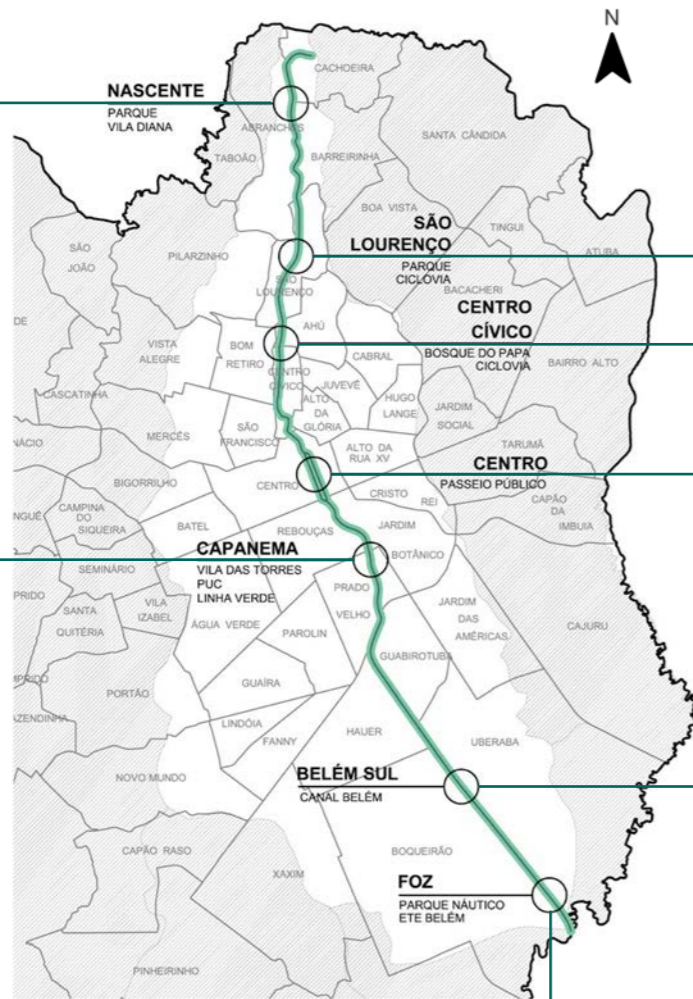


Due to its importance and the fact that the municipality has important plans for flooding management in the basin, the Belém basin was chosen for this thesis study.

Landmarks and characteristics around the river



Spring park - to protect the spring of the river



Many important landmarks and parks are located in the Belém River.

Map from Retratos do Belém blogspot



São Lourenço and Civic center



Passeio Público



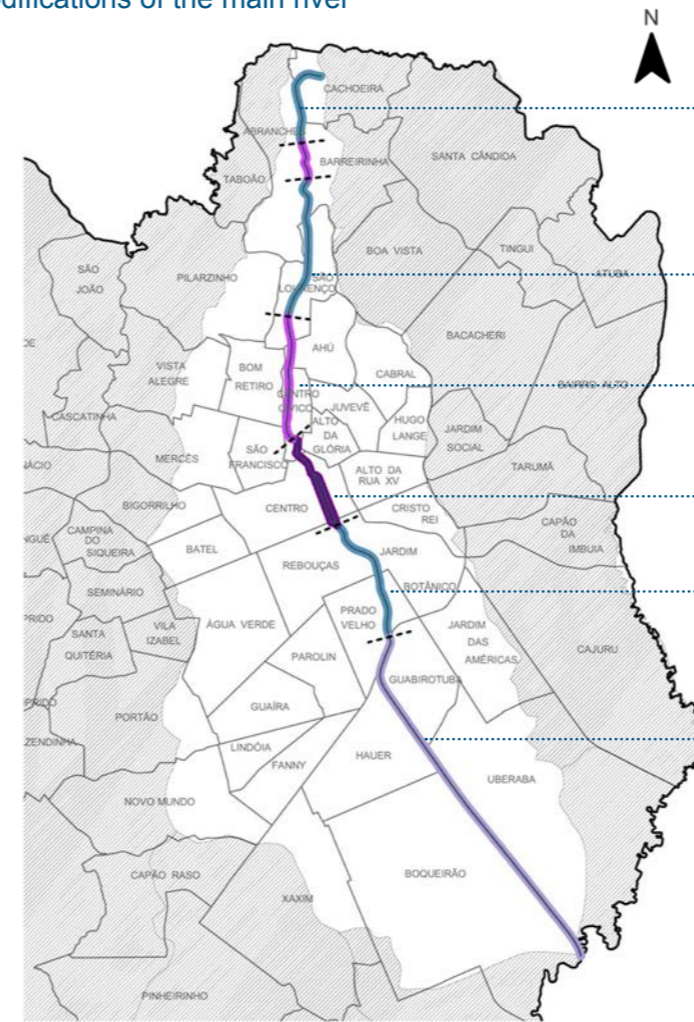
Nautical Park - where the river ends and meets Iguaçú



Capanema Stadium and the former "favela" Vila Torres



Modifications of the main river



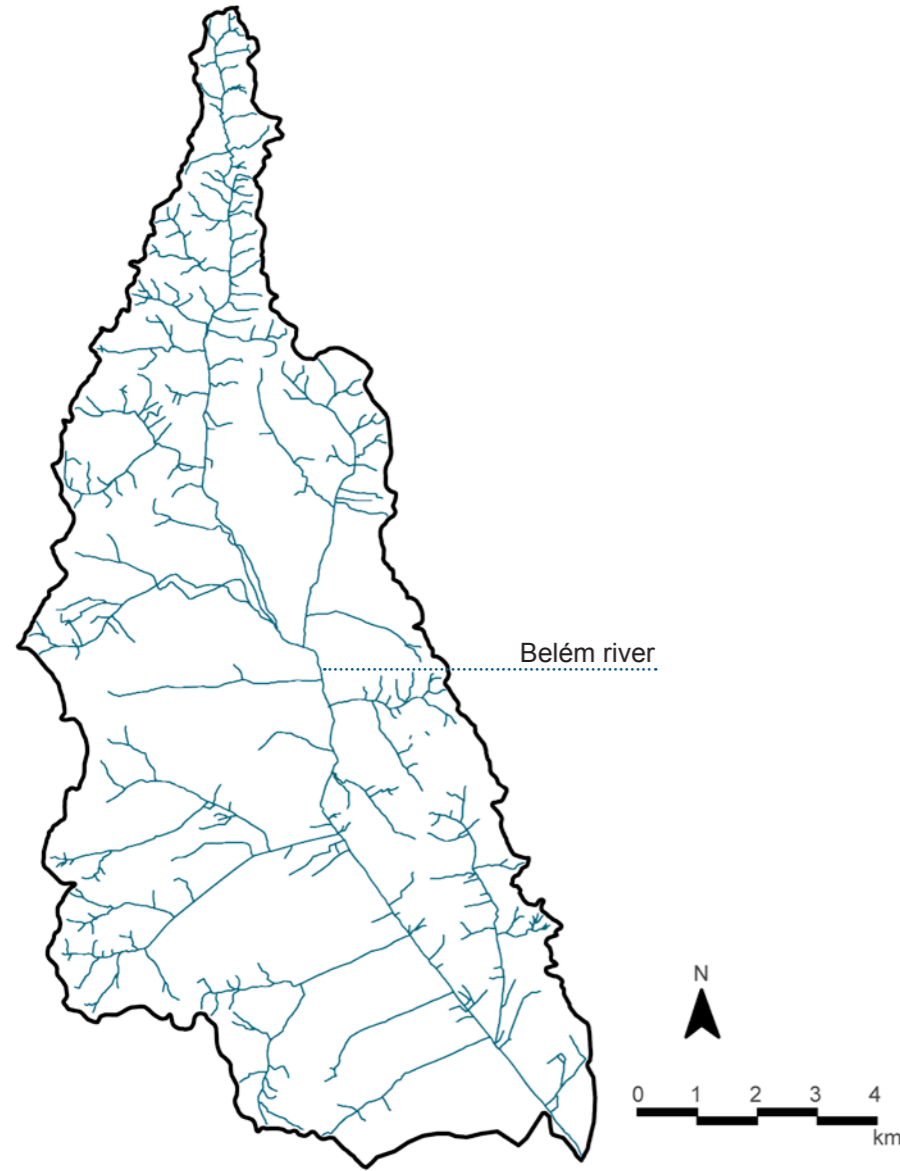
Map from Retratos do Belém blogspot



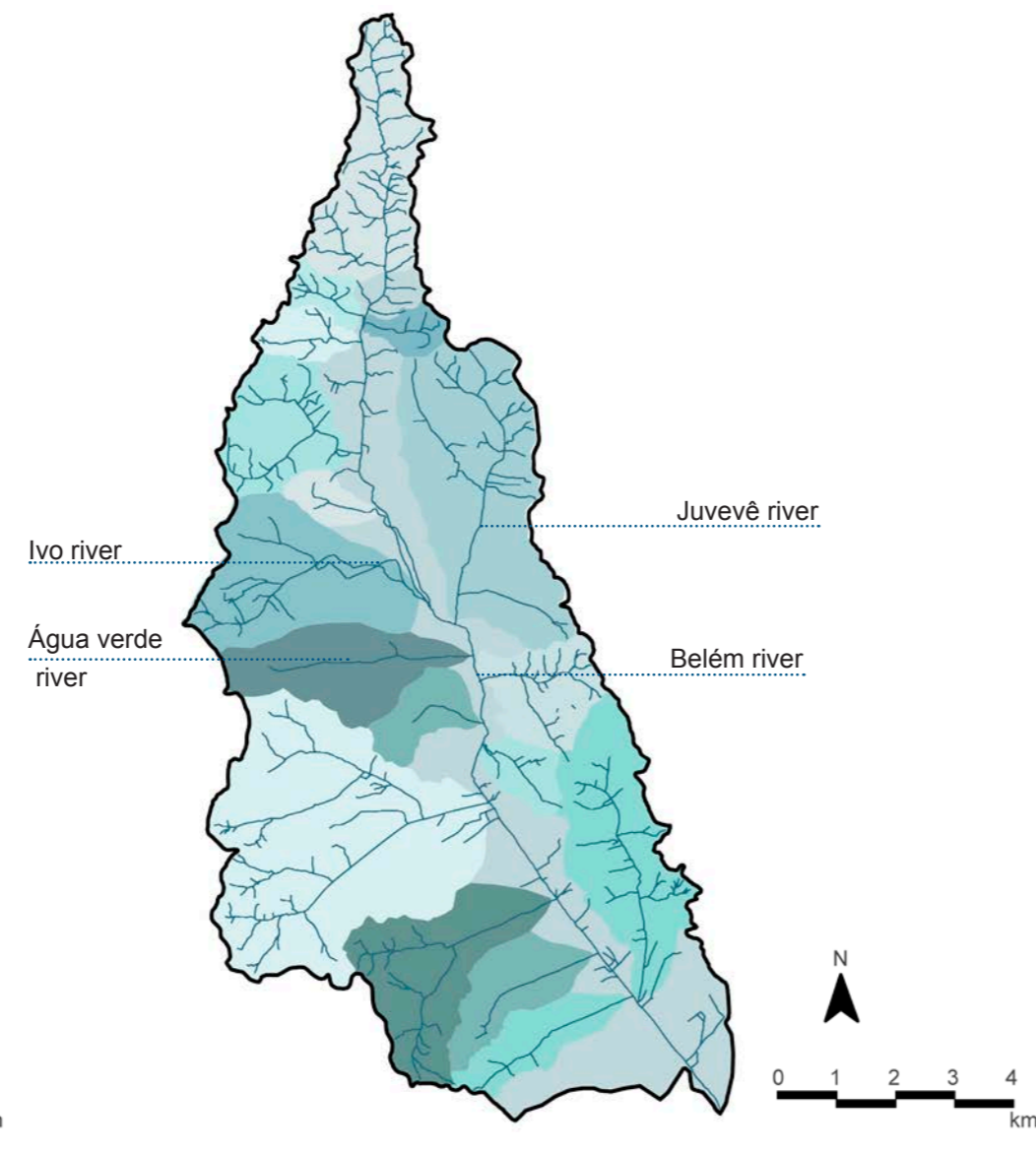
Project for straightening the Belém river, from 1933. Picture from Jornal Correio do Paraná

The river suffered many changes from its natural form to what it is today. Some sections were straightened, while others were covered by street infrastructure.

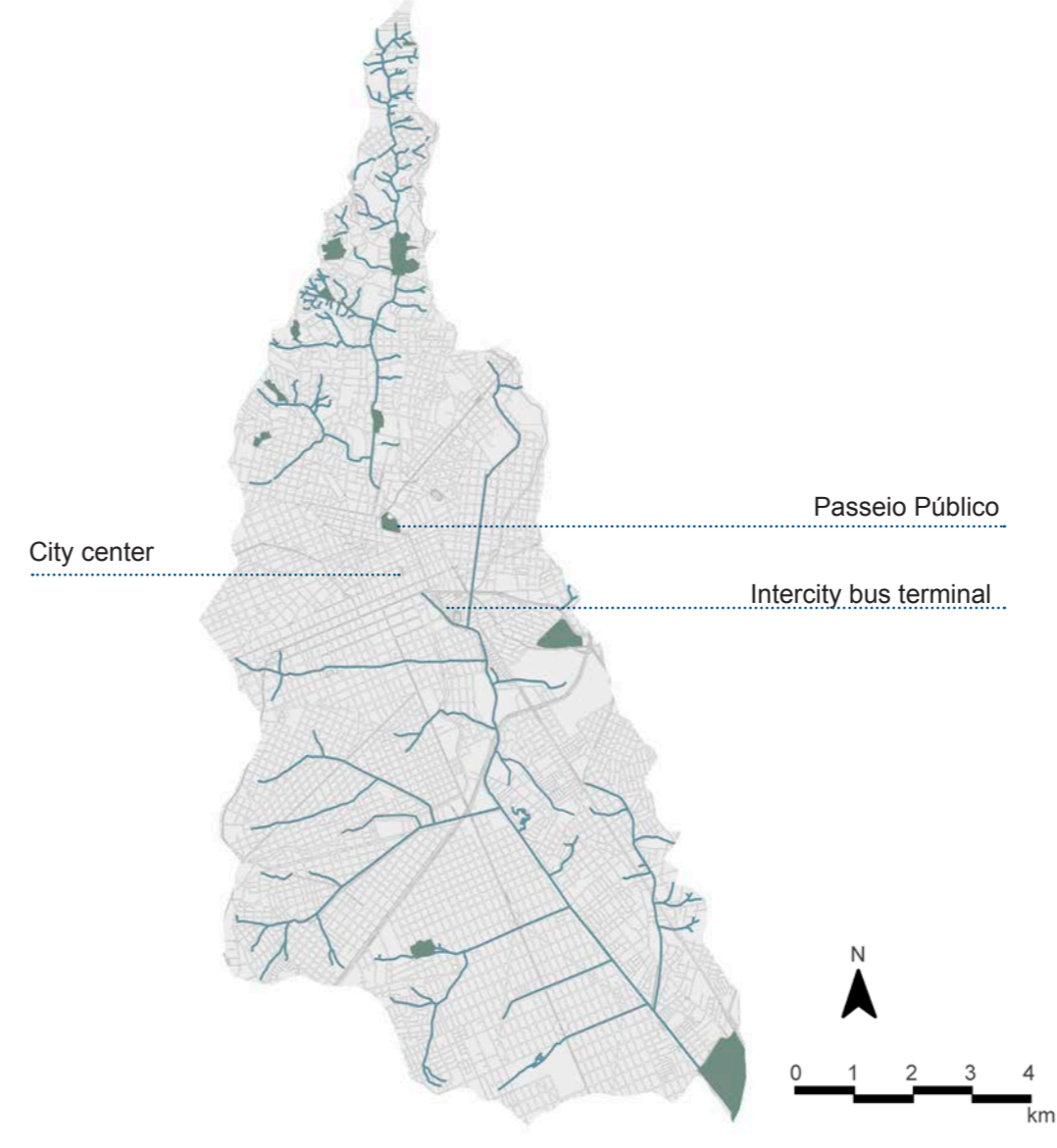
Sub basins, Green areas and Street Grid



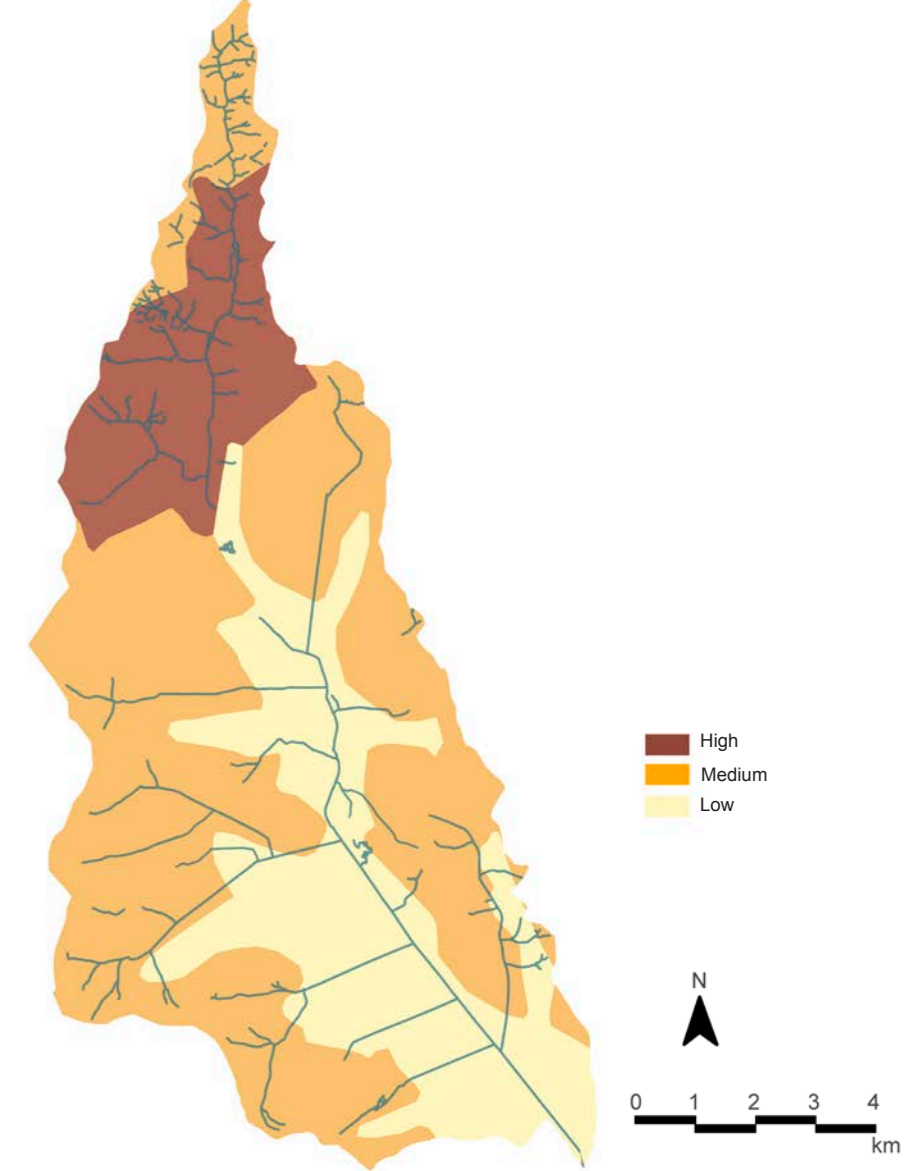
Main river and tributaries
Adapted map from IPPUC



Sub basins of the Belém
Adapted map from IPPUC



Main Green areas and Street Grid (covering some of the rivers)
Adapted map from IPPUC



Soil Impermeability
Adapted map from IPPUC

High
Medium
Low

2.6 Belém Basin: Flooding risk analysis

The Belém basin has the highest density of the city, reason why it is the basin with the higher risk of flooding. The higher density around the main river is on the central area (200hab/ha).

Here is a flooding map and analysis, made with base on a municipality study of 2017 (PDD Curitiba):

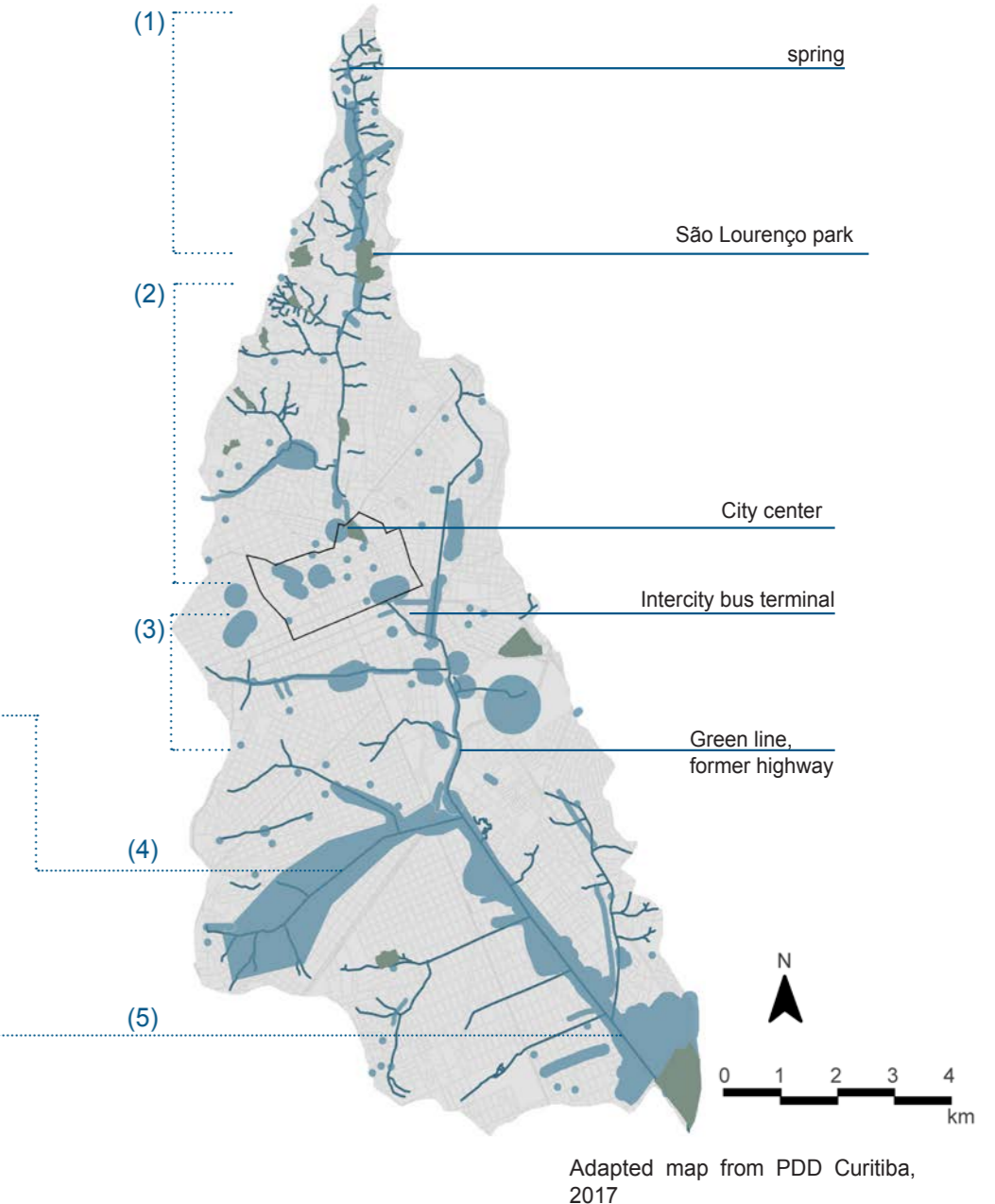
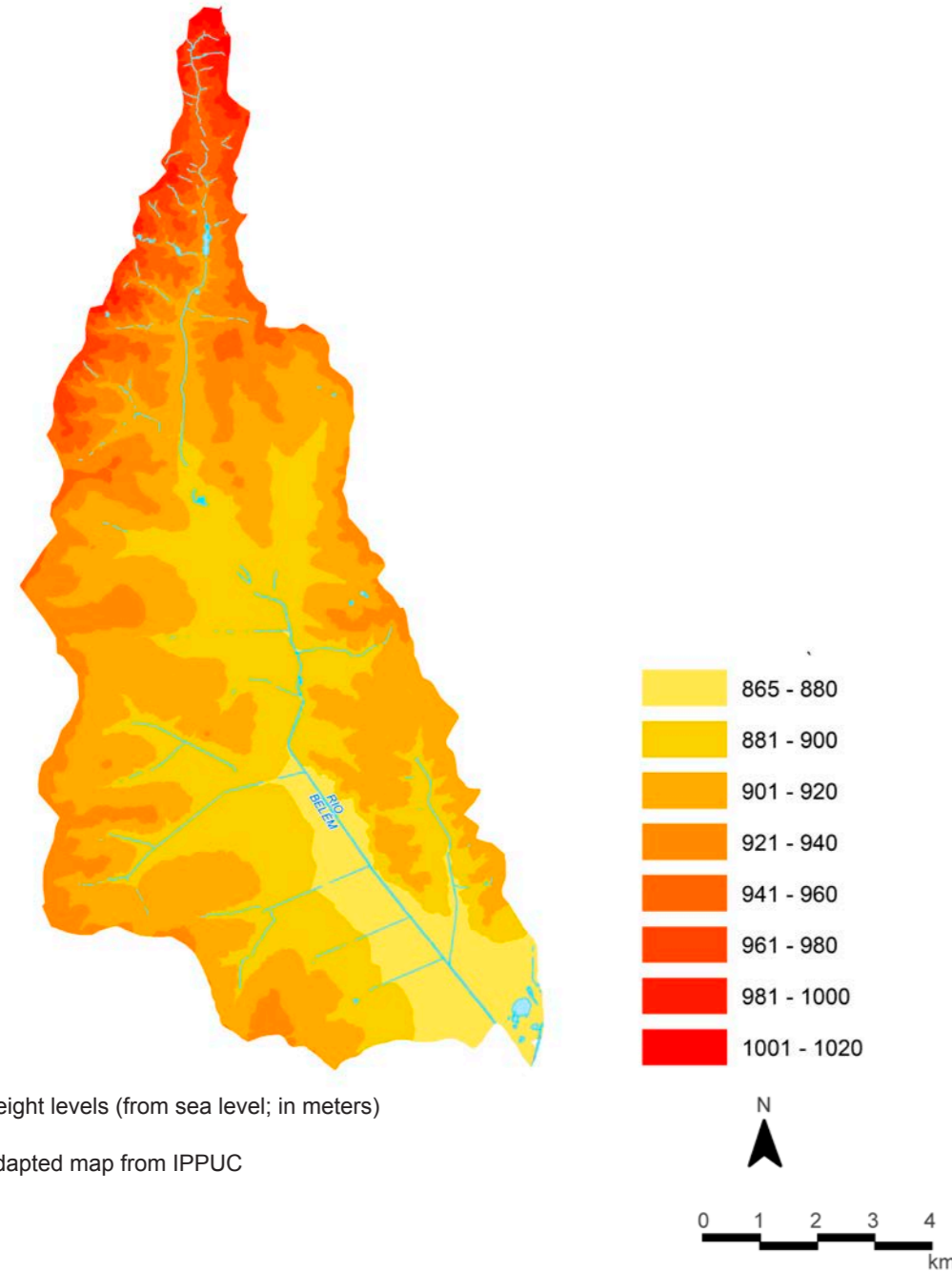
(1) On the upper section of the river, near the spring, there is more greenery and less urban development due to the topography of the area. This means that flooding is not the main issue in this area, only slightly around the main river.

(2) From the São Lourenço park until the intercity bus terminal, the river passes through the city center and therefore, the highest density. The river also receives water from its many tributaries, coming from various parts of the center and surroundings, all of which also have high density areas around them. For these reasons, this part of the basin has high risk of flooding, not necessarily at the main river but at all its tributaries. Another fact that contributes to the flooding risk is that the main river and its tributaries are greatly covered by streets and buildings.

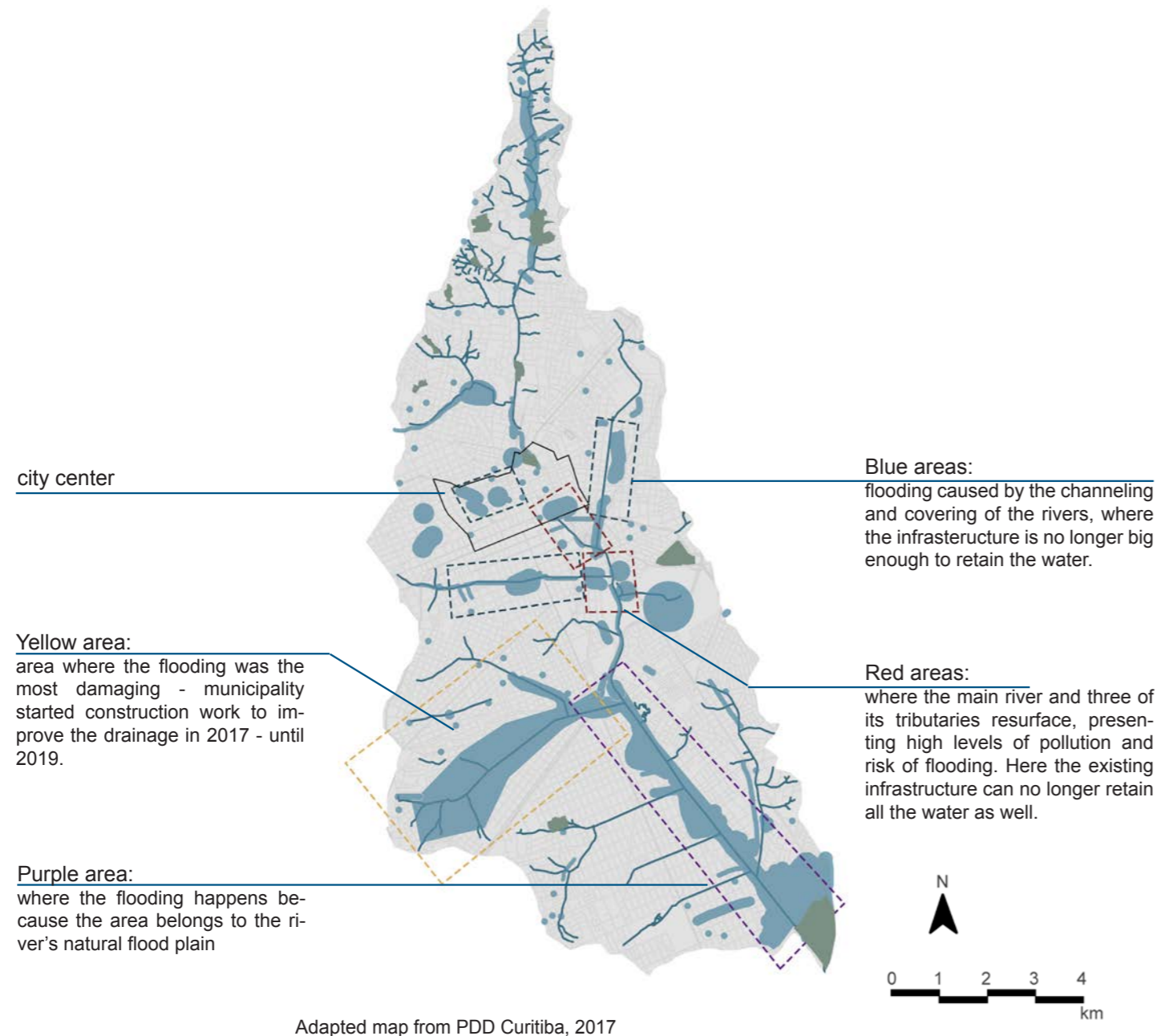
(3) From the intercity bus terminal until the Green Line (a former highway that crosses the city), the basin also has a high density occupation. The area had an irregular settlement (favela), which was made regular by the municipality. The area has high risk of flooding, especially on the tributaries. This is because the tributaries are either covered by infrastructure or with settlements on the floodplain. Not only that, they also have a high level of pollution and waste, coming from the upper parts of the city and from the immediate surroundings. The most vulnerable areas are close to the Brasília Itiberê street and Água Verde river.

(4) The Henry Ford tributary has a high flooding risk due to the irregular settlements (favela) located on the floodplain of the river. The water has high levels of waste and pollution.

(5) On the south section of the river, until its ending, there is medium population density. Even though the area is a big natural floodplain, with many settlements, the area has medium risk of flooding.



Based on the flooding analysis of the municipality, the frequency of occurrences and the characteristics of the river in each part, some flooding areas were highlighted and classified in four situations:

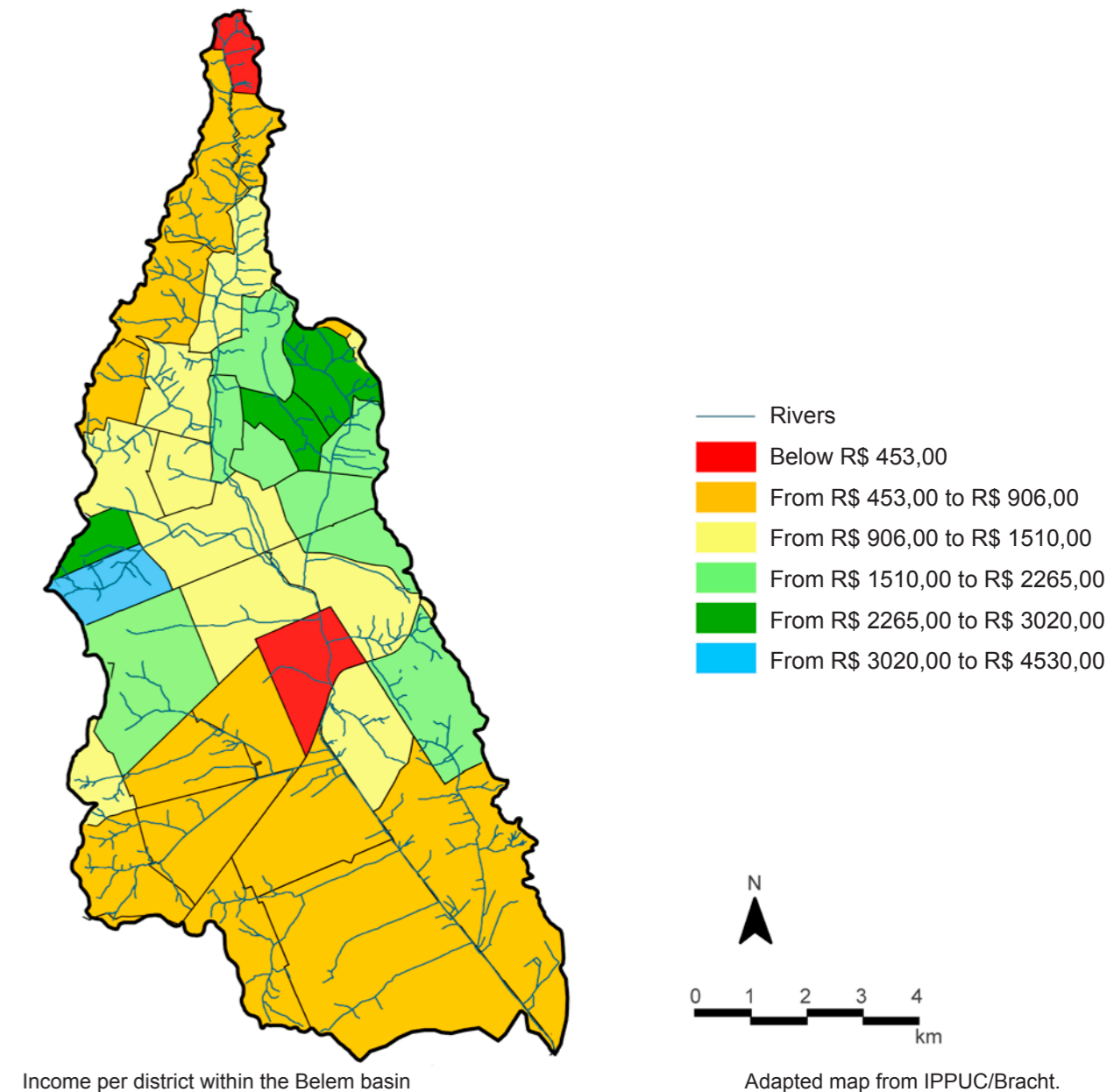


2.7 Belém Basin: Social aspects

The Belém river passes through various districts, in which live people of different incomes.

The red districts are the ones where the income is the lowest, while the dark green and blue represent the highest income.

In the middle of the Basin, in red, there is the Prado Velho district. The former favela around the river, mentioned earlier, is located here. Even though the area has become regular by the municipality, its inhabitants have lower income. The area suffers prejudice and difficulties to get integrated with the surroundings.



2.8 Belém Basin: Municipality's plans

From the municipality's website and local news, the main plans for the Belém Basin and its region were collected and presented here. They also serve as a starting point for the project, considering what is in the municipality's agenda for the future and how the river will change from those actions.

1. The Belém River

The municipality has recently gathered 339 million reais (approximately 80 million euros) for new drainage systems, cleaning and improvements for the Belém basin. One of the municipality's slogan for 2018 is "the year of the Belém river". This shows the importance of the river, not only historically but also nowadays. Work around part of the basin has already started, as mentioned before, at the Henry Ford tributary.

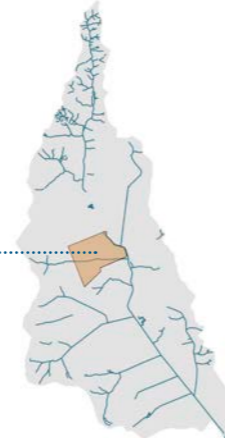
The biggest aim of the municipality is the cleaning of the Belém river - especially on the illegal sewer aspect. By 2019, the aim is to no longer have illegal sewage connected to the river.



A starting point for this thesis project to work is the cleaning of the Belém Basin. This project presumes that the municipality's efforts to clean the rivers are successful and outlines strategies from that.

2. The Rebouças

In terms of urban requalification of the areas located within the basin, the municipality has plans for the district called Rebouças. The district, which was an industrial part of the city around the 1900's, is next to the inter-city bus terminal and the former train station.



When Curitiba started to grow, the neighborhood was the first to get developed, with the first sewer systems and infrastructure improvements. However, after the industries of the city were relocated to an area further away (CIC), Rebouças started its decline. Today the area is neglected, with many empty plots and abandoned buildings.

The new mayor was elected under the campaign that the area would be requalified as an innovation hub, where startups would meet and grow.



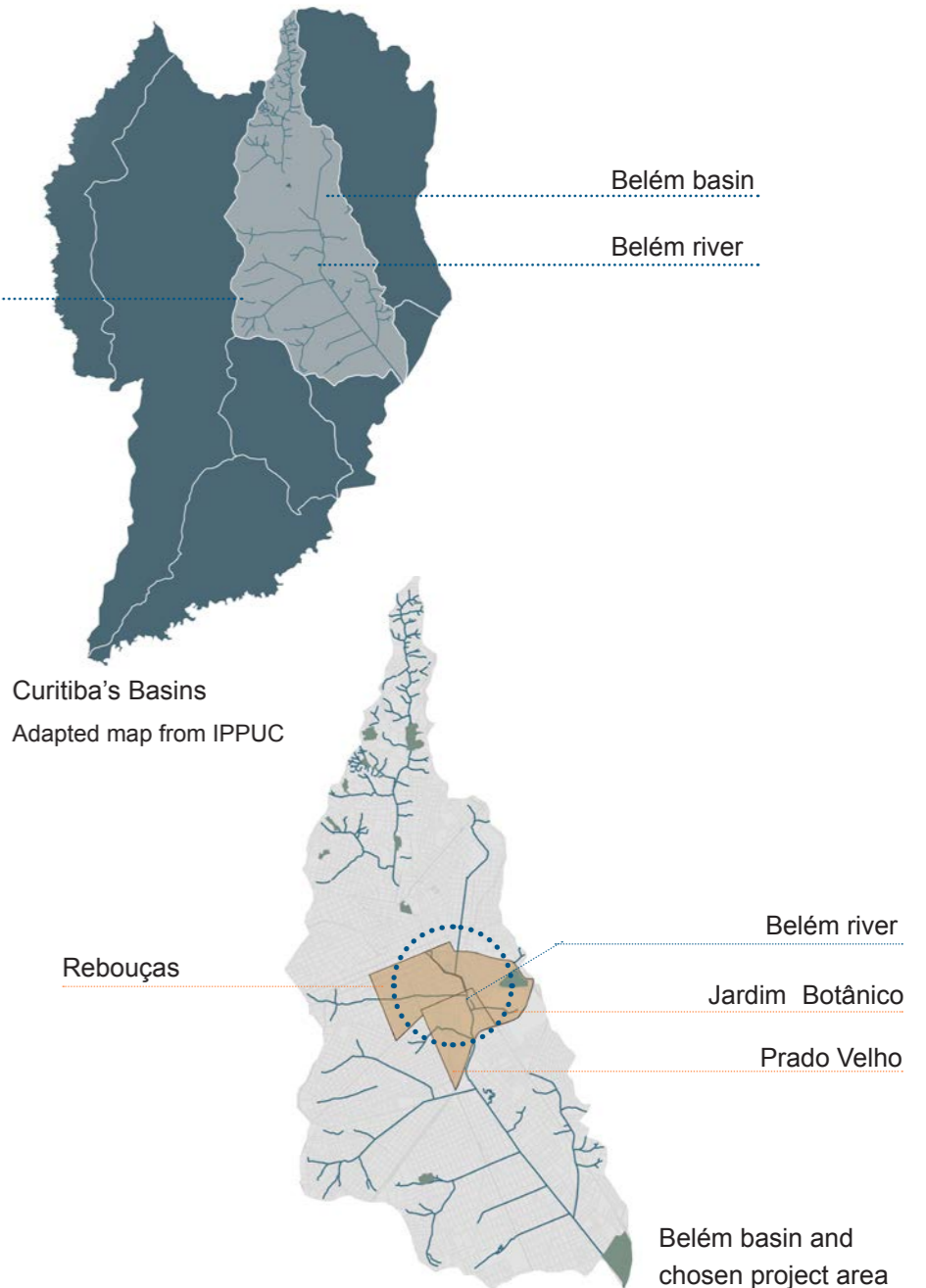
2.9 Conclusions and Chosen Area

The brief research shown in this chapter supports the importance of dealing with flooding and cloudburst events in the city of Curitiba.

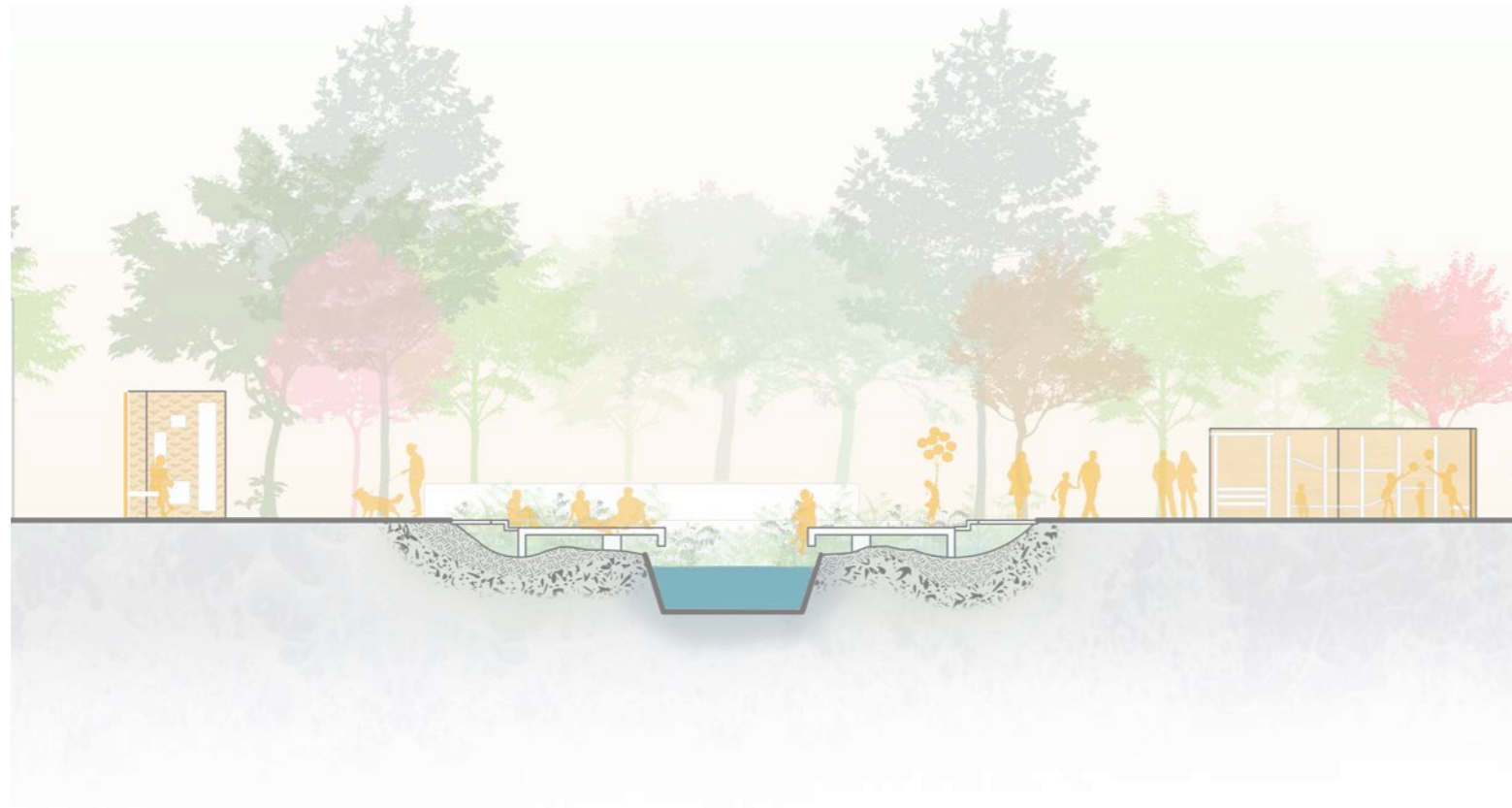
The rivers and basins suffer with the urbanization and impermeabilization, with the channelling and covering of rivers. They also suffer with high levels of pollution, from waste to illegal sewage connections. In addition to that, climate change increased the number and intensity of the cloudburst events. As a consequence, there is a lack of emotional connection and identity of the people to the rivers.

In this chapter the importance of the Belém river and basin within the city context was also outlined, which justifies this basin as being the starting point of the study.

The area chosen for the project, within the Belém Basin, is also supported by this chapter. The choice took into consideration the physical aspects, flooding risks, social characteristics and the municipality's plans for the future. The area is located on the encounter of three districts, Rebouças being one of them. The chosen area will be explained in more detail on the Project chapter.



3 the project



- 3.1 Main challenges, Vision and Opportunities
- 3.2 Strategy - Work in 3 different scales

3.3 Scale 1 - The Basin and River

- 3.3.1 Main Challenges
- 3.3.2 Toolbox
- 3.3.3 Strategy for the whole basin and river

3.4 Scale 2 - The Responsive System

- 3.4.1 The Chosen Area
- 3.4.2 The site
- 3.4.3 Communities and main functions
- 3.4.4 Pictures - existing situation
- 3.4.5 Strategies and Toolbox
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- 3.4.8 Adding Layers
- 3.4.9 The new public spaces: combining stormwater management and new public realms

3.5 Scale 3 - Detailed Design

3.1 Main challenges, Vision and Opportunities

As stated before, the main focus of this thesis is flooding and cloudburst events that occur in an existing dense urban context.

This issue will be dealt with in two main layers: the environmental and the social layer. Here is a summary of how the project intends to answer the challenges:

Main challenges

How to turn a “problem” – rivers and heavy rain – into an opportunity?

Vision and opportunities

1. Environmental layer



Flooding and cloudburst events



Create a responsive and resilient system to cloudburst events and flooding

Take into account the existing urban tissue

Use different design strategies to filter, retain and delay floodings, and at the same time support a wide range of urban programs

2. Social layer



Relationship of citizens to rivers



Create new relationships between people and water, reintroducing the riverside to inhabitants

Encourage encounters between people of different backgrounds and the growth of a river related identity

3.2 Strategy - Work in 3 different scales

As stated before, the strategies for flooding management were proposed in three different scales. Firstly, stormwater management strategies are outlined for the whole basin and river. The chosen basin is the Belém, the most dense in the city.

On the second scale, an area within the basin is chosen. The same strategies created for the first scale

are used in a responsive system against flooding. The aim of these two first scales is to serve as a case study, with solutions which could be applied to other parts of the city as well.

And finally, the detailed design shows more specifically the combination of flooding protection solutions with the creation of a new kind of urban public space.



Physical Model

Scale 1 - the basin and the river

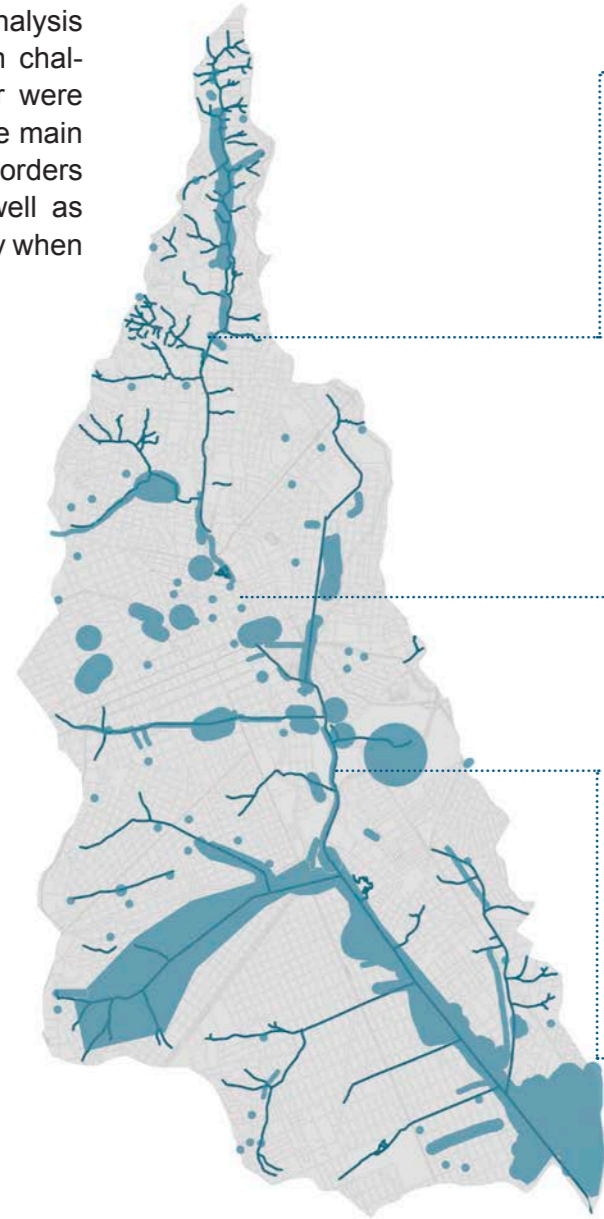
In this scale, the aim is to identify the main problems that happen along the extension of the whole river and create a toolbox that responds to these problems. This toolbox have strategies that could be applied in different spots of the river or in other basins with similar problems.

Later on, the same toolbox will be used on the system scale, where they can be detailed.



3.3.1 Main challenges

Based on the flooding analysis from the last chapter, the main challenges around the Belém river were identified. In order to identify the main issues, the Belém river and its borders were taken into account, as well as some of its tributaries, especially when they meet the main river.



Lack of proper space for the river
Housing on the river's natural flood plain
Poor environmental quality of the edges of river



Lack of continuity and difficulty to access



Lack of stormwater space
Excessive Impermeabilization
Channeling and covering of the rivers, infrastructure is no longer big enough to retain the water.



3.3.2 Toolbox

The Belém river is long, but a few of the same issues can be seen in several spots. Therefore, these challenges were organized in three groups, which are answered in three main toolbox strategies.

The toolbox is meant to be a guideline for different parts of the river, with strategies that can help in flooding events and on the daily maintenance of a healthy river condition.

Lack of proper space for the river
Housing on the river's natural flood plain
Poor environmental quality of the edges of river



Reveal and restore

Lack of continuity and difficulty to access



Connect and access

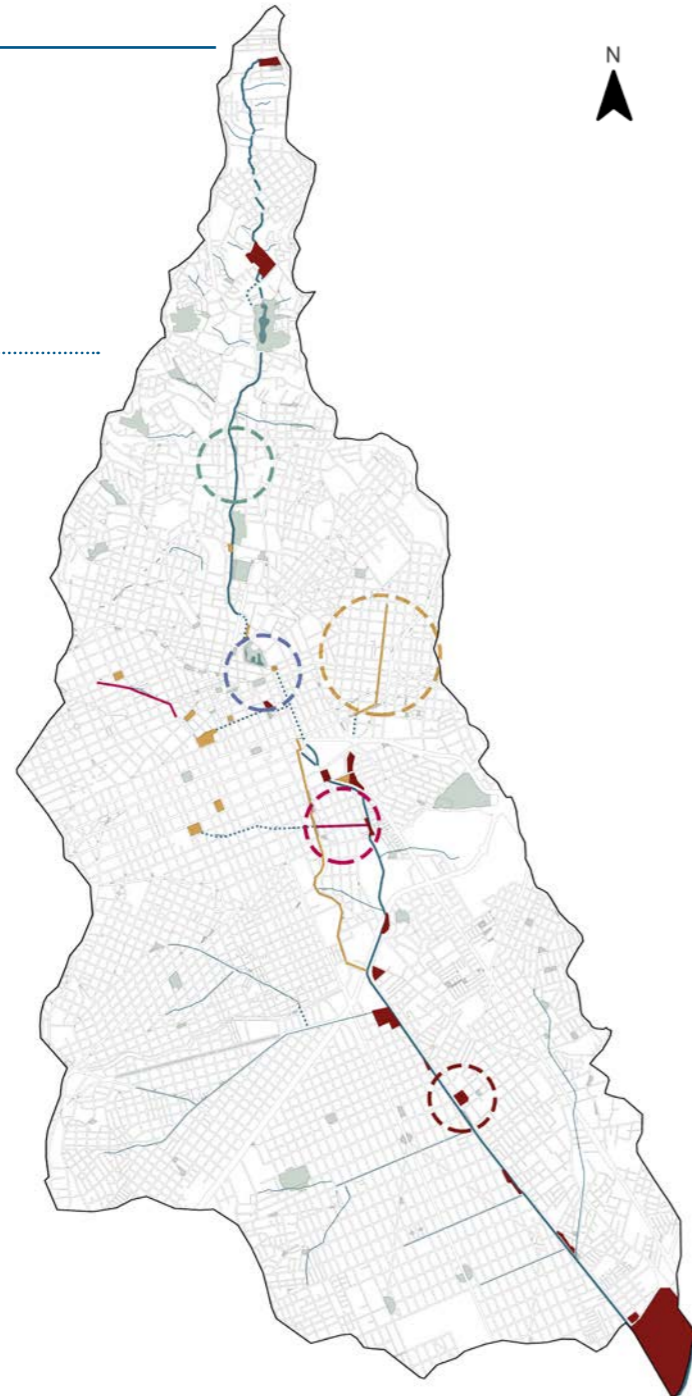
Lack of stormwater space
Excessive Impermeabilization
Channeling and covering of the rivers, infrastructure is no longer big enough to retain the water.



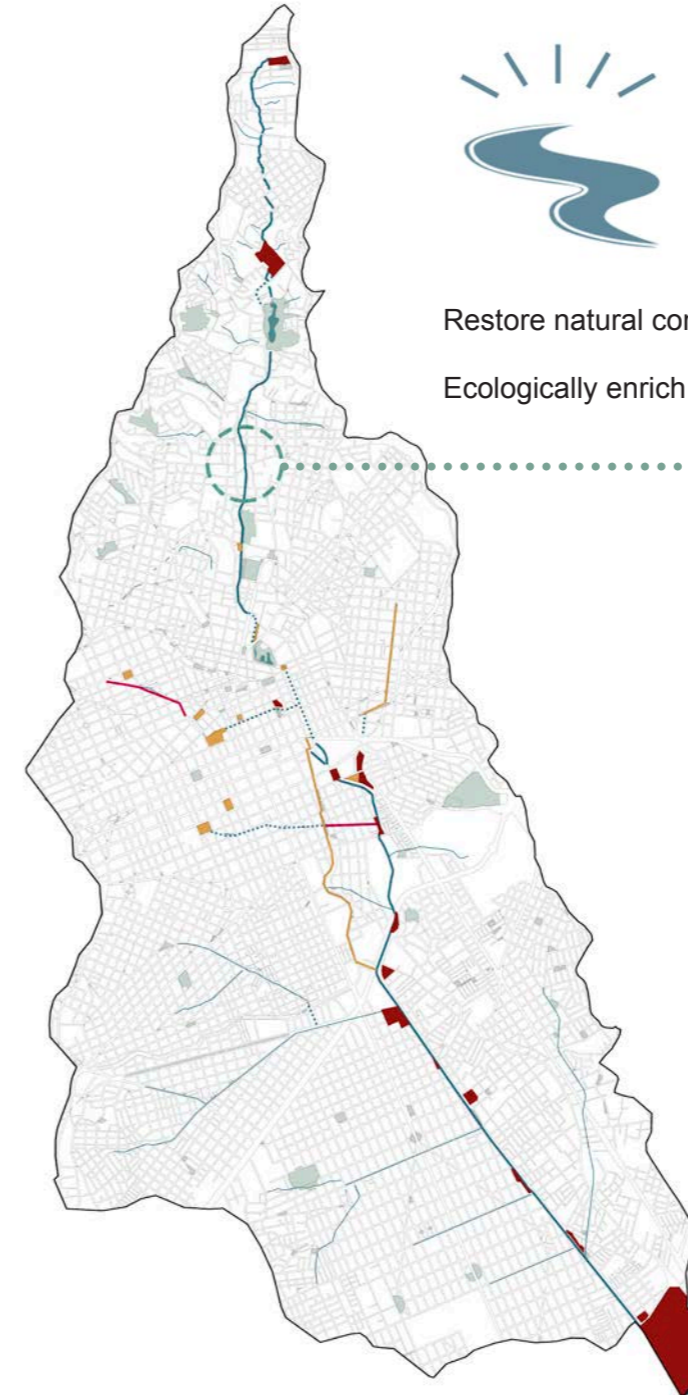
Delay and Retain
stormwater locally

3.3.3 Strategy for the whole basin and river

Each of the toolbox items represent a global action, and can be further divided into more specific strategies. For each strategy, a different colour was used on the map and an area (circle) was chosen to exemplify where and how this strategy could work. The sections on the next pages were made specifically for each circled area, but they represent a principle that should be replicated in other parts of the basin.



1. Reveal and restore

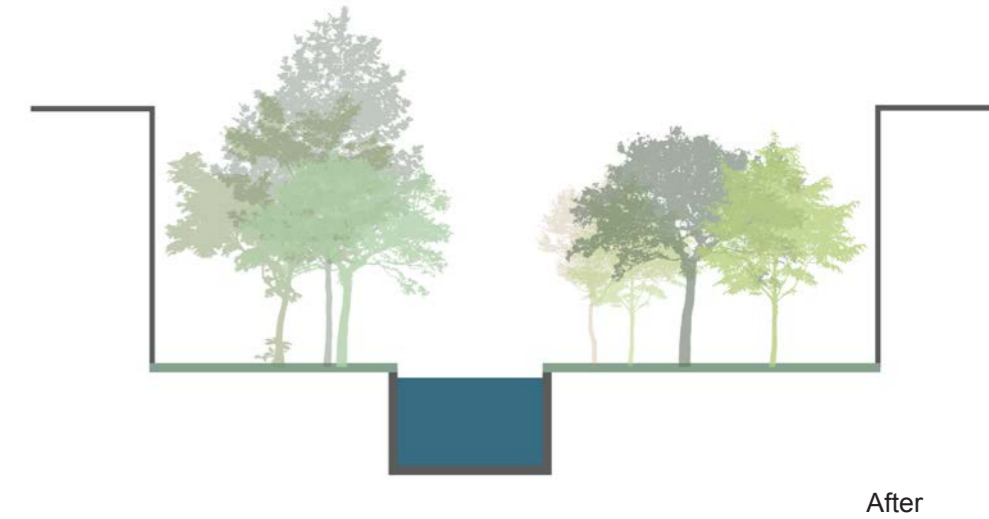


Restore natural conditions

Ecologically enrich the borders of the river

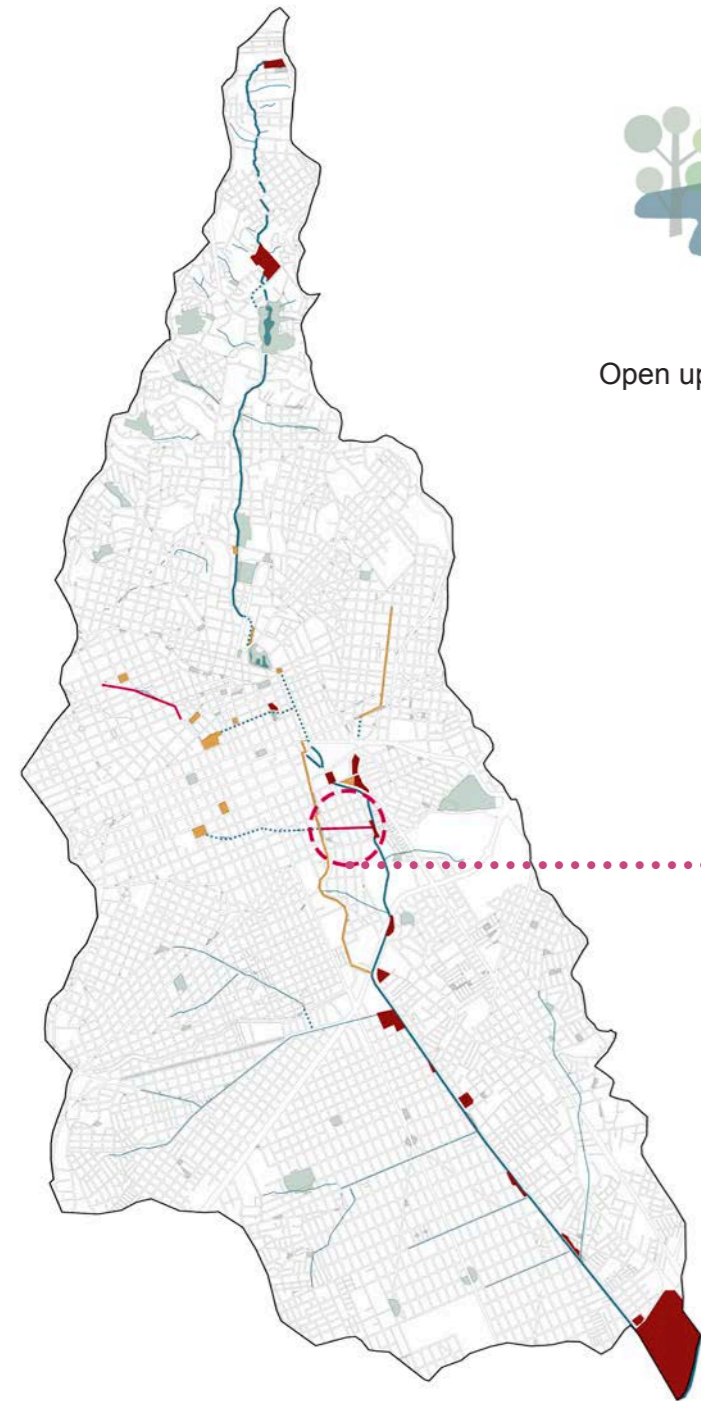
In these areas, the river has enough space around it, but those areas are usually of poor ecological quality, with only grass on both sides.

The strategy here is to restore the natural conditions of the borders, ecologically enriching it.



After

1. Reveal and restore

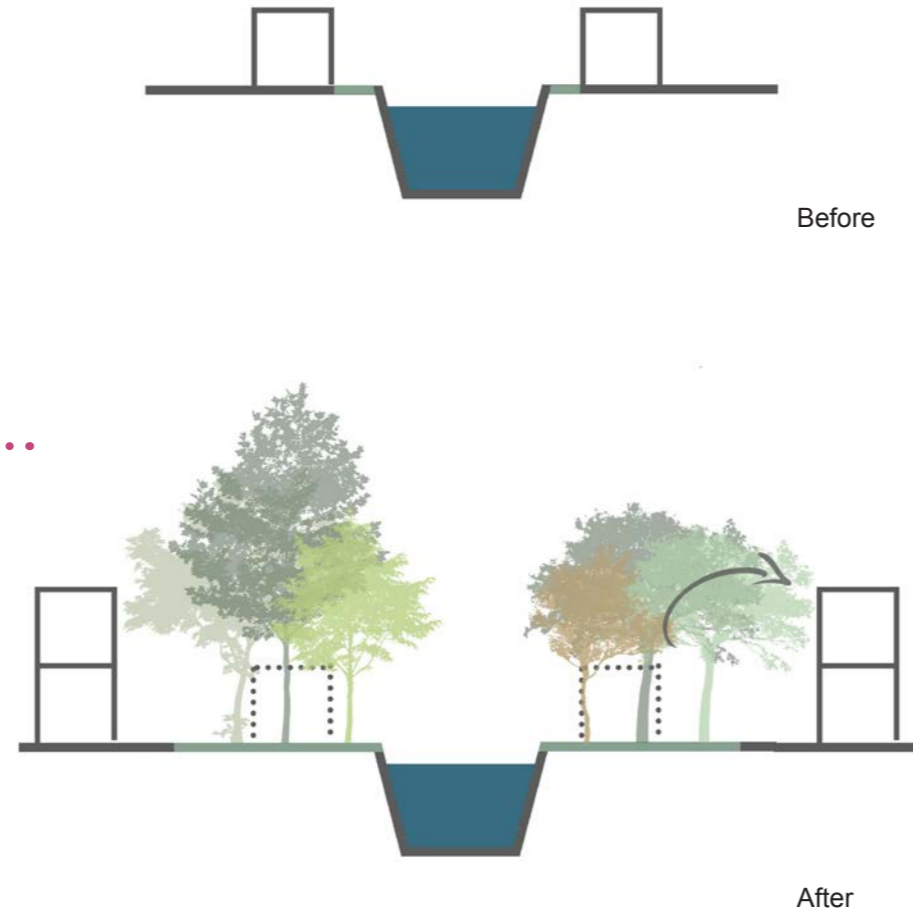


Open up the river

In these areas, the river does not have enough space around it. Constructions and pavement are too close to the river, or even on top of it.

The strategy here is to open up the river, giving it more space.

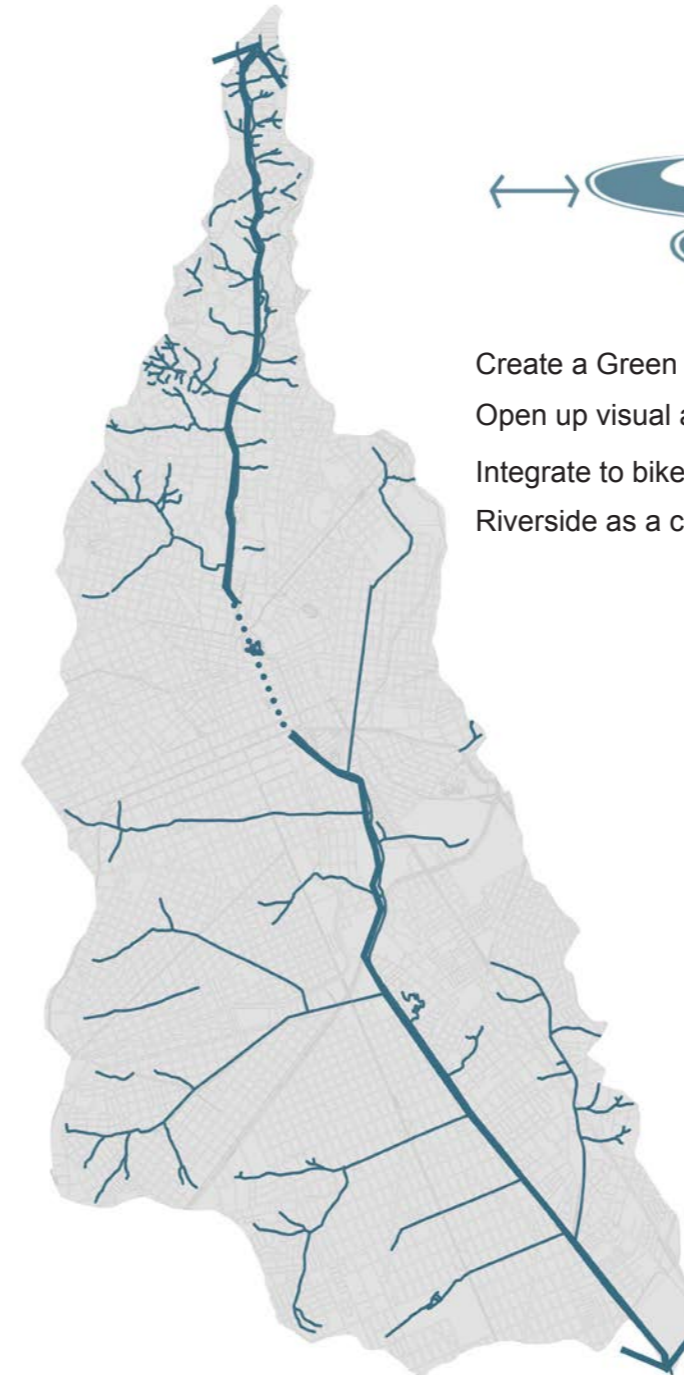
The houses that are too close to the borders would be removed. The buildings that shape the new green area could be densified to accommodate the families that once lived on these border houses.



Before

After

2. Connect and access



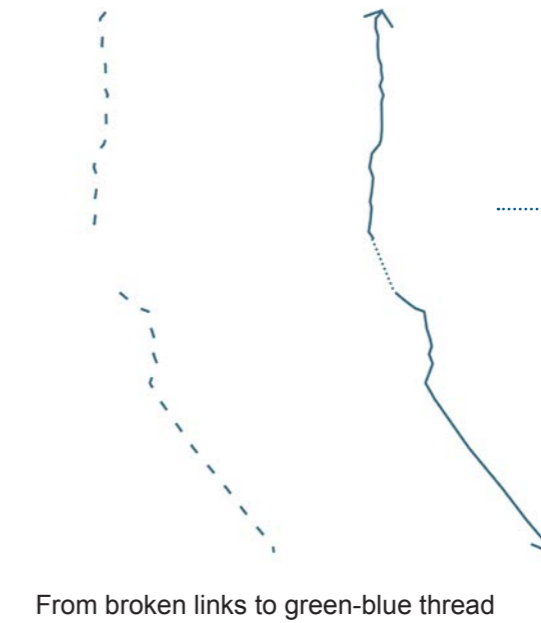
Create a Green - Blue thread

Open up visual and physical connections

Integrate to bike and bus connections

Riverside as a connection, more than a destination

The main river is very difficult to access in several spots. It lacks visual and physical connections to the surroundings and it also lacks connections in itself. Following the river as a thread is not possible, since it is interrupted several times by streets or infrastructure.

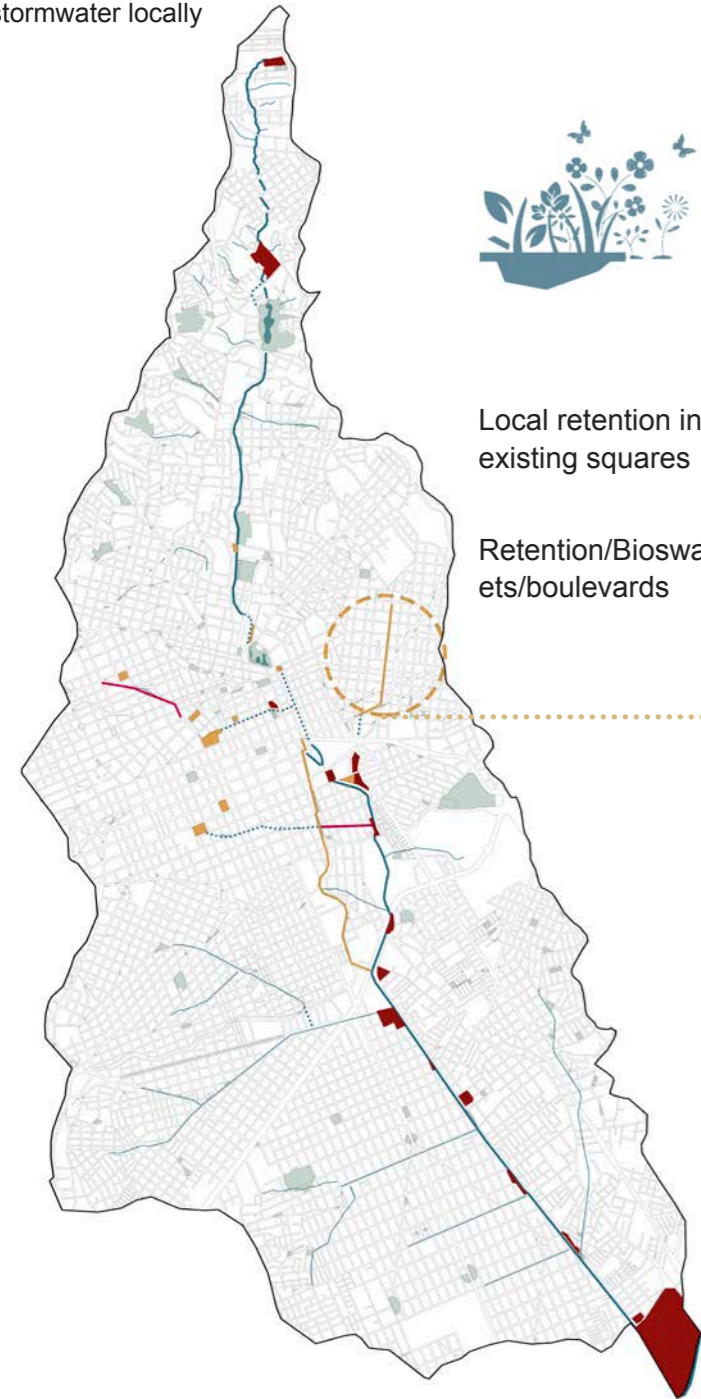


From broken links to green-blue thread

The strategy here is to create a Green-Blue thread, creating a riverside walk, integrated to biking lanes. Opening up as many visual and physical connections as possible and adding elements to the riverfront, so it can be an attractor of people.



3. Delay and Retain stormwater locally

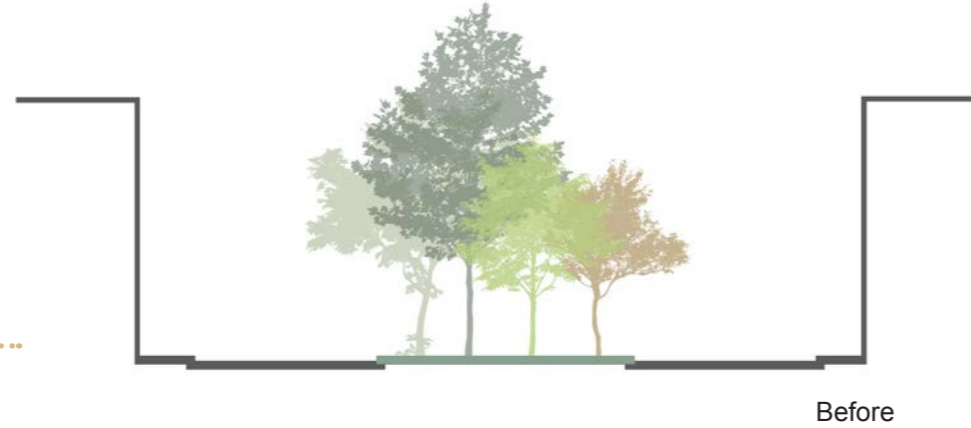


Local retention in residual spaces/
existing squares

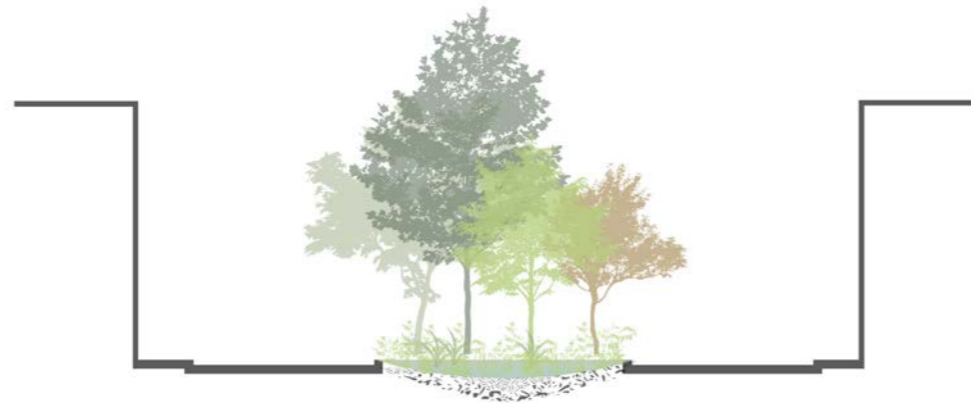
Retention/Bioswales streets/
boulevards

Due to changes on the urban tissue or its functions, the city has many residual spaces - which today are frequently green areas with no use. They are usually made of grass and some trees, but don't offer a quality space, in ecological or public space terms.

The strategy here is to use these existing green spaces to create new retention boulevards or squares, adding a layer of sustainability to these residual spaces.

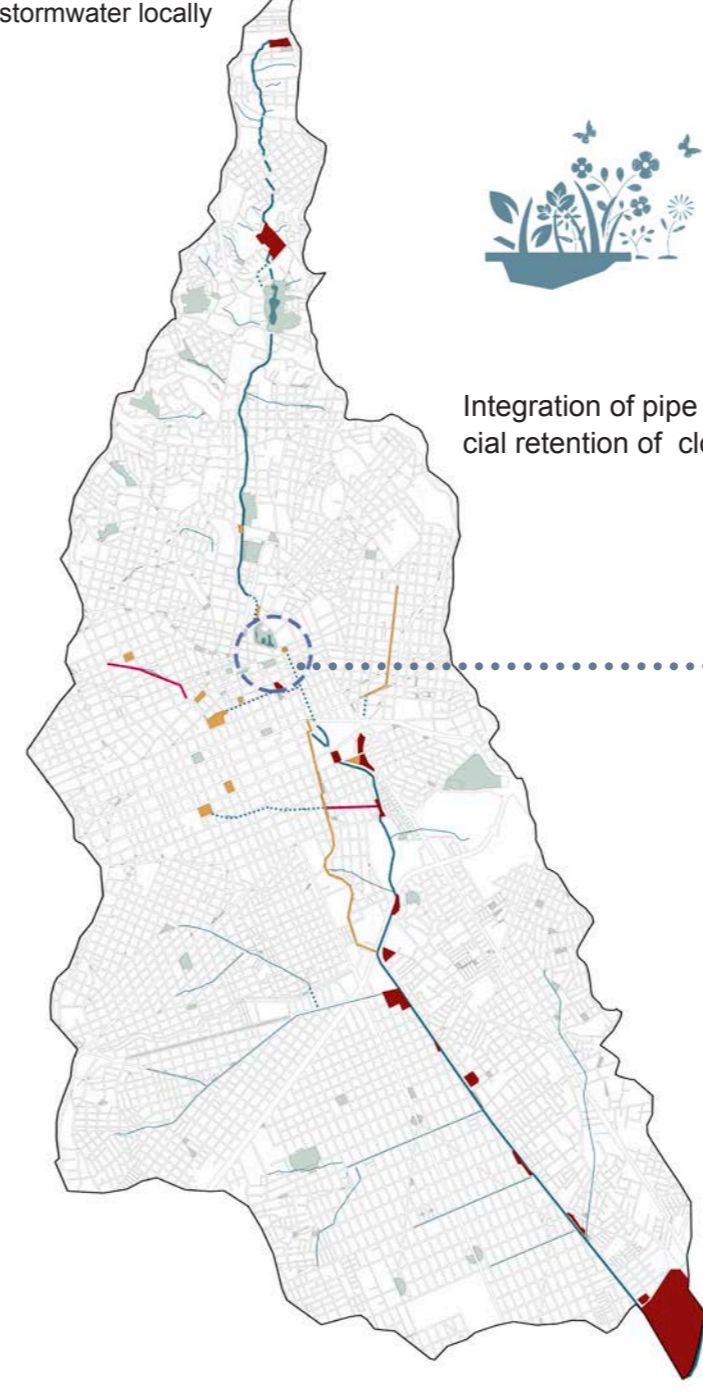


Before



After

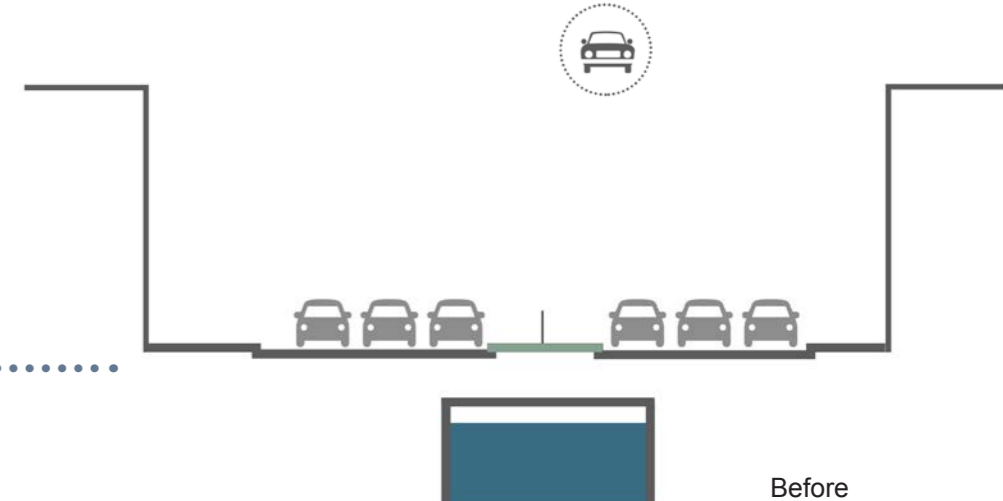
3. Delay and Retain stormwater locally



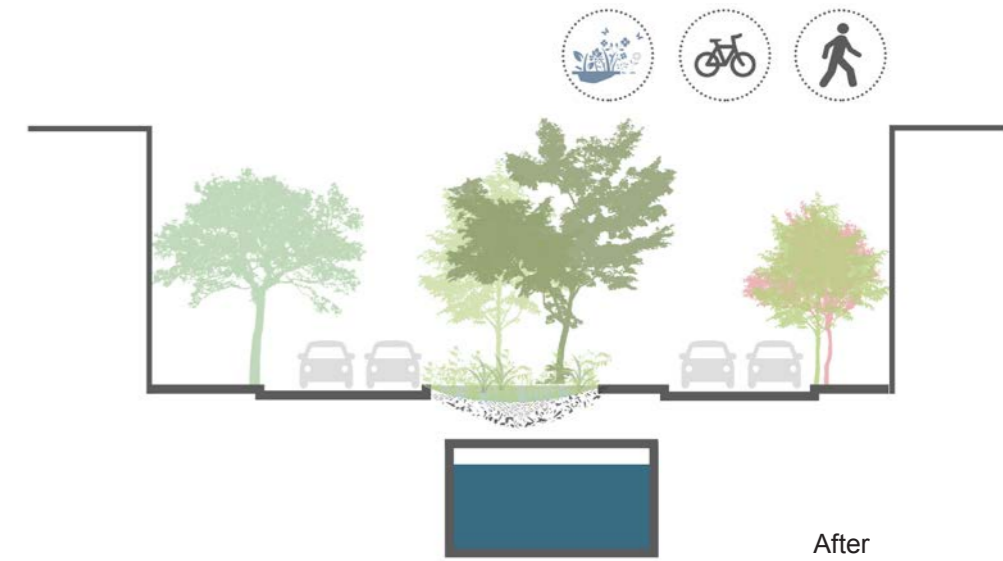
Integration of pipe systems + superficial
retention of cloudburst

These are streets where rivers were channelled and covered underneath them. Today, in some areas, the infrastructure that contains the rivers is insufficient for the water volume. Most of these streets are mostly dedicated to cars.

The strategy here is to create retention streets, which help on the surface level the existing infrastructure. The streets would also have more space for pedestrians and bikes.

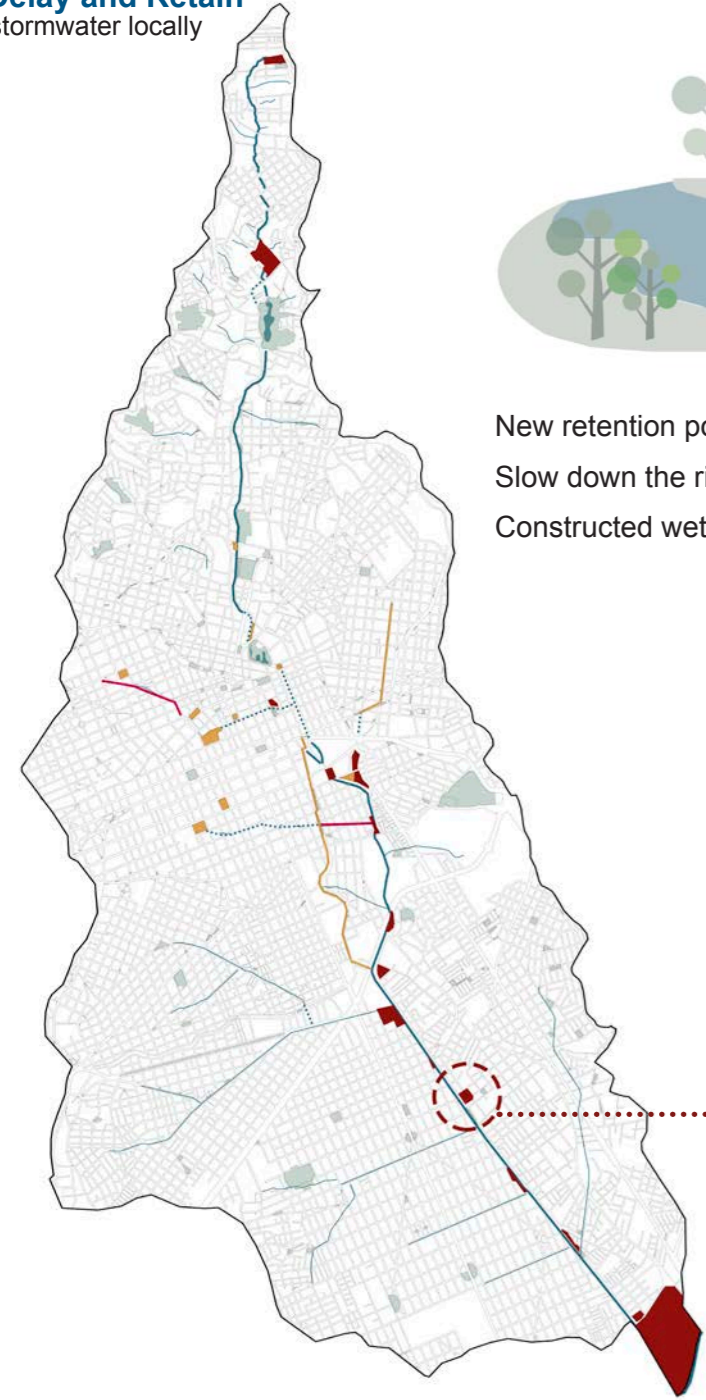


Before



After

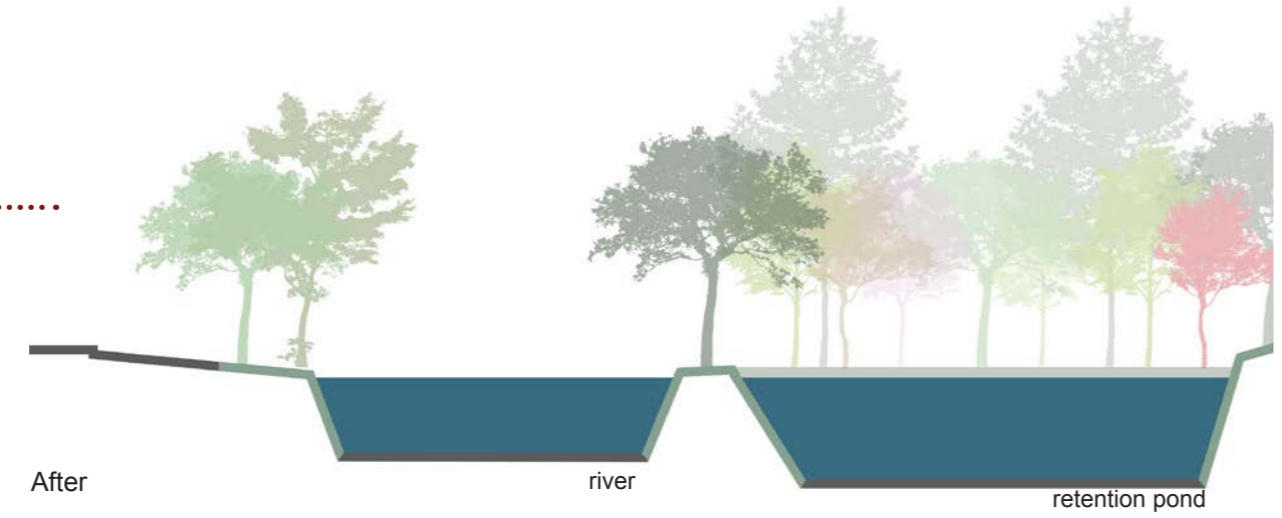
3. Delay and Retain stormwater locally



Along the main river, there are already some parks dedicated to retaining water. However, new retention ponds/parks and constructed wetlands could help on the flooding events. As such, the spots marked on red are new retention ponds and parks.
The location of these parks

was chosen whenever there was enough space and an adequate topography. Especially on the south part of the river (where the circle is), where Belém has been straightened, the aim of this new retention ponds is to slow down the river water, protecting the settlements located to the south.

New retention ponds/parks
Slow down the river water
Constructed wetlands



After

river

retention pond



Physical Model

Scale 2 - the responsive system

In this scale, an area within the basin was chosen for implementing the three main toolbox strategies in more detail. The three strategies will work separately but respond to cloudburst events as a system, reason why it is called a responsive system.

When assigning the areas and strategies, not only ecological factors were taken into consideration, but also the cultural and social dynamics of the area.

That is why after developing the design strategies for flooding, two new layers were added to the project - new buildings (that bring more people into the area) and new urban programs and activities.



3.4.1 The chosen area

Since many areas suffer from flooding and vulnerability around the Belém river, the choice of the site was made according to several reasons.

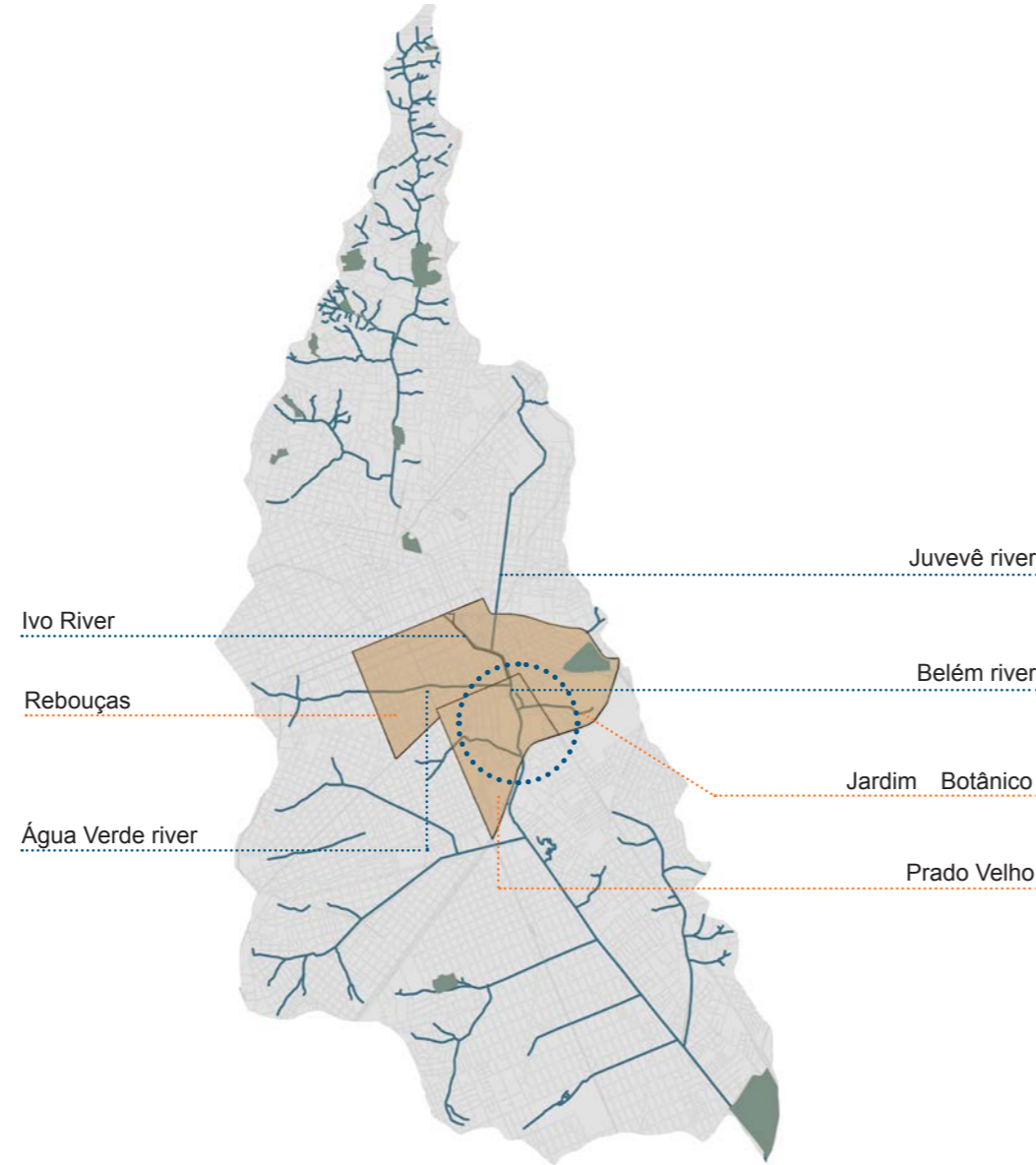
Firstly, the area has not only the main Belém river, but also three tributaries meeting the main river course. These rivers are either difficult to access or partially hidden/covered, but have much potential for a riverside.

Secondly, the Rebouças and Prado Velho districts were neglected areas for many years, with old industrial sites. This is why the municipality

has plans for these areas, to reactivate the neighborhood through startups and innovation. The system created here can also be part of this requalification process.

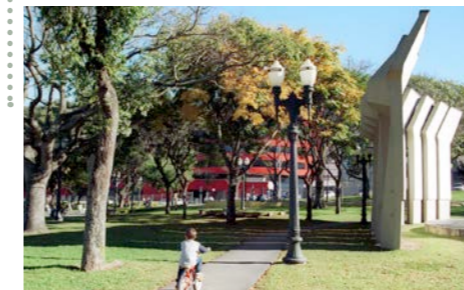
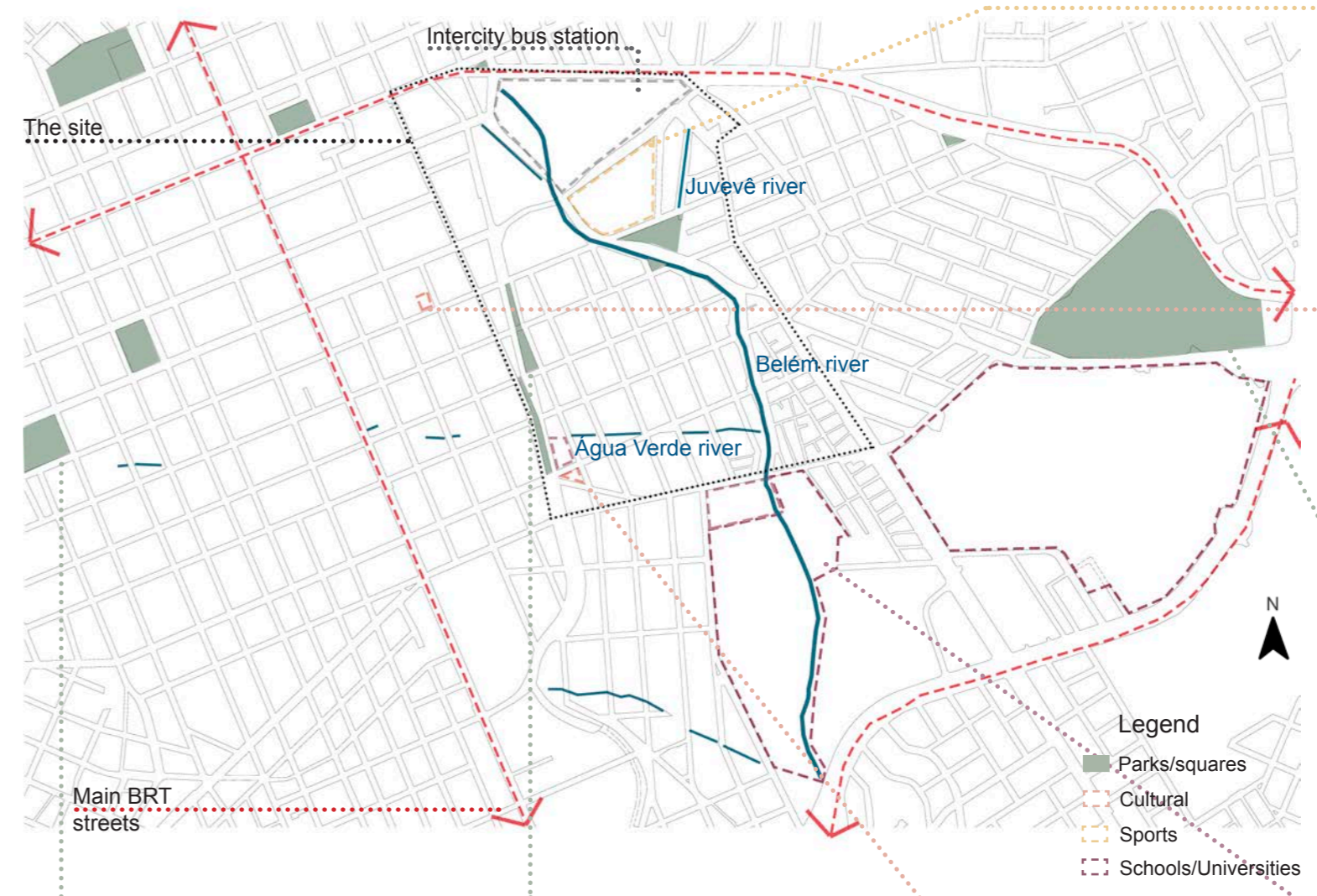
The area also has residual spaces from former train tracks, which will be used as part of the stormwater management system.

Finally, the proximity to the center and the existing diversity of communities were factored in, since these people could help activate and support the project.



Rivers and Districts that are part of the chosen area.

Zoom in: Existing landmarks and green areas



Athletico square



Former Train tracks space



Paiol Theatre



PUC University



Capanema Stadium

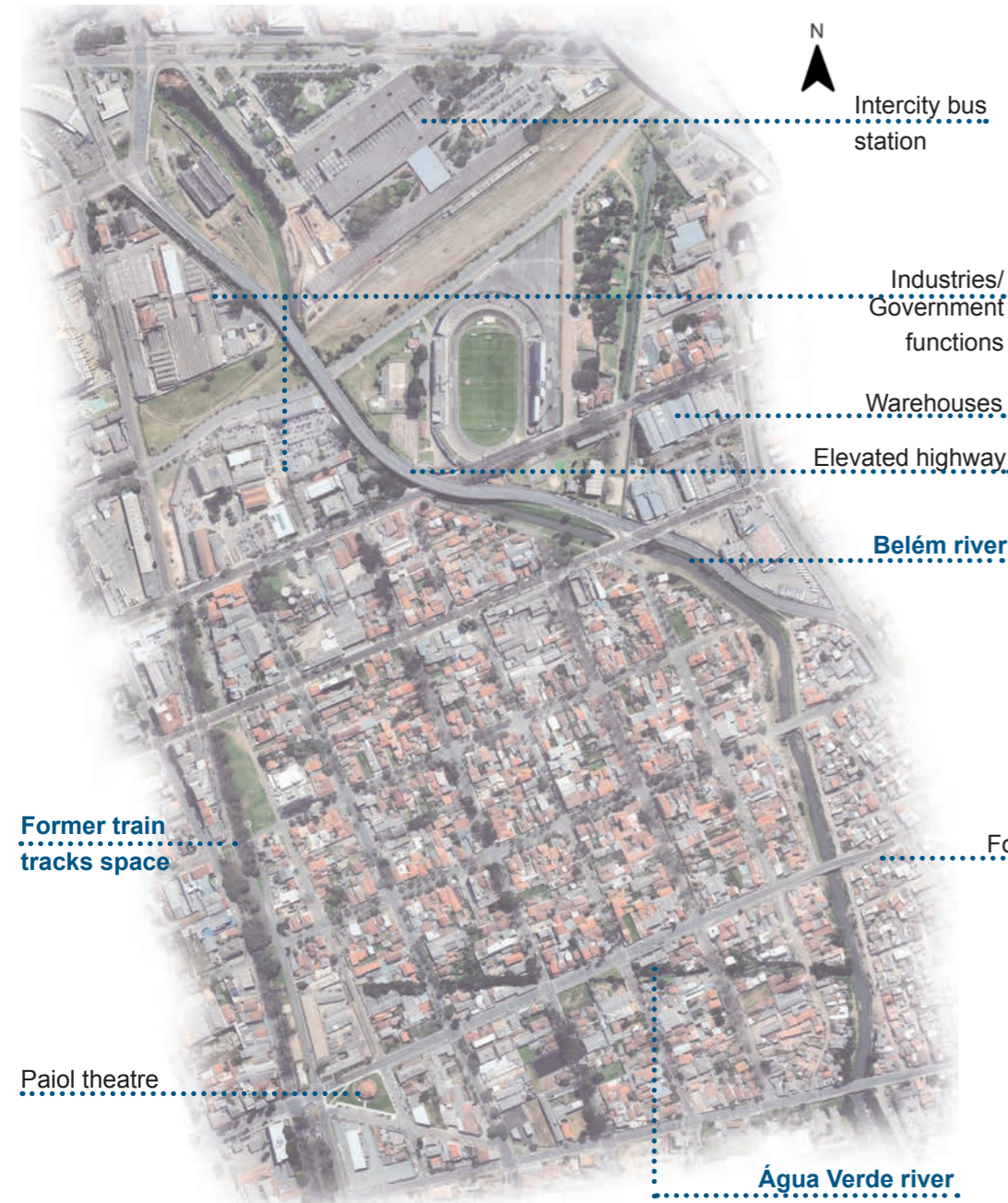


Startup innovation center



Botanical Garden

3.4.2 The site



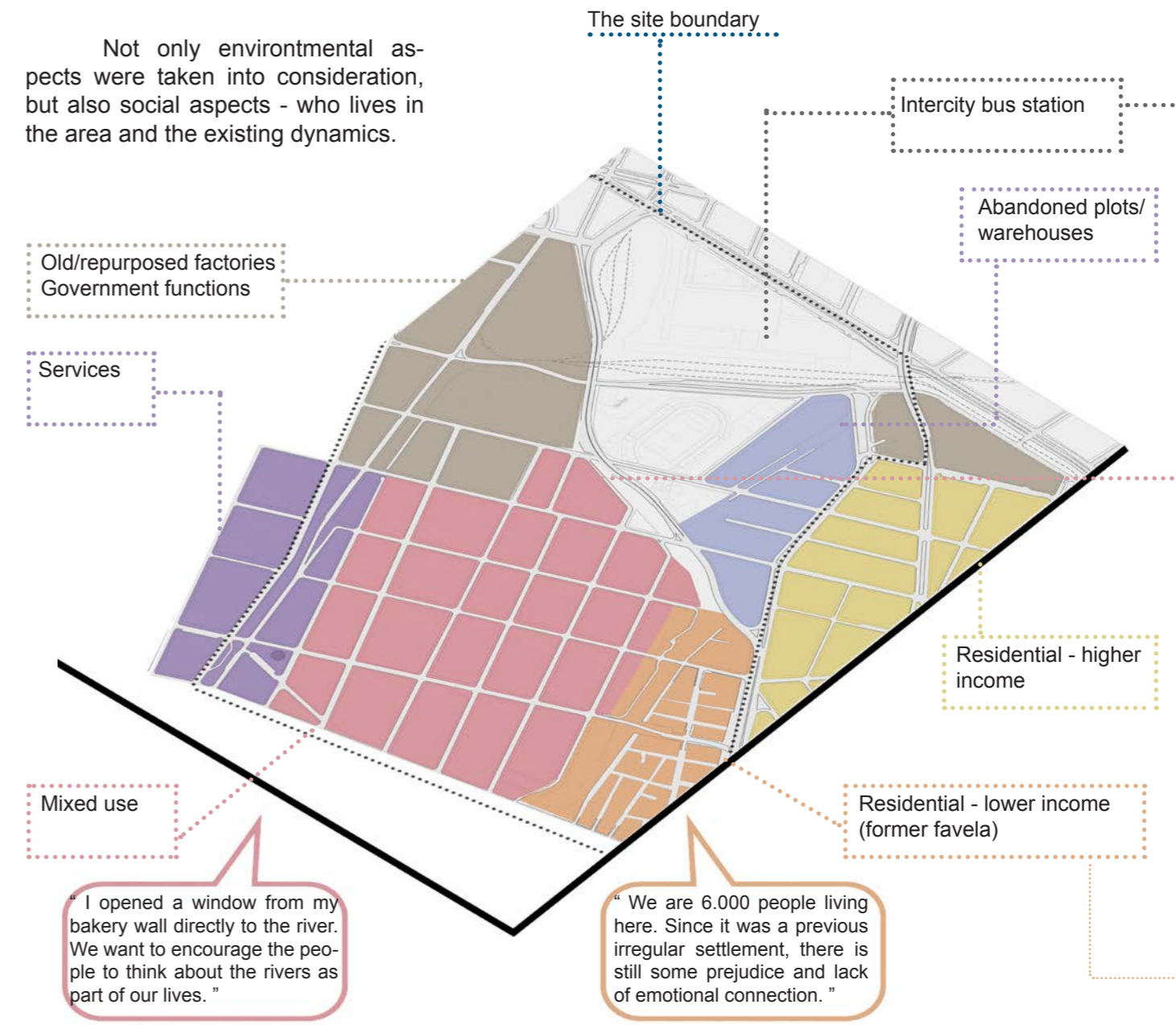
Within this chosen area, some spaces were considered of great potential for implementing the toolbox strategies. The main Belém river, the Água Verde River and the existing residual space from former train tracks, which is today an unused green axis.

Scale comparison of the site to Lund, Copenhagen and LTH.



3.4.3 Communities and main functions

Not only environmental aspects were taken into consideration, but also social aspects - who lives in the area and the existing dynamics.



"I opened a window from my bakery wall directly to the river. We want to encourage the people to think about the rivers as part of our lives."

"We are 6.000 people living here. Since it was a previous irregular settlement, there is still some prejudice and lack of emotional connection."



Mixed use



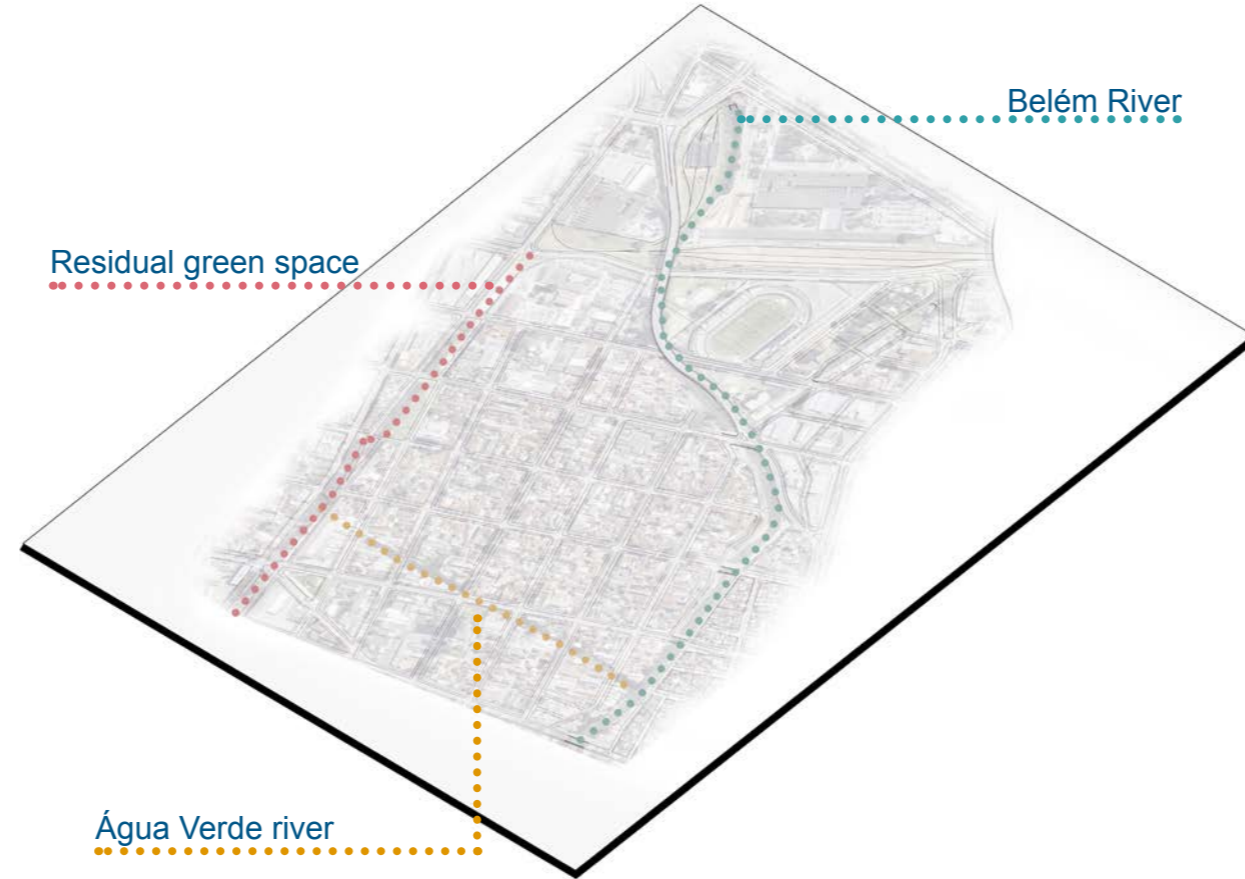
3.4.4 Pictures - existing situation

Pictures of the area in the existing situation, all from personal site visits



Residual green space with no use today - Former train tracks space

Água Verde river, a tributary of Belém - covered or with very little space around it



Belém river and the elevated highway that goes over/beside it



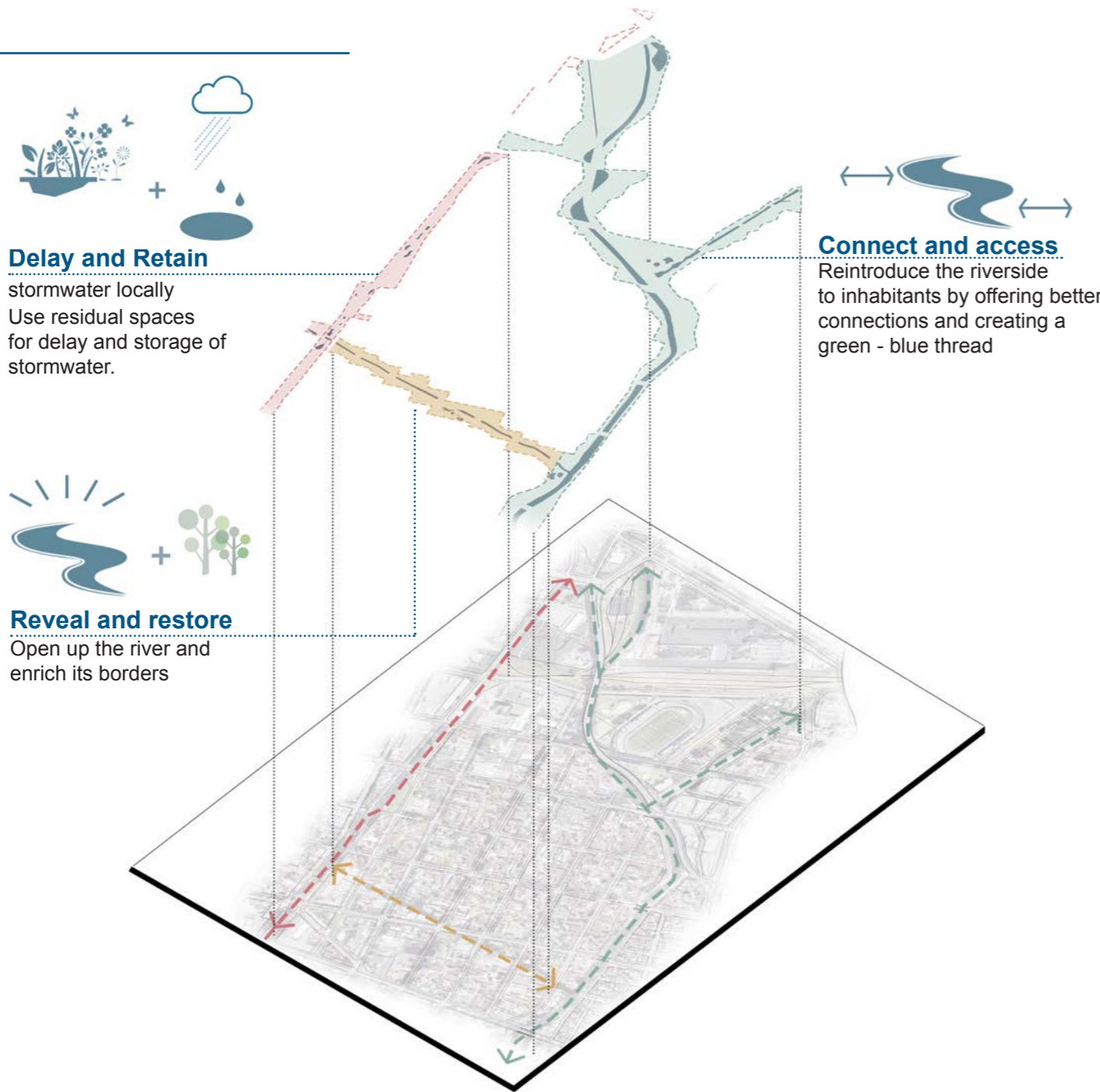
Belém river - difficult to access and not well connected in N/S directions, or E/W.

3.4.5 Strategies and Toolbox

The three strategies created for the basin were assigned to the three areas identified on the analysis.

They will work separately but respond to cloudburst events as a system, a responsive system. Each of the three parts of the system is unique, but connected with the other two.

In an extreme event, the idea is that, together, all three toolbox strategies can offer protection to the citizens and the city, in a dynamic and resilient way.



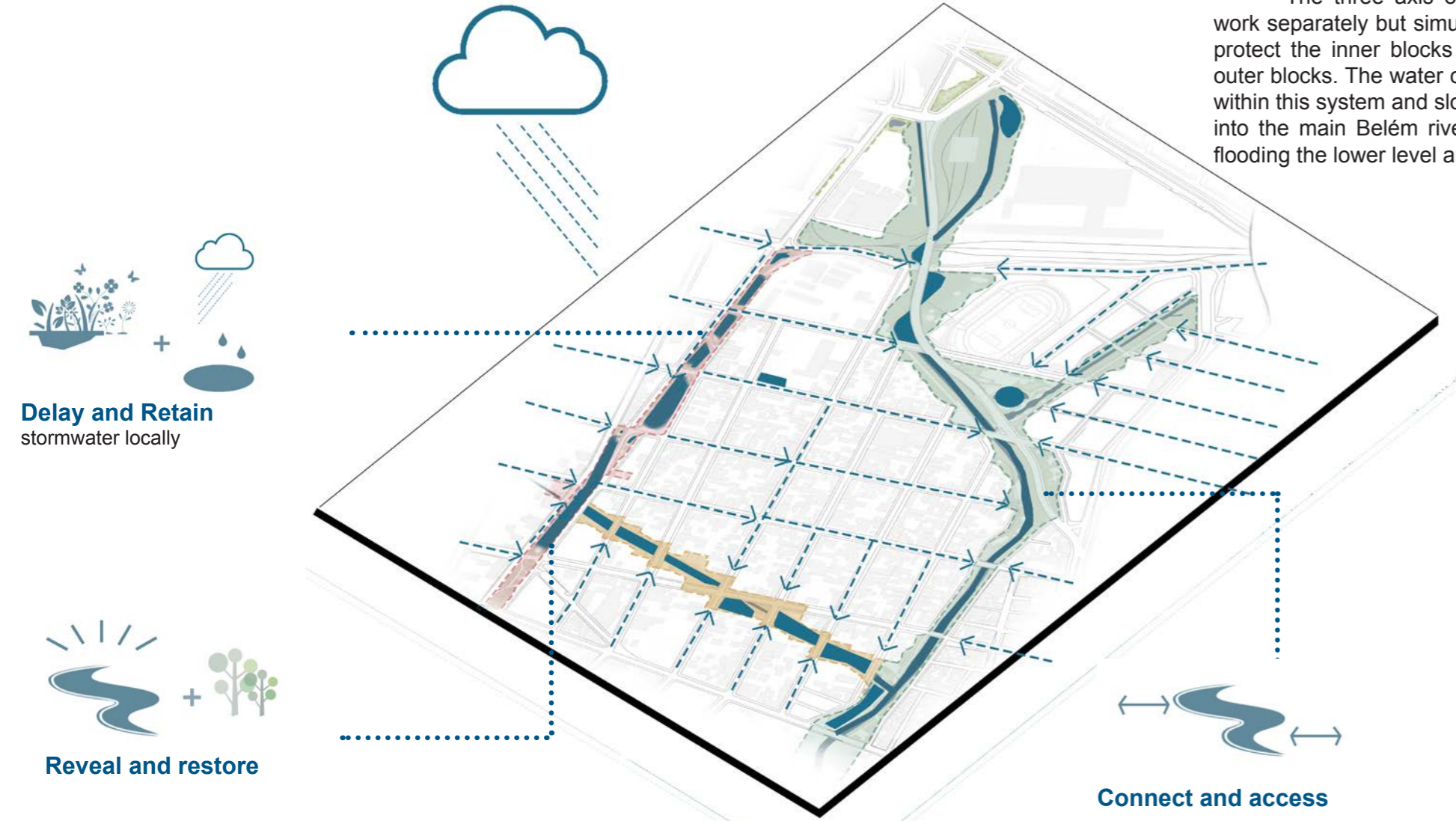
3.4.6 Strategic Master Plan

New buildings that shape the new public spaces



3.4.7 Stormwater management

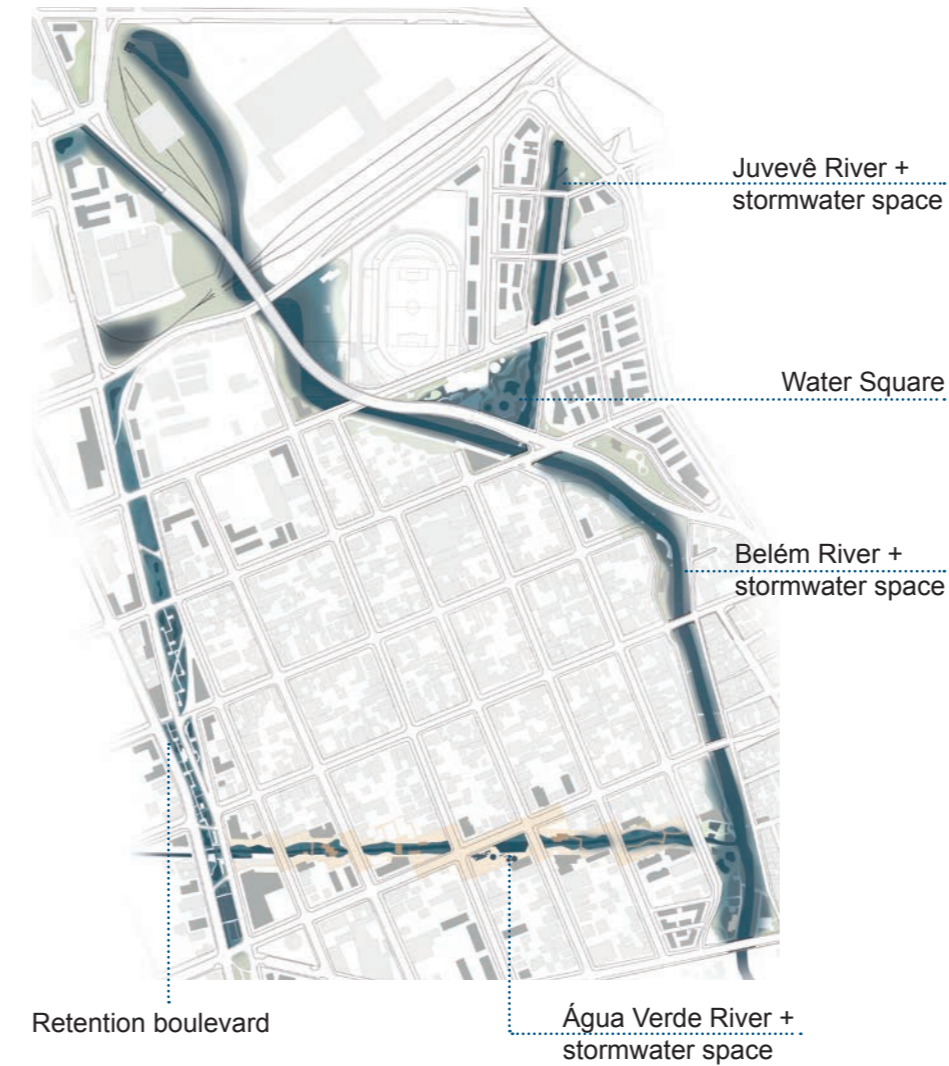
This diagram shows how the stormwater management works, according to the topography of the site.



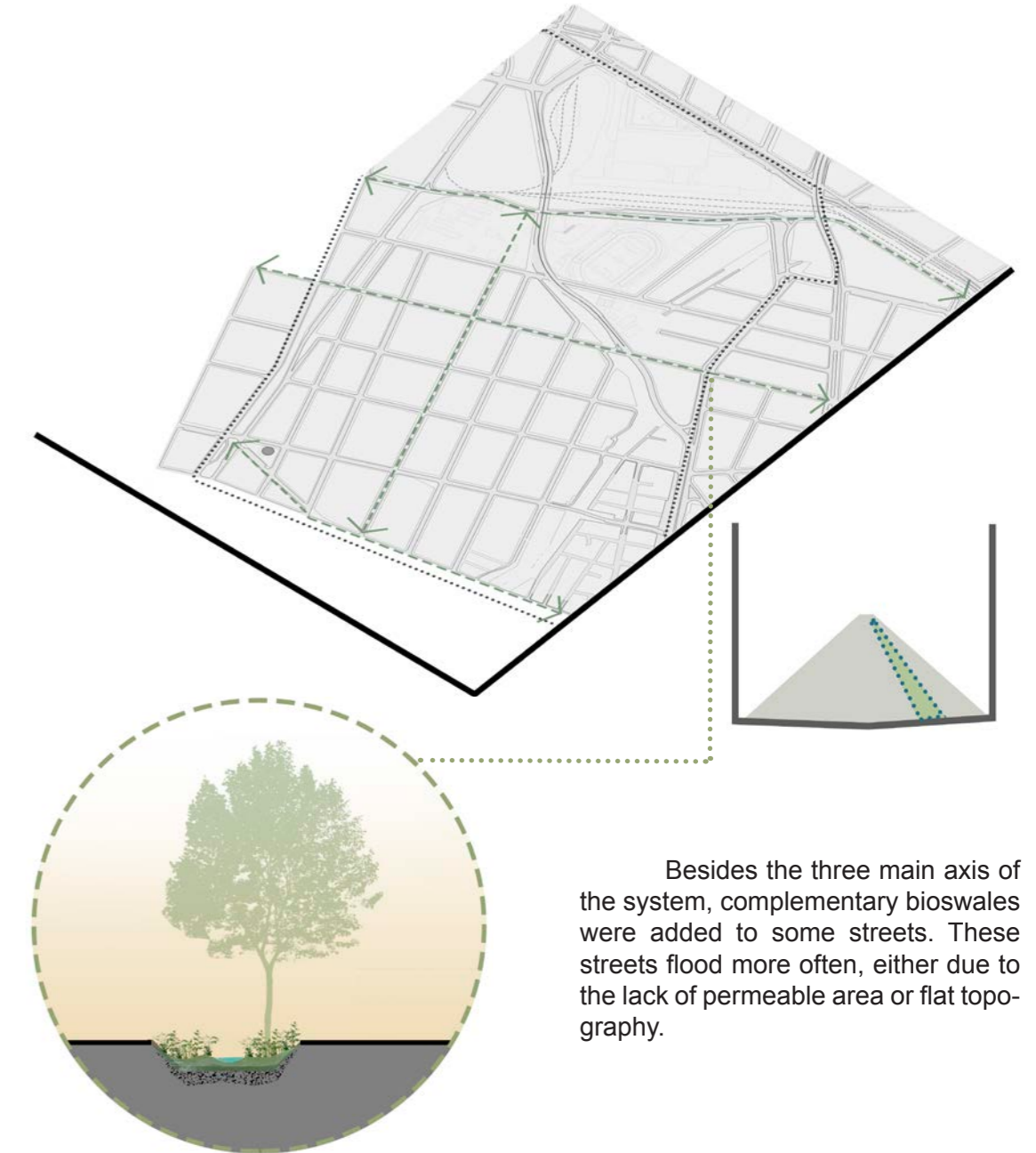
The arrows point to the direction where the water will flow and the marked blue areas are the spaces where the water can accumulate.

The three axis of the system work separately but simultaneously to protect the inner blocks but also the outer blocks. The water can be stored within this system and slowly released into the main Belém river, instead of flooding the lower level areas.

Flooding event - main areas where the stormwater can be contained



Complementary Bioswales



3.4.8 Adding layers

In order for these spaces to work as quality urban realms, as well as stormwater management areas, it was important to add layers to the project. The question here was how to make the protective measures attractive and relate them to its surroundings.

Firstly, it was important to bring people in, creating new buildings to shape the public spaces.

The area is already dense, but has many monofunctional spaces - with services and warehouses. The aim was then to **MIX** residential functions to the existing service.

Secondly, there was the question of making the public spaces attractive. To that the answer proposed was to add programs that create a unique **IDENTITY AND CHARACTER** to each of the protective areas.



1. new buildings- MIX!

The aim here is to mix more functions into the area, especially the residential function. Today, especially around the Delay and Retain axis, many buildings are monofunctional, with services and warehouses.

Therefore, the plots surrounding the new public spaces were analysed and five strategies for the buildings were outlined, depending on its location and current use.

How densification and Urban planning works in Curitiba

In Curitiba, Urban planning is mostly about creating public spaces and laws. When it comes to private buildings and densification, the municipality can only set rules about the function (what it can be, but not exactly what it has to be), maximum height, maximum square footage and distance from the street/plot boundaries. Apart from that, the design decisions are completely up to private owners, including the building typologies.

In order to have some control over the typologies of the buildings in strategic locations, a new category of building was created for this project, named municipality owned or co-owned.

Curitiba also has a special urban mechanism called "Potential acquisition". The law allows a maximum square footage and height, but if the owner decides to "buy potential" he can increase these numbers into a new maximum, also set by the municipality.

In this area, for example, the law allows buildings with maximum three floors for residential functions or two for services. However, it is also stated that if a private owner wants to "buy potential" he can then build up to 8 floors of residential function and increase in 1,5 times the amount of square footage built.

For these reasons, the new buildings on this project were divided into three main sections, which will be better explained on the following pages:

1. the municipality owned or co-owned buildings (divided into activators and affordable housing), where the function and the height could be controlled by the municipality;

2. the incentive to increase potential buildings (divided into Under-used plots and Poor condition buildings) which, based on certain characteristics, would receive free potential acquisition;

3. the future developments, which are plots that, with time, will be sold to developers and densified, especially when the new public spaces are fully developed.

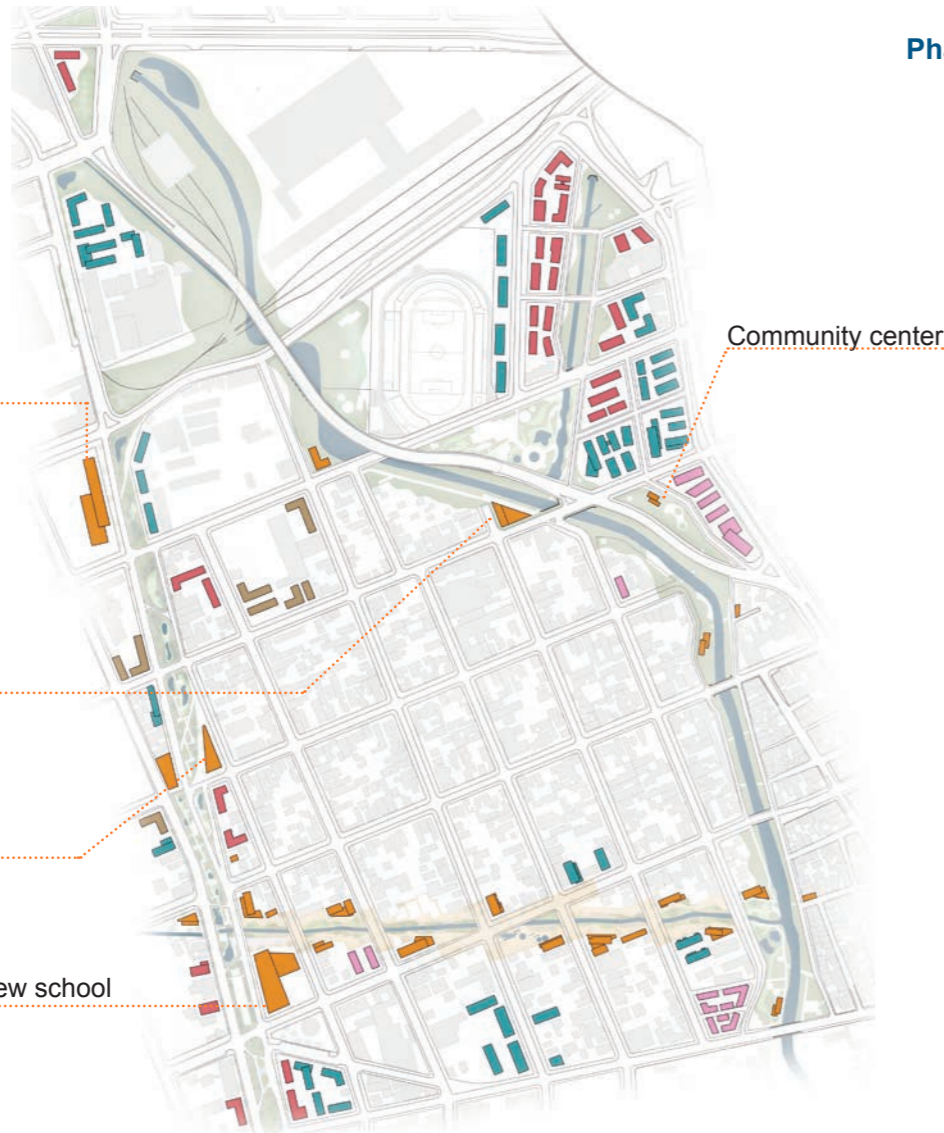
Most of the new activator buildings were thought to be residential or mixed use, but some of them, in key locations, received special functions, according to what was needed in the area.

Recycling center
Many people that live in this area are collectors of recycled material - a designated building for recycling could not only help their local economy but also keep the rivers clean.

Info point learning center about environment

Innovation hub/showroom
where local startups could show their products/services

New school



Phasing

- 1 Activators
municipality owned or co-owned
- 2 Affordable Housing
municipality owned or co-owned
- 3 Under used plots
privately owned
- 4 Poor conditions buildings
privately owned
- 5 Future Developments
privately owned

A phasing



New streets were opened when needed in order to break the big blocks into smaller ones.



1. Activators (municip.owned)

These are buildings that have a special location or function, which means that they would help activate the new public spaces. For this reason, they would be owned by the municipality or co-owned by the municipality and a private investor. The functions vary depending on the building, but they can be community centers, libraries or residential buildings. On the buildings timeline, they would be the first to be built, acting as activators.



2. Affordable Housing (municip.owned)

In order to assure that the area will have diversity in terms of people and income, some areas were chosen to be developed as affordable housing. The buildings would vary between 4 to 6 floors and would also be built by the municipality.



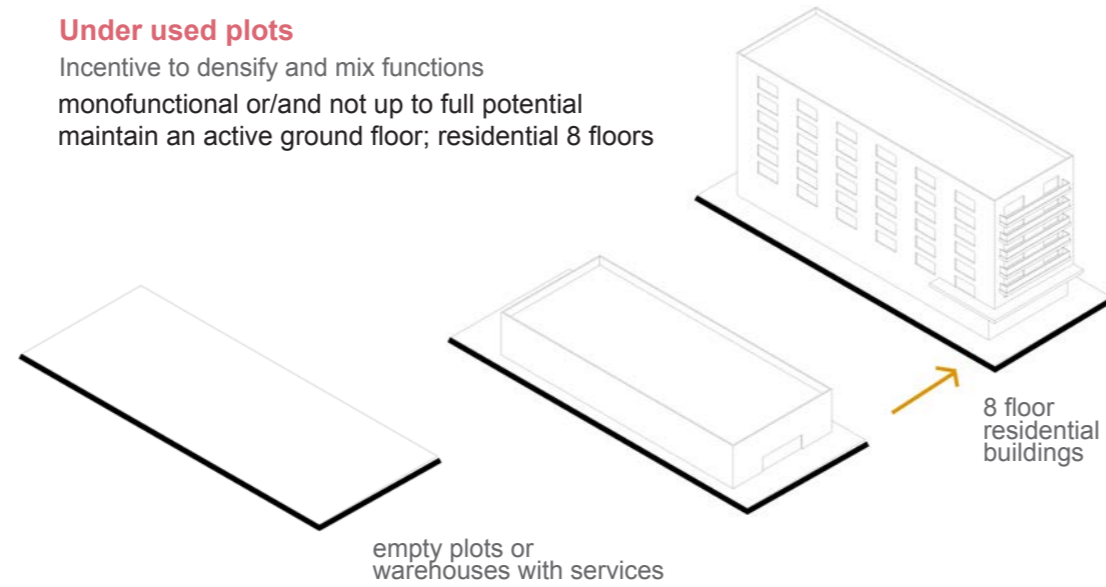
3. Under used plots (privat. owned)

In Curitiba the term “under used” plot means that it does not fulfill its full potential - in terms of constructed area or height. A typical example of an under used plot is a ground floor car park in an area where 8 floors could be built - a very common situation in Curitiba. In this area, plots with warehouses were also considered under used,

due to the monofunctional use and low height - mostly service warehouses with 1 to 2 floors. For these plots the idea is to maintain an active ground-floor but densify on top of it, with residential buildings of up to 8 floors. Plots that match these requirements would receive an incentive to densify, with a free “acquisition of potential”.

Under used plots

Incentive to densify and mix functions
monofunctional or/and not up to full potential
maintain an active ground floor; residential 8 floors



4. Poor conditions buildings (privat. owned)

As the under-used plots, the buildings that were considered in poor conditions would also receive an incentive to densify, with a free “acquisition of potential”, to build up to 8 floors of mixed use buildings.



5. Future developments (privat. owned)

These buildings also frame the public spaces but don't have a priority in the development of the area. They would be built on the last phase of the planning and are mainly residential/mixed use buildings.

2. IDENTITY AND CHARACTER

By adding a layer of identity and character to each of the protective areas, they can become attractive public spaces as well as flooding areas. The identities were inspired by particular characteristics of each area.

The aim is to create new positive encounters, relationships and experiences in these public spaces, which will be inclusive of all ages, lifestyles and social status/income.

"What matters is not that everyone is included. It's that no one is excluded"

Suketu Mehta



Culture and innovation through playful decks

The axis connects south to north, from an existing theatre to the area planned by the municipality to become an innovation district.

Urban celebration of water active sidewalk + walls

A new public space is created, with the river being revealed in the middle of an urban area. New features inspired by interaction with water and new social encounters are brought in.

The Riverfront Experience

Ecological corridor

The main river is already a natural ecological corridor, from North to South of the city. With the addition of sports and daily activities, a new riverfront is created.

Elements/Activators

New elements/activators (such as buildings or outdoor spaces) were added to each of the protective axes, according to the identity created.

Here are some of the elements researched as possibilities to enrich the public area.

Daily social habits

- Boardwalk
- Canopy walk
- Observation decks
- Benches + tables
- Playground
- Outdoor gym
- Deck and stairs
- Dog park
- Canopies
- Green house
- Urban farming
- Info point
- Bar and restaurants
- Local food market

Sports

- Skate
- Bike parking/renting
- Climbing
- Adventure Park
- Volleyball/basketball field
- Running track

Culture/Innovation

- Open stage/amphitheatre
- Library
- Learning/community centre
- Street Art
- Startup demonstrations
- Innovation hub

Environmental Recreation

- Interactions with water
- Butterfly park
- Bird houses
- Edible park
- Sensory Garden



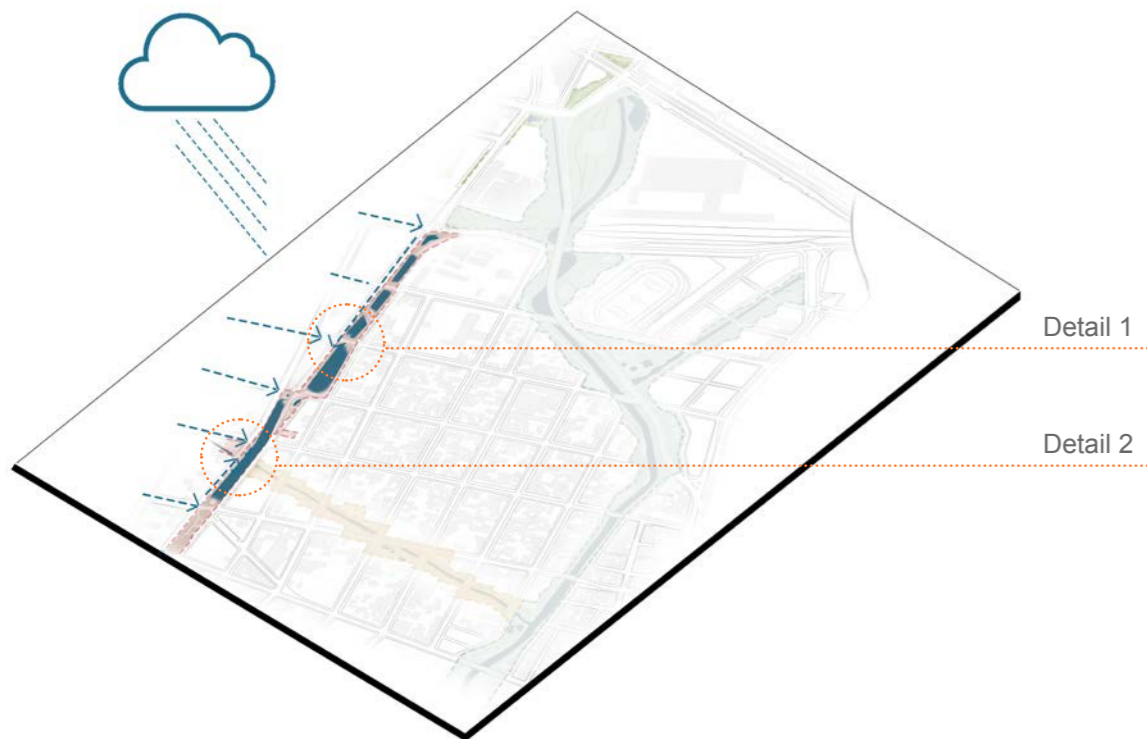
3.4.9 The new public spaces: combining stormwater management and new public realms

Each of the protective areas is now further detailed in sections.



Delay and Retain
stormwater locally

Culture and innovation
through playful decks



The former train track space, today a residual space in the urban tissue, is transformed into a retention boulevard to delay and retain the water from flooding. The idea is that the water can be stored here and slowly released to the rivers, minimizing flooding events.

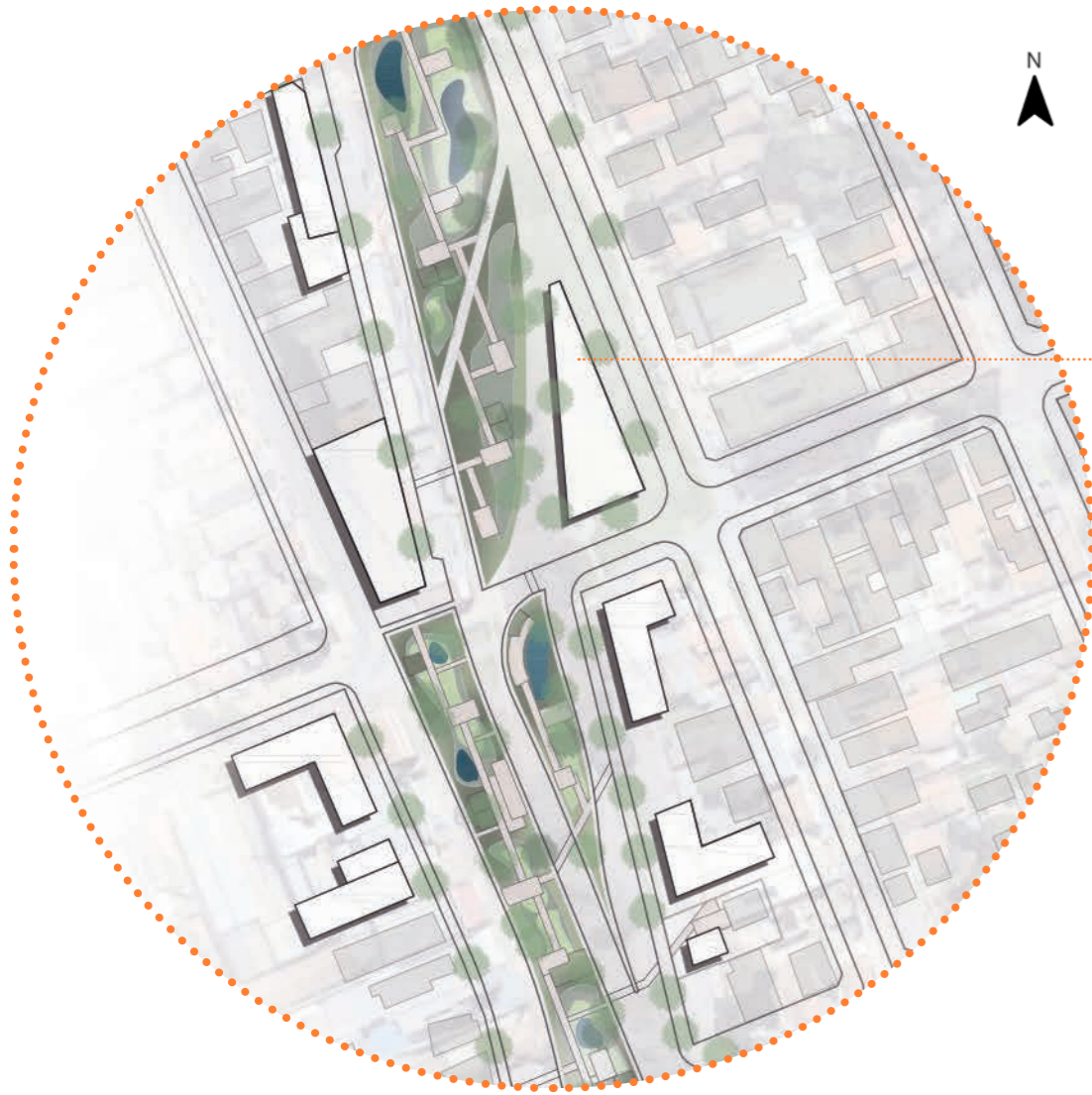
Due to its proximity to the Paiol theatre and to the future startup

innovation centre, it becomes a cultural and innovation axis. The idea is that this space could be used for pop up events on innovation and arts.

The decks are part of this new space, being the base of the public space. They allow the water retention to happen underneath them. With time, new functions and small pavilions can be added, temporary or permanent.

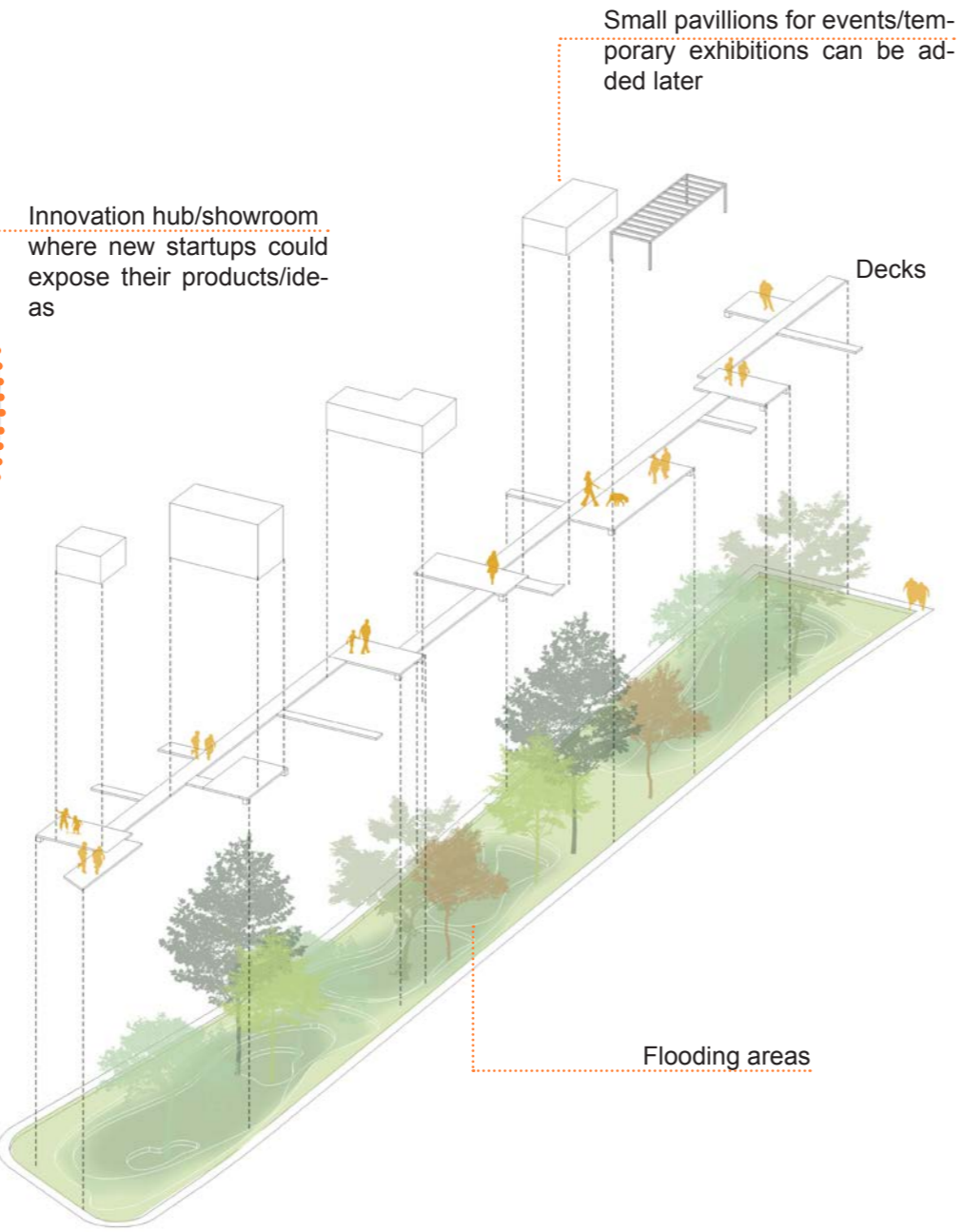


Section 1:200



Detail 1
Scale 1:2500

Retention boulevards and add-on decks



Small pavillions for events/tem-
porary exhibitions can be ad-
ded later

Innovation hub/showroom
where new startups could
expose their products/ide-
as

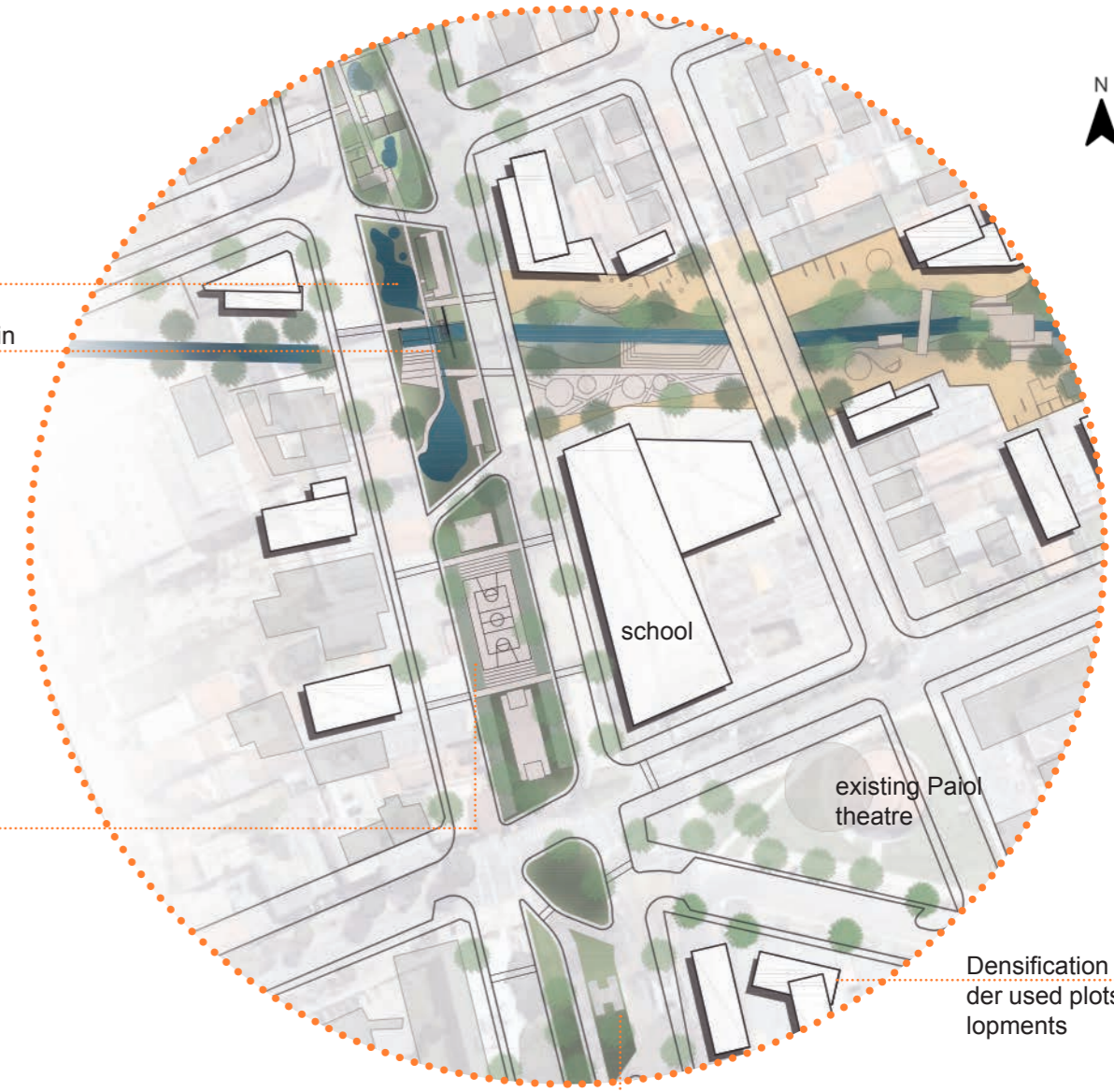
Decks

Flooding areas

Detail 2
Scale 1:2500

Where the two axis meet. The area
has already some sport fileds today,
that were rebuilt in different levels, to
allow them to also contain water if ne-
cessary.

The existing theatre is maintained and
the school is rebuilt in a new building.
Today, it is usual that the school has
floodings, due to the low level of the
building in relation to the street. With
the new responsive system and the
building in a new upper level, the idea
is that the cloudburst events will have
less impact on the school.



retention ponds

old historical train
bridge

school

existing Paol
theatre

Densification as part of the un-
der used plots and future deve-
lopments

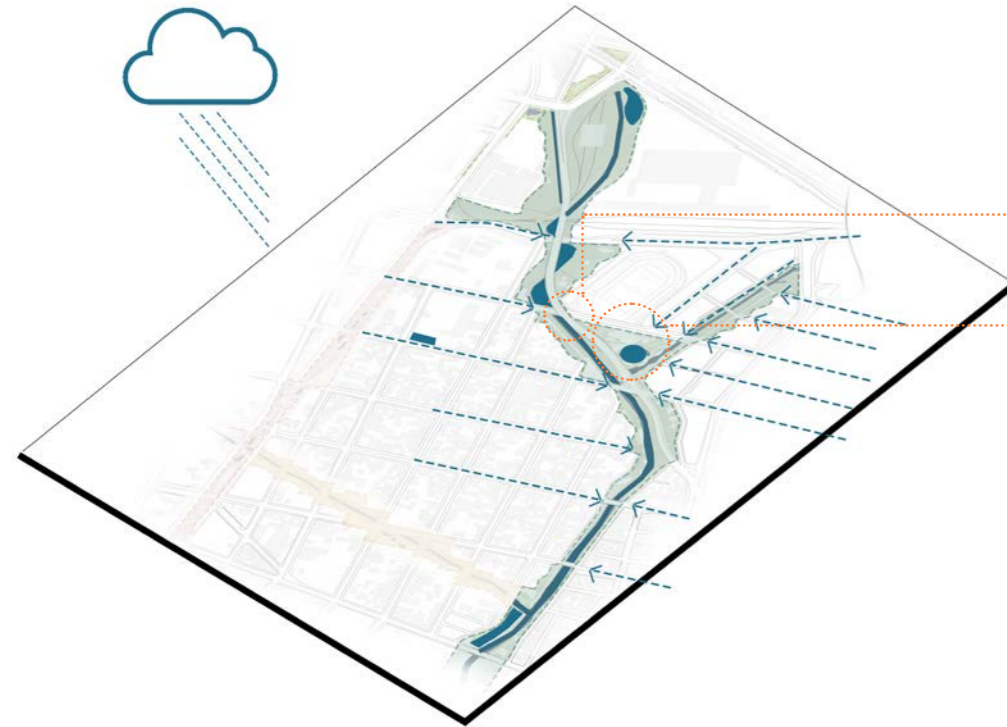
Current bus stop is maintained



Connect and access

The Riverfront Experience

Ecological corridor



Elevated highway sections

Water Square

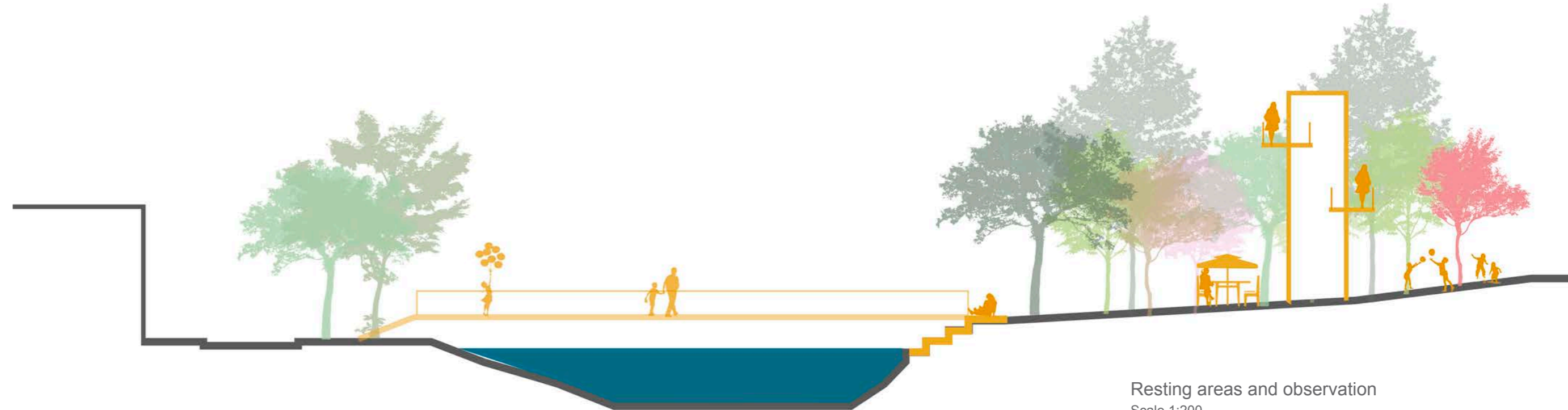
This area contains the Belém river and one of its tributaries, the Juvevê river. The area is difficult to work with due to the narrow space around the main river and the elevated highway that passes along it.

The idea here was to create a blue thread and ecological corridor along the main river. As much as the existing urban tissue allowed, the area around the main course was enlarged. When the topography allowed, and based on the areas that usually

flood, flooding ponds were also created.

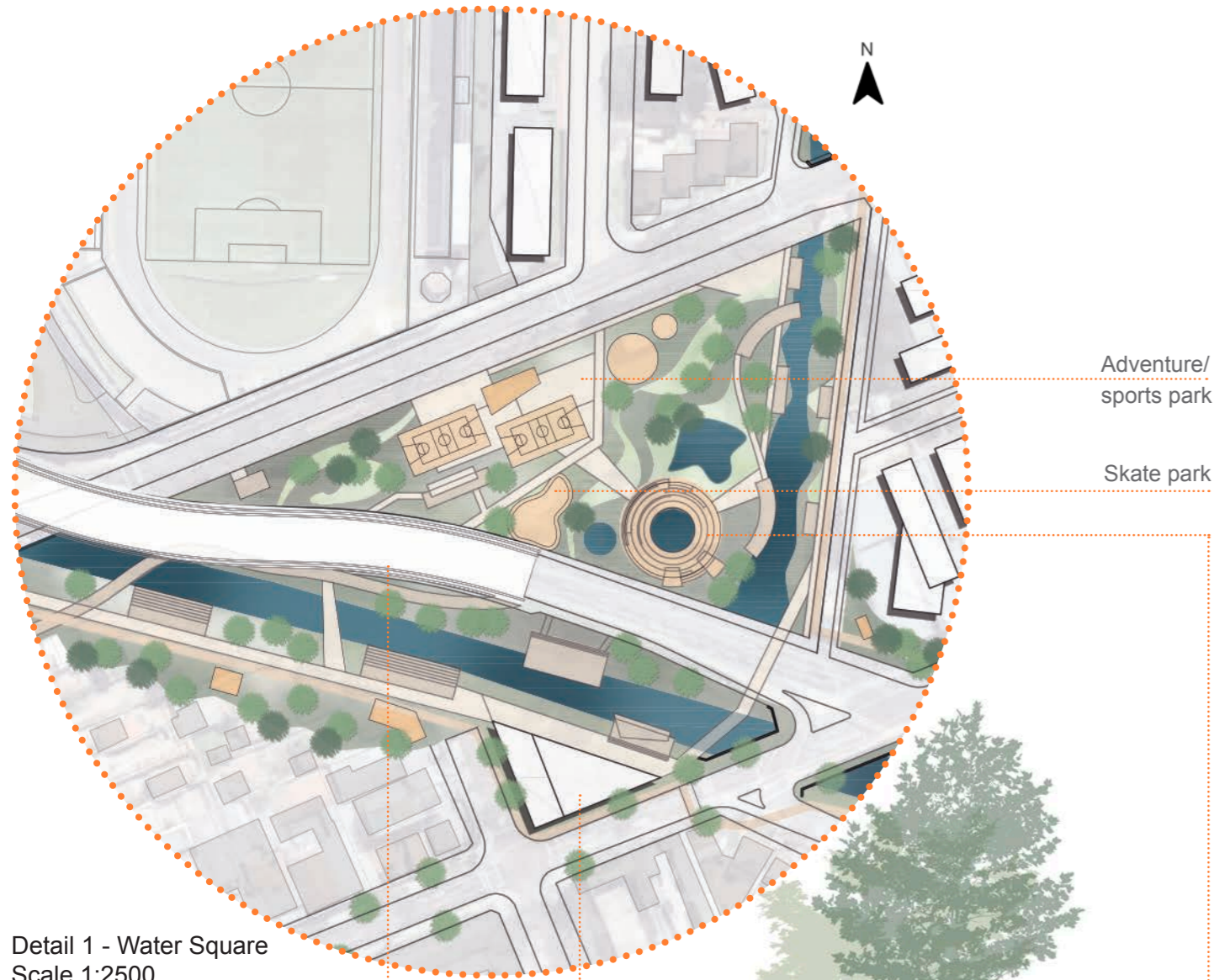
Connecting both sides of the river in different areas, making the crossing easier was also one of the aims.

This was also a key place for reintroducing the river into people's daily lives. That is why it is called the Riverfront Experience. Interaction with water, resting areas, canopy walks and observation decks/towers are all part of this reintroduction.



Resting areas and observation

Scale 1:200



Detail 1 - Water Square
Scale 1:2500

Elevated highway - once taken away,
the water square and the main river
can be completely integrated

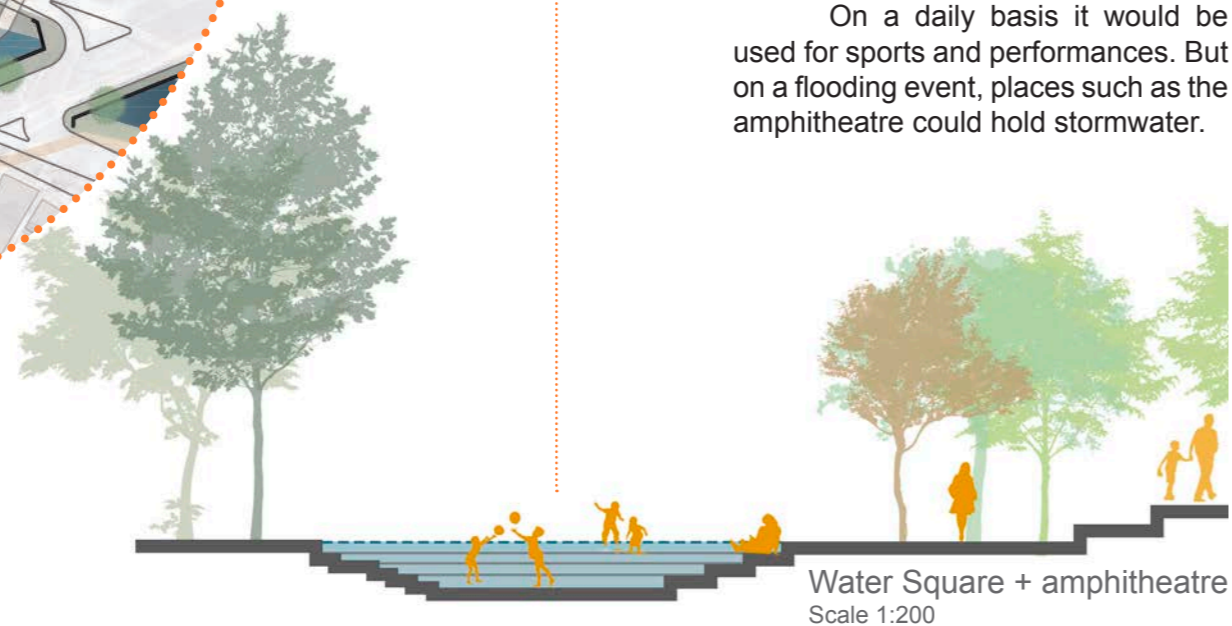
Info point

An important part of the design of this area was the Plinio Tourinho Square. Today, this square is dedicated to sports but its mainly abandoned. It is enclosed with a fence all around it and it has an unsecure atmosphere. Many people choose not to use it.

The redesign of the square was part of the idea of renovation of the area, maintaining some of the functions found today, but integrating it better with the city and the river.

Adding the stormwater management ideas into the square led it to be called the Water Square. This is because the square is on a lower level in comparison to the surrounding areas. The intention is that the square can flood completely on a flooding event.

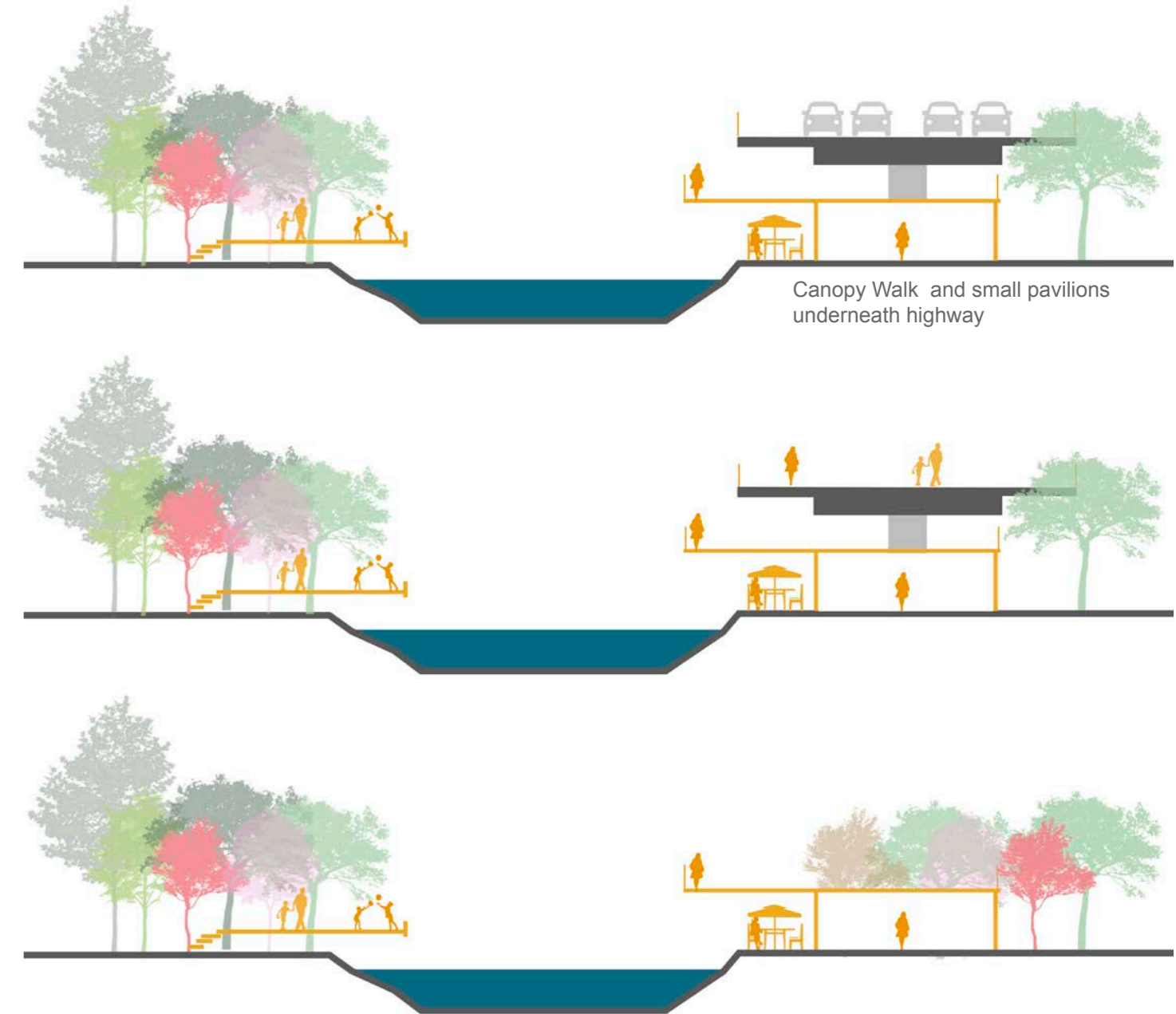
On a daily basis it would be used for sports and performances. But on a flooding event, places such as the amphitheatre could hold stormwater.



Water Square + amphitheatre
Scale 1:200

A timeline of how the space underneath the highway could be used and integrated to the public space. Eventually, the elevated highway can be removed.

- 1 First intervention
creation of a canopy walk that intersects the elevated highway.
- 2 in 3 years
the traffic is rearranged in a way that the elevated highway can be used only by pedestrians, or in a shared way
- 3 in 5 years
the elevated highway can be demolished and the river is free



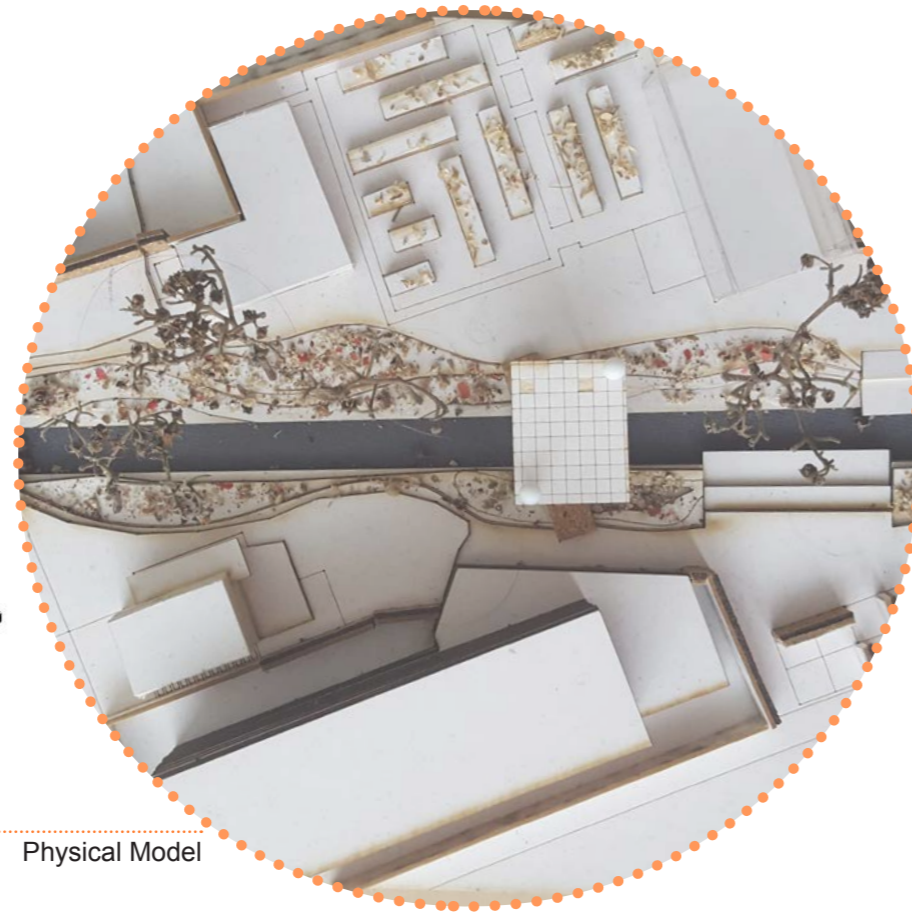
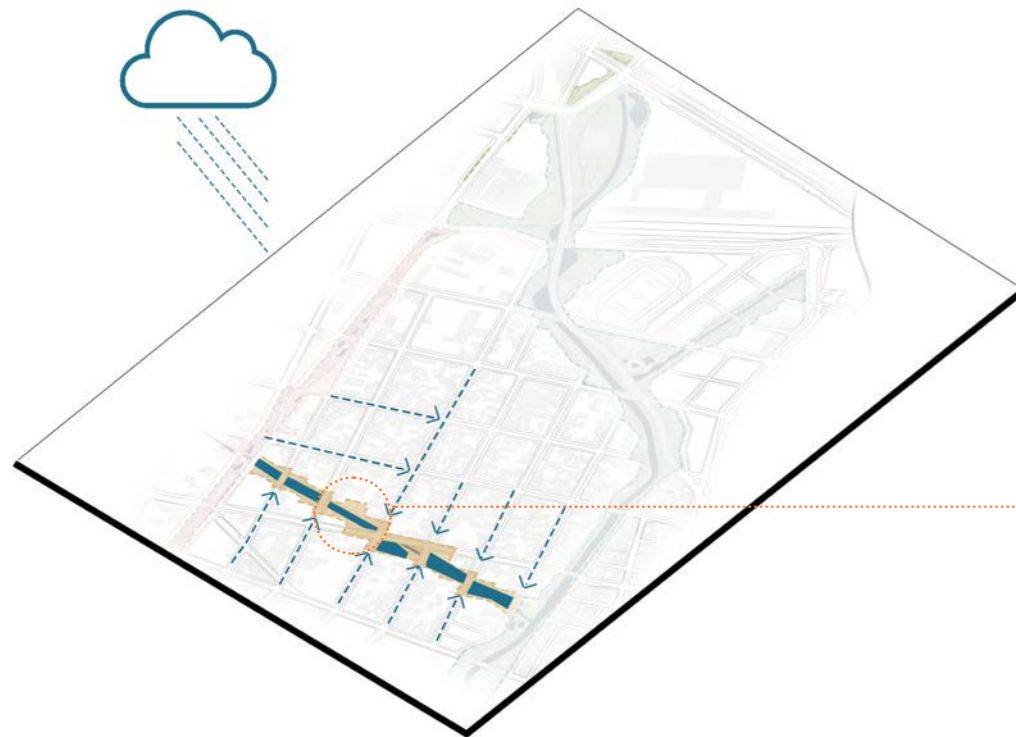
Canopy Walk and small pavilions underneath highway



Reveal and restore

Urban celebration of water

active sidewalk + walls



Scale 3 - detailed design

In this scale, one of the areas of the system is detailed. The chosen area is the revealing of the Água Verde river.

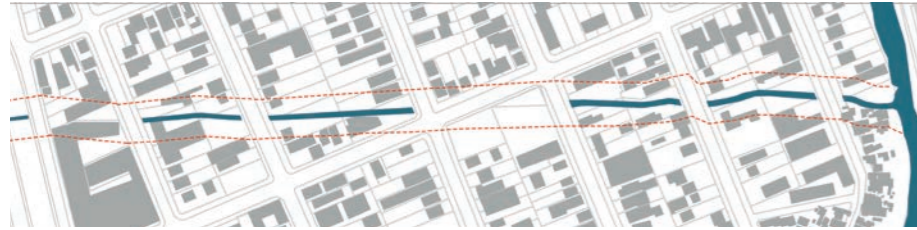
The toolbox for this area is Reveal and Restore. This means that the Água Verde river, which is today hidden by walls or streets, can be re-discovered again. More space will be given to the river, so that in a flooding event, it can contain the water within itself.

The plots where the Água Verde river passes through are privately owned and fenced. The idea here is to “carve” into this walls and reveal the river, creating a new public space.

In addition to the stormwater management layer, the additional layers of - Mix -, adding new buildings, and - Identity and Character - will be also further detailed and explained.



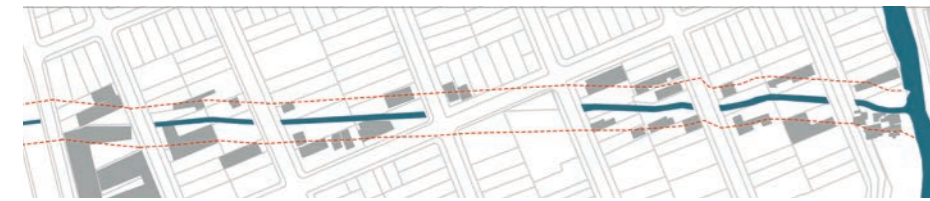
The first step on the revealing of the river was to mark 15 meters on each side of it. That would be the minimum space around it.



Existing situation



Existing situation: walls don't allow people to see the river, even when it is not covered



Buildings that needed to be removed because they were on the 15 meters mark.



First study model built - with the walls "carved". It was then possible to see what type of space was being formed, in between walls.

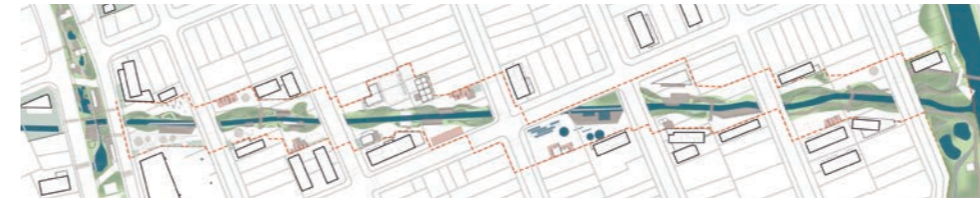
The river passes through the middle of the blocks, connecting the former train tracks to the Belém river. In Curitiba, and especially in this area, the standard way to build is to first build a wall around the property and then the building itself.

This meant that all the properties were surrounded by walls, and when the

buildings and coverings of the top of the river were taken out, a new type of place was formed: an enclosed space, with walls on both sides and no buildings facing the new area. This became a new challenge to overcome, how to make sure that the area would function well as a public space?



Additional plots beyond the 15 m that could be used to create a bigger public space or bring new buildings/functions around it.

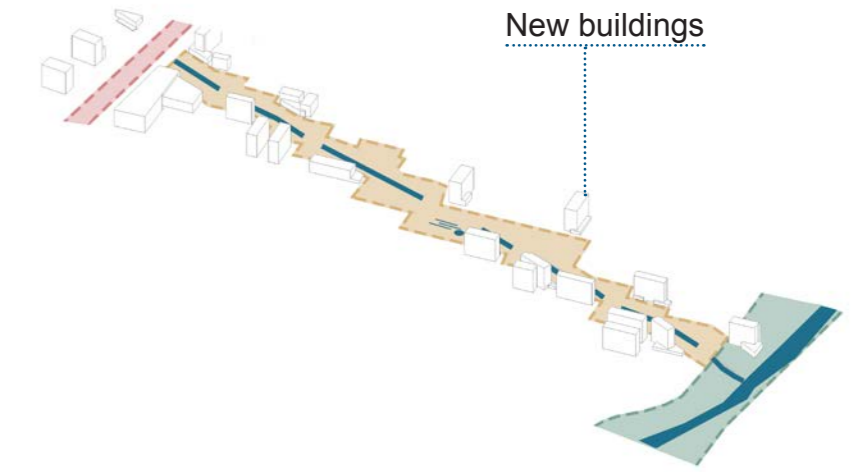


Within the newly opened area, a new public space started to be created, with wetlands on the immediate surroundings.

Besides the buildings that had to be removed, another set of plots around the marked area were analyzed - in terms of use and current condition.

The plots containing empty, monofunctional warehouses or buildings in bad conditions were incorporated to the space, to be able to bring new buildings and mixed function to the area.

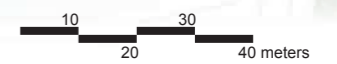
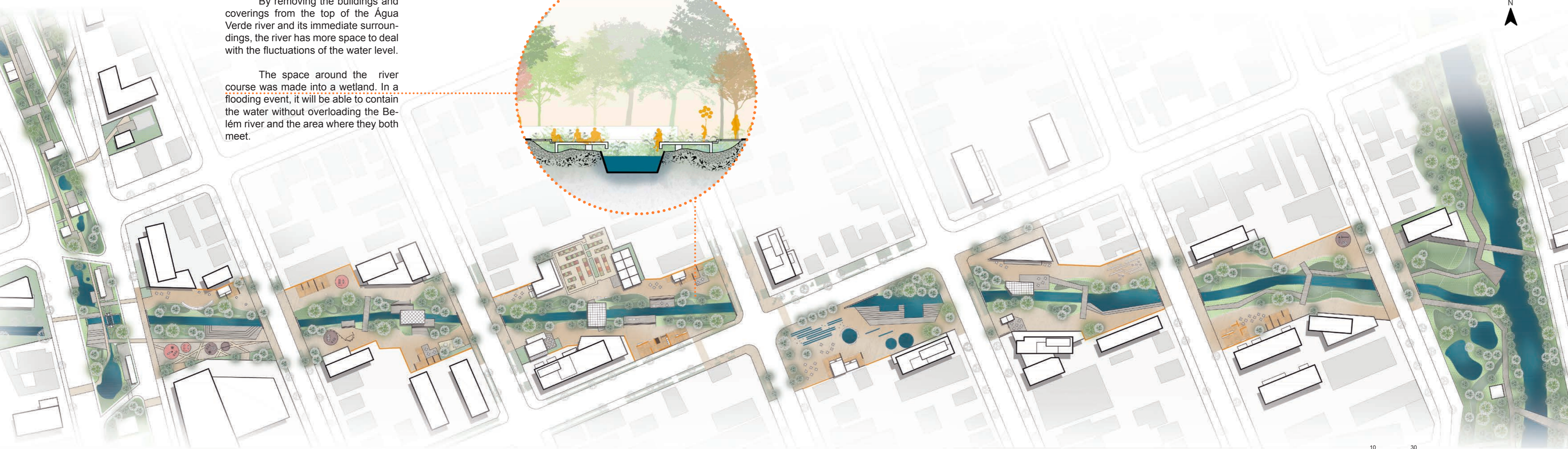
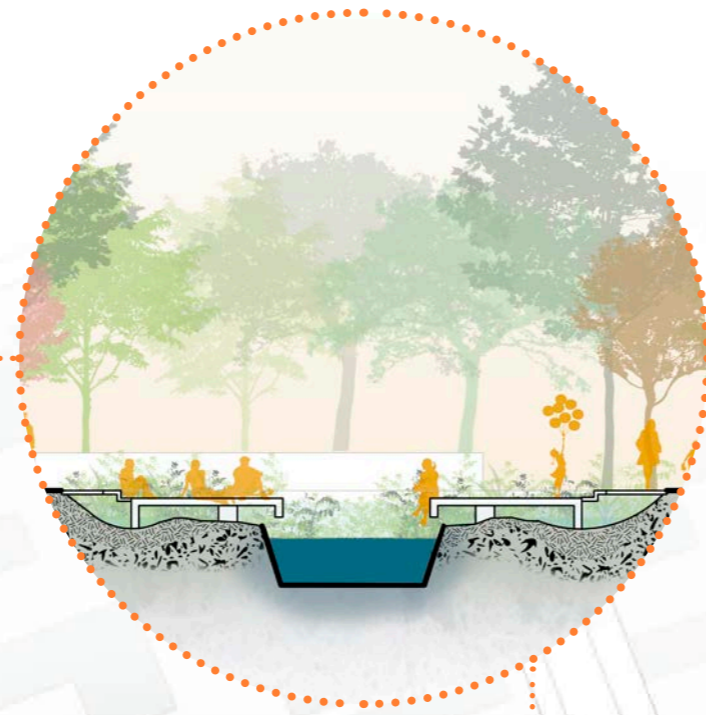
The new buildings would also help in having façades facing the new public space.



New public space shaped by walls/new buildings.

By removing the buildings and coverings from the top of the Água Verde river and its immediate surroundings, the river has more space to deal with the fluctuations of the water level.

The space around the river course was made into a wetland. In a flooding event, it will be able to contain the water without overloading the Belém river and the area where they both meet.



Mix! Building Typologies

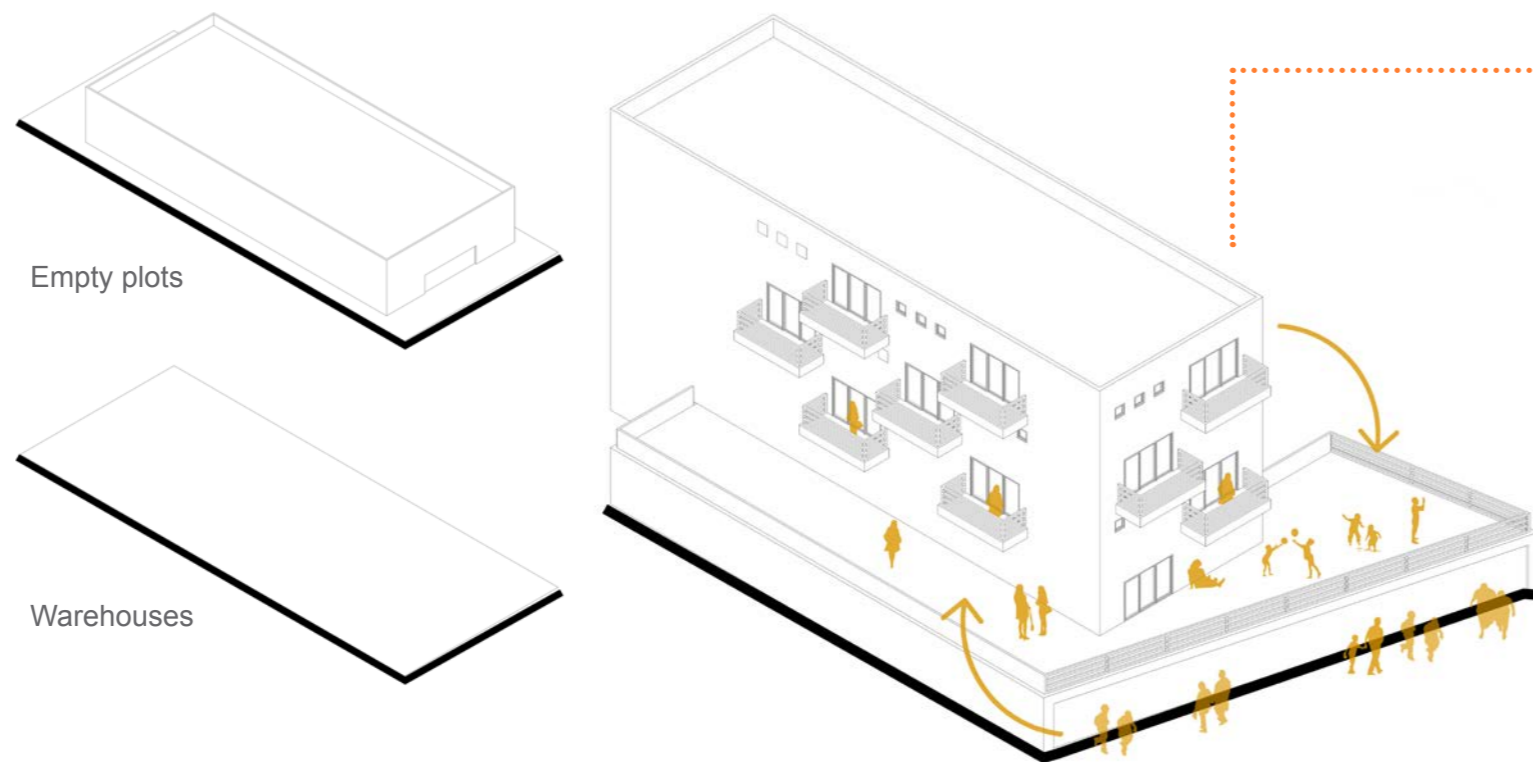
After the 15 meters on both sides of the river were secured, the existing boundary plots around the new space were analysed. Among those plots, the ones with empty plots and warehouses were the base to densify and mix the area, bringing in a new mix use typology.

In the case of existing warehouses, the idea is that some of their functions could stay, but a new residential building could co-exist in the same plot.

It was important that this new buildings had their front façades to this new public space, in order to activate it.

One of the issues considered here was the level of security that this new urban space could provide. It is often the case in Brazil, that areas with

a small number of users and with no front façades towards the public space become dangerous. The mixed use and the wide range of activities proposed to the area are the answers used here to activate the area and make sure that the space will be used frequently, therefore increasing its security.



Empty plots

Warehouses

Active Groundfloors (services)
4 floors residential building
First floor offers gathering spaces for both the residential building above or the groundfloor services, depending on time of the day and need.

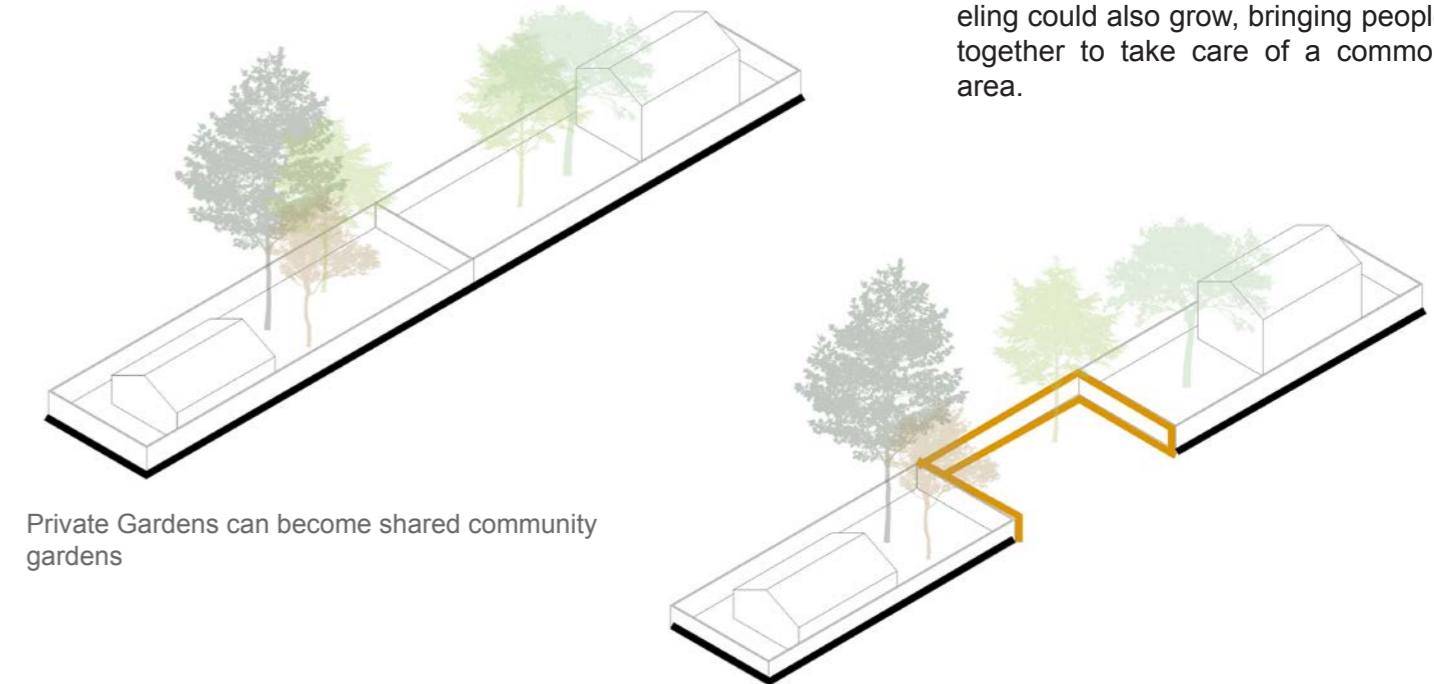
Following the idea of activating the area, a building typology was proposed. The buildings that frame this new urban space were thought to be part of it, interacting with it. The ground floors would be services and the first floors will have balconies. The buildings have residential functions on the upper floors, up to 4 floors.

Most residential building in Brazil have social gathering areas, which are unused most times during the weekdays. In this case, this area was placed on the first floor, creating a shared space between the residential building and the service bottom floor. This would maximize its usage. The open terrace also enhances a connection to the public space on the ground floor.

Besides empty plots and warehouses, the area has many single houses with big private gardens.

In order to further integrate the private areas to the public one, some of the plots with private gardens were added to the public realm as community gardens.

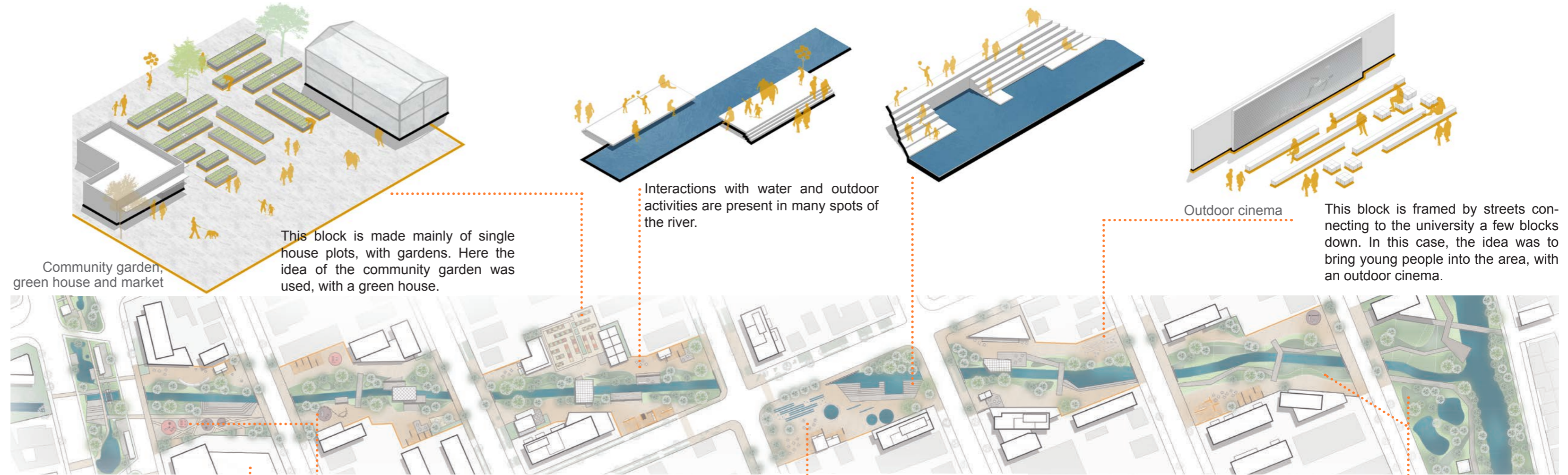
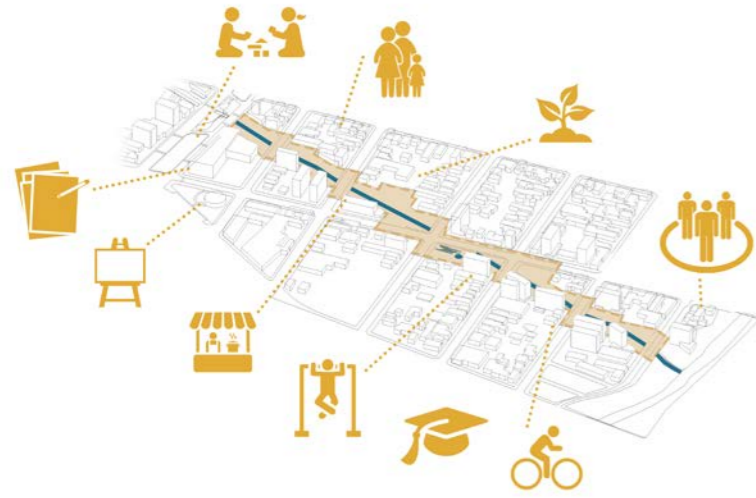
In that way, the community feeling could also grow, bringing people together to take care of a common area.



Private Gardens can become shared community gardens

Identity and character - Public space typologies

Finally, it was important to attract the people of the surrounding areas into the new public space. In total, 6 blocks are being cut through by the river and now new public space. For each one, different urban programs and activities were added, taking into account the surrounding block's existing functions and users.



Community garden, green house and market

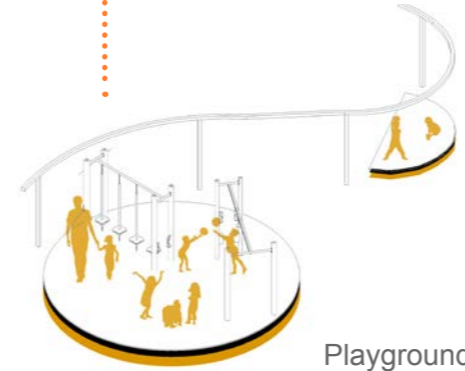
This block is made mainly of single house plots, with gardens. Here the idea of the community garden was used, with a green house.

Interactions with water and outdoor activities are present in many spots of the river.

Outdoor cinema

This block is framed by streets connecting to the university a few blocks down. In this case, the idea was to bring young people into the area, with an outdoor cinema.

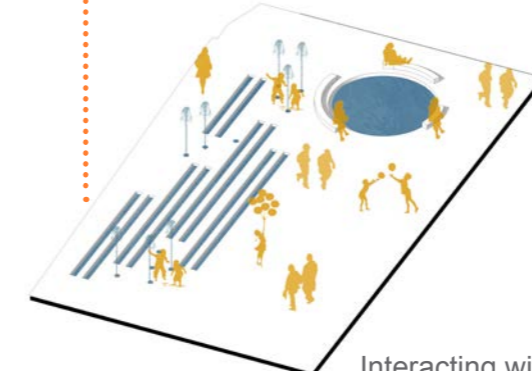
The first block had a school that usually flooded because of the level where it was built - below the street level. The idea was then to build a new school building in the same place and, on the first two blocks, create playgrounds and areas for children and their parents, that can be used on weekdays, before and after school and also on weekends.



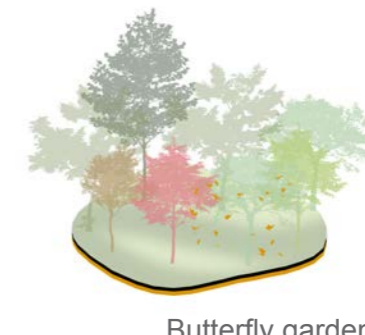
Playground



Outdoor gym



Interacting with water

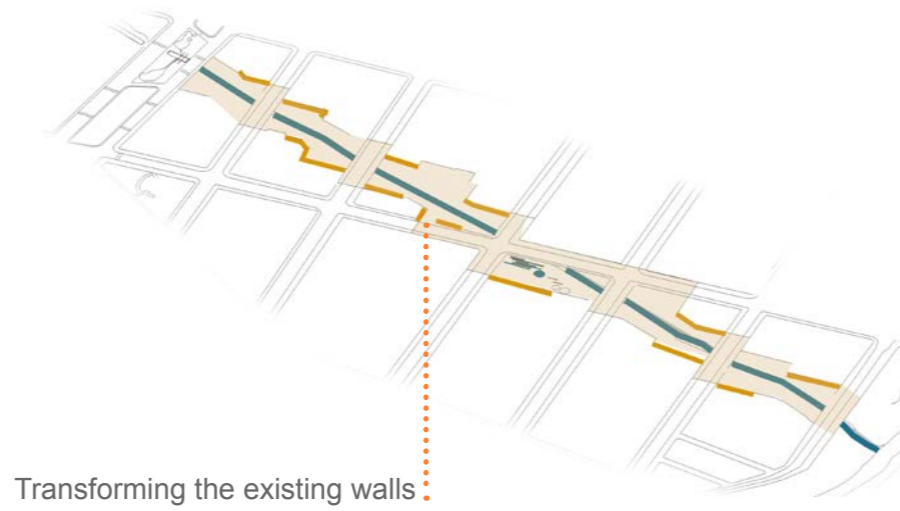


Butterfly garden

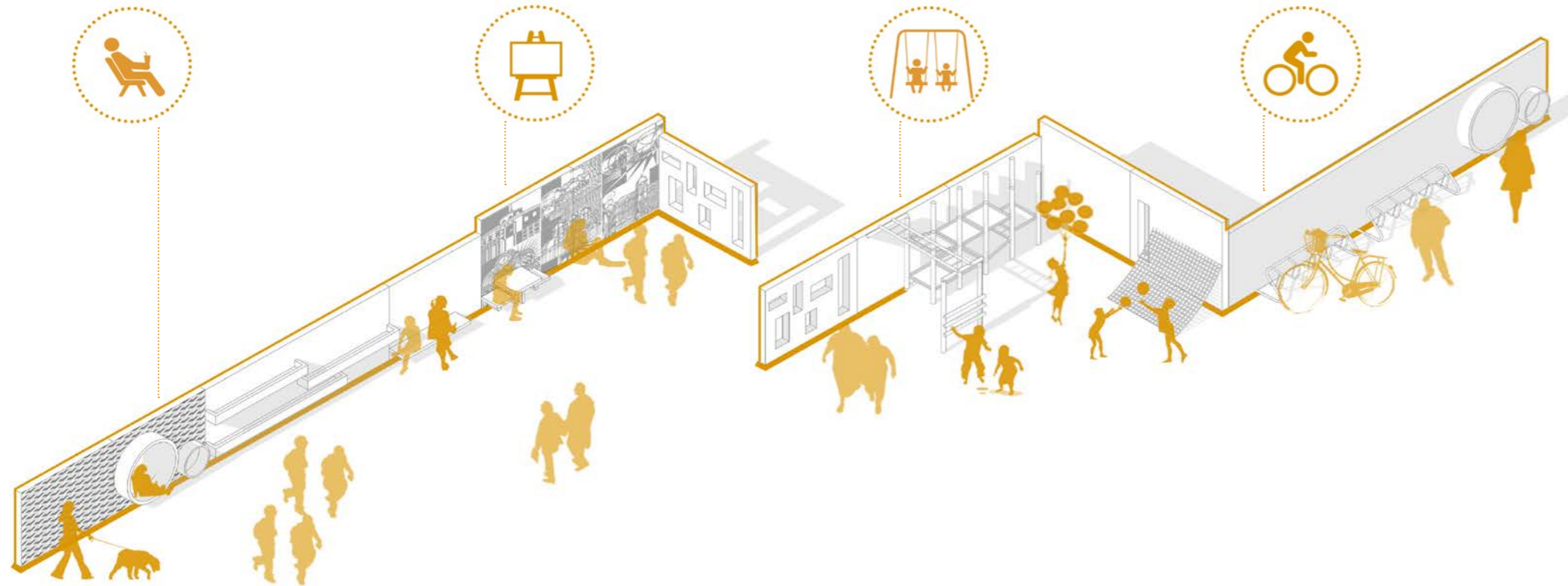
Closer to the main river, where the flooding is usually more severe, a constructed wetland was proposed. The biodiversity here is enhanced with gardens, as the butterfly one.

active wall + sidewalk

The existing walls were a big part of the character of this new urban space. The idea was to turn this challenge into a tool to make this urban area attractive. They were made into “active walls”, where functions can be added to them - street art, playground, sitting areas, bike parking, etc.



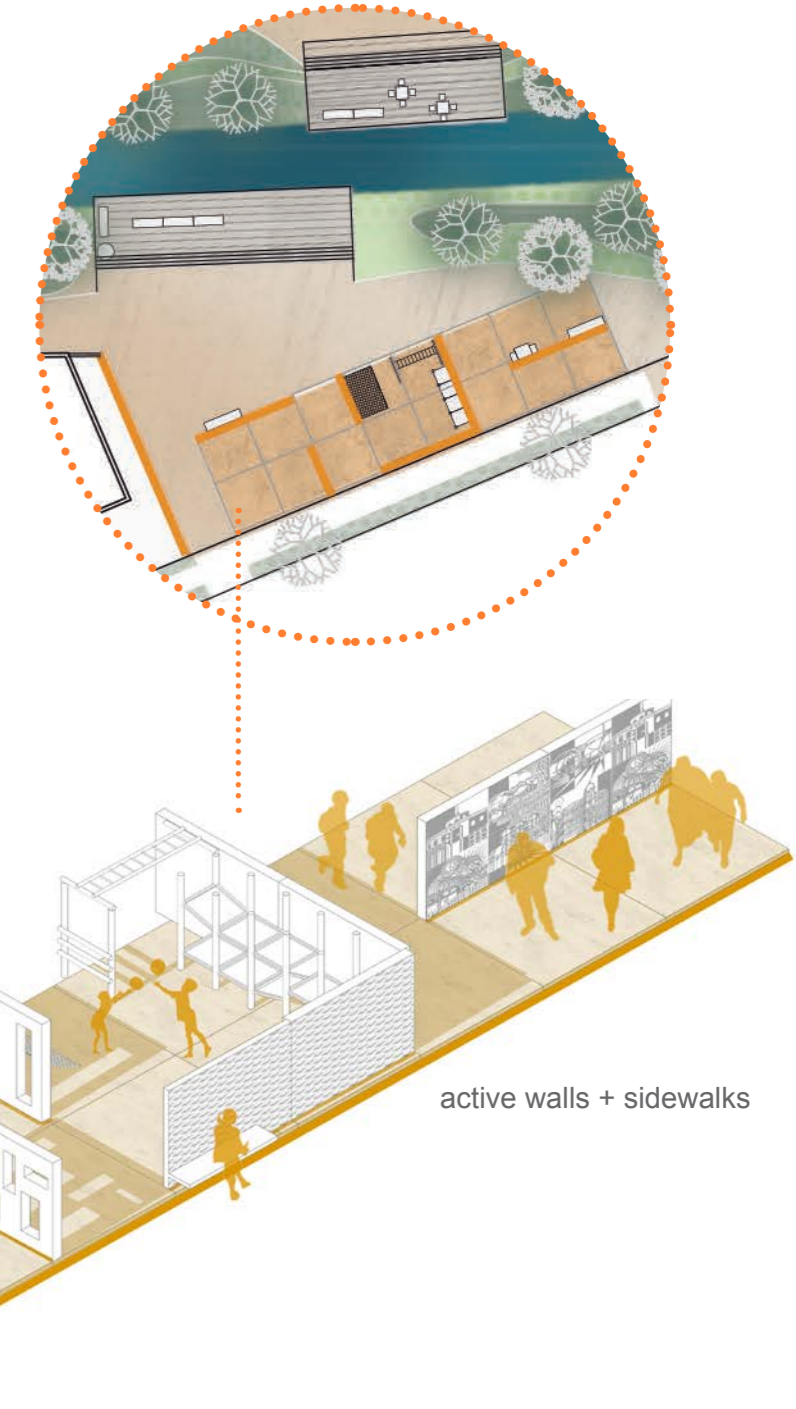
Transforming the existing walls



For the past years, a new way of meeting in Curitiba increased its popularity. People started taking over the sidewalks to eat and drink, in a more casual way, with no tables. The places that sell food and drinks are usually quite small - there's enough space for a counter and a tiny kitchen.

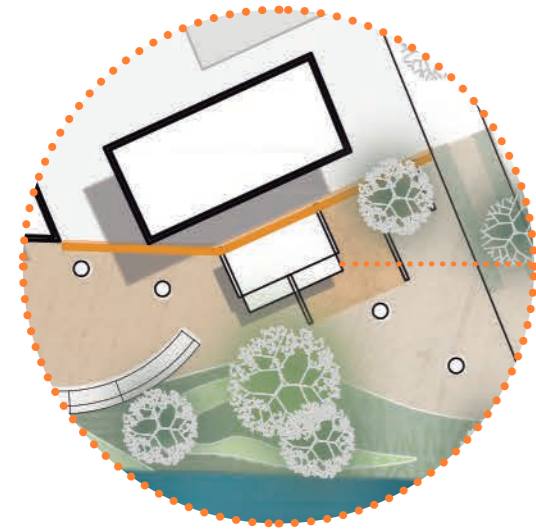
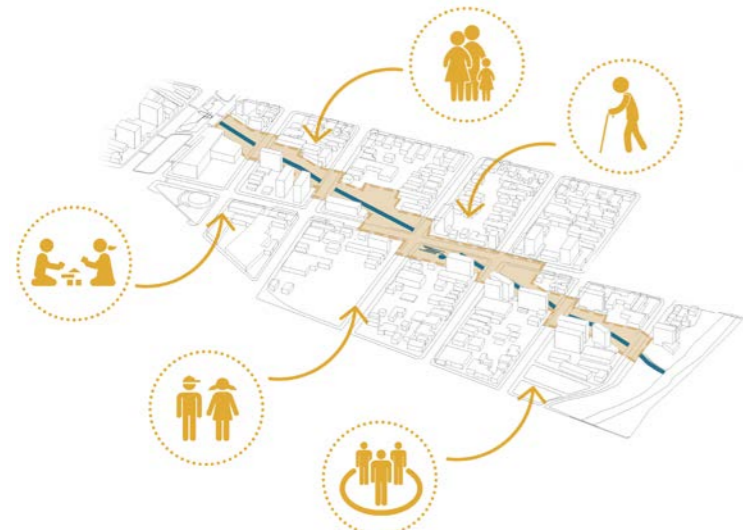
Since it has no tables or waiters, the food becomes cheaper, and therefore, this type of business became a huge success.

The idea was to bring this concept, which is very “Curitibano”, to the site with the active sidewalks.



active walls + sidewalks

The active sidewalks would offer a base structure that could later on have elements/buildings added to it, creating stores, food shops or exhibitions spaces. The variety of activities is key to bring a variety of people.



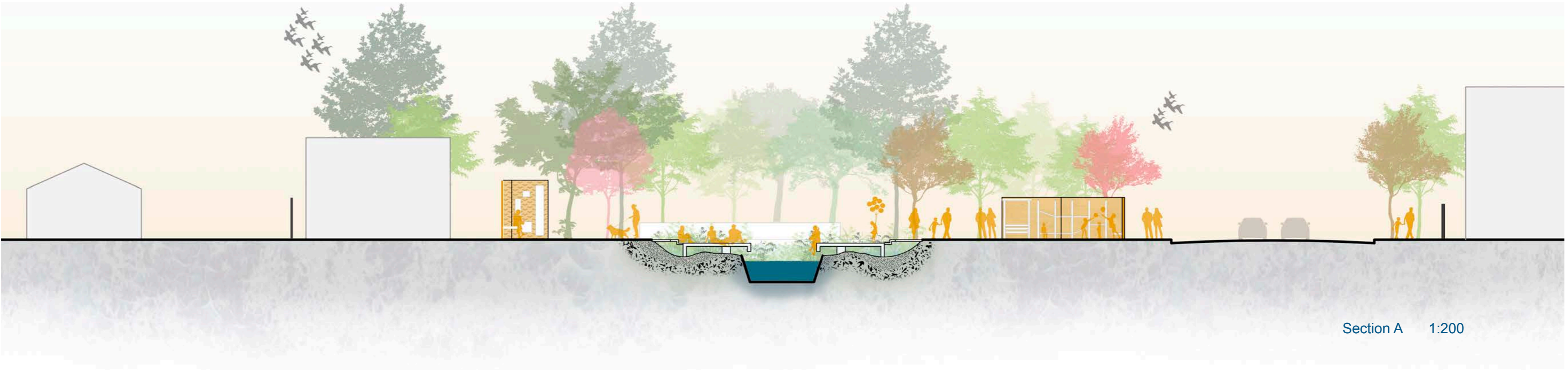
Flexibility: initial base structure

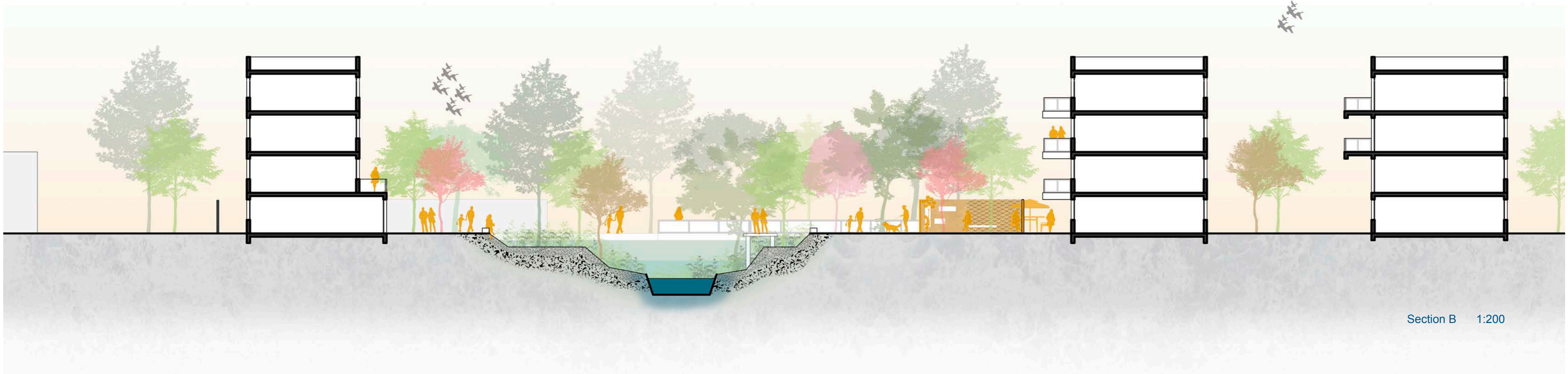


stores/elements added



3D view





Section B 1:200



Physical model



3D view

Thoughts on timeline and costs

A phasing was already mentioned when talking about the new buildings and the elevated highway. In the first case, the phasing was based on the needs to improve and mix the area.

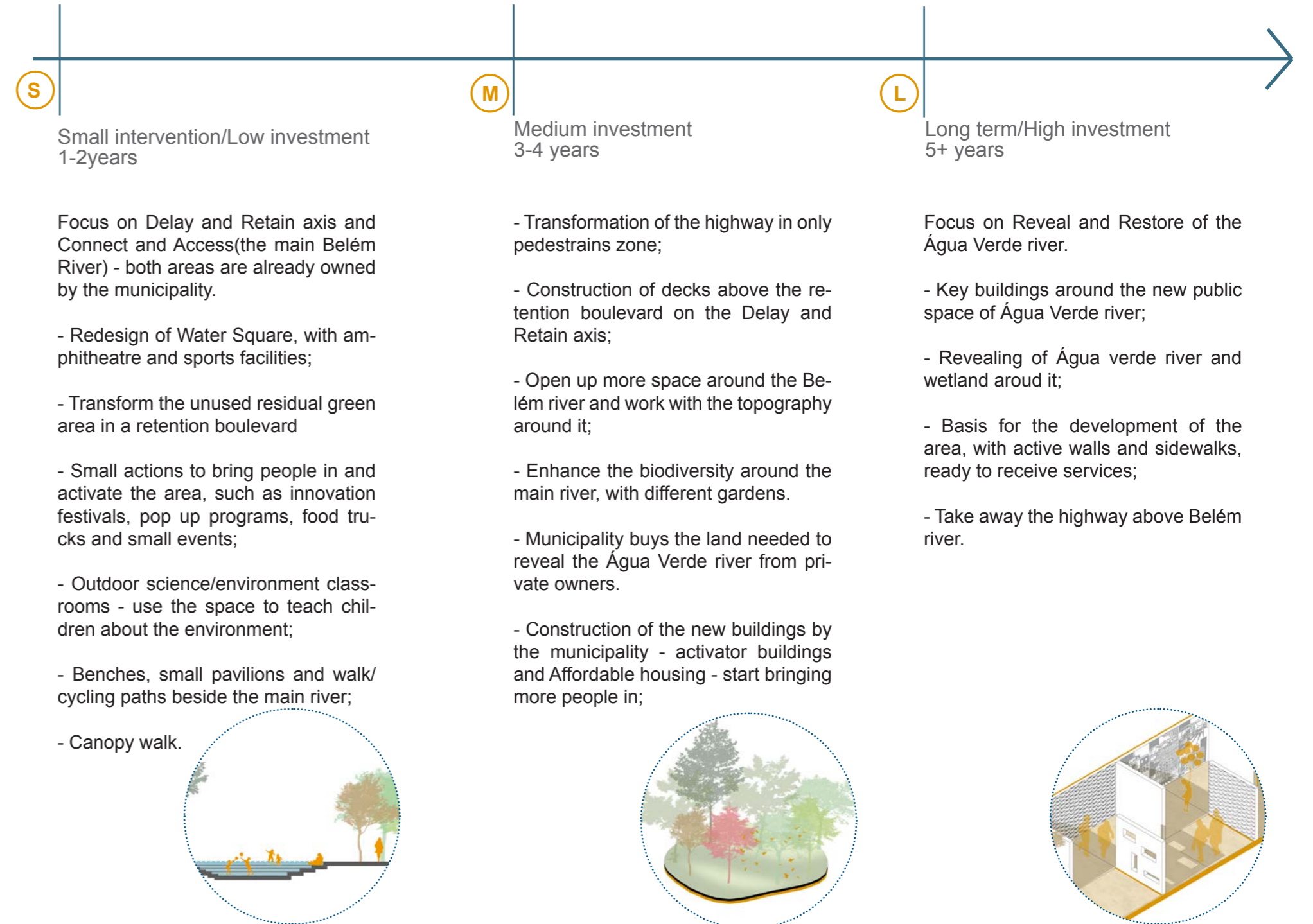
In the case of the highway, it was made due to the importance of that street in the city today. Rearranging the traffic and repurposing the elevated highway would need further infrastructure developments around the area - to make sure that the traffic would still work without that particular street.

However, another important issue when considering phasing in this project is the cost of all the interventions, especially in a developing country such as Brazil. The eventual shortage of money for the investments suggested in this thesis project was the biggest issue considered.

The whole project would be too expensive to be implemented at once, so the idea is to divide it into a phasing menu that takes into account the amount of money needed.

In general, the strategies contained in the Delay and Retain toolbox and Connect and Access would be the first ones to be implemented. The Reveal and Restore actions requires more investments from the municipality, being left for a later stage.

Within the three parts of the system, some actions were thought to be of small investment, which could be done in 1 to 2 years. Some were considered of medium investment, made on the third and fourth year. And later on, some parts of the project were considered a long term investment, due to their high cost. They would be done after 5 years. In this way, from the fifth year on, the whole strategy would be able to function as a whole.



conclusion

The thesis aim was to show alternatives of how to deal with flooding and cloudburst events in an existing dense urban tissue. The two main goals were to respond to flooding (environmental layer) and create a relationship between people and the rivers (social layer). Both layers were dealt with by bringing ideas that were site specific but that could also be applied in other sites within Curitiba and even other cities. If this work would be continued, it would be interesting to try to apply similar ideas and the stormwater management toolbox to other areas in Curitiba.

Many ideas were proposed here, which, in this thesis, work all together. There were two reasons for the variety of the solutions proposed:

(1). responding to the various situations encountered;

(2). adjusting to the fact that the budget for projects like this may be limited in Brazil. The aim was to show that even small interventions can be done and that they could make a difference. Of course, they would work better if all combined, but the interventions could be done over time, as the budget allows.

Finally, the ideas proposed here represent the beginning of an investigation of how to deal with flooding. They lack the numbers and the calculations to make sure that the amount of space proposed could really hold all the volume of water needed. A deeper study on the costs of this proposal could also be interesting, with a more concrete timeline according to a real budget. These would both be the next steps to further the ideas proposed in this thesis.

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