URBAN RIVER LANDSCAPE RESTORATION

The case of river Grande de Morelia, Mexico

MASTER THESIS LANDSCAPE ARCHITECTURE
WAGENINGEN UNIVERSITY

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COLOPHON

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WAGENINGEN UR
For quality of life

PREFACE

This thesis is born of the interest in learning from ecosystem services and the benefits they bring to humanity by integrating them within landscape architecture.

For the minor thesis I researched how to find elements of the concept of ecosystem services in projects of landscape architecture within Europe and how these elements could be assessed. During the research I noticed that the awareness of the concept of ecosystem services and the values it brings to humanity could bring more landscape design projects that go beyond the aesthetics of a design, by improving the resilience and robustness of an ecosystem. Since, have the concept of ecosystem services present during a design process promotes a holistic vision for the realization of it.

Nevertheless, how to apply the concept of ecosystem services to a landscape architecture design with the objective of improve a sustainable transition area? This question will be discussed through the lenses of landscape design and sustainability. And answer by a research-based design that offers innovation and change to a selected area.

According to von Haaren et.al (2014) a landscape planning approach evaluates landscape functions and ecosystem services. However, this thesis would not be an evaluation of the concept; it would be a landscape design proposal that would take into account the concept of ecosystem services during a research-based design process

von Haaren. C.; Warren-Kretzschmar. B,; Milos, C., Werthmann, C. 2014. Opportunities for design approaches in landscape planning. Landscape and urban planning. 130: 159-170.

ABSTRACT

The amount of people living in cities compared to rural areas is increasing. Development plans which not take into account the health of ecosystems, uncontrolled urban growth, and a poor sewage drain structure has resulted in the canalization of rivers and the urbanization of its Floodplains. Creating a risk factor to flooding and a poor structure that allows the natural regulation of the river. Such oversights eventually stop being just a local problem, bringing as consequences problems to a region, including its loss of biodiversity.

In this thesis the health of a riparian ecosystem is developed through the creation and performance of urban green landscapes. This is done through creating green infrastructure connected with the blue one, and by the creation of ecological systems that improve the water quality of the river. Creating a connection between man-made systems and natural systems.

To ensure the partial restoration of the river was needed, at urban level, the support of systems that could regulate the amount of water and pollution that reached the river. The recovery of floodplains and the construction of wetland allows the natural regeneration of the river and the recolonization of native flora and fauna. Ensuring the health of the river and recovery of biodiversity. The restoration of the river not only bring health to the ecosystem it also brings health to the people, by providing several services that are related to well-being.

By applying the "six step framework" methodology in a research-based design, the main problems were located and the selection of a design area was possible. The design of the Morelia ecological park response to the needs that the research introduce.

READERS GUIDE

The concept of ecosystem services was the base to follow this research. However, the concept didn't act as a research frame, this only helped as a support to frame the scope of the study.

A brief introduction to the global content of the thesis is presented here.

Chapter 1 Gives an introduction to the fascination of the topic, and explains why and how this research-based design has been conducted.

Chapter 2 This chapter gives a summary of the selected methodology for conducting this thesis.

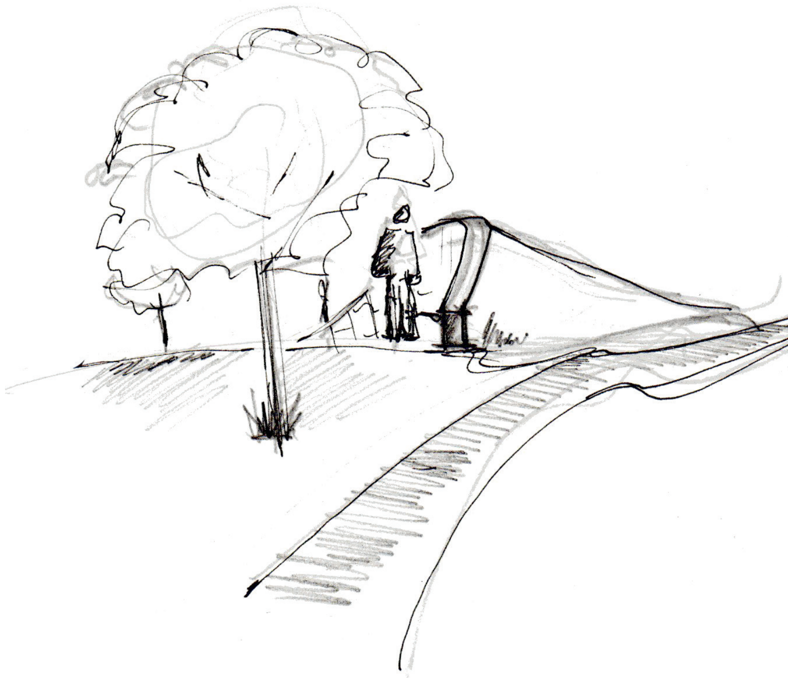
Chapter 3 Gives an overview of the theories that helped to frame the structure of this research.

Chapter 4 The research of the case of study, regional (macro scale), urban (meso scale), and local (micro scale), that was needed to be able to conduct the performance of the design. The thesis is written in a multi scale approach and following the methodology of the six step framework by Steinitz (2012). To identify in which step is, a colour code is used to identify each steps. Being RED for the representation models, ORANGE for the process models, YELLOW for the evaluation models, GREEN for the change models, BLUE for impact models and PURPLE for decision models.

Chapter 5 On this part the results or design part is conducted.

Chapter 6 This chapter draw the discussions and conclusions of the research.

CONTENT



Chapter 1

I DONT FEEL THAT IT IS NECESSARY TO KNOW EXACTLY WHAT I AM. THE MAIN INTEREST IN LIFE AND WORK IS TO BECOME SOMEONE ELSE THAT YOU WERE NOT IN THE BEGINNING. IF YOU KNEW WHEN YOU BEGAN A BOOK WHAT YOU WOULD SAY AT THE END, DO YOU THINK THAT YOU WOULD HAVE THE COURAGE TO WRITE IT?

WHAT IS TRUE FOR WRITING AND FOR LOVE RELATIONSHIPS IS TRUE ALSO FOR LIFE. THE GAME IS WORTHWHILE INSOFAR AS WE DONT KNOW WHERE IT WILL END.

Michel Foucault, 1982

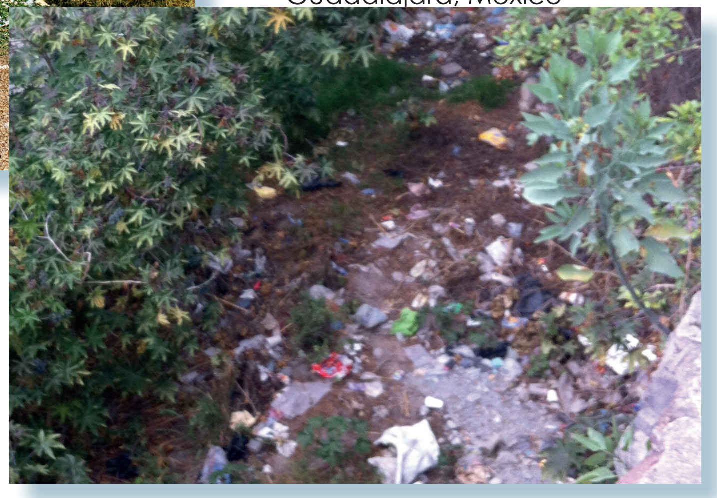
THE CONTAMINATION OF RIVERS IN MEXICO CAN BE FOUND AT SEVERAL PARTS OF THE COUNTRY.

River Remedios
State of Mexico

River Queretaro
Queretaro, Mexico

River El Salto
Guadalajara, Mexico

Stream De las Canchinches
Guadalajara, Mexico



INTRODUCTION

One of the most interesting ecosystems are the rivers which offer several services to humanity. They are very dynamic and are in constant flow. However, with the expansion of cities and the lack of integrating those to landscape are at risk of disappearing.

According to the World Bank (2013) the rivers of Latin America are the most contaminated. Since the 70% of waste water return to the river without being treated. Water management is of particular concern in cities, where 80% of the population and largely live nearby settlements contaminated sources.

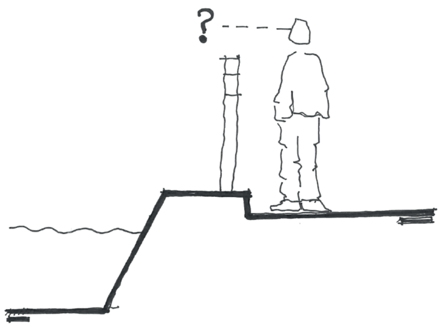
On the other hand, Latin America is one of the most biodiversity regions in the world and owns a third of the world's water sources.

In Mexico the benefits of urban rivers are not clear, those are seen as drainage channels. This perception is transforming them into sources of pollution and sometimes are the reason of severe flooding. Nevertheless, it is increasing the interest in the rescue of urban rivers and the services they offer to cities, as shown by the project to rescue the river of Magdalena in Mexico city (Gonzales et al. 2010.; Jujnovsky et al. 2010).

According to Nassauer et.al (2009), the study of ecosystem services in design can help to bring an overview of the on-going exchange between the goods and benefits that the ecosystem and landscape provide for people. Because. the functions, services and dynamics of ecosystems are broad and complex (Nassauer and Opdam, 2008), it makes necessary to conduct a case study that identifies, at least, one element of the concept of ecosystem services on a process of deterioration.

For this research, the river Grande of Morelia in Michoacán de Ocampo, Mexico, is selected. It is part of the hydraulic system of the basin of the Lake of Cuitzeo. It has a length of approximately 26 km of which 10 are located in an urban area, the city of Morelia. The river is part of the hydraulic system of the basin of the Lake of Cuitzeo. Within this basin is located the second largest lake of Mexico, that has high ecological importance to the region and the country (NMX-AA-159-SCFI ,2012), offering economic, cultural and social aspects to the inhabitants of the area (regional, municipal and urban).

The river Grande of Morelia is the main source of water to the lake. It originates in the southwest part of the basin of the lake of Cuitzeo at 2400amsl, flows direction northeast reaching the dam of Cointzio (2000amsl) and the city of Morelia (1890amsl). After the city, it crosses the agricultural valley Morelia-Querendaro before it end its journey in the Lake of Cuitzeo.



1.2 PROBLEM STATEMENT

The river Grande of Morelia is an important key ecosystem service for the region of Cuitzeo that is being affected by the contamination and pollution on the urban area of the municipality of Morelia, in the state of Michoacán de Ocampo, Mexico.

The lack of a proper drainage system and the canalization of the river, have promoted the rejection of the inhabitants and therefore the lack of care of it. On the other hand, the uncontrolled growth of the city and the loss of permeable areas has increased flooding in rainy season.

1.3 PURPOSE STATEMENT

Rescue the functions and provision and regulation of the river Grande of Morelia by a landscape architecture approach which also promotes the cultural functions that riparian ecosystems offers for well-being.

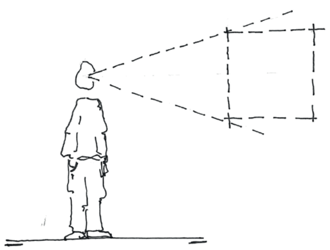
Ahern (2014) suggest that in green infrastructure the ecosystem services and functions can take place because it is multifunctional and can function at multiple scales. In addition, it has anthropocentric values that spatially organize a landscape environment (Ahern, 2007).

Therefore, green and blue infrastructure is a good opportunity for landscape architecture design that integrates the functions, services and benefits of ecosystem promoting ecocentric and anthropocentric values.

1.4 THE LANDSCAPE ARCHITECTURAL LENS

Landscape architecture is a holistic discipline (Koh, 1982) that understands the process of landscape, ecosystems and man-made systems. The vision of landscape architecture is to integrate these processes in man-made systems for the benefit of humanity.

The design processes should take into account generative and adaptive strategies (Koh 2013) being that landscape architecture is a discipline that supports and enhance the resilience and sustainability of natural landscapes for the benefit of biodiversity and humanity.



At the same time, the landscape architecture lens considers the social and economic aspects. As a research-based design takes into account the aspect of landscape as culture (Koh 2013) from a "healthy, safe and welfare" environment (Deming and Swaffield 2011).

1.5 KNOWLEDGE GAP

In Mexican urban settlements, do not exist a recognition of green and blue infrastructure. For example, wetlands and floodplains are not recognized as main actors involved in the support of provision, regulation, habitat and cultural functions of riparian ecosystems.

According to historical maps and literature (Morelia, 1873) the river Grande of Morelia was channelled in order to protect the city on rainy season of constant flooding. Without giving importance to the type of landscape that was there, which is identified as a marsh and wetland landscape. The uncontrolled growth of the city has minimized the required space of the river to regulate and maintain its natural course.

1.6 OBJECTIVES OF THE RESEARCH

Taking into account the knowledge gap mentioned before the objectives of this research are:

- The integration of blue and green infrastructure in the urban settlement for the improvement of the riparian services.
- The improvement of water quality of the river.
- To protect from flooding the surrounding areas.
- Enhance the functions and services of the riparian ecosystem by integrating them to the urban environment.

1.7 PHILOSOPHICAL KNOWLEDGE CLAIM

The approach is a qualitative research within a constructivist world view (Creswell, 2009), using as case study the river Grande of Morelia. The research is mainly focused on the improvement of water quality and protect the city from flooding by enhancing the green infrastructure, the aesthetic values and the services that the riparian ecosystem offers to the inhabitants of the area.

1.8 RESEARCH QUESTION AND SUB-QUESTIONS

The research question deals with the issue of the improvement of key ecosystem services objectives, that will help on the creation of more regenerative landscape architecture designs.

The main research question is:

- What ecological strategies and spatial interventions can improve the water quality of the river and protect from flooding risk the surrounding area?

The following sub-questions contain the scope of the research:

- What is the pollution process of the river?
- What is the river flood risk?
- What are the landscape values of the area?
- Which criteria can be selected for design evaluations?

The following sub-question covers the scope of the design.

- How can design strategies and spatial interventions can enhance the landscape values that benefits the inhabitants of the city of Morelia?

1.9 RESEARCH METHODS

In order to follow a case study the Six-step framework by Steinitz (2012) will be used as methodology.

The Six-step framework by Steinitz (2012) offers an interesting methodology that can be divided in two parts. The first part is descriptive and evaluative and is associated with landscape ecology dealing with the pattern: process landscape dynamics (Ahern, 1999). For this part the next questions should be answered.

- I. How should the study area be described?
- II. How does the study area operate?
- III. Is the current study area working well?

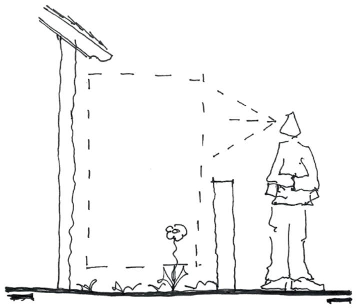
The second part is prescriptive and planning, it is related to landscape planning and design (Ahern, 1999). On this part the next questions should be answered:

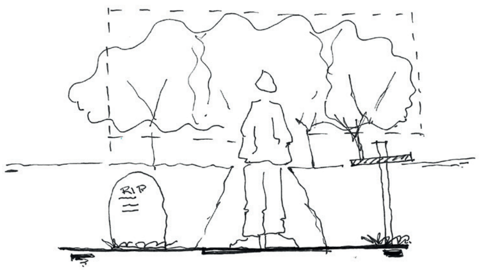
- IV. How might the study area be altered?
- V. What differences might the changes cause?
- VI. How should the study area be changed?

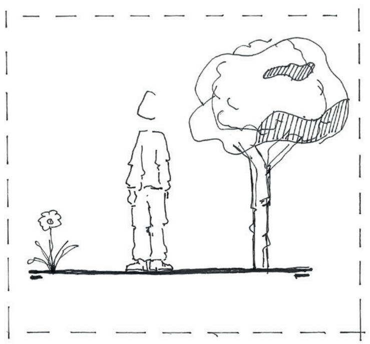
The design process will bridge the theoretical framework and the integration of the ecosystems with a landscape design model, by designing, sketching, assessing, taking decisions, in an iterative process that is not linear.
It will culminate with a design proposal for an explicit area.

On chapter 2 a more detailed methodology is given.

Where is the urban landscape?







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Chapter 2

METHODOLOGY

METHODOLOGY

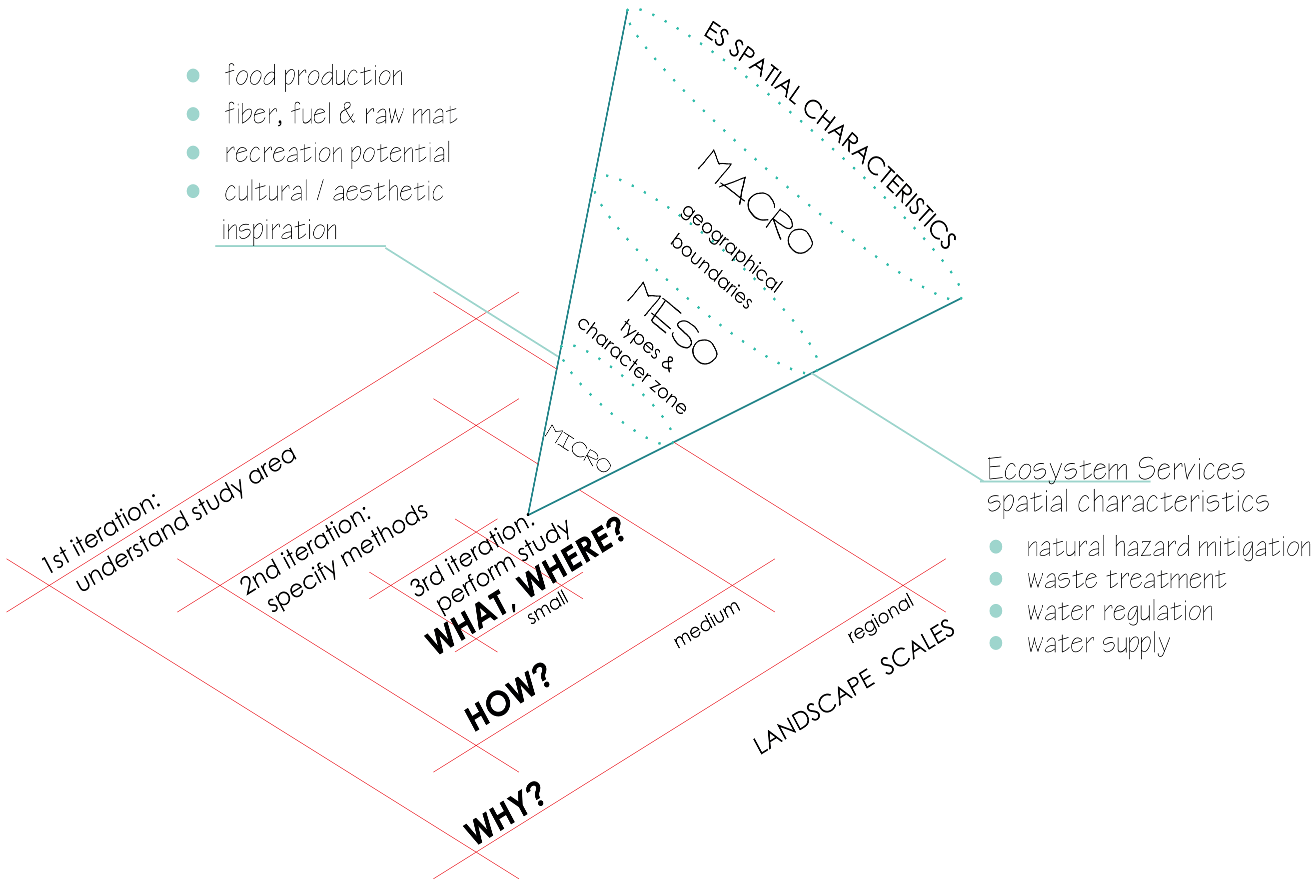
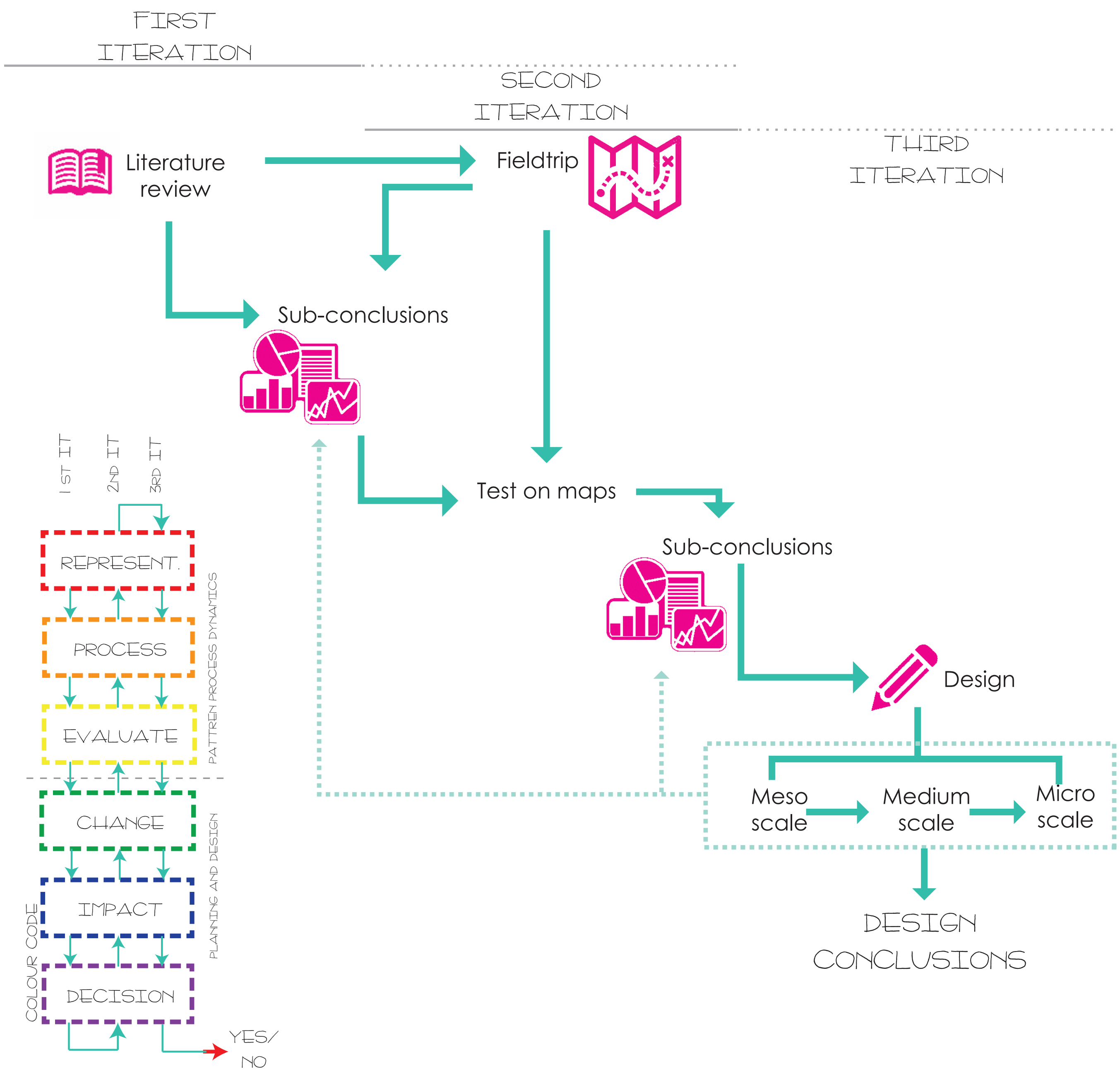


Fig 2.11 Scales and Methodology

This chapter presents the essential steps of the methodology. This methodology follows the six step framework by Steinitz (2012) with a multi-scale approach by Makhzoumi (2000).

The methodology is divided in three iterations. Each iteration follows the six step approach that is a set of questions focused on solving each step or model, which are: representation, process, evaluation, change and impact. A brief explanation of these questions was given on chapter 1.

The multi-scale approach defines the spatial characteristics of the ecosystem services (Costanza, 2008) by framing the landscape (Forman, 1996).



2.2 FIRST ITERATION

The main objective of the first iteration is the understanding on the study area achieved by desk study and part of the field-trip. The approach is at macro (region) and meso (urban) scale. A survey of maps (historical and contemporary) was made. Scientific literature of sustainable development at regional scale (Bravo et. al, 2012) was reviewed.

The objectives of this iteration was to understand at macro and meso scale:

- The geographical boundaries
- The source of water contamination and/or pollution.
- Identify the landscape units, and
- Understand the genealogy of the place.

The field-trip served to data collection (photographs, newspaper, and recognition of the area), and to detect the main source of the problem and the impact of the same.

- The analysis of the GEOGRAPHICAL BOUNDARIES covered at regional scale: (1:50,000) topographical, land use and vegetation charts (INEGI, 2015)]. The watersheds were identified by the flow simulator [SIATL, 2016).

- At meso scale the LINEAR STRUCTURE was analysed by urban maps, google maps and field trip.

• The analysis of the URBAN SETTLEMENT is a compilation of the Zoning plan (ZP, 2010); the Urban Development Program of the Population centre of Morelia (UDPPM,2014); the Municipal Development Plan 2012-2015 (MDP, 2012) and the Chart of the Urban Population centre of Morelia 2010 (CUPCM, 2010).

• The analysis of the GREEN INFRASTRUCTURE combine google maps, internet-based research and field trip.

• The analysis of the WATER POLLUTION was identified on first hand on the visit field and then triangulated with the study of scientific literature (Godinez, 2007; Garcia, 2011, Soto Galera, 1999). The information was represented on maps and diagrams.

• The analysis of FLOODING RISK emerged on the study of scientific literature. Internet-based research helped to identify flood zones tagged by citizens. Historical maps and literature about the place confirms the historicity of the floods. This information is compared with scientific literature (Corona, 2009; Arreygue, 2007; Hernandez, 2010 and Garza, 2011). The information was represented on maps obtained by the web page of the *Atlas Nacional de Riesgos* (ANR, 2015).

• LANDSCAPE UNITS were identified by scientific literature (Granados, 2002; Rojas and Novelo, 1995; CONABIO, 2015) and land use and vegetation charts (INEGI, 2015).

• To understand the GENEALOGY OF THE PLACE was necessary to visit the 'General Archive of the Nation' (AGN) to get maps, drawings, and photos that tell the history of the city of Morelia. It was triangulated with literature (Morelia, 1873) and scientific literature (Argueta and Castilleja, 2008).

2.3 SECOND ITERATION

The second iteration aims to specify the methods that are used on the third iteration. It is mainly developed at meso scale.

It was decided to use green and blue infrastructure as strategy to improve water quality and protect from flooding to the city. The theoretical framework took relevance and worked as a guide.

Impact models were made by identifying slopes directions on topography, the types of soil and flooding risk areas. These allowed to create suitability maps for water capture and retention, cleaning and storage, and flooding protection areas.

The surrounding areas to the river were evaluated, taking into account the infrastructure (roads and connections), housing density and proximity to green areas to identify three possible design areas. These were analysed and evaluated by SWOT analysis.

On an urban map, the location of the new green infrastructure, retention basins, the floodplain and constructed wetlands were represented.

2.4 THIRD ITERATION

The third iteration is focus at micro scale. On it, the research by design study is performed.

For the SUDS, some areas were selected as example to represent at meso scale the design. In the case of wetland, the selected area is represented in relation to the urban process (housing, services, commerce, green infrastructure, empty land, and cars flow).

The area is evaluated at two directions. The first one, the suitability of the area to create wetlands cells. Identifying the space required for cleaning, aeration, among others, and the water volume the area can capture.

The second direction is based on the needs and wishes of inhabitants. A resume of the interviews in a problem tree helped to identify them. Some aspects were evaluated at meso scale and were identified on an urban map.

Besides the two objectives already identified, two more were added, the accessibility and the cultural aspects of the area. These changes promote in the design the ecological and cultural services of the area.

To identify the impact of the changes, research by design was essential. Several sketches, sections, and plans were crucial to performing the decision models.

The final models were created by educational software products: Autocad 2015, Adobe illustrator and Photoshop 2015, and Google Sketchup 2016. The final compositions were created by the combination of own models and photographs, and some others were downloaded by internet.

The methodology allowed to outline the conclusions and discussions that are shown at the end of this report.

REMARK.

During the thesis process, was clear the need for a multi-layer approach to ensure the success of a sustainable design that meets the needs of the inhabitants, stakeholders, and politicians. However, the area is facing constant problems of security related to drug cartels, making difficult to approach to the area and realize interviews and workshops with the inhabitants of the area.

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Chapter 3

MAKE RHIZOMES, NOT ROOTS, NEVER PLANT! DONT SOW, GROW OFFSHOOTS! DONT BE ONE OR MULTIPLE, BE MULTIPLICITIES! RUN LINES, NEVER PLOT A POINT! SPEED TURNS THE POINT INTO A LINE! BE QUICK, EVEN WHEN STANDING STILL! LINE OF CHANCE, LINE OF HIPS, LINE OF FLIGHT. DONT BRING OUT THE GENERAL IN YOU! DONT HAVE JUST IDEAS, JUST HAVE AN IDEA. HAVE SHORT-TERM IDEAS. MAKE MAPS, NOT PHOTOS OR DRAWINGS. BE THE PINK PANTHER AND YOUR LOVES WILL BE LIKE THE WASP AND THE ORCHID, THE CAT AND THE BABOON.

Deleuze, G. and Guattari, F. 1980

DESIGNING LANDSCAPE AND ECOSYSTEMS SERVICES WITH AND THROUGH GREEN AND BLUE INFRASTRUCTURE IS AN OPPORTUNITY TO IMPROVE THE VALUE / BENEFIT OF THE SAME, AND SUPPORT SUSTAINABLE DEVELOPMENT IN URBAN AREAS

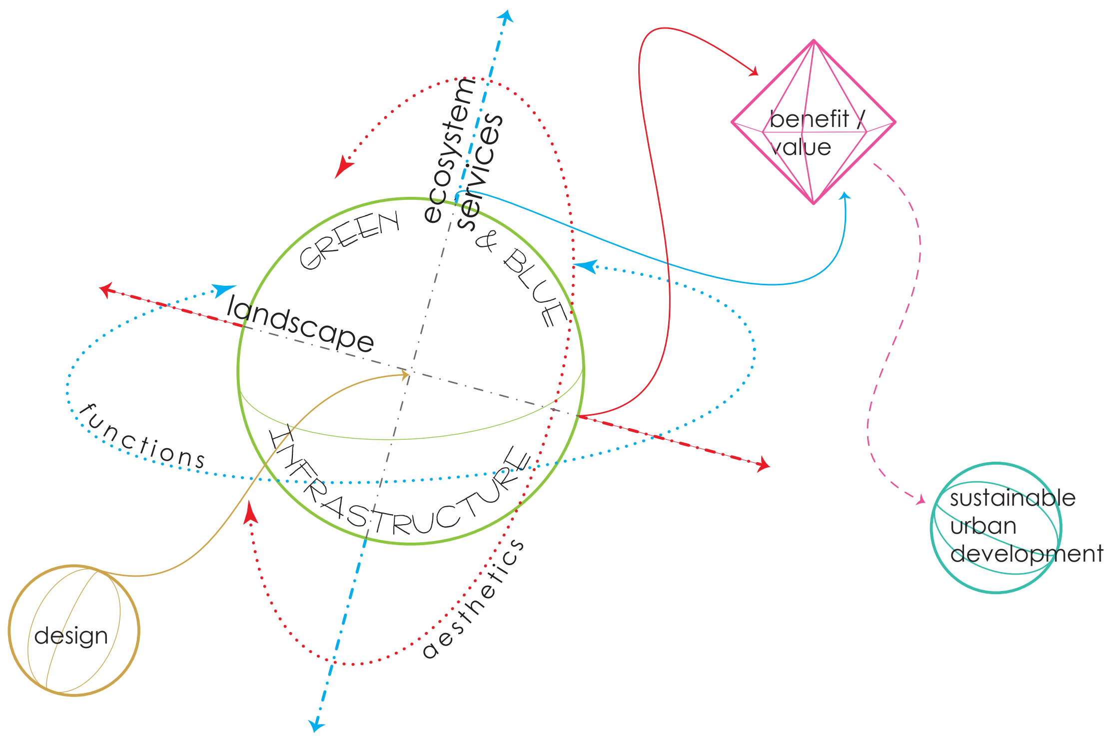


Fig.3.1. Conceptual framework diagram.

The preceding sentence summarizes the framework in which this thesis bases its research.

In ecological terms landscape is defined by Forman and Godron (1986, cited in Ahern, 1999) as a heterogeneous area composed of the interaction of several ecosystems that are repeated in similar forms throughout it. This interaction can be identified through the pattern: process dynamics (Forman and Godron, 1986) that are useful to understand spatial units and vertical relationships.

In an urban settlement that has fragmented the interaction of the ecosystems, the green infrastructure is used as a strategy to reorganise and restructure the ecological interactions of natural systems with man-made systems.

3.1 GREEN /BLUE INFRASTRUCTURE

Green and blue infrastructure can be found within, around and between urban areas, at all spatial scales and include all natural, semi-natural and artificial networks of multifunctional ecological systems (Tzoulas et. Al. 2007). It is a network of corridors and spaces that are assembles from ecocentric, anthropocentric and mixed components (Austin, 2014).

Pict 3.1. Corridors and patches- Morelia, Michoacán, México. Google earth, 2016.

Pict. 3.2. Land and city- Morelia, Michoacán, México. Google earth. 2016

The picture 3.1 is the area where the river Grande of Morelia emerge from the underground. It is a natural landscape with natural systems, but also with human interventions that are causing fragmentation. Networks like rivers, streams, patches mountains forest open areas, are shaping the natural system.

From an ecocentric perspective, a natural green infrastructure give services to all the species. It is a network used by wildlife to move from one place to other (transport), it offers habitat, food, energy among other services to all species (plants and animals).

According to Austin (2014) an ecocentric perspective hold that every species should have an equal survival opportunity. A natural green and blue infrastructure that supports life species has an intrinsic value given by the contributions that it offers to maintain the health and integrity of an ecosystem (Farber et al., 2002).

On the second image (pict. 3.2) we can see how the city and the needs of the people have been changing and shaping the landscape to anthropocentric requirements and values like, agriculture, housing, transportation, among others.

An anthropocentric perspective gives to humans an elevated status (Austin, 2014). It gives value to human needs. According to Farber et al. (2002) the satisfaction in human preferences about landscape are defined by the benefit that it grant to people, for example, the beauty of the landscape that a lake offers to attract tourism.

Something that contributes to rich specific goals objectives or conditions has a value (Farber et al., 2002). The services offered by landscape and the ecosystems have an immanent value at the moment that contributes to well-being. The continuous network of corridors and spaces of green infrastructure sustain healthy ecosystems functions (Austin, 2014). It can mitigate pollution, generate recreation and economic values to the urban structure and contribute to sustainability (Ahern, 2007).

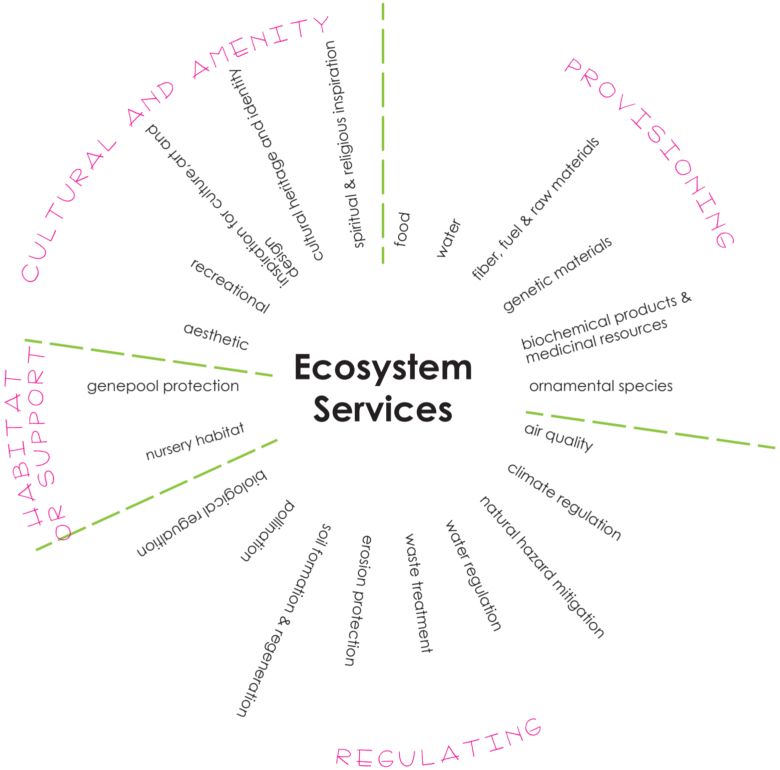


Fig. 3.2. Ecosystem functions and benefits
Based on de Groot et al. 2002.
The diagram shows the elements that integrates each function within the concept of ecosystem services

A green infrastructure interacts with three systems: The ecosystem services, ecosystem health, and human physical and psychological health (Austin, 2014).

ECOSYSTEM SERVICES refers to the distribution of provision, protection and maintenance of goods and benefits that ecosystems bring to humanity (Millennium assessment, 2003; de Groot et al., 2002, Bolund and Hunhammar, 1999) This concept helps to give value to the ecological functions that have a direct benefit to humanity in physical, economic and social terms (Ahern, 2007).

The ecosystems like a forest or a river are divided in different functions that are separated in four main groups: Provision, regulation, habitat and cultural services.
The provision functions 'provides' materials to humans like food or water. This function provides elements that are taken from nature to obtain a tangible benefit.
The function of regulation is not tangible, it 'regulates' the ecological processes of the ecosystems. Like the temperature on earth or the volume flow of rivers. It also support the ecological cycles, for example trees can protect from runoff in rainy season.
The habitat functions is the one that provide refuge and reproduction habitat to wild life.
And the cultural functions are the benefits that people obtain from ecosystems by contact with them, like the enjoyment of a beautiful landscape (fig. 3.2). The services that these functions offer can be done through green infrastructure, as long as they be healthy (Austin, 2014).

An ecosystem is HEALTHY when the integrity of habitat systems is maintained, and when the interactions of abiotic and biotic systems can establish the ecosystem structure and processes.

In urban and peri- urban settlements, green and blue infrastructure could influence the ecosystem health by contributing to resilience and organisation, preserving and enhancing the diversity within them (Tzoulas et. Al. 2007).

Austin (2014) defines the health of an ecosystem by six parameters: Air quality, water quality, soil structure, energy and material cycling, habitat and species diversity and ecosystem resilience. These parameters have a close relationship with the functions and services of ecosystems and can be related to human health.

For example, according to the ecological society of America (ESA,2015), several pollutants such as metals, oils, sediments are processed and filtered out as the water moves through wetland areas, forest and riparian zones. This process of purification cannot be completed if the riverbed is channelized or the ecosystem is fragmented, influencing the ecosystem health. Therefore, the provision of drinking water will be affected, chaining to another set of problems, as water will be not suitable for wild life habitat, recreation, among others.

HUMAN HEALTH includes physical and psychological aspects. The health of physical aspects is related to physical activity and the psychological to stress reduction (Austin, 2014; Tzoulas et al., 2007).

Landscape planning and architecture design can develop green infrastructure that besides ecological functions promotes physical activity like walking, jogging or cycling. The design of open areas next to urban environments can foster to people gather to socialize and release stress of urban life and contribute to well-being.

WELL BEING embrace biological, sociological, economical, environmental, cultural and political factors (Tzoulas et al. 2007).
Although it is difficult to define what well-being is, there are two types of dimensions that can offer an idea: the objective and the subjective.

The objective dimension is related to material and social characteristics including many basic needs (human, economic and environmental). The subjective dimension is associated on how individuals can perform their own thoughts and feelings. (Summers et al., 2012).

The components that integrates human well-being are related to Maslow's pyramid, composed of four primary components: basic human needs, economic needs, environmental needs and subjective happiness. The first three are related to the first to levels of the pyramid: psychological and safety needs.

Fig.3.3. Maslow's pyramid of needs
Source: happonomy .org

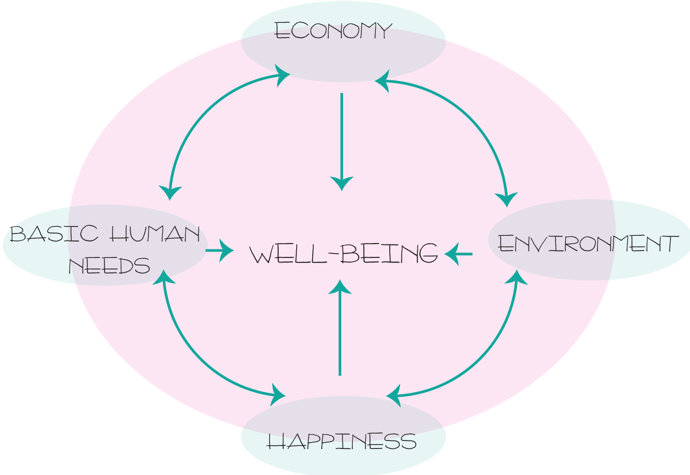


Fig 3.4. Components of well-being
Based on Summers et al., 2012.

Subjective happiness is related to the other levels of Maslow's pyramid: love/belonging, esteem and self-actualization.

Unlike Maslow's pyramid of needs (fig. 3.3), components of well being have not hierarchy (fig. 3.4). The well-being in a community is only possible when these components can create social connections and collaboration.
When an ecosystem is fragmented and lose its health, it damage the environmental needs for well-being.

For example, when a river is channelled to cross

as quickly as possible by a city. In addition to losing their own regulatory functions, is no longer a safe habitat for several species, as it has lost the natural characteristics as nutrients that require several aquatic species.
Generating reduction of populations and thereby biodiversity. Services, such as provision of food or recreation such as fishing, are diminished.

The environmental needs go beyond individual desires, as is the provision of drinking water, are more related to the impact that the lifestyle of a community is generating to a bigger scale (Summers et al., 2012). For example, the water contamination of a river does not only affects a locality and the provision of water, it can affect the needs of health, work and recreation of a whole region

3.2 GREEN / BLUE INFRASTRUCTURE SPATIAL CONFIGURATION

In an urban environment Bolund and Hunhammar (1999) define a city as a one single ecosystem or as a set of several individual ecosystems (green and blue areas in the city).
They identify seven different ecosystems: street trees, lawns / parks, urban forest, cultivated land, wetlands, lakes/ sea, and streams. Ahern (2007) catalogued these ecosystems according to their spatial configuration: Patch, corridors or Matrix(Fig 3.5).

Urban Patches	Urban Corridors	Urban Matrix
• Parks	• Rivers	• Residential Neighborhoods
• Sportsfields	• Canals	• Industrial Districts
• Wetlands	• Drainageways	• Waste Disposal Areas
• Community Gardens	• Riverways	• Commercial Areas
• Cemeteries	• Roads	• Mixed Use Districts
• Campuses	• Powerlines	
• Vacant Lots		

Fig 3.5 Urban landscape elements.
The patch- corridor-matrix model. Source: Ahern, 2007.

An urban GREEN CORRIDOR is integrated by ecological components, streams and rivers, swales and cultural components like bike/ pedestrian paths, boulevards and convenient infrastructure(Austin,2014). Together serve for the movement of animals, plants, humans, nutrients, wind, or can help as barriers (Ahern, 2007).

OPEN SPACE ELEMENTS of green infrastructure can be divided in urban patches and urban matrix.

An URBAN PATCH is a non linear area that is different from the surrounding area. It can provide multiple ecosystem functions to a city. Including habitat, aquifer recharge areas, regulating functions like climate regulation, air quality, among others (Ahern, 2007). The ecological components of it are, habitat preservation, habitat fragments, constructed wetlands, and cultural components, parks, yards, community gardens, green roofs, and plazas (Bolund and Hunhammar, 1999; Ahern, 2007; Austin,2014).

An URBAN MATRIX is the dominant land cover type in terms of an area. It controls the dynamics of the landscape by the degree of connectivity or continuity (Ahern,2007). For example, how many gardens are in a housing area, and how these are connected.

The connectivity of this components are the result of the interaction of landscape structures and functions. Unfortunately in urban areas the connectivity is usually reduced and fragmented, splitting the habitat apart (Ahern, 2007).

3.3 URBAN GREEN CORRIDORS

At municipal scale the network of a Patch-corridor model can reduce the loss of many native species and can mitigate the fragmentation and loss of habitat. Corridors can be differentiated by function (commute, migration and dispersal) and habitat. The habitat type is distinguished by the type of ecosystem (Austin, 2014). The role of green corridors is to facilitate the movement of organisms through landscape, and can be designed to achieve certain goals (Bolund and Hunhammar, 1999). In a city, such objectives range from the connection of open space areas and increased aesthetics to the urban environment health.

For example, on urban areas the lack of pervious areas plus roofs and paving cause greater rainwater volume and have a negative impact to streams and rivers. Rain water washes the street of pollutants and drag solid matter to them. As result, flooding and sedimentation of streams and rivers are overwhelming the capacity of natural and man-made water system. In this case, green corridors can be designed for storm water management by capturing and regulating storm water, and at the same time providing aesthetics and greenery to the city.

A green corridor as manager of rainwater can protect the city from the impact of runoff and improve water quality of storm water polluted from air and land surfaces plus toxic substances, such as heavy metal and excess of nutrients. At the same time, the control and treatment of storm water can contribute to a multifunctional green infrastructure. (Austin, 2014).

A SUSTAINABLE URBAN DRAINAGE SYSTEM (SUD's) is an urban strategy to address flooding risk and improve water quality by activating natural processes, such as retention, infiltration, evaporation and transpiration (Fryd et al. 2012). The elements of urban green infrastructure like boulevards, street line trees, community parks are part of this approach to regulate storm water. This action consists of a drainage network of rainwater which captures water and filters it into green areas (fig 3.6).

In the urban area of Birmingham, UK, for example, this system was implemented for the lack of open space and impermeable areas. According to Ellis and Viavattene (2013) the system reduced substantially the pluvial flooding and reduce pollutants on water, increasing the greenery of the area.

SUD's in Birmingham, UK.
Source: ice. org

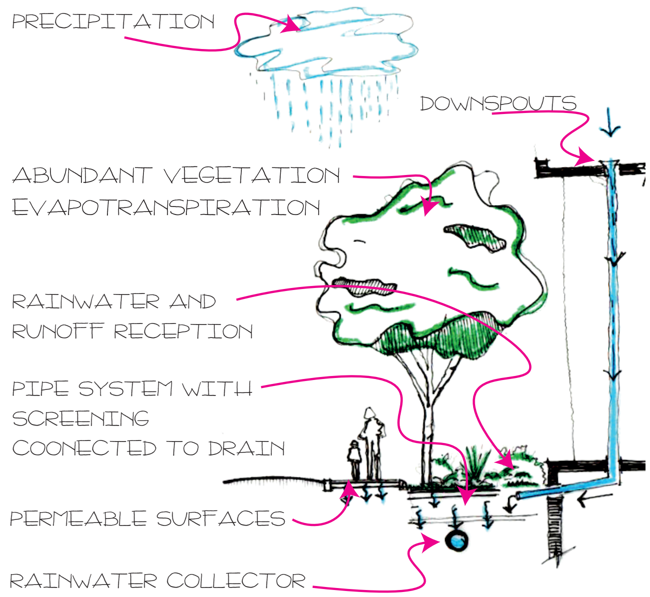


Fig 3.6. SUD's section scheme.

To achieved successfully this system is necessary to reduce surface runoff and minimize impervious surfaces, and divide the catchment areas to avoid the concentration of large volumes of water draining into green areas, parks and open space areas (Castro et al. 2005).

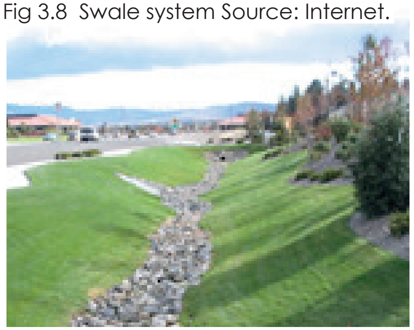
Some examples of SUD's elements are:

PERMEABLE SURFACES are pavements that allows the passage of water through them, such as grass, gravel, porous pavements, among others. This act as a filter allowing to water to be reserved in the bottom of the system or it is address into a regulating or catchment basin.

Fig 3.7 Permeable surface system
Source: Internet.

SWALES are shallow channels with vegetation that are designed to store storm water and transport it to retention basins meanwhile remove pollutants.

Fig 3.8 Swale system Source: Internet.

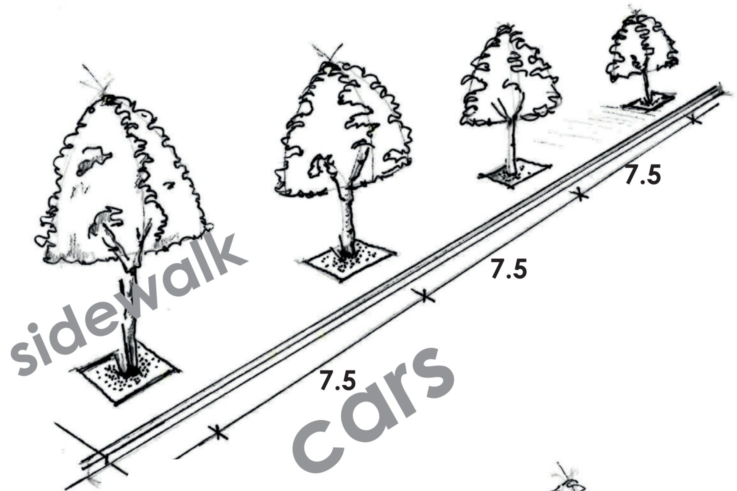


RETENTION BASINS help to regulate the volume and velocity of water, protecting the natural water system. It is a permanent pool water with capacity to store rain water temporarily. It do not improve water quality adequately but can offer attractiveness to an area.

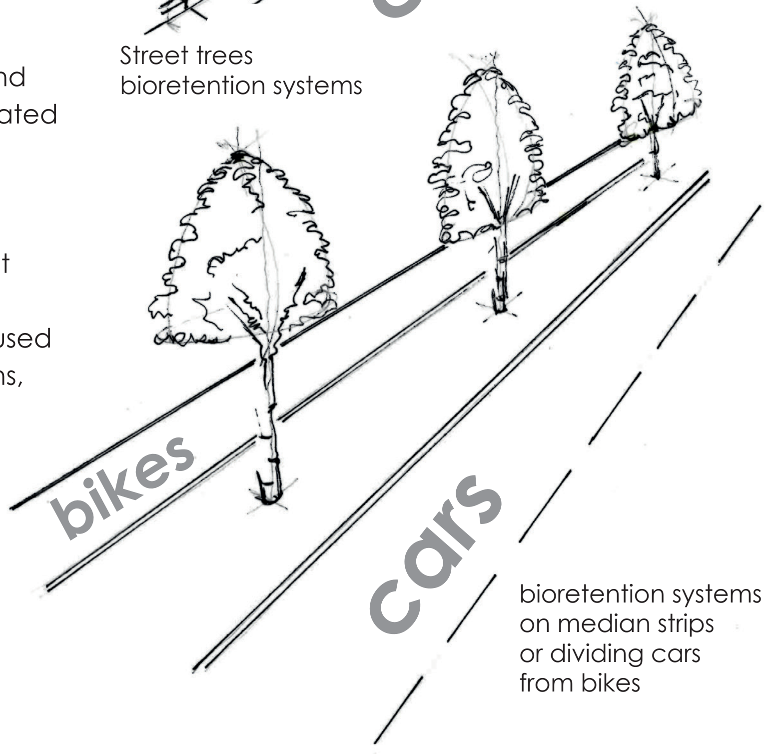
Fig 3.9 Retention basin
Source: Internet.

These systems are a mix between green and blue infrastructure. And can be well integrated to blue corridors like rivers.

Exist several design options that can be integrated to a SUD's system, such as street trees retention systems in the sidewalrk or along both sides of a street. Even can be used as division between cars, and cycling paths, grassed swale-type, among others.



Street trees bioretention systems



bioretention systems on median strips or dividing cars from bikes

3.4 RIVERS

Rivers as urban blue infrastructure has several functions. They are a resource of water, protection of nature and recreation. From an anthropocentric view they are used with several purposes such as drinking water, irrigation, industry, transportation, swimming, aesthetic enjoyment, among others.

For a proper restoration of an urban river, it is important to know how it is set and what their functions are.

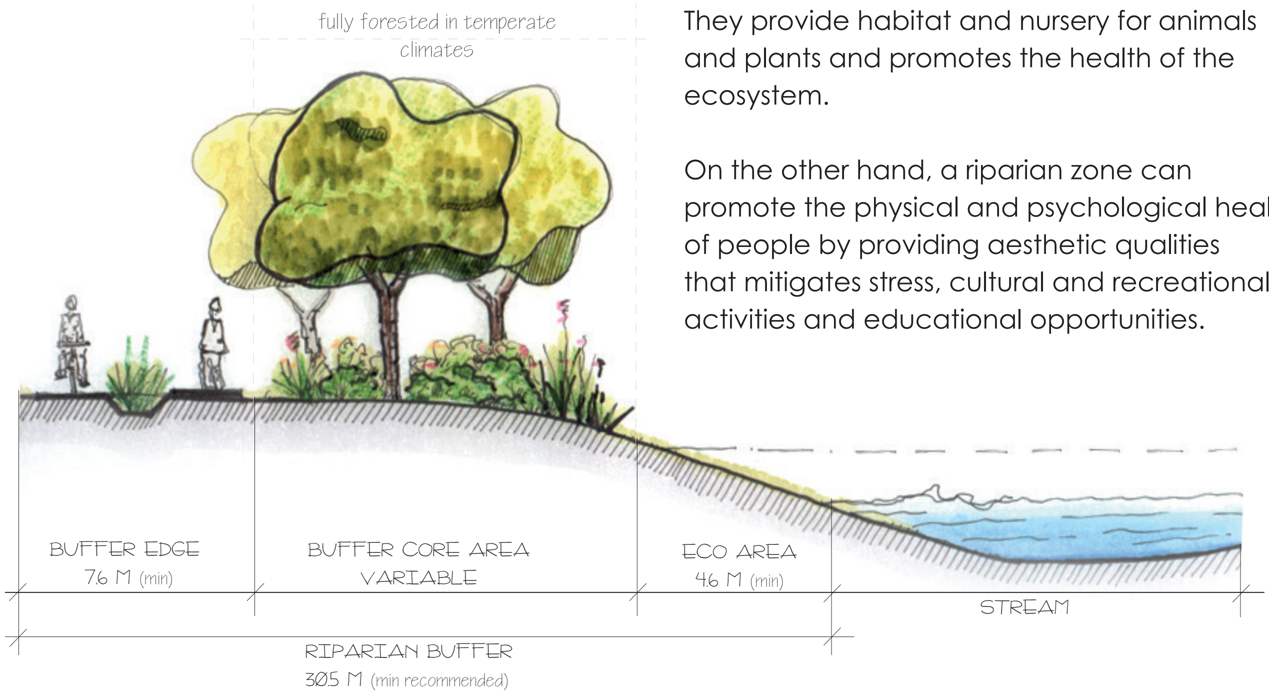


Fig.3.10 Riparian zone with recommendations (Austin, 2014).

A RIPARIAN ZONE is an area where the terrestrial and aquatic ecosystems interact. Its boundaries extends outward the floodplain and higher than the vegetation next to the stream (Stanley et al. 1991).

The benefits of a riparian ecosystem cover the cultural, provision, regulation, and habitat functions. According to Soman et al. (2007) they can decrease soil erosion, store, and recycle organic matters, and nutrients; remove excess of nutrients such as phosphorus and nitrogen. They provide habitat and nursery for animals and plants and promotes the health of the ecosystem.

On the other hand, a riparian zone can promote the physical and psychological health of people by providing aesthetic qualities that mitigates stress, cultural and recreational activities and educational opportunities.

Next to the channel of the river or stream is located the riparian buffer, which is an area of trees and other vegetation next to water bodies. It can mitigate the surface runoff, the waste water, and the subsurface flow of rivers and reduce the movement of nutrients, sediments, and organic matter. Moving and deposit them into floodplains (Soman et al., 2007; Kiedrzynska, 2015). In urban environments, a riparian buffer can improve the water quality and can provide several services as shade, climate regulation, flooding protection, shelter, and food for species. They can enhance the scenery and the aesthetics of the area and create opportunities for recreation.

RIPARIAN BUFFERS can filter and treat some pollutants from urban areas next to the river before they enter to it. According to Austin (20014) some studies indicate that a riparian buffers between 13 to 22m width can reduce nitrates. Sediment of storm water can be removed in a buffer between 4.6 to 9.1m (pg. 154). For a proper operation of the riparian buffer the design should follow the minimum recommendations outlined in fig, 3.10.

Hardscapes such as roads, sidewalks, paved paths and other impermeable surfaces obstructs rainwater filter through soil, fragmenting and affecting the functions of the riparian zone.

According to Cengiz (2013) the planning development of a river front design should regard the natural structure of the river: The characteristics of the watershed, the floodplain, the water flows and timing, water chemistry and the biological needs of wildlife, and guarantee the health of the river.

A healthy urban river can have several benefits for a city. Apart from water quality improvement and flooding control advantages, it can increase the attractiveness for tourism and property values. For this, it is important that society enjoy river front features and cares about it in long-term. The regeneration of a river front in an urban area should consider the physical, political, social, and economic barriers. Taking into account the community by making them able to experience the river closely.

Physical and visual experiences can create a sense of community if they integrate and balance the ecological, social, and economic concerns. To attract people is necessary to provide public access, connections, and recreational opportunities, like bicycling and bird watching.

CASE STUDY

The Cheonggyecheon stream
Seoul, South Korea.

This project is a restoration of 10.9 kilometres of the Cheonggyecheon stream that was a neglected waterway hidden by an overpass. It is a recreation space in downtown Seoul, in South Korea.
The project had the purpose of preserving the unique identity of the natural environment and support the surrounding business area. The daylighting of the stream was created through the city centre, with fountains and paddling areas, and open wildlife space in the more natural downstream end.

The Cheonggyecheon was restores as an urban stream in nature, with a waterfront and walks along the shoreline. Embankments were built to withstand possible floods in a base of 200 years, and the number of bridges were reduce in order to prevent bottleneck effect during heavy rain season. The wide of the stream is at least 13.5 m per side, and accommodates one way two-lane road (Kee Yeon Hwang, n.d).

Although the river do not use recycle waste water and is fed by treated water pumped from the larger Han River, it offer several benefits to the area:

The Cheonggyecheon stream

www.inhabitat.com

ENVIRONMENTAL

- Provide flood protection for up to a 200-year flood,
- increase biodiversity,
- reduce the urban heat island effect,
- reduce small particles of air pollution.

SOCIAL

- Contribute with the increase of use of public transport,
- attract visitors and tourists,
- increase the visitor spending to the Seoul economy.

ECONOMIC

- Increase the price of land,
- increase the number of business growth in downtown Seoul (www.
landscape performance series.org).

The project works as a multifunctional linear park. It flows from the Cheonggyecheon plaza, equipped with market stands for food and craft vendors. During its flow it becomes progressively more natural. It is integrated to the urban fabric and host several events and installations.

3.5 OPEN SPACE AREAS

In urban areas open space can provide social and civic life to inhabitants. With multifunctional uses can stimulate network connections within the city. This thesis will focus on floodplains and wetlands (areas of ecological service) and parks (socio-cultural areas).

FLOODPLAINS

A river floodplain (fig 3.11) is an integral part of a valley-river system that usually function as a natural wetland. Its key role is water retention and flood protection. According to Palmer et al. (2015) to reconnect urban channels to its floodplain wetlands can create ecological restoration.

Preserve the floodplain can decrease the outflow velocity of water from catchment and the probability of flooding, can increase the water retention capacity and used as a reservoir system. Furthermore, reduce flood pulses, surface erosion and the transfer of nutrients and pollutants to the river (Kiedrzynska, 2015).

A sustainable management of floodplains can provide flood protection and water quality improvement by absorbing and retaining sediments, nutrient and micro pollutants. The riparian ecosystems can improve their resistance and resilience by the restoration of floodplains along the river if anthropogenic impact is reduced.

According to Kiedrzynska (2015) in order to increase the water and pollutant carrying capacities in floodplain ecosystems, it is necessary to perform some strategies:

- Increase mosaic character of catchment area,
- extend the ecotone buffer zones. These slow down the water runoff from the basin to the river,
- increase the permeability of water catchment areas by the use of permeable or partially permeable materials, for example in parking lots or pedestrian paths,
- increase the capacity of water retention of the whole catchment area of the river by forestation, river and wetlands restoration and creation of new ones. Building flood reservoirs with bio filtering systems.
- define a border for residential and economic development.

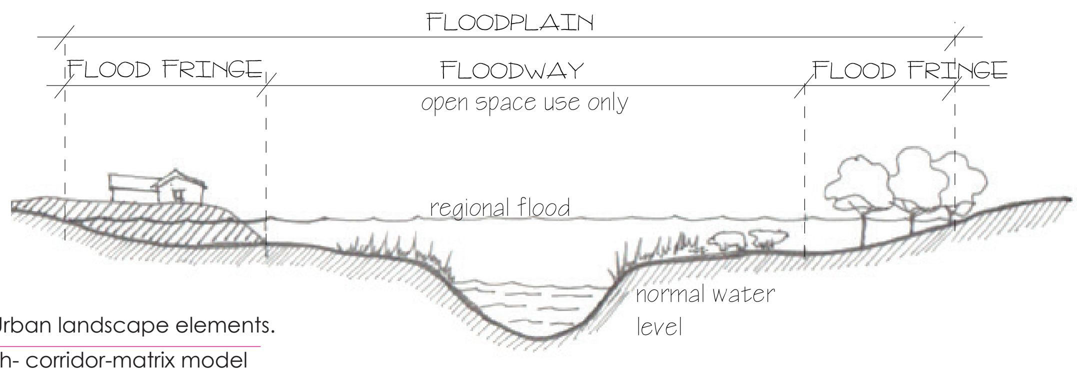


Fig 3.11.Urban landscape elements.
The patch- corridor-matrix model
Source: Ahern, 2007

WETLAND

A wetland is a densely vegetated area that is saturated of water, permanently or seasonally. They are transitional land between aquatic and terrestrial areas. Usually land is covered by shallow water or the water table is near the surface. A wetland can combine ecological functions like water regulation, habitat, among many others, with the aesthetic beauty of the place.

Different plant communities may be found in different types of wetlands. Buffer vegetation can moderate the velocity of drainage water and can protect, restore, and enhance habitat near and in the stream (Soman et al. 2007). A wetland system can reduce many contaminants like suspended solids, nitrogen, phosphorus trace metals and organics (BOD, COD) (Vymazal et al., 1998; 2009).

With the uncontrolled growth of cities and the little knowledge about the importance of wetlands, cities have conquered that space to create land for agriculture or building areas. According to France (2003) wetlands have a cumulative effect at large scale. The loss of a wetland at a local scale can affect the process of wetlands at a regional scale. The creation of man-made wetlands can mitigate the loss of natural ones.

A constructed wetland is an engineered sequence of water bodies designed to filter and treat water borne pollutant found in sewage, industrial effluent or storm water runoff. Trough the field of landscape architecture a constructed wetland is an opportunity to improve water quality of rivers meanwhile provides wildlife habitat; human activities like aesthetics, education, recreation, and enhance ecosystem services and human health.

There are three types of constructed wetland according to the life form of the dominating aquatic plant that grown in or near the water (macrophytes) (Vymazal et al., 1998). These waste water treatment systems can be combined with each other in order to take advantage of the different systems.

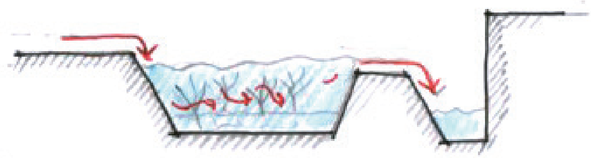
FREE-FLOATING MACROPHYTE WETLANDS.

- Detention time 10-20 days
- Media depth 1.9 – 0,9m
- Vegetation Eichhornia crassipes
- The use of multiple cells is essential.

This system is designed for treatment or raw wastewater, primary effluent, upgrading of existing secondary treatment systems. It is efficient in remove BOD and provide good conditions for microbial nitrification. It can present mosquito growth problem if the systems are overloaded organically and anaerobic conditions develop.

SUBMERGED MACROPHYTE - BASED SYSTEMS.

- Detention time: -
- Media depth 0,6 – 3m
- Bottom slope -
- Vegetation- Elodea canadesis (native species of the lake of Cuitzeo).

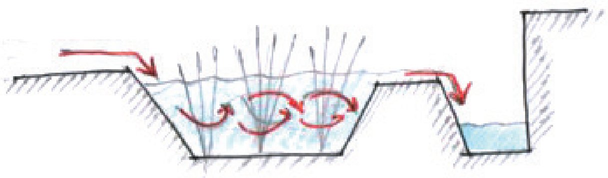


This system is used for polishing secondarily treated wastewater. It can dissolve inorganic carbon in water and increase the content of dissolved oxygen. Creating favourable conditions for the mineralization of organic matter in the water.

EMERGENT MACROPHYTE- BASED SYSTEMS.

FREE WATER SURFACE FLOW.

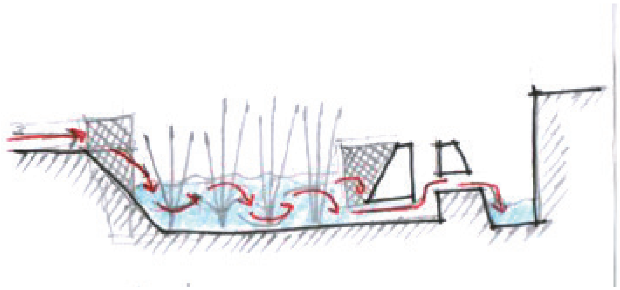
- Detention time: 5 - 15 days
- Media- washed gravel, crusted stones.
- Media depth 0,2 - 0,4m
- Bottom slope – 0.5%
- Soils 20- 30 cm
- Vegetation- Typha spp



It is used as land-intensive biological treatment system. Inflow water containing particulate and slowly dissolve pollutants spreading them through a large area of shallow water and emergent vegetation. The system regulate water flow especially in long and narrow channels

HORIZONTAL SURFACE FLOW.

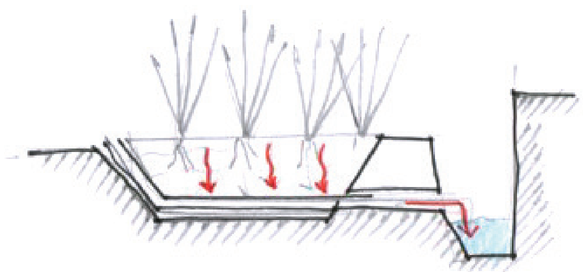
- Detention time: 5 days
- Media- washed gravel, crusted stones.
- Media depth 0,8m
- Vegetation- Typha spp.



The effluent moves horizontally, parallel to the surface. These are easy to build and can receive wastewater continuously. During the effluent the waste water will come into contact with a network or aerobic and anaerobic zones. The waste water is cleaned by microbiological degradation and physical and chemical processes.

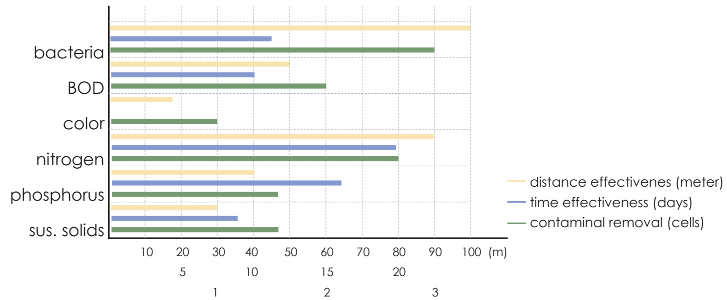
VERTICAL SUBSURFACE FLOW.

- Detention time: 1-2 days
- Media- gravel, sand
- Media depth 0,8m
- Vegetation- Phragmites australis.



Also known as infiltration fields. The effluent moves vertically from the planted layer down through the substrate. This system is applied as biological stage (secondary treatment) for pre-treated wastewater.

The size of the wetland and the time that water stay on it ids fundamental in contamination removal. The size should be a 2 to 4 % of the contributing water shed area. The transport time effectiveness takes between 10-20 days (fence, 2003; Vymazal et al., 1998) to flow through the wetland cells (constructed wetlands). According to France (2003) the average number of removal cells are 3. Being necessary 1 cell to remove colour, 2 cells to remove suspended sediments, phosphorus, and BOD, and 3 cells to remove bacteria. The distance effectiveness for colour, suspended solids, phosphorus and BOD removal is between 20-40 meters, and 100 meters to remove nitrogen and bacteria (diagram 3.1).



Diag 3.1. Wetland effectiveness

Based in France, 2003

CASE STUDY

- Ningbo East Town eco-coridor
- Location Ningbo Zhejiang
- Size 101.2 ha
- Landscape architecture office SWA

The project is an open space area for recreation an adaptive reuse, serving as a green lung to the city of Ningbo. The plan includes mixed-used urban development organized around an Eco-corridor.

The project is focus on restoration of wetlands and site specific intervention with historical and cultural relevance, regarded to eco-consciousness. Since agriculture and urban development were decreasing the evergreen oak forest of the area and promoting the loss of wetlands.

Ningbo East Town eco-coridor

Source: Asla professional awards, 2013

PROJECT IMPLEMENTATION

A network of waterways were organized to treat polluted water from the canal system. Manage storm water runoff, establish riparian zones for wildlife habitat restoration, and provide recreation and education opportunities to the inhabitants of the area.

The area is designed to slowdown the hydrological flow, approximating to the original conditions of the lowland floodplain, in order to support the re-establishment of native vegetation (Asla, 2013).

By mimicking ecological processes of the area, the watercourse improves the quality of the canal water from class V (industrial and agricultural uses) to class II (suitable for ecological restoration and recreational use).

A system of hills and valleys located in the floodplain helps to direct water flow and remove pollutants through settlement, aeration and bio- processing. On the valleys the creation of natural season ponds allows water retention for aquifer recharge

The constructed hills serve to buffer the urban environment and frame views to the city providing vista point for visitors.

Hills and valleys also create a system of wetlands along the flow the river. The use of native vegetation supports plant diversity and promotes wildlife habitat.

PARKS

As a model of open space area, parks can provide several physical and psychological benefits. They provide important environmental services such as air and water purification, climate regulation, wind and noise filtering. Next to a riparian ecosystem a park contributes with habitat to different species and mitigates the urban impact on riparian ecosystems Austin (2014).

According to Tynon (2014) there is a positive relationship between outdoor recreation and pro-environmental attitudes, and behaviour. Since outdoor recreation experiences can be linked to a more ecocentric set of beliefs, as these experiences represent the best opportunities for nature contact, and a sense of connection to nature. Furthermore, Chiesura suggest that natural elements can function as natural tranquillizers that are beneficial in areas with high levels of stress on daily living. They can offer a sense of challenge, privacy, intimacy, aesthetic and historical continuity. However, Schultz (cited by Tynon, 2014) suggest that the activities which natural elements are highly controlled or contained (such as a zoo or a channelled river) have a tendency to be destructive and can promote a sense of disconnection to nature.

Urban parks can fulfil many social functions and psychological needs, Nevertheless are different motives to visit a park that goes from recreation, social to spiritual aspects. There is many factors that influence the use of urban parks. According to Austin (2014) these are:

1. park access and quality
2. recreation facility location and variety
3. the mix of land uses and desirable destinations
4. residential density
5. street connectivity
6. ease of pedestrian transportation
7. walking and biking facilities
8. traffic speed and volume
9. pedestrian safety elements
10. the degree of neighbourhood civility or order
11. threat of crime
12. presence of vegetation

America and UK had define some recommendation for open space areas. This recommendations defines the types of parks in relation to its size and radius of service they provide (Fig 3.12).

The uses of an urban park can be divided into passive and active recreation. Active recreation is that which requires intensive development like playgrounds, ball fields, gymnasiums, among others, and the passive recreation emphasizes the preservation of natural habitat. Involving a low level of development.

Fig 3.12 Park parameters
Source: Austin ,2014

National Recreation and Park Association Standards – United States		
Park Type	**Service Radius (miles)**	**Size (acres)**
Mini-Park	less than ¼	0.06–1
Neighborhood Park	¼–½	5–10
Community Park	½–3	30–50
Large Urban Park	One per city	50 minimum, 75+ acres preferred
Nature Preserve	No recommendation	no recommendation
Sports Complex	One per city	25 minimum, 40–80 preferred

ANGSt Standards – United Kingdom		
Park Type	**Service Radius**	**Size (acres)**
Neighborhood	1,000' (300 meters)	5 (2 ha)
Community	1¼ miles (2 km)	50 (20 ha)
Large Urban Park	3 miles (5 km)	250 (100 ha)
Regional	6 miles (10km)	1,236 (500 ha)
Nature Preserve		2.5 (1 ha) for each 1,000 population increment

3.6 SUB-CONCLUSIONS- THE VALUE MAP TOOL FOR ECOSYSTEM SERVICES

URBAN GREEN CORRIDORS | WETLAND | PARK

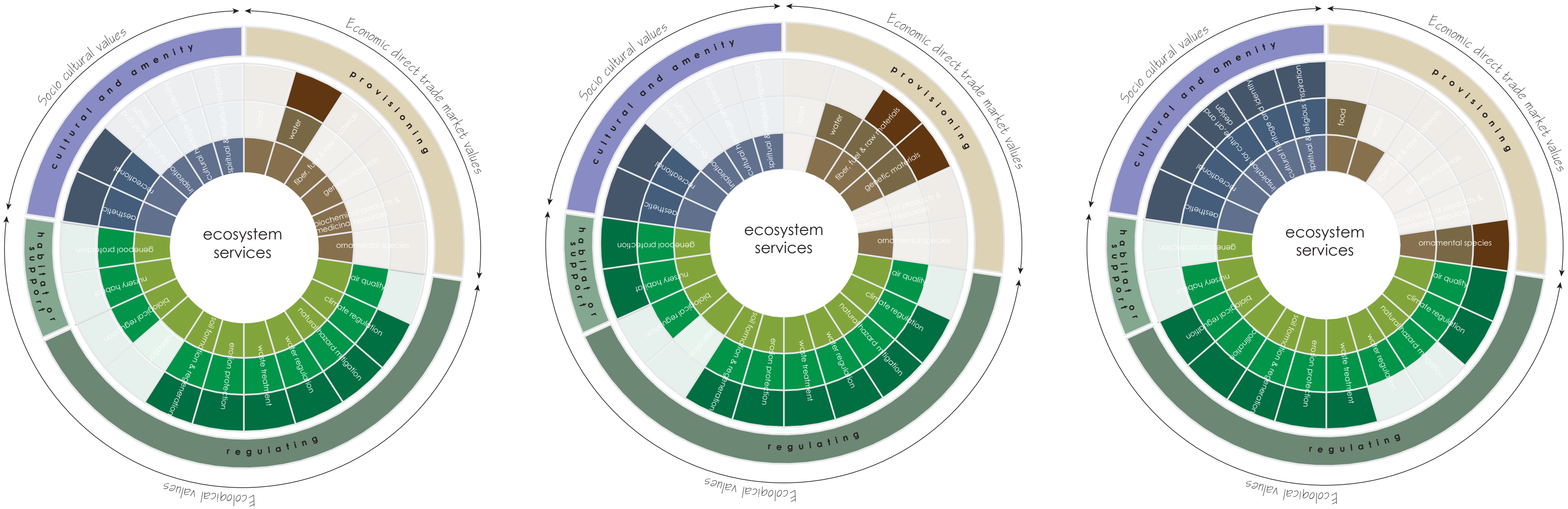


Fig 3.13 Value map tool
The use of ecosystem services in each concept

The concepts discussed in this chapter have shown that are able to regulate and clean the water of a river, which are the main objectives intended for this research. They also offer other ecosystem services that enhance and promote ecocentric and anthropocentric values by promoting, providing or regulating several functions and services of the ecosystems.

For example, urban corridors have strong regulating functions that benefits the whole city. Wetlands have strong ecological functions that are good for the regulation and cleaning of the river that are beneficial for the inhabitants of the city and areas after the city.

Besides they are also beneficial to the improvement of the flora and flora of the area, providing good habitat that can protect the biodiversity of the area. They can provide aesthetic and recreational elements that are useful for the health of the people, by freeing them from stress. Can provide space for children and adults bringing them closer to nature and to learn from it, creating a sense of consciousness towards nature protection.

On the other hand, a park can create a stronger link between inhabitants and natural systems, and offer cultural, recreational, and spiritual activities. Being the place for social cohesion.

The synergy of the three concepts would provide a good basis towards the creation of a sustainable city.

The value map tool for ecosystem services (fig 3.13) was developed during the minor thesis. It provides an overview of the use of functions and services of the ecosystem. While the use of an ecosystem service can bring imbalance to other services, the map offered a graphical recognition of it.

In the slide graph (fig 3.14)the first block represents a low use of the service, the second block moderate use and the third one a great use of the service.

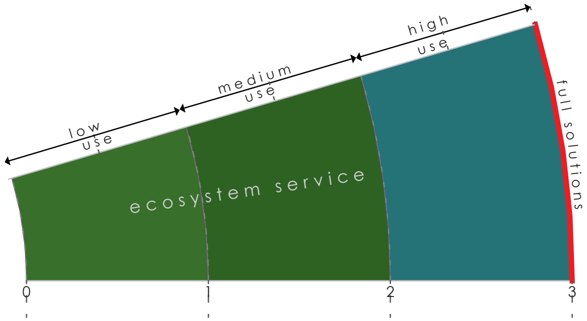


Fig 3.14 Slide graph
Explains de value of the ecosystem services

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Chapter 4

CASE STUDY

YES, YOU CAN COUNT - SIGHS EISENSTEIN - BUT WE MUST ALSO KNOW TO TRANSLATE INTO ACTION THE WORDS THEMSELVES, INTENTIONS AND IDEAS. I MEAN YOU NEED TO KNOW TO FIND THE RIGHT SCENIC SOLUTION.

Sergei Eisenstein. 1994

THE RIVER GRANDE OF MORELIA ALONG THE BASIN

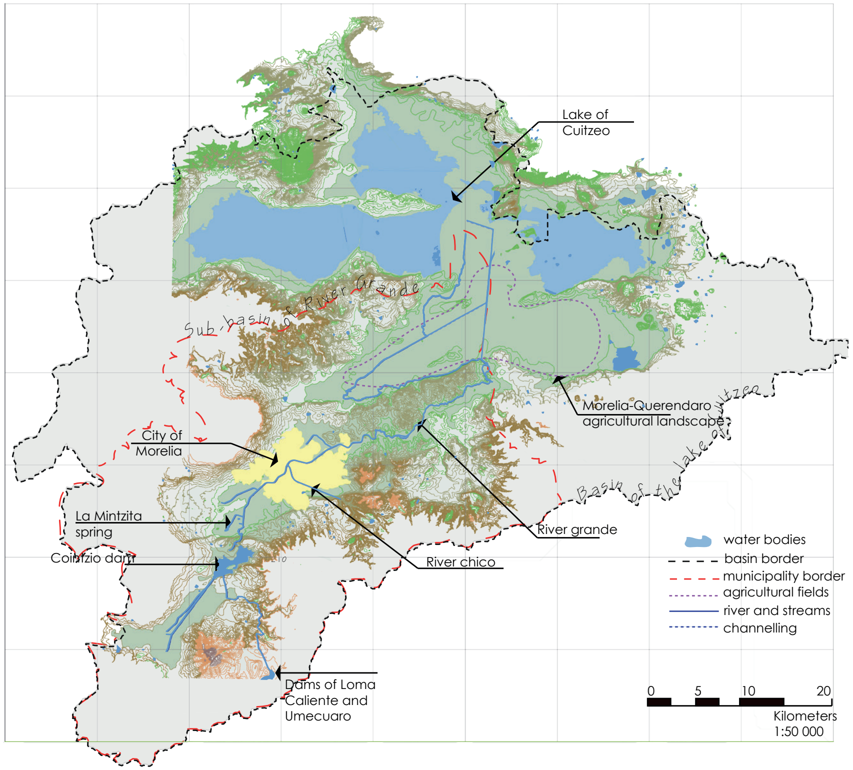


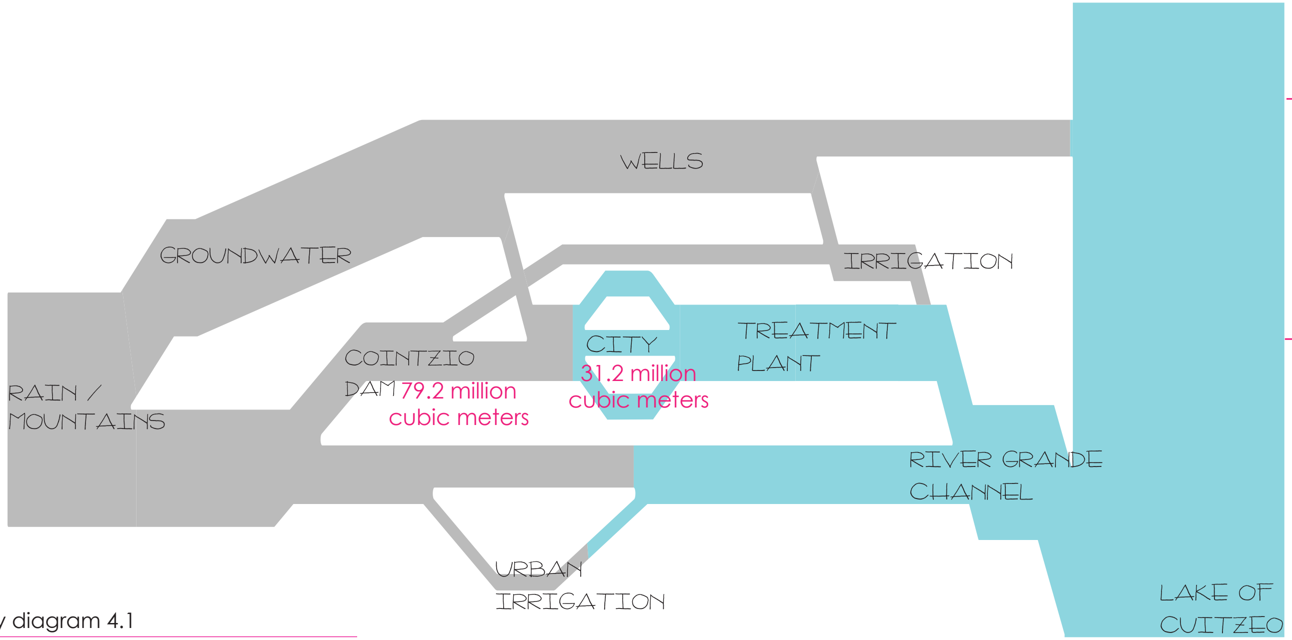
Fig 4.1 River's location

The basin of the lake of Cuitzeo.

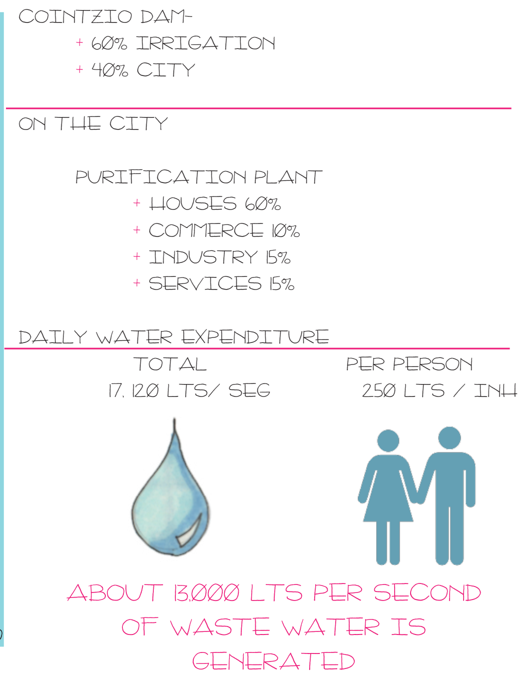
The river Grande of Morelia is the main source of water of the lake of Cuitzeo and has becoming the main source of contamination to the lake. It affects the hydraulic services (provision and regulation) that the lake offers to the region. Furthermore, in the urban section that cross the river flooding risk is increasing in rainy season affecting the adjacent areas to the river.

4.1 THE RIVER GRANDE OF MORELIA. CONTEXT

The River Grande of Morelia (RGM) is the most important on the valley of Morelia (García, 2011). It originates in the Southwest part of the basin of the river Grande, in the conjunction of the rivers Tirio and Tiripetio in the municipality of Patzcuaro (2400 amsl). The river flow direction northeast and reaches the dam of Cointzio (2000 amsl). The river bed receives contributions from many streams before it arrives to the city of Morelia (1900-1891 amsl). On the city, the River Chiquito (RCh) joins it on the right side of the river, increasing the quantity of water, later the river crosses the agricultural irrigation valley of Morelia - Querendaro (1830 amsl) in the municipality of Alvaro Obregon. Then is channelled by the rectifier river of Morelia, and on its journey to the lake of Cuitzeo (1837 amsl) receives water from the stream of Guadalupe (fig. 4.1).



Sankey diagram 4.1
From mountains to lake



The RGM can be divided on two main areas: the urban area that is integrated with a transition area (rural to urban) with the city of Morelia and the rural zone has agricultural land use on the Valley of Morelia- Querendaro.

On the first part of the river (the urban area) the dam of Cointzio regulates the flow of the river and provides drinking water to the city of Morelia and irrigation water to the valley Morelia - Querendaro. After passing through the city, the water of the RGM is canalised to the Atapaneo's treatment plant of activated sludge (sankey diagram 4.1).

According to the Mexican Norm NMX-AA-159-SCFI-2012, the river Grande of Morelia has quite low ecological importance because domestic, industrial and agricultural sewage is discharge into the river, besides it has been modify and channelled (Table 1). Because the river is one of the most important water feeds that the lake has, this thesis will focus on the urban part which has more anthropocentric interventions.

On a personal interview, Ing Hector Guizar (2015) (responsible for the river dredging program, Ooapas) explained that the water process to supply the service to the city is the following: the water is channelled from Cointzio dam to the city and then is distributed to housing and industries. Each house must have its own septic tank and each industry must have its own treatment plant. After that, the water can be discharged to the river, channelling it to Atapaneo's treatment plant.

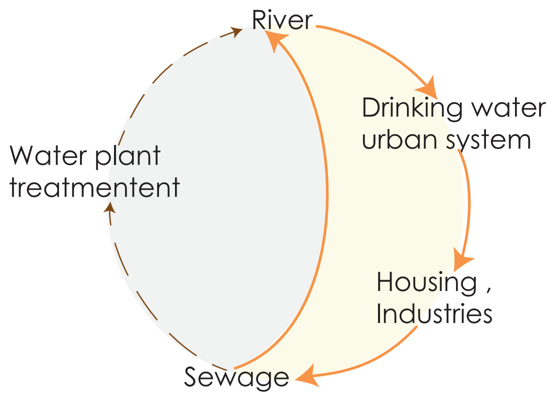


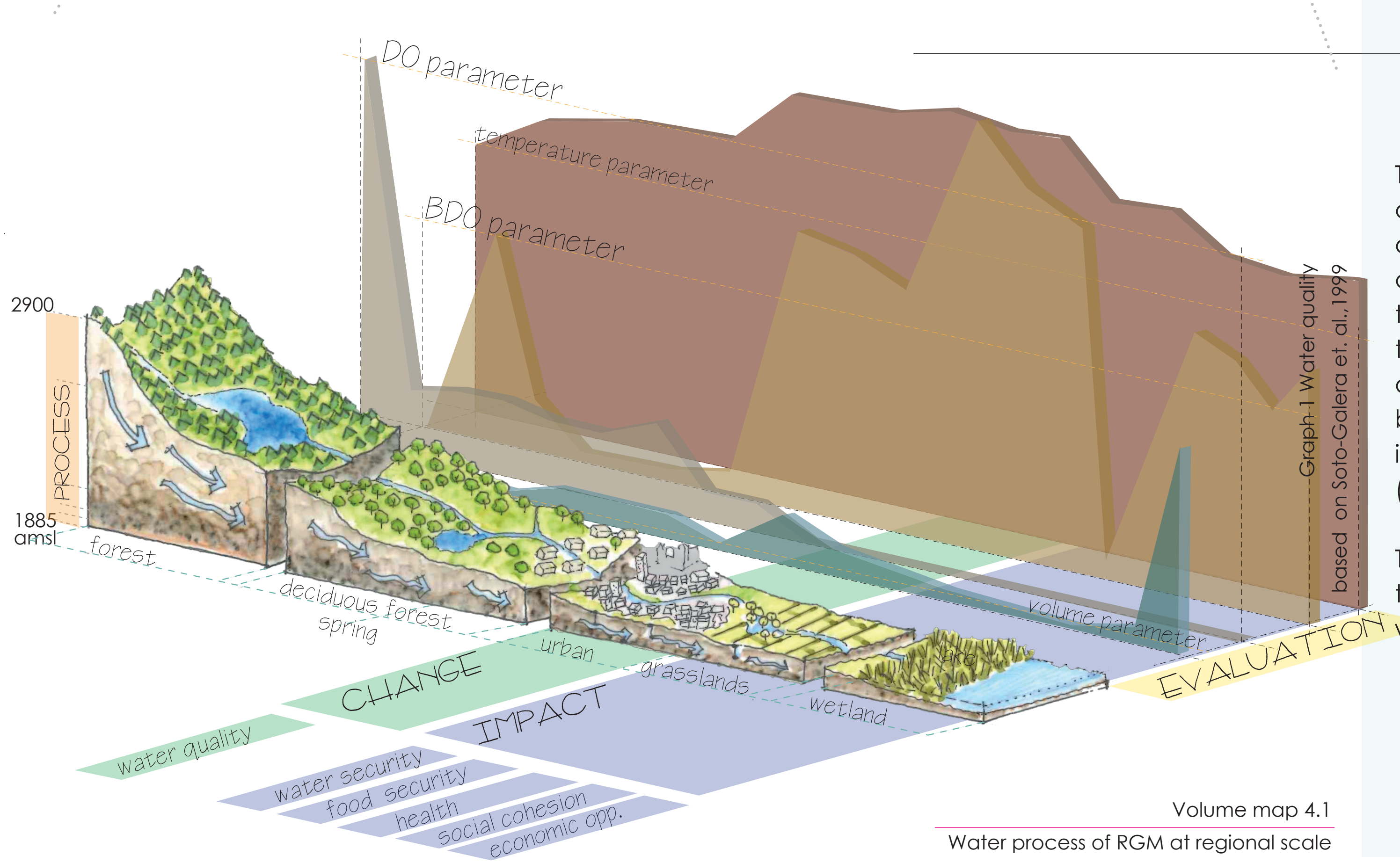
Diagram 4.2

Break of the urban wastewater process

	Biotic aspects	ecological identity	eco-hydrological alterations
Qualification	low	low	low
Rio Grande of Morelia	low presence of native species and presence of exotic species	captation zone submited to high use of water pressure and land use alteration. The river bed has been modify and channeled. The ecological integrity is loss but conserves the most basic ecosystem services.	High presence of anthropogenic infrastructure. The management is totally altered.

Table 1. Ecological importance
based on Mexican Norm NMX-AA-159-SCFI-2012

According to the Article 40 of the "Construction regulation of the city of Morelia" (1999) any type of construction is subject to treat and reuse water. However, either the regulations are not enough or is not complying with the standards, breaking the water quality process (diagram 4.2).



The volume map1 shows the altitude and distance of the river, from where it arises to the lake of Cuitzeo, crossing 5 different ecosystems. On the graph, the parameters of water quality are taken into account, to evaluate the area where the temperature and the biochemical oxygen demand (BOD) increase; and the dissolve oxygen (DO) is decreasing.

The most impacted area is identified in the city which affects the services and well-being of the adjacent areas.

Volume map 4.1

Water process of RGM at regional scale

Some studies about the quality of the water of the river Grande of Morelia (e.g. Soto-Galera, 1999; Garcia, 2011; Ruiz, 2011) shows that the critical spots of drain pollution are founded on the section that goes from the drain "cienega" where the city of Morelia begins, to the Industrial area, where the city ends.

Furthermore, other studies emphasis a loss of the water level of the lake. According to Granados, Mendoza and Acosta (2002) the surface of the lake is decreasing, mainly because water consumption for housing and industrial services on urban areas and agricultural irrigation systems on rural areas. For Mendoza et.al (2010) one of the reasons is, among others, that the inhabitants of agricultural fields drain water from the underground for irrigation because the water of the river is not feasible any more.

The misuse of water in the urban area is bringing negative consequences for agricultural production areas and the lake of Cuitzeo. The improvement of the water management by landscape architecture in the urban area will improve water quality as well as protecting from flooding. This would have a positive impact for the inhabitants and consequently to the agricultural fields and lake.

4.2 UNDERSTANDING THE STUDY AREA

THE CITY OF MORELIA - SETTLEMENT AND DEVELOPMENT

The city is approximately 19km horizontal and 10 km vertical length. It was founded in the portion of the strip of transition between dry plains and central highlands and the wet and wooded elevations in the shaft of the Mexican Volcanic belt system in the valley of Guayangareo.

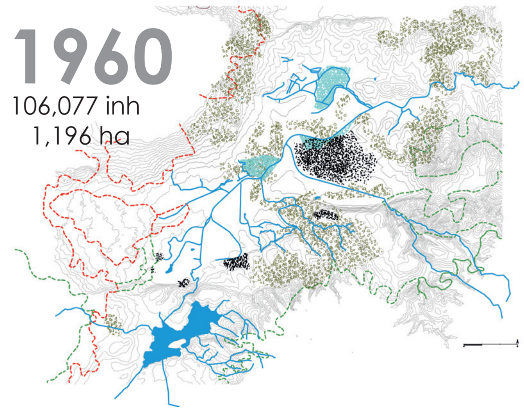
The city has an important place in the history of the country because historical events and personalities who were born or live there. The historic centre has nearly 500 years of settlement, and is a designated UNESCO World Heritage Site. Most of its monuments are located on the protected core area, 'the historical centre'.

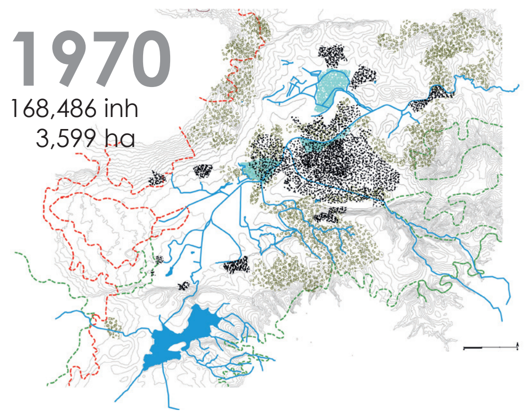
According to Garza (2011) the area does not follow the urban-territorial pre-Hispanic logic, and for that reasons there is no evidence of human settlements before the Spanish conquest. However, it follows the Novo Hispanic spatial order that was based on the exploitation of natural or human resources of the territory and the conquered society.
The water bodies served to separate the Hispanic population of the indigenous population, black or caste who had settled in adjacent neighbourhoods. Some of them were settled on the floods crossed by the RGM and RCh. Both are considered important buffer zones to the historical protected area, because explain together the dynamics and evolution of the city.

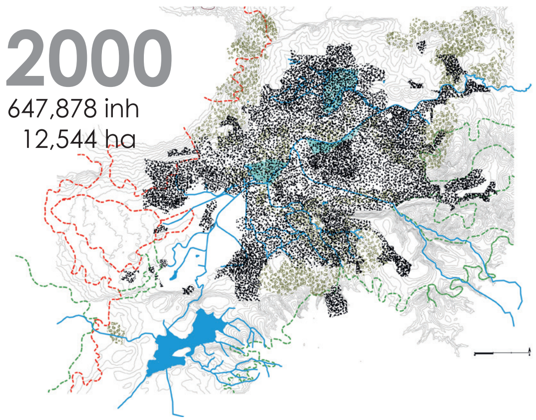
From the second half of the twentieth century the city has been experiencing a fast growth (fig 4.2). After 1980, the urban process became more evident, mainly with constant movement towards outskirts of the city, occupying areas of difficult access for the provision of services marked under the irregularity and located in natural flooding areas (Hernández, 2010).

Hernandez, Vieyra and Mendoza (2012) suggest that the North area of the city is on a process of peripheral urbanisation where the interface of goods and services between the rural and urban area is happening. This area has the characteristic of have productive type soils but in a process of land use change. With a lack of basic services, inadequate building structures, deficient structural materials, crowding and improper land tenure.

Fig 4.2 Growth of the city
Based on data of INEGI, 2016







4.3 LANDSCAPE ANALYSIS

The landscape analysis is based on data collection of the area that took into account the meteorological aspects of the area; the abiotic and biotic models on the natural setting, and the cultural models in the urban frame. These allowed to understand the impact of natural dynamics in man-made systems.

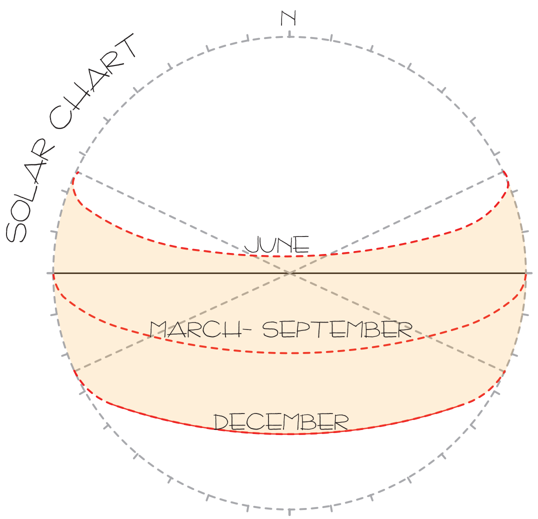
WEATHER

SUN POSITION. The city of Morelia is situated at 19°46' north latitude and 101°11' longitude west. The solar chart diagram shows the course of the sun at the equinoxes and solstices. The sun has an angle of 45° in December, on March 63°, June 93° and 71° degrees in September, being June the highest point of the sun (graph 4.1).

The TEMPERATURE of the city is temperate sub humid with summer rains (Cw) according to the classification of Köppen (Cabeza and Lopez, 1998). The mean annual temperatures oscillate between 1.6°C in the mountains and 20°C in the lower areas. The highest temperatures (25 - 26°C) are during the months of April, May, and June, and the lowest (19 °C) in December, and January (graph 4.2).

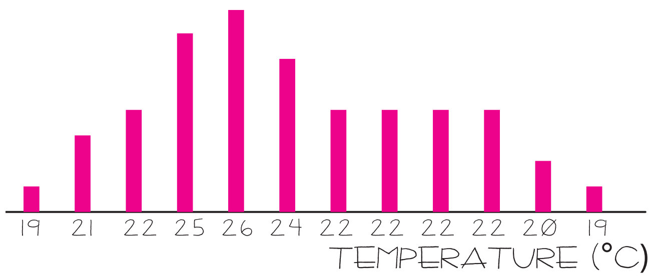
The mean annual PRECIPITATION is about 800 mm (Correa- Ayram et. al., 2014). Being the months of June to August the highest precipitation. Is an area with drought half of the year and abundant rain the other half (graph 4.3).

The prevailing WINDS comes from the Southwest and Northwest, varying in July and August with intensities from 2.0 to 14.5 km/h (graph 4.4).



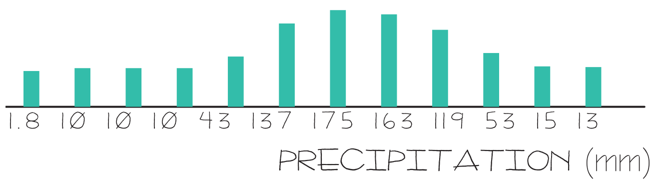
Graph 4.1 Sun chart

Based on suncalc.net, 2016



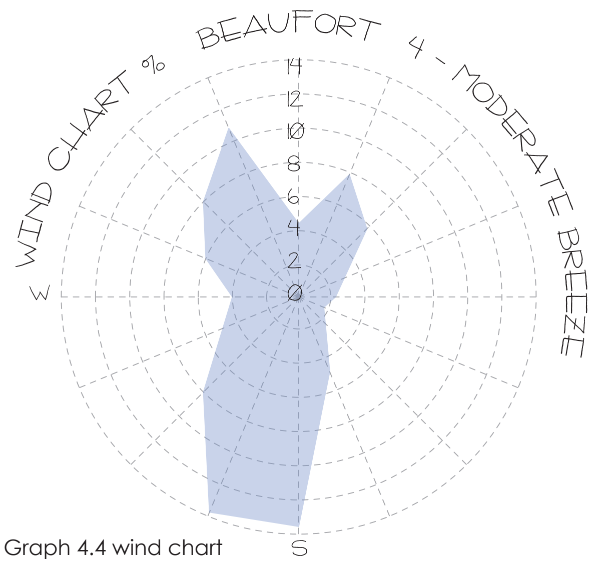
Graph 4.2 Annual temperature

Based on data of windfinder.com



Graph 4.3 Annual precipitation

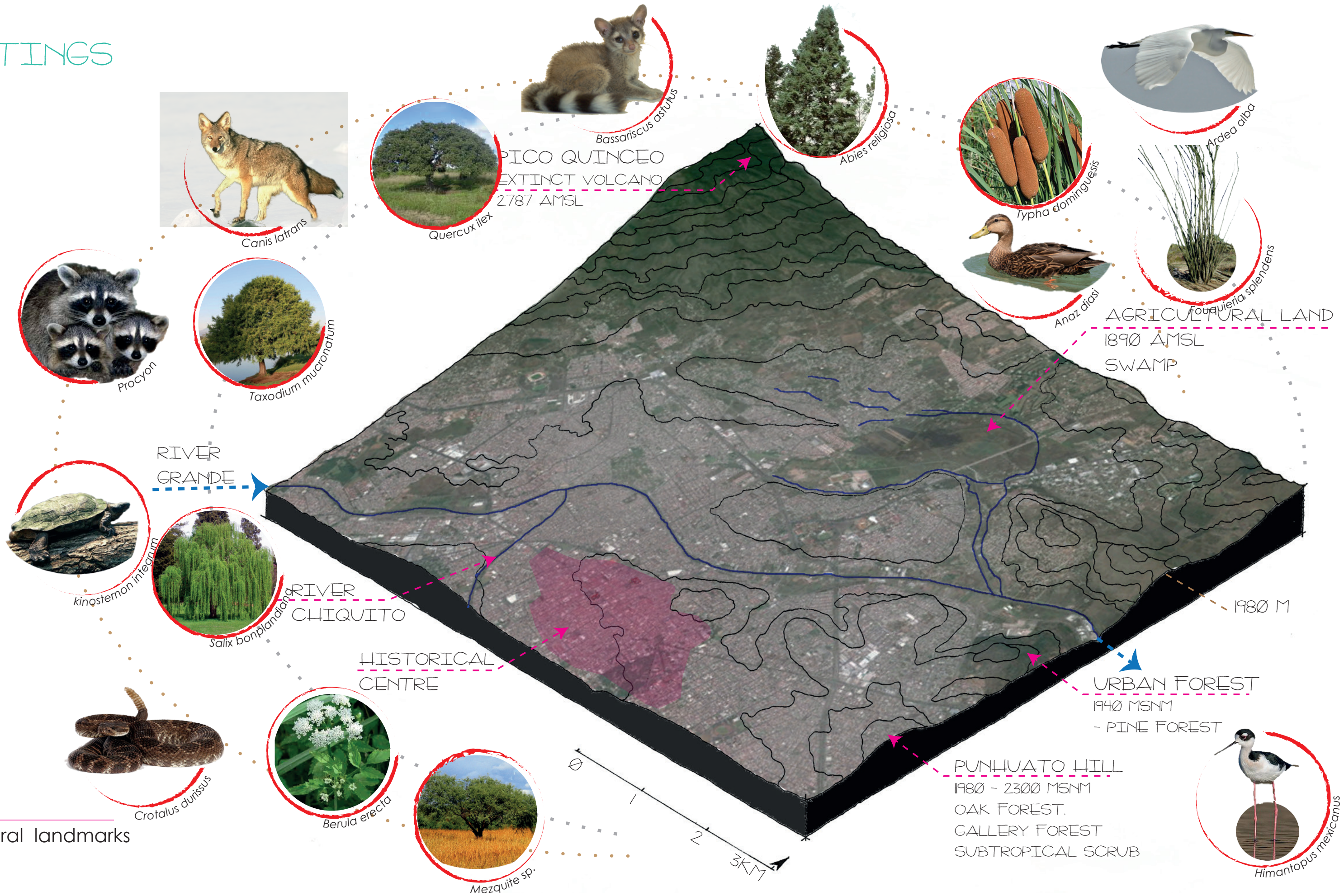
Based on Correa- Ayram et. al., 2014.



Graph 4.4 wind chart

Based on windfinder.com

NATURAL SETTINGS



Volume map 4.2

Location of the city and natural landmarks

The city is located in a broad valley formerly called Valley Guayangareo in the centre-north of the town. It is surrounded by hills and slopes (volume map 4.2). At the east the hill of Punhuato is located, it is an oak and gallery forest with subtropical scrub. At the west the peak of Quinceo is the highest mountain and is and extinct volcano that works as a cultural landmark for the citizens. On it, shrubs and some oak trees are the main vegetation.

At the south of the city a pine forest on the hills of Santa Maria and the peak of "La aguila" is located (not showed at the volume map).

The biodiversity of the state makes it difficult to list all species there are. According to the altitude we can find: Oak and pine forest, gallery forest, subtropical scrubs,and swamps. Wild species such as frogs, salamanders, toads, turtles, snakes, birds, eagles, pigeons, hummingbirds, coyote, fox, armadillo, rabbits, skunks, weasel, tlacuache, country mouse, among others.

URBAN FRAME

GREEN INFRASTRUCTURE

The green infrastructure along the river is mostly conformed by empty lands, some trees on the sidewalks and flood way. In the west part is located an Arboretum, that is an urban park of pines and oaks. In front of it crossing the river the old train cargo station is situated, and it is an empty land for different uses.

In the west side a protected area is located, on it some agricultural fields can be identified. Next to it the floodplain has been respected. However, the zoning plan allows the construction of housing with mixed used. On this area the forest protected by the industry works as buffer between the housing and industry area.

Within the city are several sport fields, some cemeteries and few parks, a zoo and the green areas of universities and medical clinics.

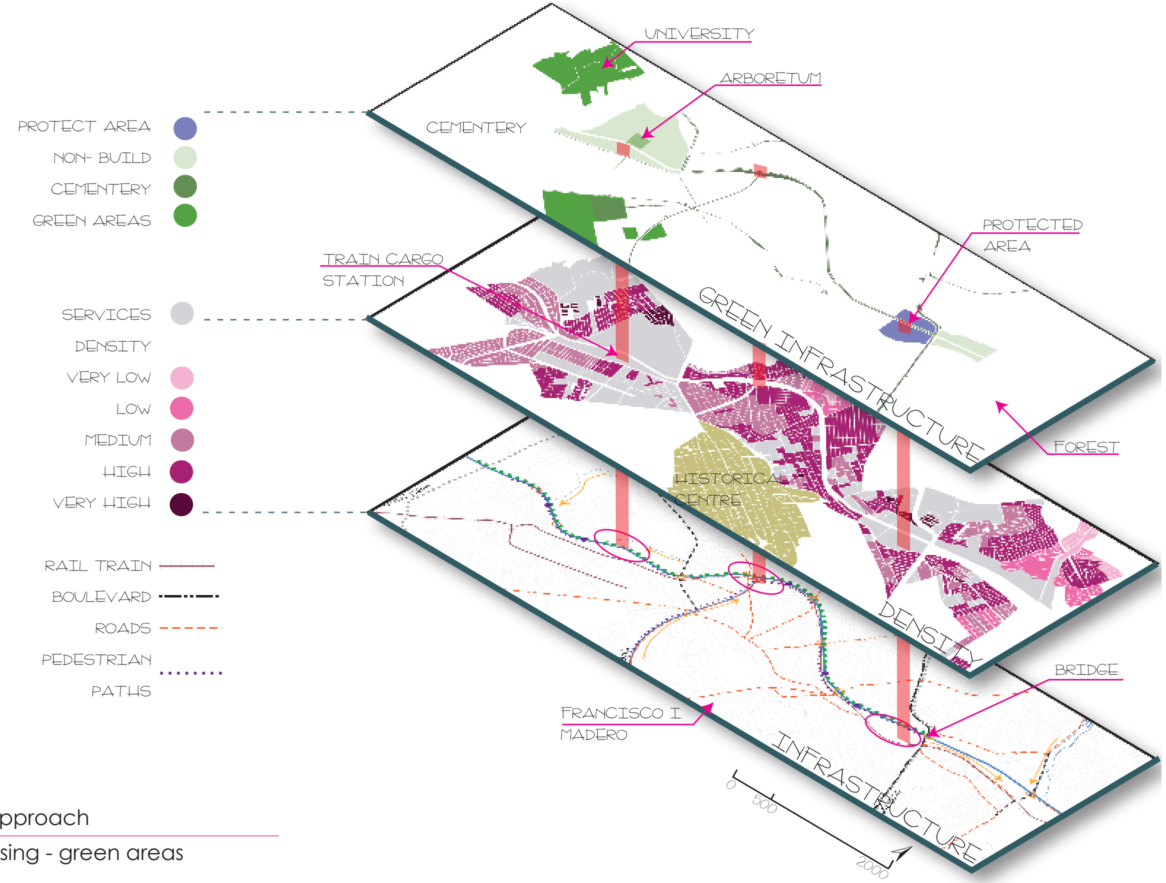


Fig 4.3 Layer approach

Network _ housing - green areas

BUILDING DENSITY

According to the UDPPM (2014) the area along the river is for mixed use, this mean that is for housing, offices and basic service (less than 250m²). Housing density is high to medium. Most of the building are houses of no more than two floors, some vacant lots and few business premises. The construction quality is medium to low according to the cadastral values of the country.

TRANSPORT AND NETWORKS

Along the river, at both sides, a 3 lines- avenue are parallel to the river. The rail freight train, parallel in the south side, used to transport explosive material. According to several local newspapers the train will be relocated to the outskirts of the city.

The river is crossed by 6 bridges that connect the north area with the city centre. From west to northeast the federal road 15 (Av. Francisco I. Madero) is a main road that cross the river and the city direction to the lake of Cuitzeo. From north (Tarimbaro) to south the Morelos avenue is one of the most important streets that connect the north side to the city centre.

Five pedestrian bridges at street level along the river are located. The sidewalks has no more than a meter wide, and the light poles, telephone network and vegetation set aside it, minimising the walking paths. The city does not count with infrastructure for bicycles.

HYDRIC PROCESS

WATER QUALITY

According to Godinez (2007) the channel of the river was designed to flow 90m3/sec of water. It receives from the Cointzio dam a volume flow of 0.160 m3/sec and 0.76 m3/s from river Chiquito of Morelia. Along the urban section of the river 4 drains, 4 municipal discharges and one creek were identified.

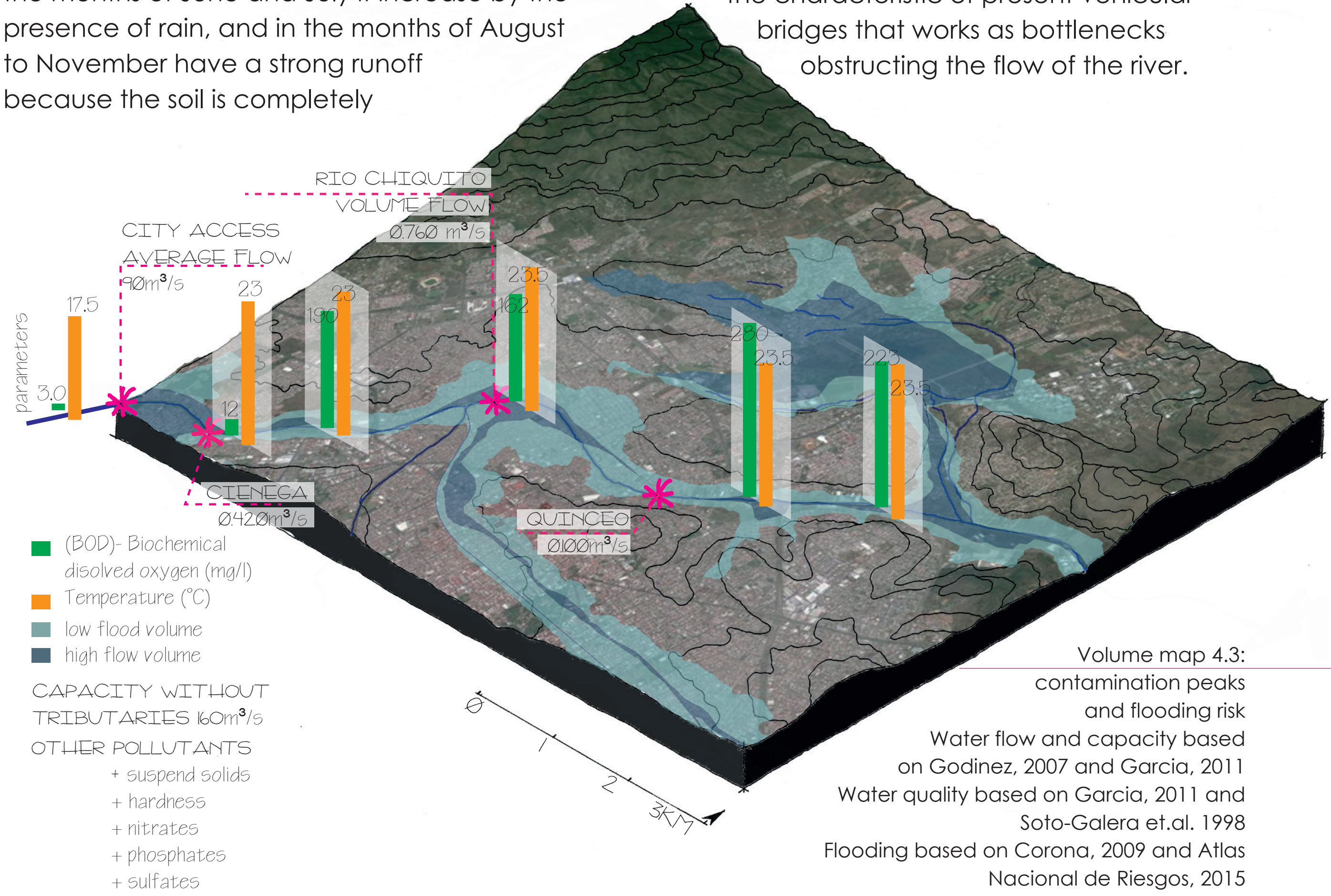
The river have problems of pollution due to dumping of different wastewater discharges from domestic, commercial, agricultural, industrial use and agricultural returns. The water samples obtained by Garcia (2011) and Soto-Galera et al.(1998) in the Cointzio dam were taken as water quality parameters, following the water quality index of the National Water Commission.

The study took into account the temperature and the biochemical demand as sample to locate the areas with higher concentration of physico chemical parameters (suspended solids, hardness, nitrates, phosphates, sulphates, turbidity) that reduce water quality.

FLOODING RISK

According to "*La ciudad de Morelia*" a book written in 1873, the city already presented flooding problems that were formed in the lower marsh and swamp floods. Nowadays, the intensive building development results in outflow acceleration and reduction of water retention time.

According to Corona (2009) in the period from January to May is low water infiltration, but in the months of June and July it increase by the presence of rain, and in the months of August to November have a strong runoff because the soil is completely saturated not allowing infiltration, and causing superficial runoff. The volume map 4.3 shows the areas that are more susceptible to flooding (Corona, 2009; Atlas Nacional de Riesgos, 2015) in a return period of 100 years. These areas have the characteristic of present vehicular bridges that works as bottlenecks obstructing the flow of the river.



Volume map 4.3:
contamination peaks
and flooding risk
Water flow and capacity based on Godinez, 2007 and Garcia, 2011
Water quality based on Garcia, 2011 and Soto-Galera et.al. 1998
Flooding based on Corona, 2009 and Atlas Nacional de Riesgos, 2015

CULTURAL ASPECTS. INTERVIEWS WITH INHABITANTS

During the field trip, interviews regarded river perception were made to inhabitants (appendix I). Most of those interviewed showed concern about flooding and the disease that the river can lead, specially to children. The main issues were placed on a problem tree diagram to identify the causes and the effects of them (diagram. 3).

CAUSES AND EFFECTS

The problems are related to the management of water. Flooding problems usually occur in the middle of rainy season (August-October). In the case of contamination of the river it increase on rainy season, however the dump of garbage to the river happens throughout the year.

The causes of flooding due to the absence of rain sewage drainage, and the lack of infiltration areas. On the other hand, the trash thrown into streets and rivers are clogging the drains. The effects of flooding are material and economic losses to the inhabitants, specially the neighbours of the river. Stagnant water that fosters the spread of mosquitoes and therefore disease.

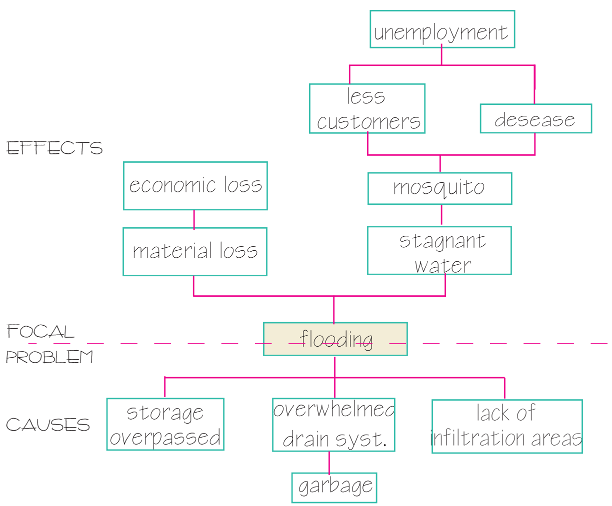
The causes of water pollution are more complicated. In some areas, wastewater is sent to the river without treatment. The canalization of the river and the lack of accessibility has caused people perceive it as a waste water channel, provoking that inhabitants dump trash to the river. Despite it is forbidden by law.

From an ecological point of view, the rectification and canalization of the river increases the speed of water but decreases the ability of the ecosystem to regulate itself. Moreover, the elimination of the flood plains to place avenues has denied to the river a necessary space to perform its own functions.

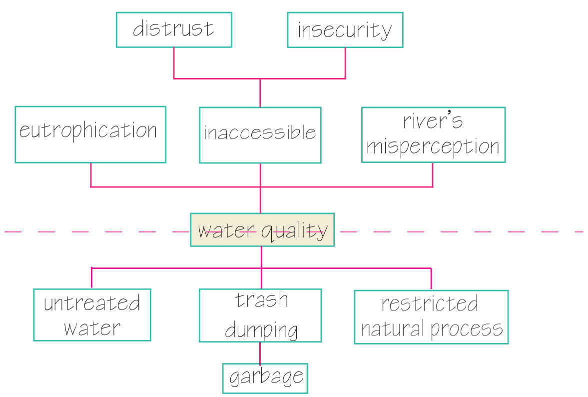
NEEDS AND DESIRES.

The field trip along with interviews also yielded a list of needs and desires:
Garbage disposal, odour elimination, and flood protection were the principal needs. Improving communications like bridges, walking, and cycling paths. Areas for children and elderlies, illumination at night for safety, and trash deposit areas were the most important requirement for people.

FLOODING



WATER CONTAMINATION



Problem tree diagram 4.3
Based on interviews during field trip

4.4 SPECIFY METHODS

The first iteration shows the need to take actions that allow the improvement of water quality and flooding risk mitigation. This actions involve the capture of storm water by increasing green and pervious areas, the regulation of waste management and the recovery of the river buffer zone.

DECISION

It is proposed to create a chain system that allows the collection and cleaning of water, storage and filtration areas. This system will work in conjunction with the recovery of the riparian buffer.

The system consists of a chain of sustainable drainage (fig. 4.4). In its first stage the capture and filtration of water will take place. This will help to regulate and direct the water to regulation ponds, catchment areas and then towards the river. In it, the process of cleaning and regulation will continue by natural means (floodplains and the creation of a constructed wetland system).

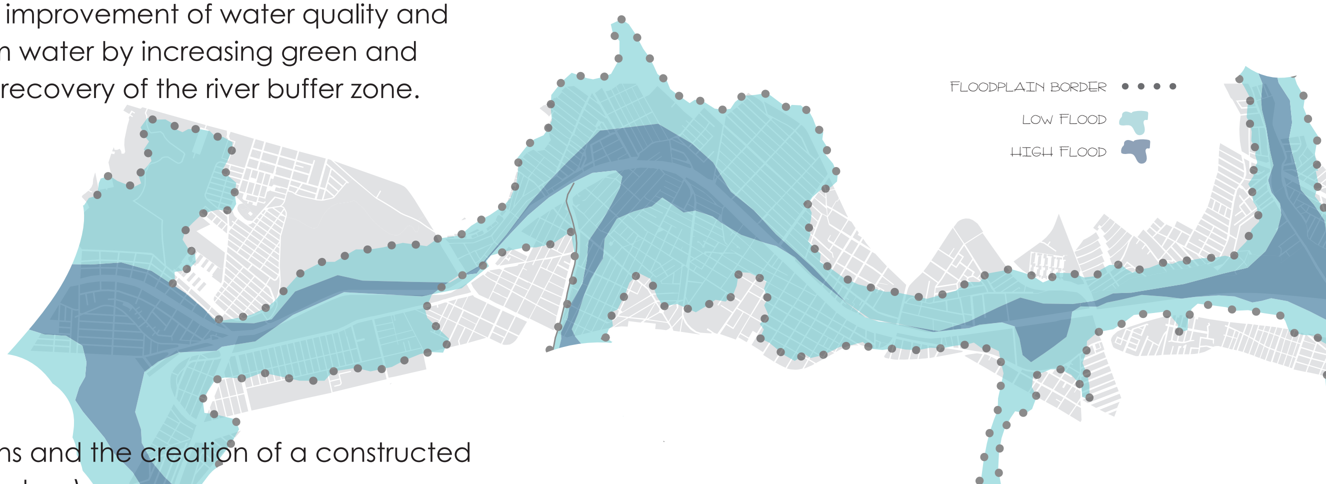


Fig. 4.5. Impact of flooding in housing

IMPACT

The urban settlement in floodplains plus the lack of pervious areas has increase the surface of flooding risk (fig. 4.5). To know the impact that these actions may have first was necessary to analyse together the topography, the type of soils and its relation with the flooding risk areas.

The topography of the land impacts in areas of water accumulation. Topographical plans allowed to set the direction required to direct drains into catchment and regulation areas.

The types of soil of the area (alluvial and monzonite) have different coefficients of filtration, which increase or decrease the water absorption capacity. The soil type maps were used to identify sections of higher and lower water filtration.

Urban density plans allowed to identify areas with less impervious area and floodplain areas that have been already built.

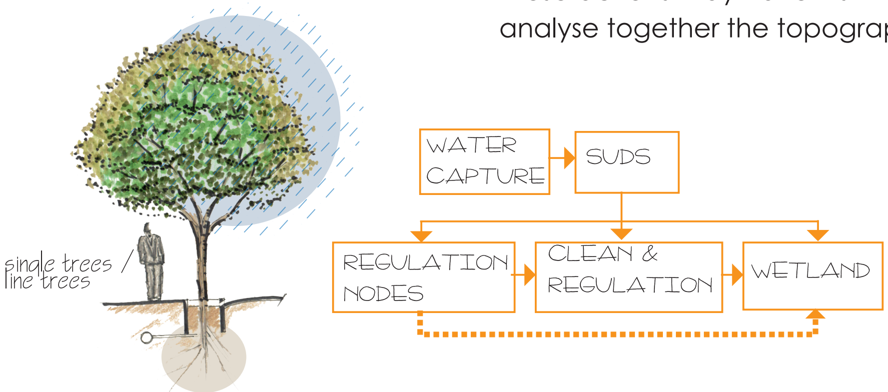


Fig. 4.4. Chain of sustainable drainage

CHANGE

To identify areas for change, three suitability maps were created.

The first map (fig. 4.6) juxtapose the type of soils with flooding risk to identify the floodplains and the flooding areas by type soil. These ones requires more attention by creating borders which can be dikes, a buffer of trees or swales.

The second map (fig. 4.7) juxtapose the topography (slope direction) with flooding maps to identify flooding areas by accumulation of water. This areas requires buffers that slow down the velocity on water and mitigate runoff.

The third map (fig. 8) juxtapose topography with the catchment sub-basins (SIATL,2016), to identify suitable areas for storage water by dividing in different basins. This helps to not distribute the water in just one area.

The maps also helped to identify in the floodplain an area that can serve as a transition zone to send urban water to the river, which has enough space for the creation of wetlands and at the same time can offer a place for recreation to the inhabitants.

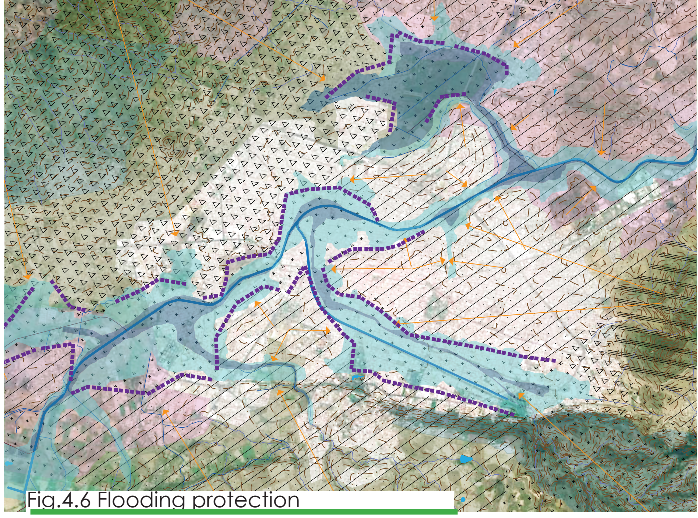


Fig.4.6 Flooding protection

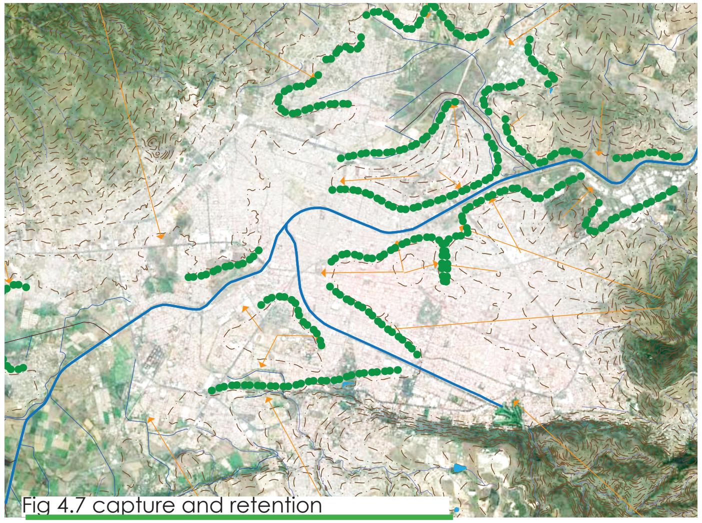
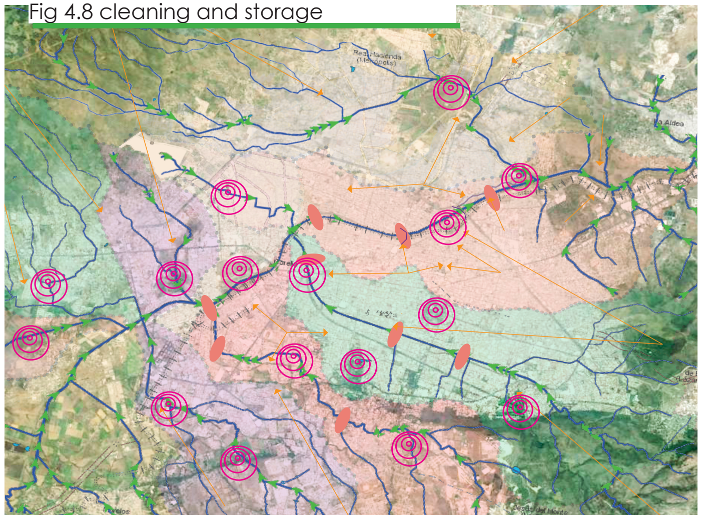


Fig 4.7 capture and retention

Fig 4.8 cleaning and storage



SIMBOLOGY

SOILS

ALLUVIAL

BAZALT

MONZONITE

FLOODING

LOW FLOOD

HIGH FLOOD

SLOPE DIRECTION

FLOW DIRECTION

FLOODING PROTECTION

WATER CAPTURE AND RETENTION LINES

WATERSHED BORDER

PRE-TREATMENT CELLS

WATER STORAGE PONDS

Suitability maps give as result the increase of the green structure. Which will be through tree lines which are part of the drainage system SUD (fig 4.9 and 4.10).

The system consists of main water capture lines that connect with the river. Secondary capture lines serve as support.

The water is directed to regulation ponds that send water to pre-treatment cells, channelling the water into the river or wetland.

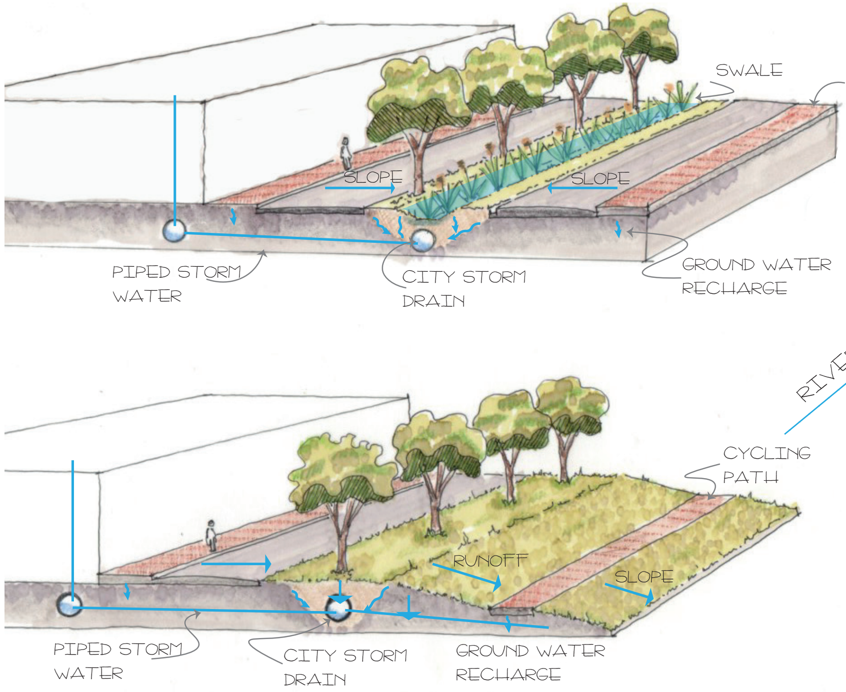


Fig 4. 9. Urban green infrastructure and SUD's

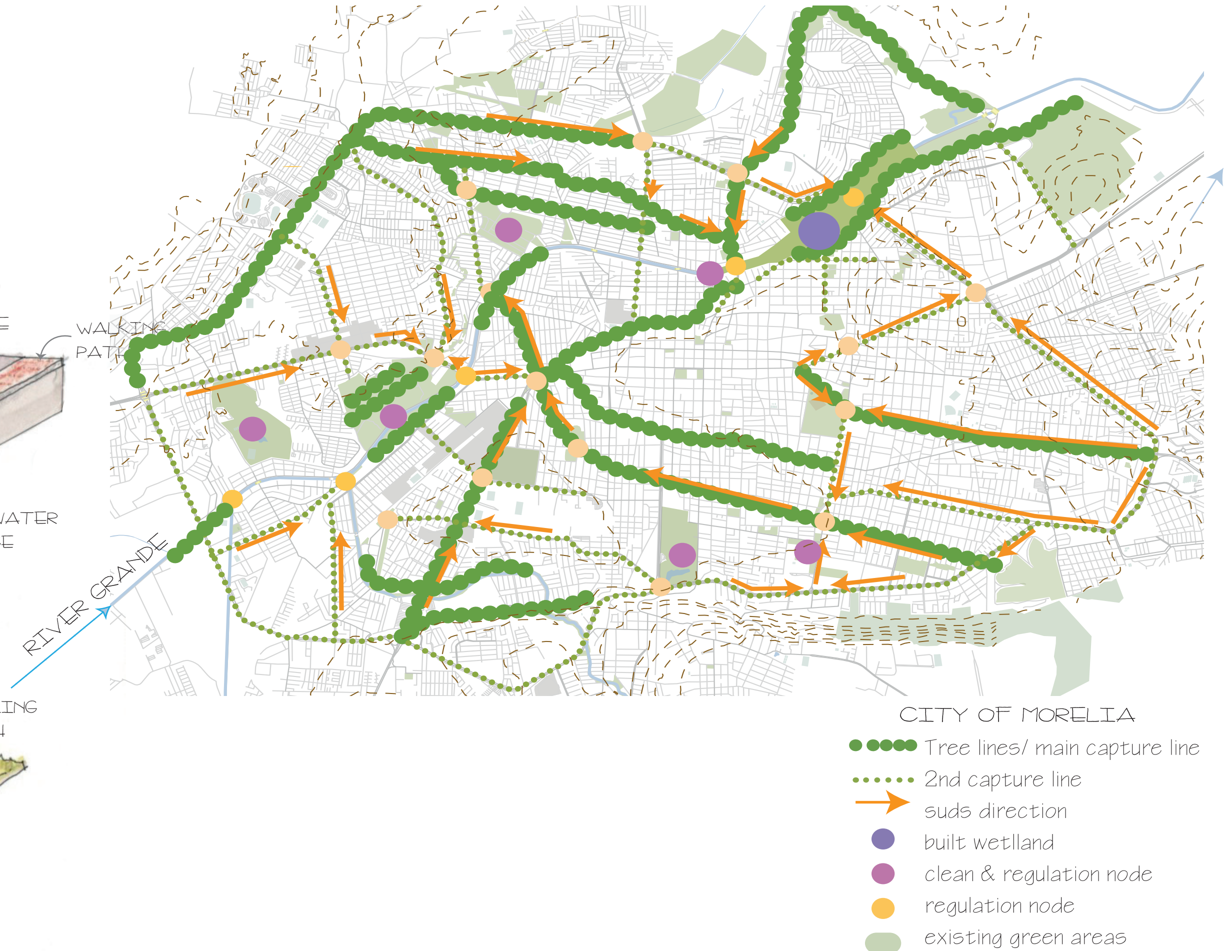
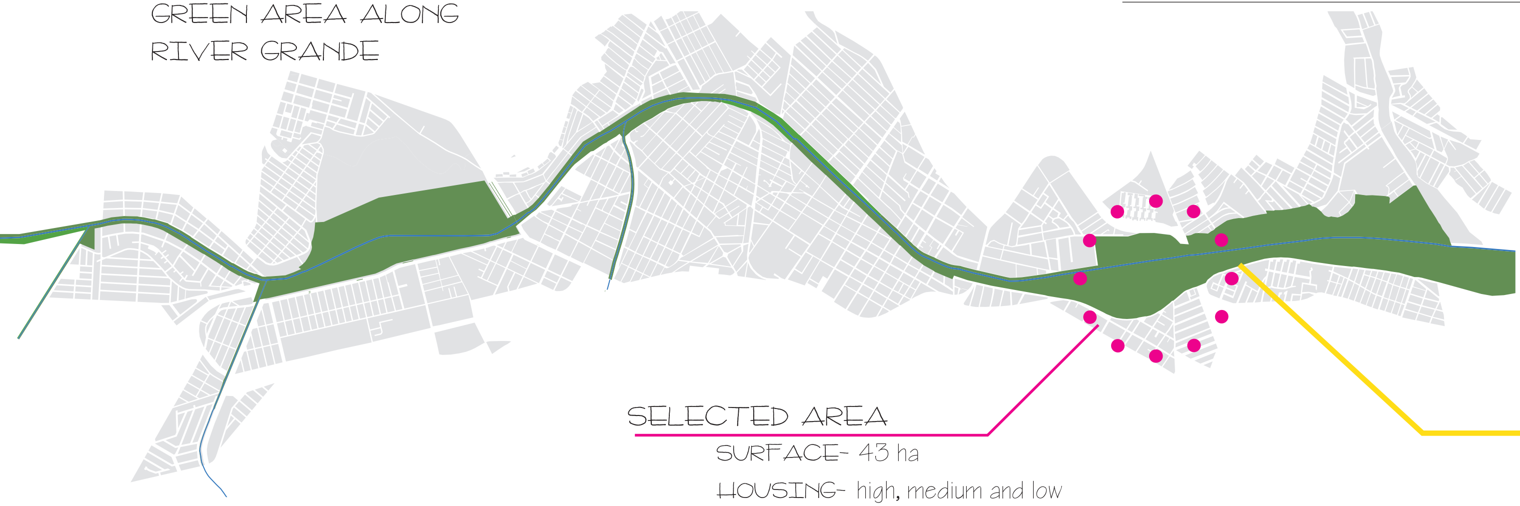


Fig 4.10. Meso map
Urban green infrastructure and SUD's

GREEN AREA ALONG
RIVER GRANDE



SELECTED AREA
SURFACE- 43 ha
HOUSING- high, medium and low density
TYPE OF SOIL- aluviol and basalt

Fig 4.11 location of selected area

STRENGTHS	WEAKNESS
High floodplain area conserved final section of the urban area	Housing density streets along the river
OPPORTUNITIES	**THREATENS**
Connection to the historical centre close to the urban forest Near to 2 main access to the city	Fast urban growth

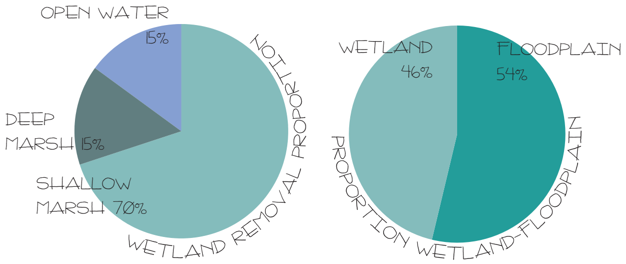
EVALUATION

To select an area for constructed wetlands three areas along the river were evaluated by SWOT analysis (appendix II).

The selected area (fig 4.11) is located in the area part between the historical centre and the urban forest. It has space enough for the creation of wetlands and to claim the floodplains.

On this area, the floodplain is not fully built, making the zone a good opportunity to recover it and promote river restoration.

WETLAND SPACE PROPORTION



Based on France, 2003

PROCESS

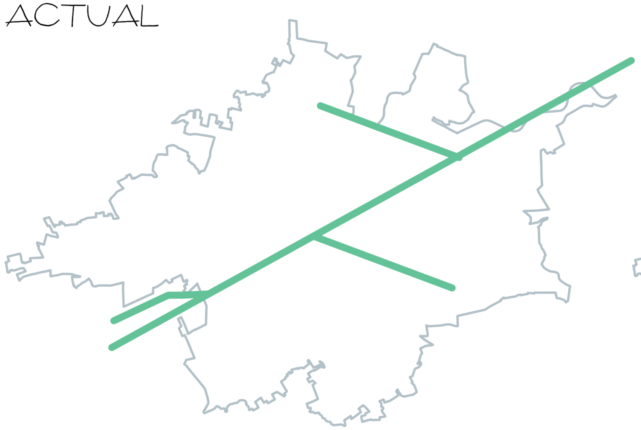
In a surface of 43 ha, the 46% (19.6Ha) will be used for the construction of wetlands, leaving the other 54% for floodplains and cultural services.

The wetland zone will be used as a core area for ecological process. On it the construction of 4 cells will regulate and control the water quality of the river. The location of the wetland cell was obtained by a detailed study of the area.

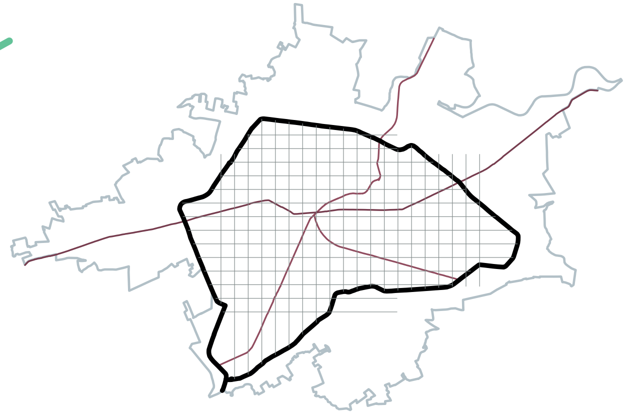
4.5 SUMMARY: PRE CONCLUSIONS

URBAN PATTERNS

ACTUAL



RIVER PATTERN

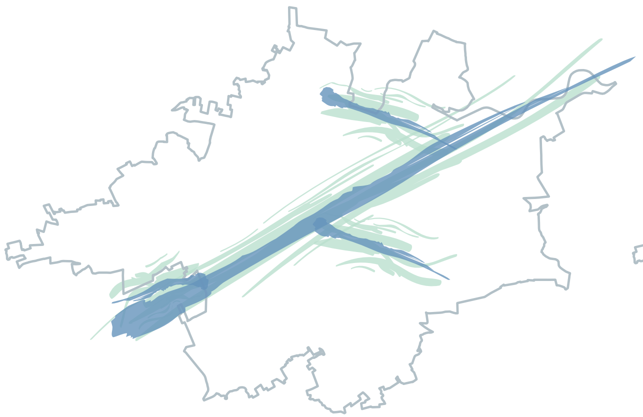


ROAD PATTERN

At meso scale a new configuration of the urban patterns is proposed. Shifting the lifeless systems to living systems.

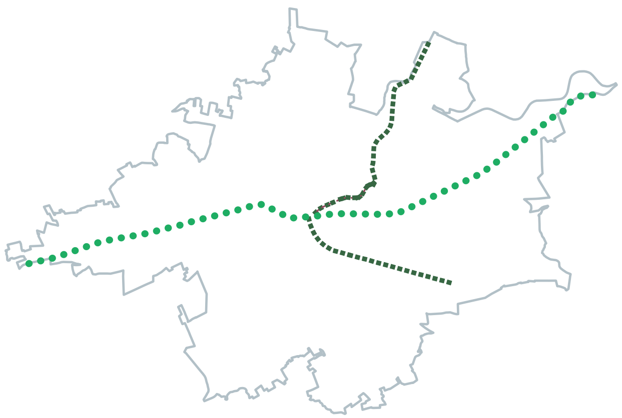
Turning the channel of the river in a biological corridor that promotes restoration of plant and wildlife within the area.
Creating the streets into green corridors that allow the capture and regulation of rainwater and provide greenery to the city. Generating tourist corridors that are attractive for economic and cultural benefit of society.

NEW ONES



LIVING SYSTEM PATTERN
BIOLOGICAL CORRIDOR

LIVING SYSTEM PATTERN
REGULATION CORRIDOR



LIVING SYSTEM PATTERN
TOURISTIC CORRIDOR

4.6 DESIGN STUDY ANALYSIS OF THE SELECTED AREA

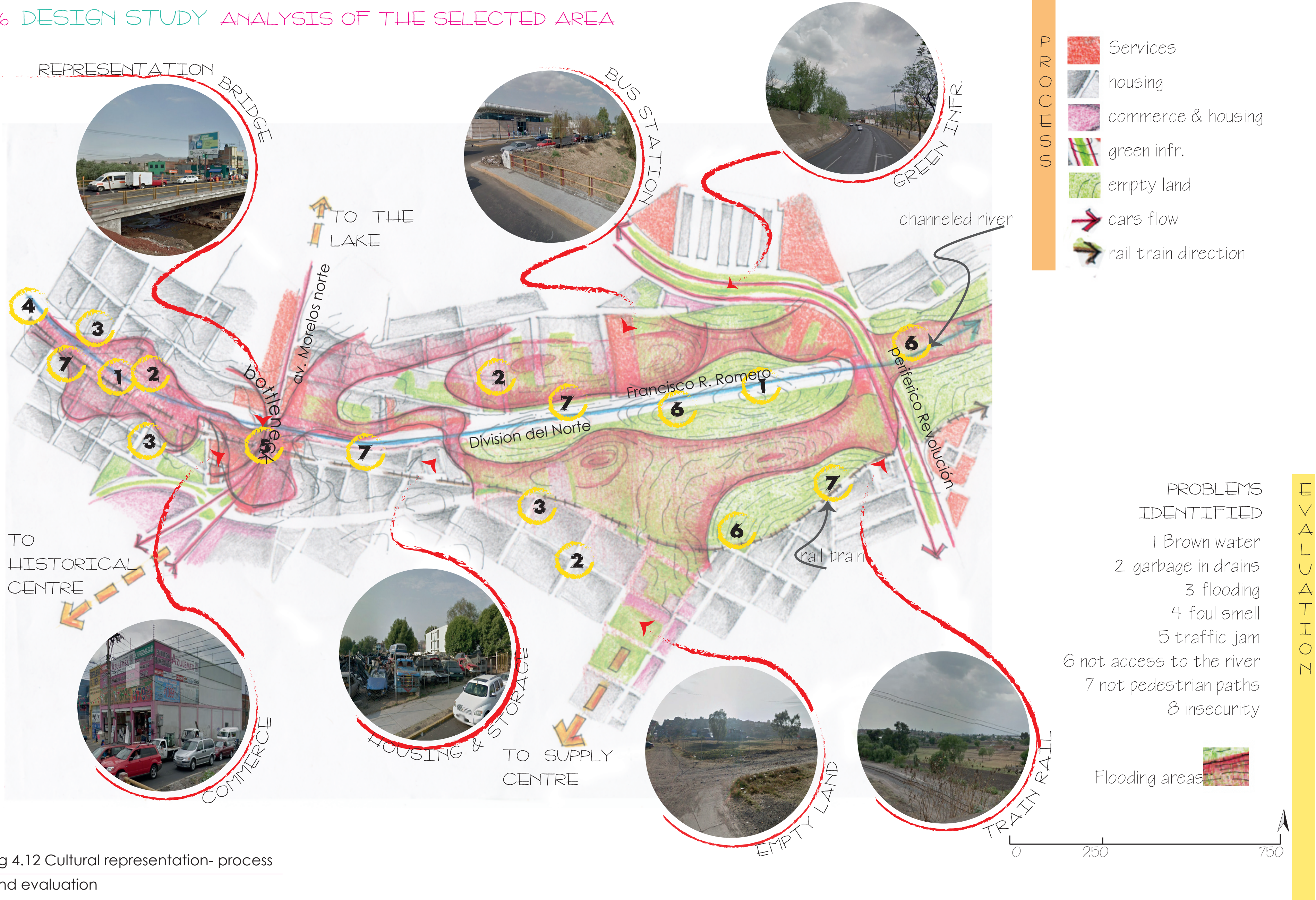


Fig 4.12 Cultural representation- process and evaluation

DESIGN STUDY

With irregular shape the land is about 3 km length and the width varies from 48m the narrowest part to 490m the widest part. The broader area is selected for the construction of wetlands.

The area is framed by two bridges. At west side is the bridge "*Avenida Morelos norte*" and at the east is "*anillo perifercio Revolución*". The river is rectified, channelled and framed by two parallel streets of three lanes each, "*Francisco R. Romero* at north and "*Division del norte*" at south. Around the area are houses, the suburban bus terminal, some commercial buildings and two gas stations (fig 4.12).

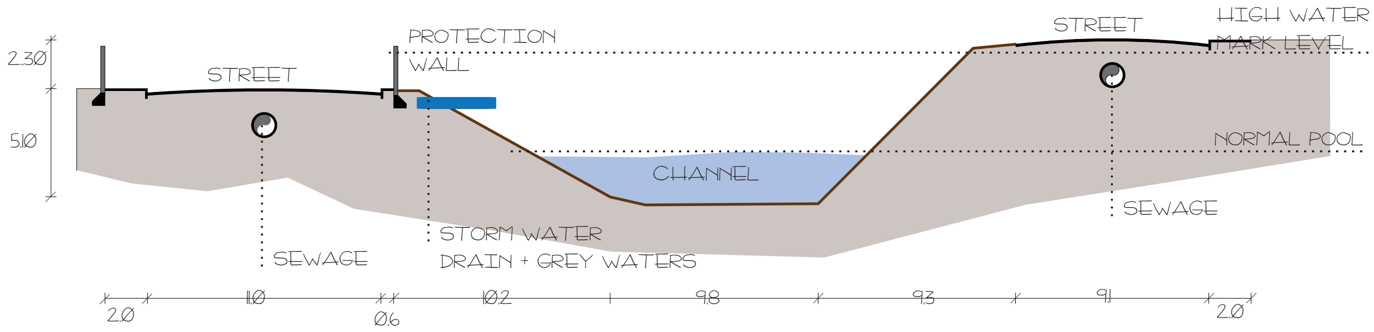


Fig 4.13 . Section scheme of the river

The canalization of the river reduce the essential space of the river, promoting the use of barriers as walls and steep slopes. Making very difficult the access to it, and creates an atmosphere of rejection from the inhabitants to the river (fig. 4.13).

In addition to the problems of pollution and flooding the area has other problems such as: a bottleneck effect on the bridge of *Av. Morelos.* There are no sidewalks or bicycle paths, and pedestrian bridges are unsafe and full of trash.

The vegetation is mostly grasses and some native trees like the *Salix bonplandiana* and others introduced such as the *Causarina equisitofolia,* which are constantly pruned by the maintenance service to allow the rapid flow of water.

During the field trip was noticed that the area is flat with slight changes in topography. However, reviewing the topographic maps could be observed differences in terrain. Through these differences is intended a new route of the river that follows the natural movement of the ground (fig 4.14). This allows the river to have a flow that promotes the process of aeration necessary to lower levels of BOD.

The zoning plan (fig 4.15) shows the planning and the different functions of the terrain. Along the river is located the riparian buffer zone with a width of 30.5m on each side of the river in total. To the west a small wetland area will support the main core area that is located in the widest part of the terrain. Within the core area the ecological services of the eco-park will take place, leaving recreational and cultural activities in the remaining areas of the terrain.

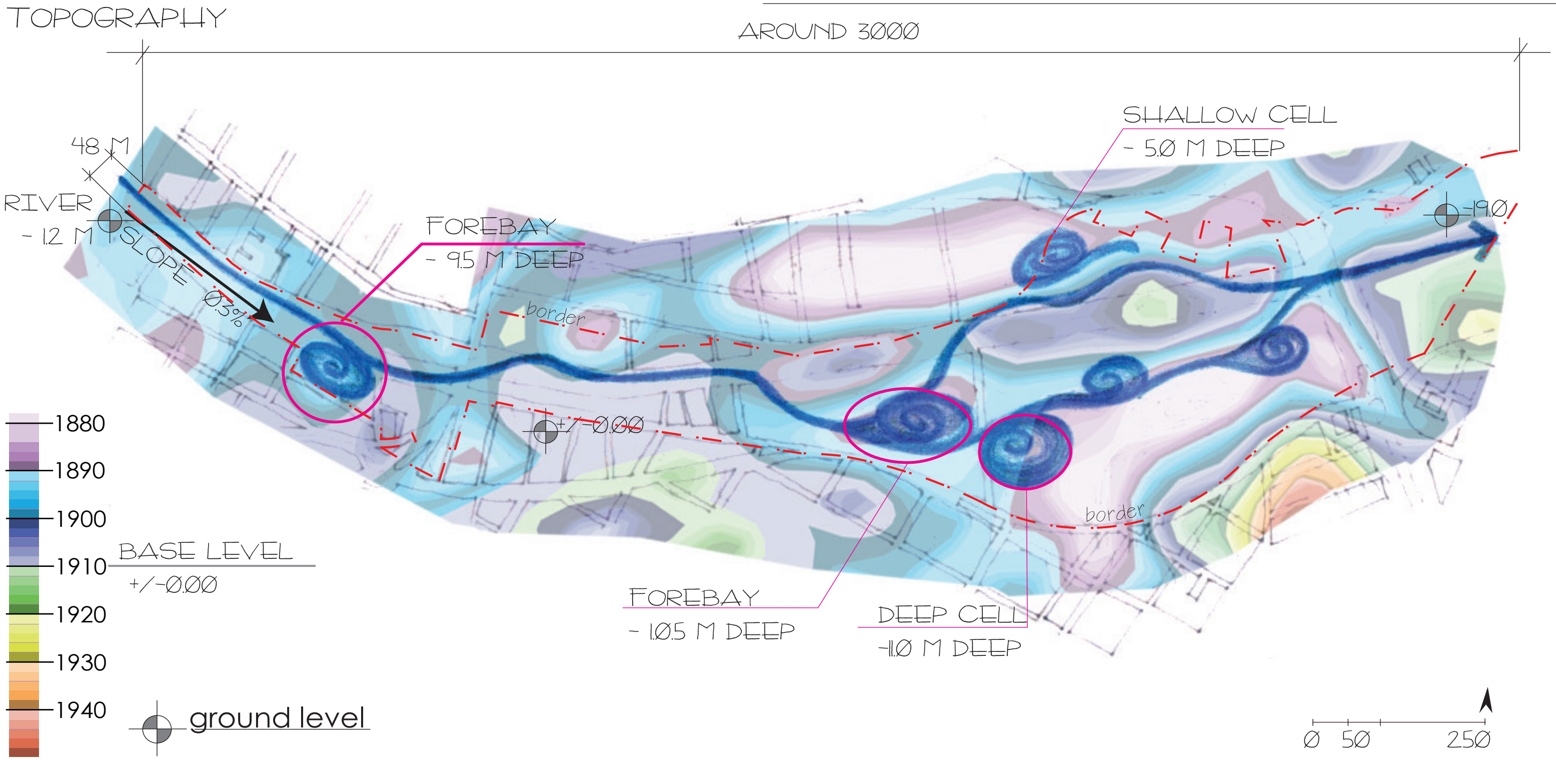


Fig 4.14 . Topography of the field and ponds location

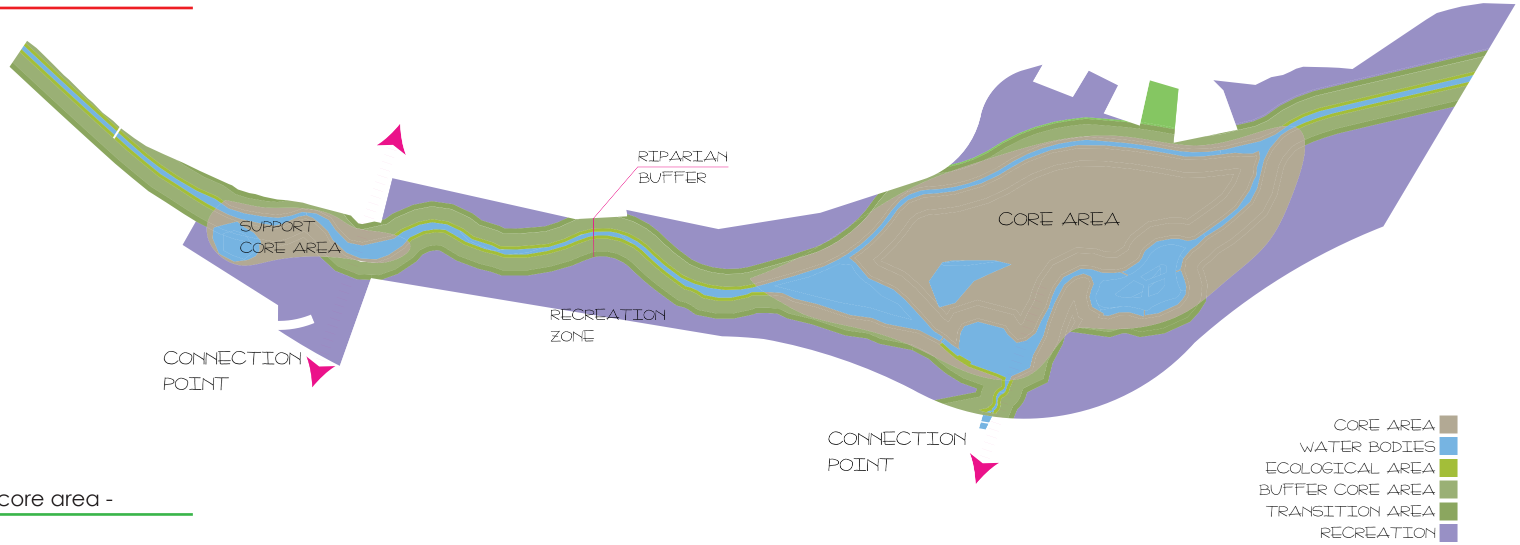


Fig 4.15 . Zoning map- core area - riparian buffers

4.7 SUMMARY:

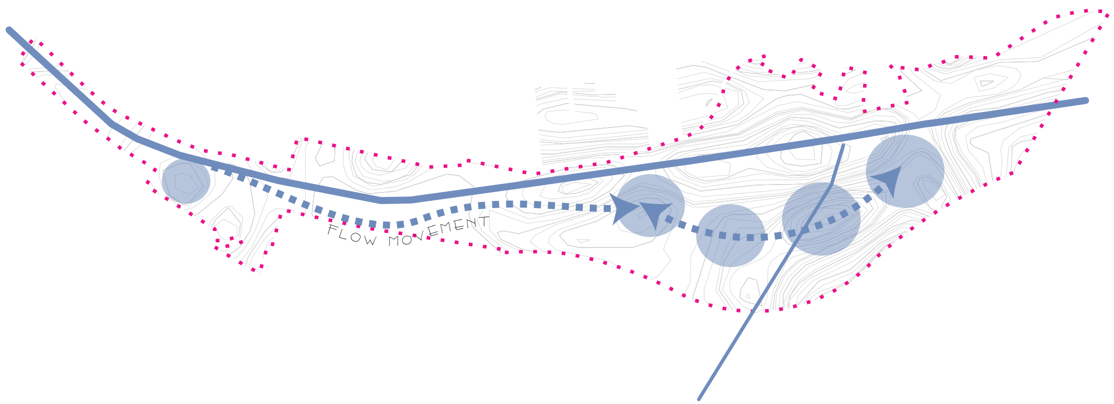
PRE DESIGN

CONCLUSIONS

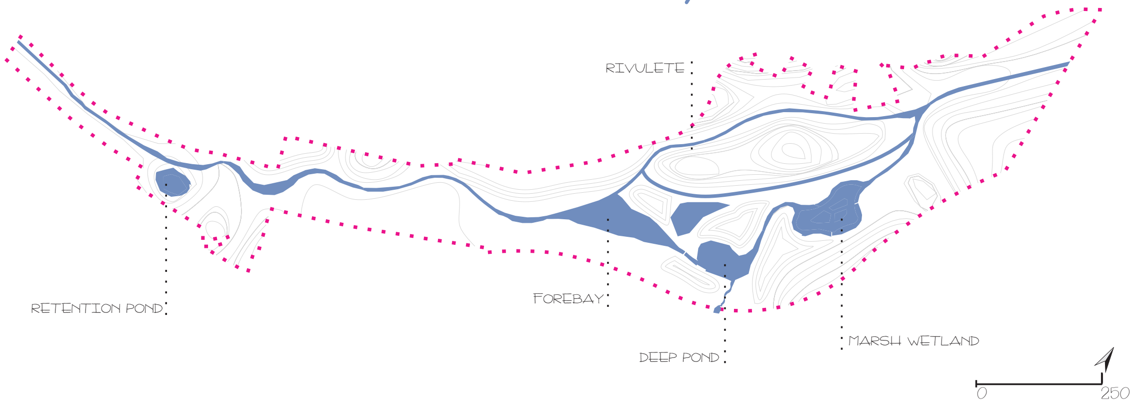
RIVER RECONFIGURATION

CURRENT SITUATION

PROPOSED WATER FLOW AND
WATER BODIES



MOVEMENT OF THE RIVER
THROUGH
HILLS AND VALLEYS



DESIGN STRATEGY.

Replace the existing water channel flow to a free flowing stream, through ponds and marsh to support the re-establishment of the ecological functions of the river.

Reshape the land with hills and valleys that provide movement to the flow of the river, improving the aeration of the same.

4.8 ZOOM-IN INTO DESIGN AREA

The selected area will be designed as an eco-corridor within an urban eco-park. It will takes into account the ecological functions and services of the riparian ecosystem.

The area was studied in depth, in order to identify the zoning of ecological areas of protection and recreation and to carry out the landscape architecture program which is described in Chapter 5.

Maps A and B (fig 4.16) shown some of the changes that will take place in the area, taking into account the problems of flooding, accessibility, regulation and water cleaning.

ACCESIBILITY	FLOODING PROTECTION	WATER QUALITY	CULTURAL
walking / jogging paths	Dikes	Water regulation	Recreation
cycling paths	Water regulation	Aeration	Rest areas
pedestrian bridges			Views (learning, heritage)
rest areas			

CHANGE

MAP A - WEST AREA

MAP B - EAST AREA

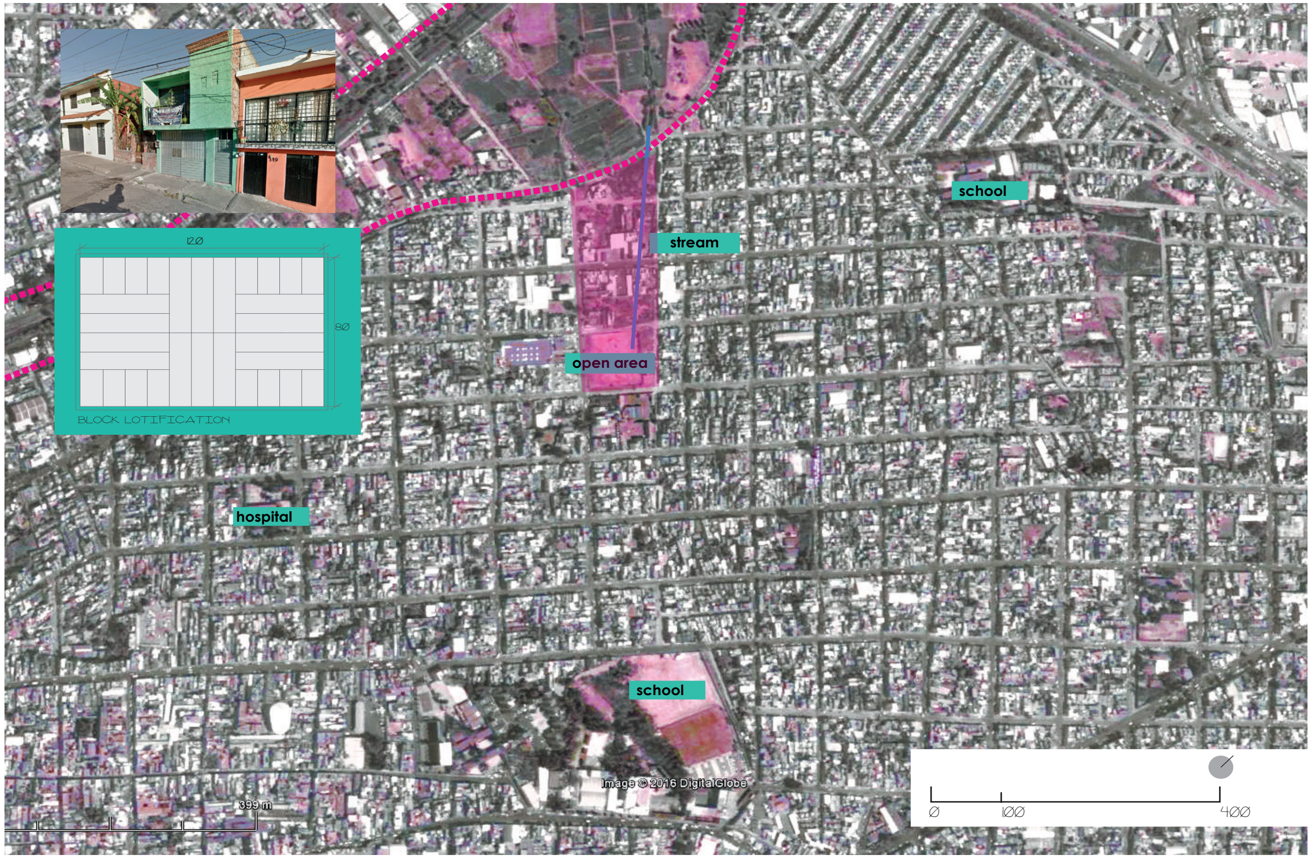
Fig 4.16. Operating maps

Map A and map B

Four neighbourhoods around the design area were analysed. Identifying green areas public areas, public services, recreation areas, schools, commerce, supply centres, gardens (patios), private gardens, Public gardens, libraries, waste land, storage areas and markets.

Analysing the urban patterns was found that there is no local parks or green areas that serve as meeting points. This promotes the fragmentation of the social cohesion. The selected area is an example of the green infrastructure of the city, which is almost null.

The selected area will work as an example to link housing areas to the urban eco- park. Promoting it as a part of the configuration of the social life.



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Chapter 5

RESULTS

ES EVIDENTE QUE LA IDEA MISMA DEL JARD.IN
DESPIERTA EN LA IMAGINACIN DESEANTE
ANHELOS DE PARAISO EN LOS QUE SE
INVIERTE NO SOLO TODO EL CUERPO SINO
ADEMAS TODO LO QUE SE CONSIDERA EL
SENTIDO MISMO DE LA VIDA.

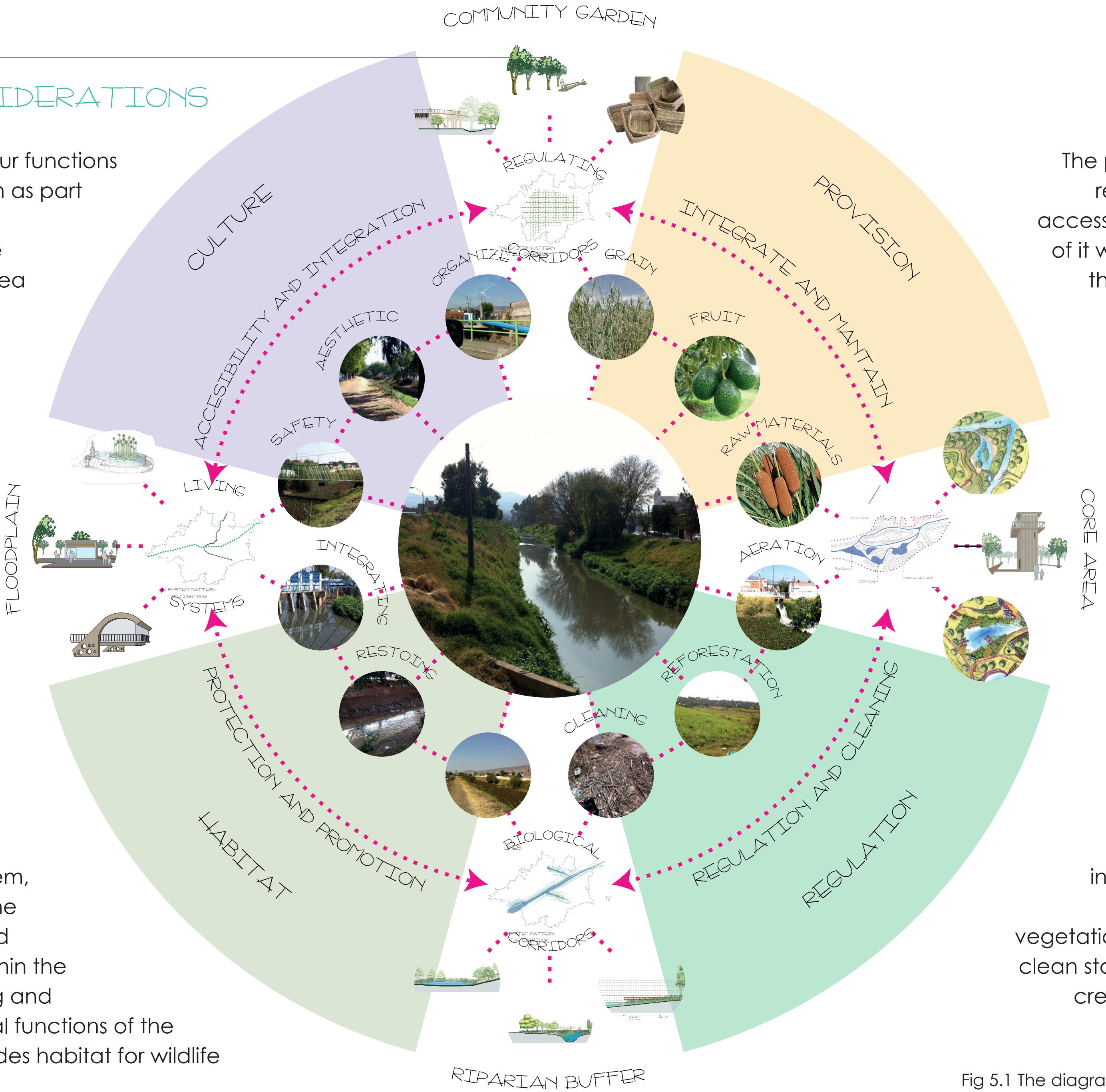
Alberto Ruy Sanchez. 2009
Los jardines secretos de Mogador.

5.1 DESIGN CONSIDERATIONS

In order to include the four functions of the riparian ecosystem as part of the program some considerations about the situation of the design area are analysed.

The main objectives of the partial restoration of the river are the cleaning and regulation of the same. For this purpose the core area of the project will functions as a living systems that cleans and regulate the water of the river, by the creation of constructed wetlands that mimic the lake scenery of Cuitzeo.

To support the living system, the riparian buffer and the floodplain will be restored (partially) along 3 km within the urban section. Protecting and promoting the ecological functions of the riparian ecosystems besides habitat for wildlife species and plants.



The promotion of the river restoration will provide accessibility and integration of it with the culture and in the urban environment by creating social cohesion.

The master plan considers flood protection areas, regulation ponds, recreation areas such as walking and cycling paths, fishing decks, rest areas.

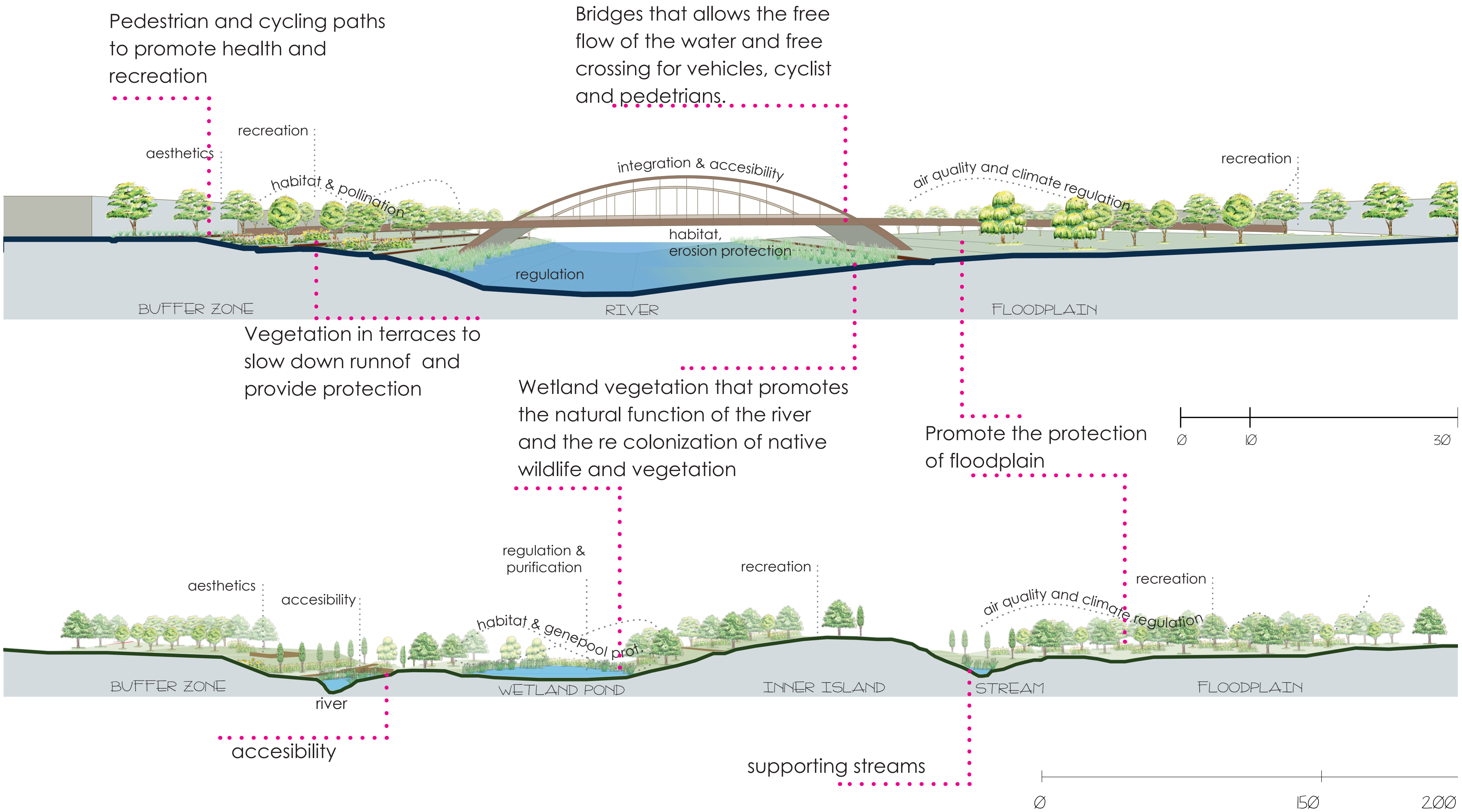
The selected vegetation is mostly native to support plant diversity and encourage the colonization of indigenous wildlife. The riparian and wetland vegetation serve to purify and clean storm water run-off and create a sense of place.

Fig 5.1 The diagram of design considerations summarize the conclusions to take into account

5.2 MASTER PLAN DESIGN.

1 cycling and pedestrian paths
2 Embankment (flood protection)
3 Regulation pond
4 Resting area
5 Children's playground
6 Fishing deck
7 viewpoint
8 Water fountain (aeration jet)
9 Wellness gardens
10 community area
11 Art gallery
12 Sculpture garden
13 Ecosystem museum
14 Parking lot
15 Core area wetland)
16 Observation tower
17 Observation bird-house
18 Pedestrian bridges
19 Community garden
20 Craft workshop
21urban agriculture

GENERAL SECTIONS



5.3 CORE AREA DESIGN

The core area accommodate the wetland that has the function of regulate and clean the water of the river and the Sud's system (see wetland design process, page 71).

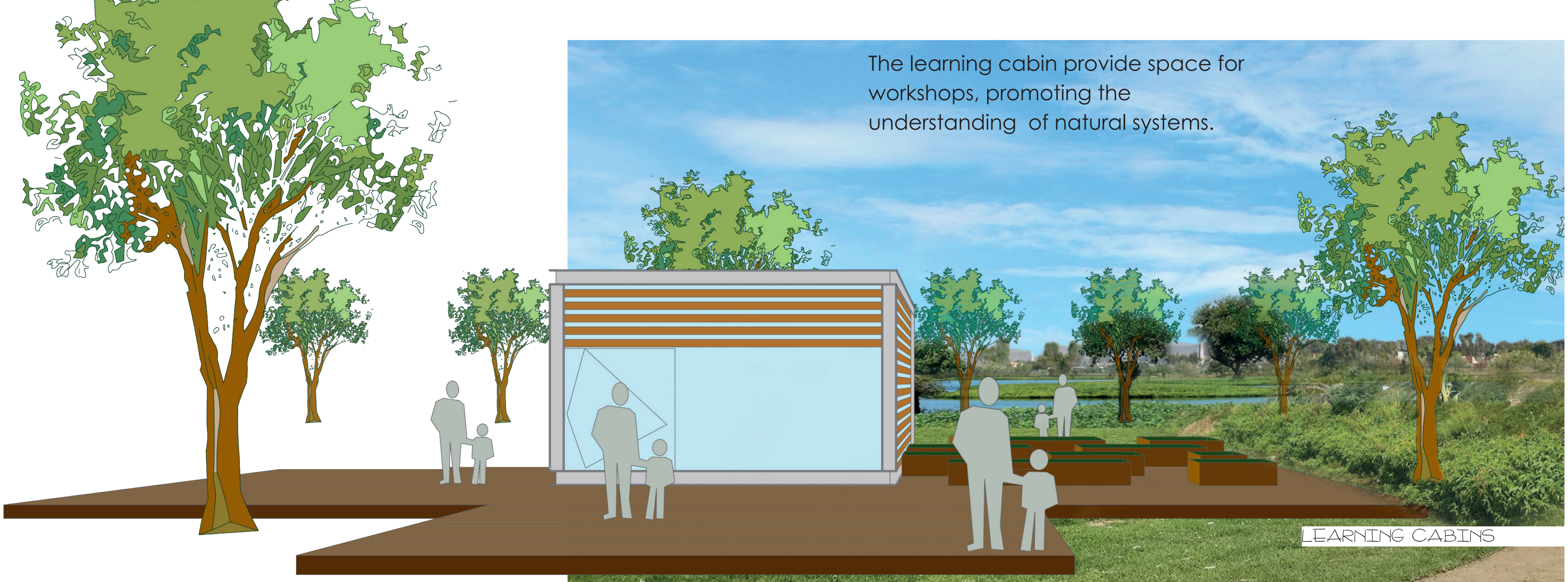
Before reaching the core area, the river bifurcates creating the effect of an island with the intention that the core area offers passive recreation. Allowing and promoting the colonization and protection of native flora and fauna.

The area stimulates the sense of closeness to nature and provide learning incomes to visitors.

Pedesrian bridges give the access to the area. Walking paths outline the route directing the visitor to wetland cells, an observation tower and a bird- house observation area. Some boulders for climbers, resting decks and a learning cabin can be found during the tour.

The wetland cells provide habitat for fishes and some ducks, and offers the opportunity of fishing and relax next to them (page 74). The last wetland cell creates habitat for native wildlife, including birds, turtles, lizards, frogs and toads, among others. In this area the house for bird observation is located (page 75).

In the highest part of the island is located an observation tower builded with light materials, and allows an overview of the park.



CORE AREA DESIGN WETLAND

The core area or wetland is designed following the principles of France (2003). It is an area of 43ha which represent the 2% of the watershed.

The distance, time, and number of treatment cells are fundamental for the contamination removal performance of the wetland (diagram 5.2). The effectiveness of the removal would take a around 10-15 days of flow through treatment cells (France, 2003; Vymazal, 1999), that are between 3-4 cell in a distance from inflow to removal plateau between 20 to 100 meters.

The water of the SUD system and river will flow to a fore bay that functions as pre-treatment sediment cell. It will continue its riverbed to the core area running into a second chamber. Both fore bays work to regulate the flow rate of water during rainy season.

On the core area the function of the wetland is set. The water will cross through three cells (diagram 5.2). The shape of the cells including fore bays, are irregular shorelines that mimic the natural system increasing nesting and resting areas for wildlife.

The proportion of the wetland is designed for contaminant removal. The first cells is a deep marsh that represents the 15% of the wetland, the aeration pond that represents the 15% and the shallow wetland that represent the 70%. This will allow to change the sequence of the depth and promote the establishment of a suite of different plants.

The preference of vegetation is based on the selection of native plants that allow to mimic the operation of the shorelines on the lake of Cuitzeo. Since, mimicking the ecosystem potentates their ability of restoration (Pedersen, 2015).

The selected vegetation will be placed according the deep of the cell (fig 14).

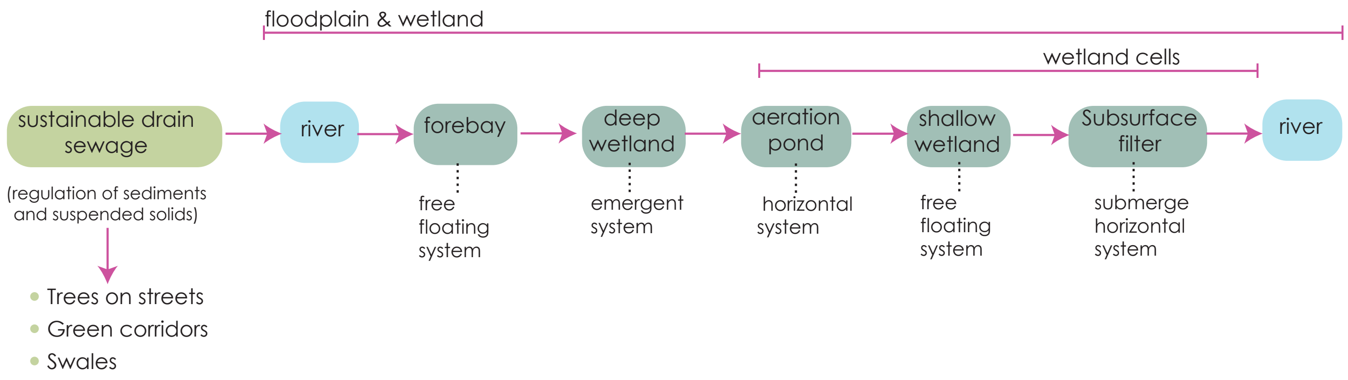


Diagram 5.2 wetland effectiveness
based of France 2003

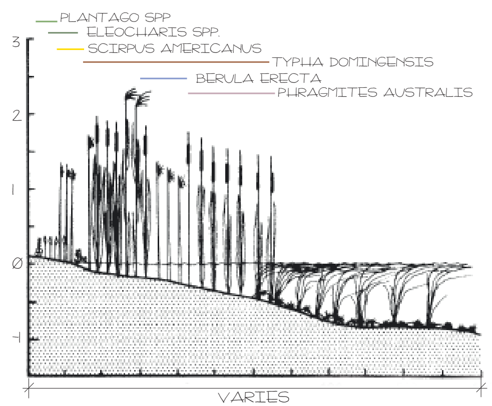


Fig.14 Depth of vegetation
based of Rojas and Novelo, 1999

CORE AREA DESIGN PLAN

1 ACCESS
2 BRIDGE
3 CYCLING PATH
4 DECK
5 INFORMATION AREA
6 OBSERVATION AREA
7 OBSERVATION TOWER
8 PROTECTION WALLS
9 WALKING PATH

RIPARIAN VEGETATION

+ Bacopa monnieri	+0,5
+ Berula erecta	-0,10
+ Chara spp	-0,50
+ Eleocharis	+0,10
+ Hydrocotyle spp	-0,20
+ Phragmites australis	-,20
+ Scirpus validus	+0,10
+ Typha domingensis	-0.,50 -1,00

A CORE AREA- PONDS & OBSERVATION TOWER

RIPARIAN VEGETATION


Bacopa monnieri


Berula erecta


Hydrocotyle spp.

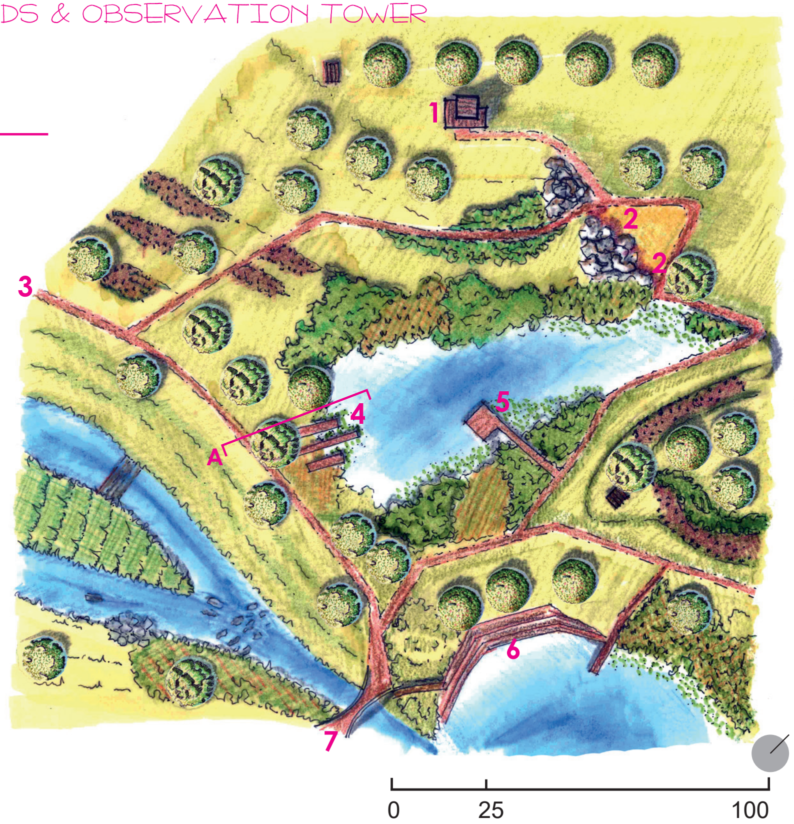

phragmites australis


Chara spp


Eleocharis palustris


S. americannus


Scirpus validus



1 OBSERVATION TOWER
2 BOULDER ROCKS
3 WALKING PATH
4 OBSERVATION DECK
5 FISHING DECK
6 TERRACES
7 BRIDGE

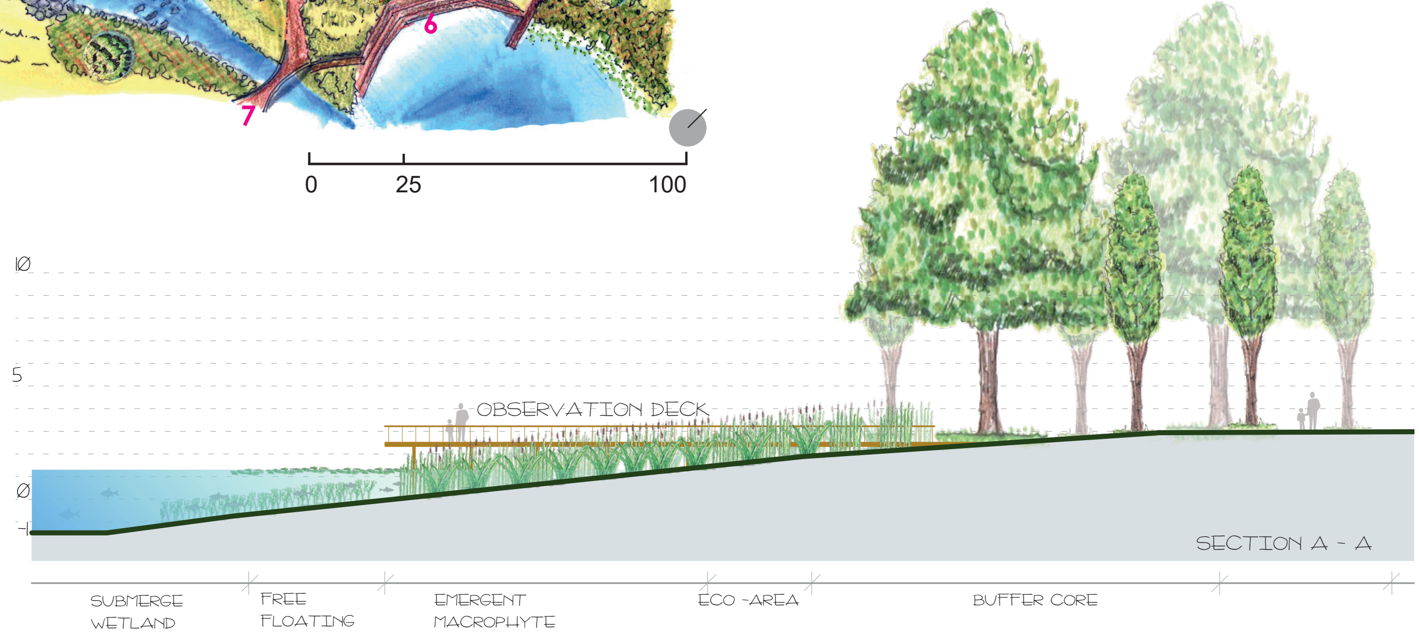
TREES / FLOOD AREAS


Salix spp

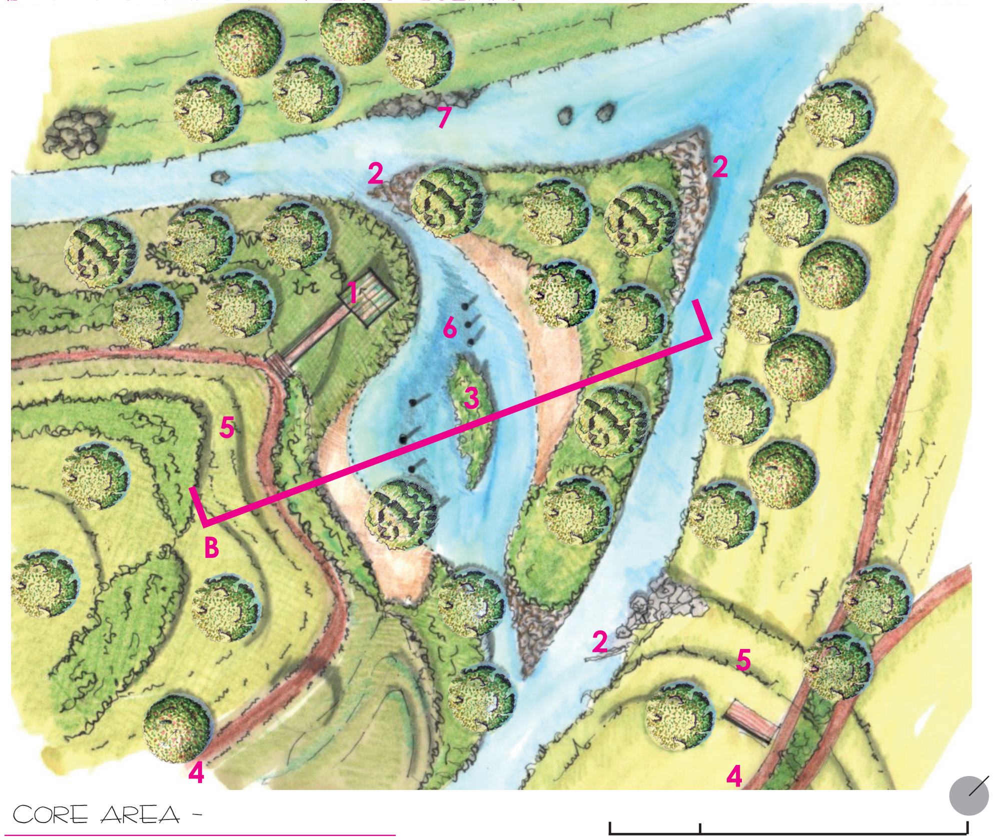

Salix bomplandiana


Alnus arguta


Platanus mexicana



B CORE AREA- BIRDS ISLAND



CORE AREA -
BIRDS OBSERVATION

FAUNA

BIRDS

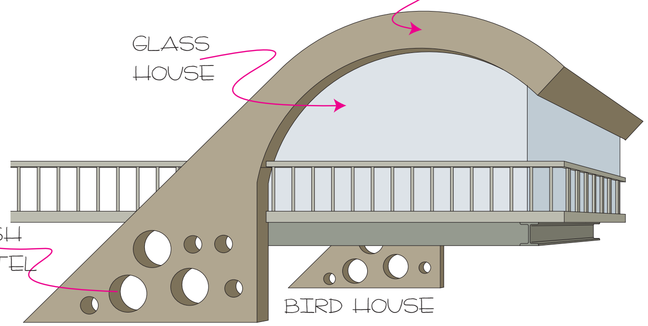
Anaz diasi · *Ardea alva* · *Balsero norteño* · *Himantopus mexicanus*

Mosquitero cardenalito · *Recurvivostra americana* · *Tordo*

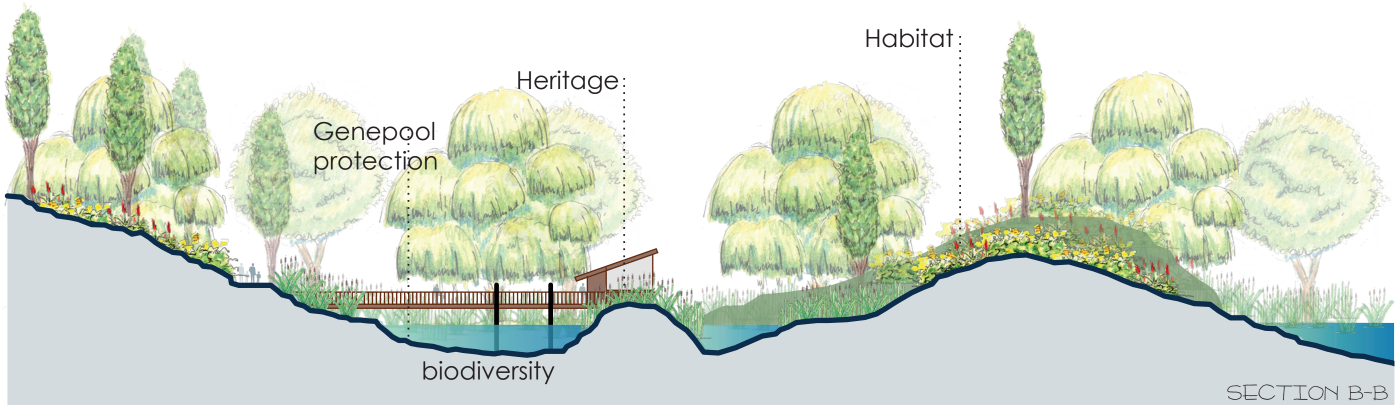
REPTILES

Sceloporus torquatus

Turtle casquito



1 BIRD HOUSE OBSERVATION
2 ROCKS
3 WALKING PATH
4 BIRD ISLAND
5 TERRACES
6 PERCH TREES
7 HABITAT LOGS



SECTION B-B

5.4 RIPARIAN BUFFER AND FLOODPLAIN PROTECT / REGULATE / PROMOTE

In addition to the ecological services that the riparian buffer and the floodplain are intended, the area provides recreational space for the inhabitants of Morelia.

The river flows at the centre of the field following the topography of the terrain. In the central part, before reaching the core area, it bifurcates. At the south, the river intersects with wetland cells, to the north a small creek serves as wetland support allowing the flow of the river in rainy season.

The buffer riparian zone along the river leaves room enough to perform its own fecological unctions.

In the transition zone some slight activities such as walking or rest are possible.
Walking and cycling paths made with permeable materials follows the flow of the river, in the outside part of the riparian buffer.

The vegetation selected for the riparian and floodplain are native trees suitable to resist flooding. It includes: *Alnus arguta* and *Platanus mexicana*. Schrubs and grasses such as *Sambucus mexicana, Salvia Sessei, typha domingensis* and *Berula erecta among others,* are optimal for the protection and biodiversity of the core area.

SCHRUBS

Salvia sessei

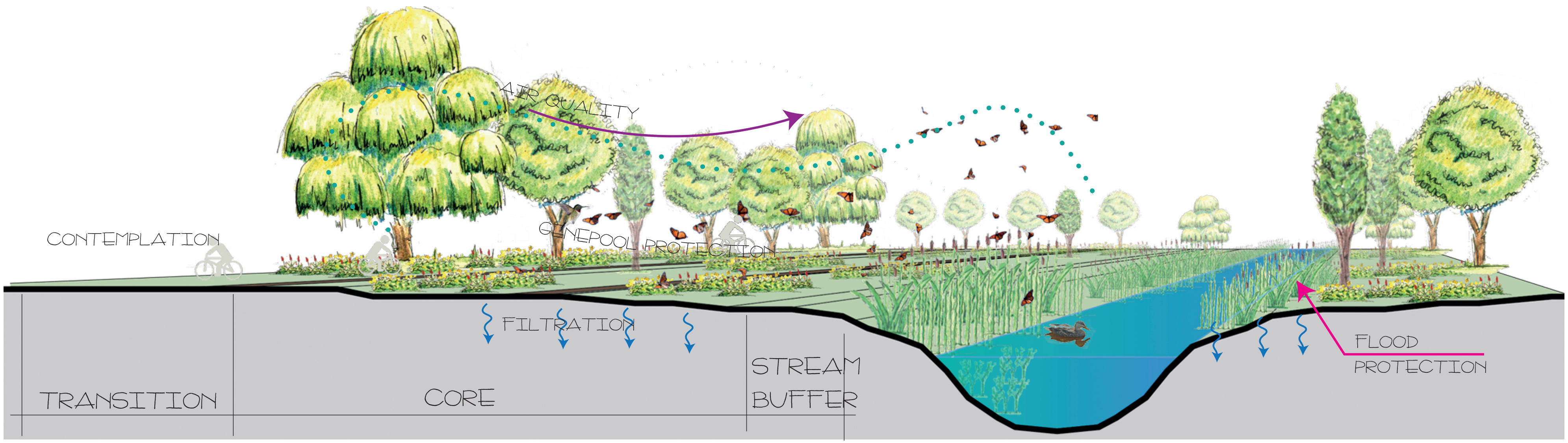
Fuchsia hybrida

Plumbago capensis

Salvia officinalis

Sambucus mexicana

Bouganvillea glabra



RIPARIAN BUFFER

FLOOD PROTECTION

Along the river some areas require strategies for flood protection, especially in the tightest part of the terrain. The construction of dikes will serve as walls for water retention. Pedestrian paths will be located along them, to provide views and human health infrastructure to the inhabitants.

The walls have curve shape maded with volcanic rock from the region. The curvature of the walls creates a vortex effect that enhance the aeration process of the river.

The use of volcanic rock aims to increase the aeration process, provide space for aquatic species and be an aesthetic element that promotes identity among the inhabitants.

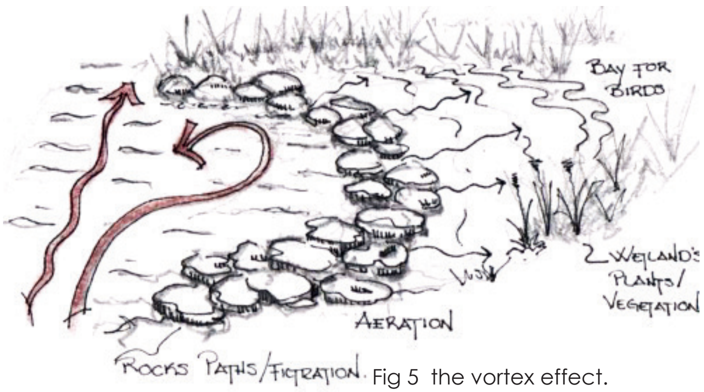
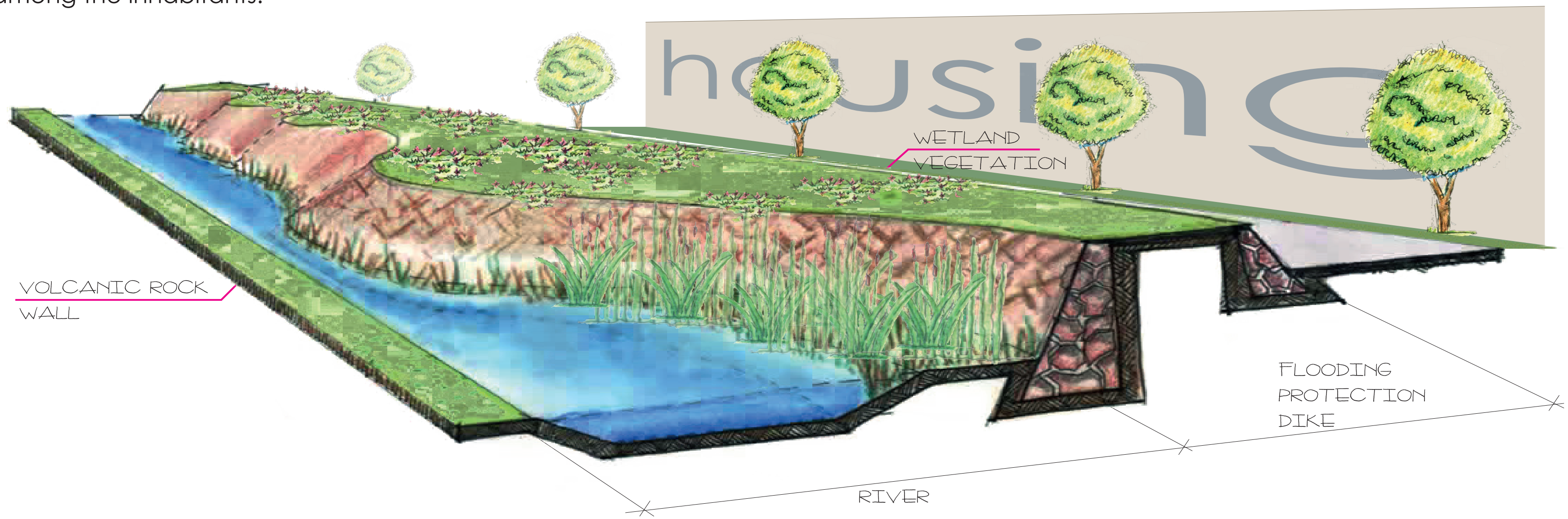


Fig 5 the vortex effect.



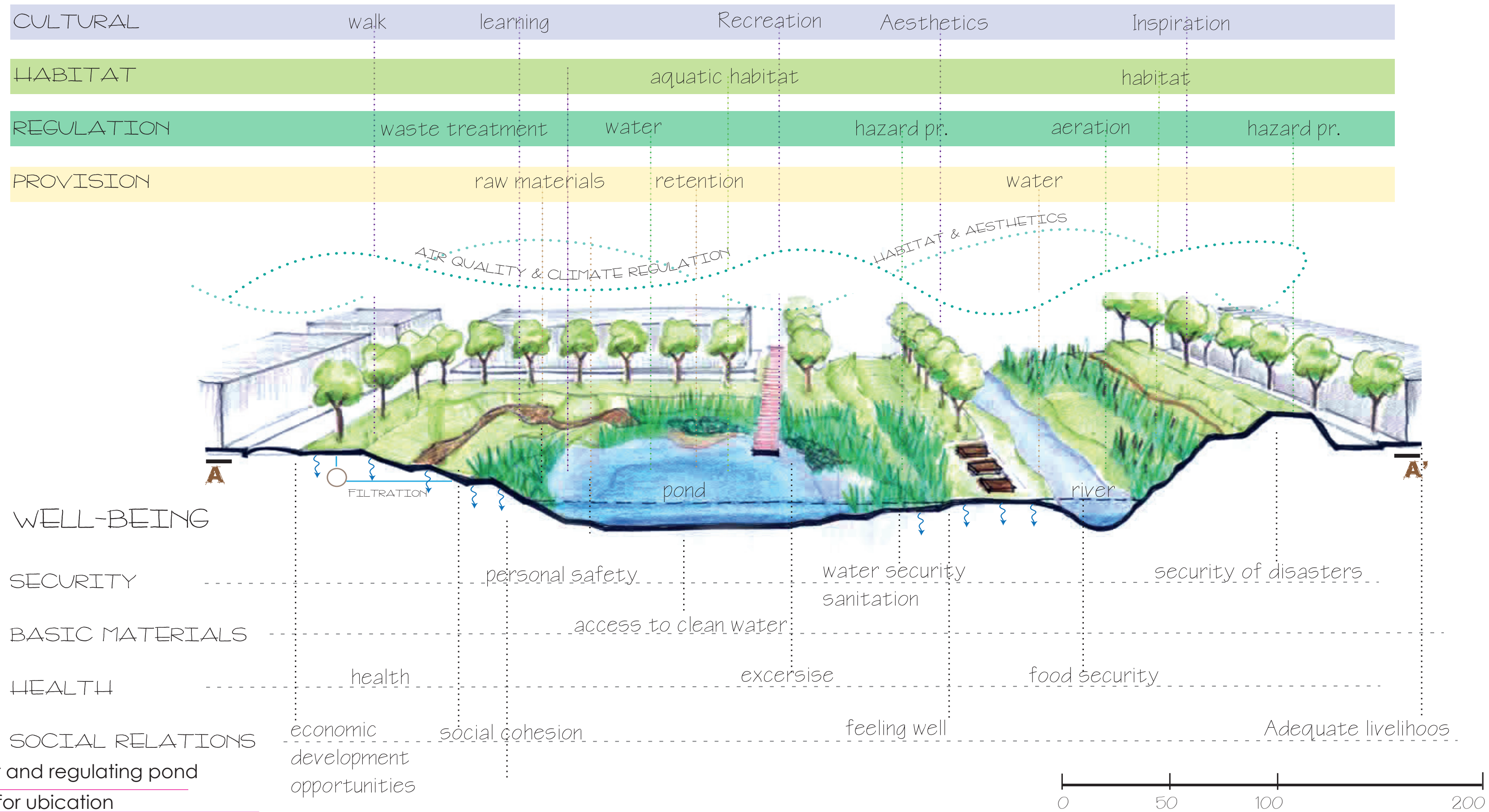
REGULATING PONDS

At the west side of the bridge *Av Morelos norte* is located a regulation pond. Which mitigate the bottleneck effect that is generated at this intersection, and will serve as regulating support to the wetlands during rainy season.

The services that the area offers within the four ecosystem functions (habitat, provision, regulation and culture) will unchain welfare in society. This space will provide space for personal safety and wellness. Raising the perception and accessibility to the river flourishing the opportunities for economic development.

It will offer adequate space for the sustenance of a quiet life and will promote access to clean water. Benefiting to the inhabitants of the city and the agricultural development areas after the city.

ECOSYSTEM SERVICES

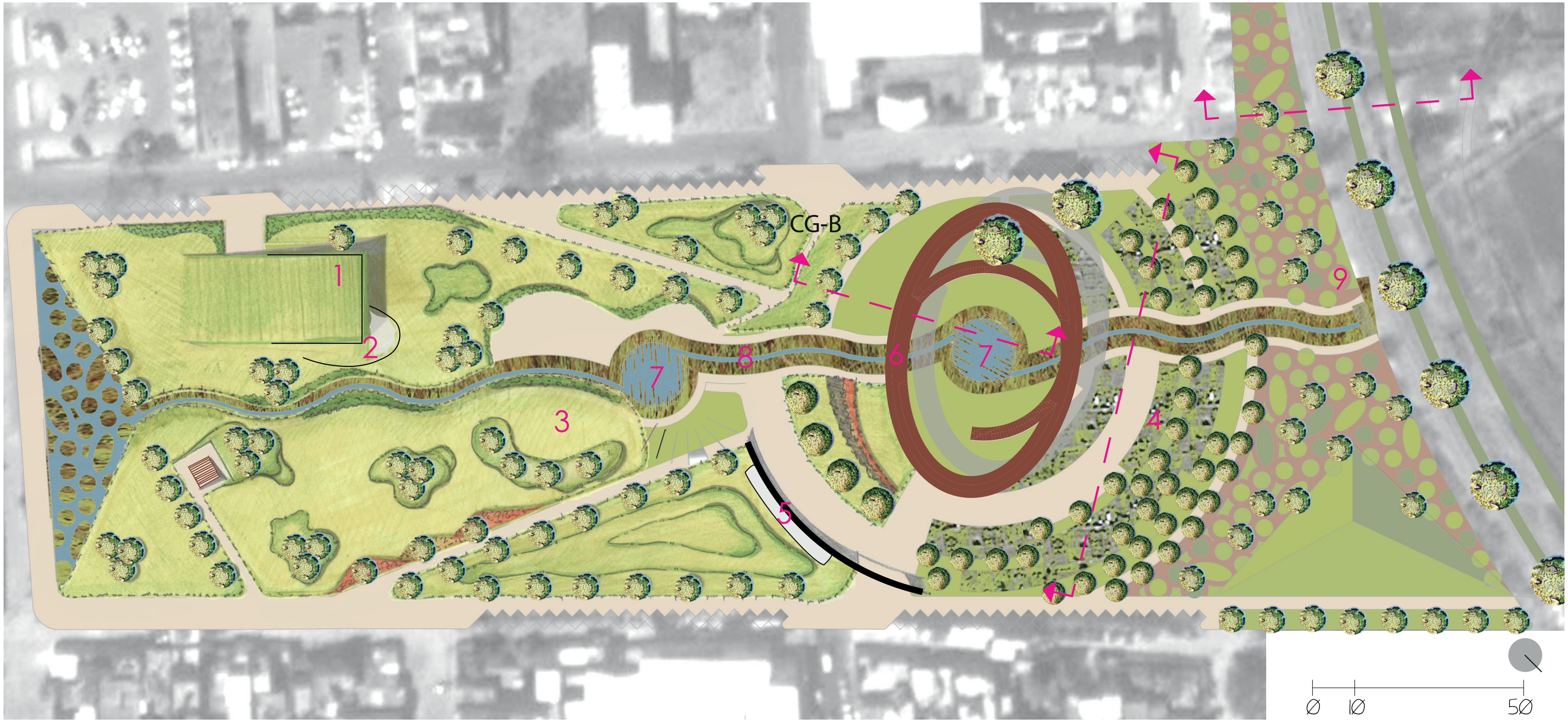


SECTION A river and regulating pond
see master plan for ubication

5.5 COMMUNITY PARK PLAN

The idea of the community garden is to create a link between the society and the ecological park.
In a terrain of 3.5 ha, the community garden will provide an area for relaxation and learning to a high dense area.

1. Art and craft workshop
2. Amphitheatre
3. Relaxation areas
4 urban agriculture
5. Community garden product store
6 observation deck
7 fountain
8. Stream
9. Transition area



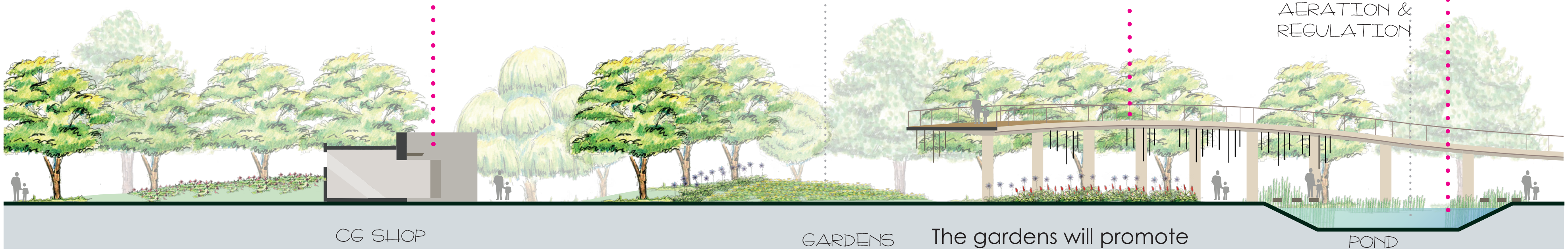
COMMUNITY PARK SECTIONS

SECTION CG- A

An area will be designated for the promotion of urban agriculture and local trade

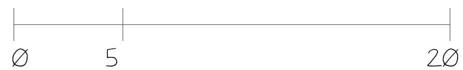
A terrace to 2.5 meters high, will provide a space for recreation and visual to the park

The pond will provide a space of regulation for the stream

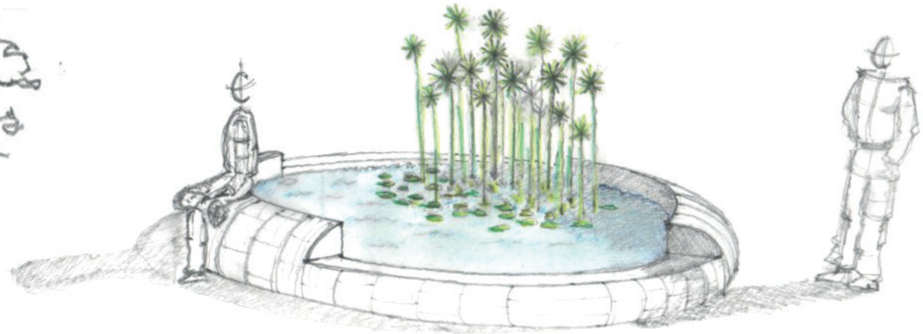


SECTION CG- B

The gardens will promote pollination and will offer space for aesthetic appreciation

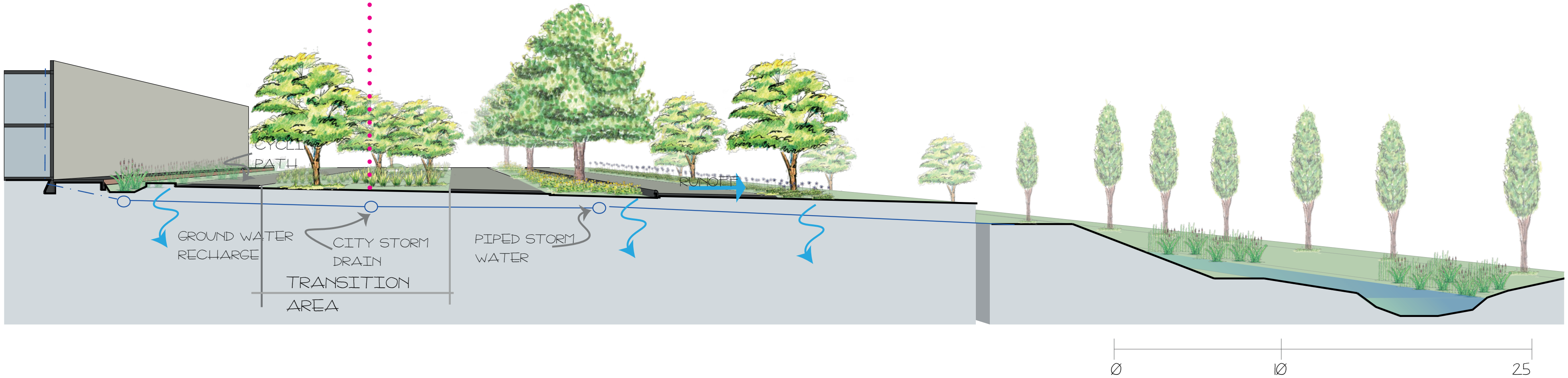


5.6 COMMUNITY GARDEN CULTURE / PROVISION



Small ponds provides water and climate regulation. The main functions is to raise awareness to the population about the use of regulation ponds, its flora and fauna. At the same time it will provide aesthetic to the area.

TRANSITION AREA- a promenade that provides greenery and a relaxation space



conclusions

discussion

CONCLUSIONS

The overall design process is based on the understanding of the riparian system. The uncontrolled growth of the city and urban plans that do not take into account the riparian structure of the river has promote the degradation of the same. Affecting not only the health of the inhabitants and local flooding. It also affects the ecosystem and the people of the lake of Cuitzeo. Causing that a local pollution problem becomes a regional environmental problem.

The restoration of river Grande of Morelia evokes a reconciliation with natural systems.

Landscape architecture is the discipline which can emerge an eco-engineering to an aesthetic ecology that take into account the needs of the people. With the use of the concept of ecosystem services, the vision of Landscape architecture gets more holistic.
An holistic discipline creates the bases for more robust and resilient projects that integrate man- made systems and natural systems, stimulating local and regional sustainability.

One of the main findings of this Thesis was the necessity to operate at different scale levels at the same time. Since a local problem can affect to a hole region.

The analysis and understanding of the urban landscape layers, and the process of the urban ecosystems represented an important phase for the design process. Bringing relevant inputs concerning the design of new ecological and natural systems for water cleaning and regulation, and also provide new landscape experiences in the city of Morelia .

WATER QUALITY

The proposed water treatment system (Constructed wetland) will bring ecological benefits the municipality of Morelia and the agricultural valley of Morelia- Querendaro, and partially the lake of Cuitzeo.

Considerations on water quality and water regulation are:

- The water system is designed to improve water quality by the reduction of contaminants and temperature, and the increase of dissolved Oxygen. The system requires 15 to 20 days to accomplish this, making more relevant the need of the SUD system as a supporting system.

- The improvement of water management and the creation of rainstorm drains should be combined with green infrastructure in the city that also will bring greenery into the city.

GREEN INFRASTRUCTURE AND ECOSYSTEM SERVICES.

- The green infrastructure is necessary to support the functions of the floodplain and wetland, since it can regulate the flow and velocity of water during rainstorms, and regulate the type of contamination that goes through the drains.

- The selection of the main design area, not only can improve the water quality of the river, it introduce a green finger to the city that can promote the colonization of native flora and wildlife.

- Was necessary to work with one key ecosystem service (water quality) to frame the scope of the research, however other functions and services were required to promote the sustainability of the project.

- Green and blue infrastructure can promote and enhance several functions and services of the ecosystem, in this case the riparian ecosystem.

LIMITATIONS OF THE RESEARCH

The state of Michoacán is considered one of the most dangerous states in the country, due to the large number of murders.
There are several problems related to drug cartels which have created a state of emergency and distrust among citizens.
This was a limiting factor conducting interviews among the inhabitants. And although an interview with water management experts was conducted, they were very careful and limiting with their responses. So it was very difficult to achieve an interpretation of the experience of the people to the river, and understand their needs related to the health of the river.

Some articles related to river contamination discussed about pollutants in the water, but could not find the type of pollutants. So the design project is only developed to treat water contamination.

DISCUSSIONS

In order to provide a holistic project, it should take into account the needs of the people and expose the to government and stake holders during workshops and meetings integrating all the participants.

The project is just limited to the urban area. To promote the health of the river interventions along the agricultural fields are necessary.

Mexico is considered a biodiversity country, for an ecological approach would be necessary to take into account keystone wildlife and vegetation.

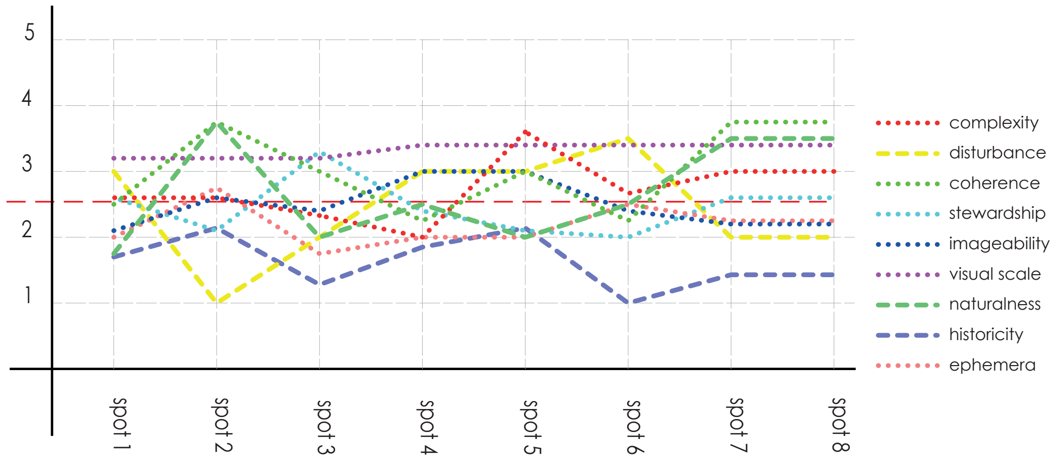
LIST OF FIGURES

Most of the pictures and images are made by myself. Most of the images have the reference in the picture footnote.

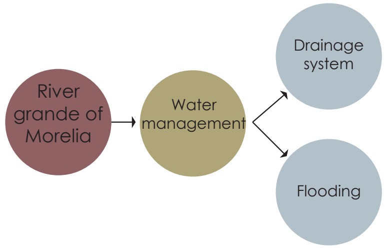
For those who do not have it, hereby the list of figures

appendix


Route II
1
2
3
4
5
6
7
8

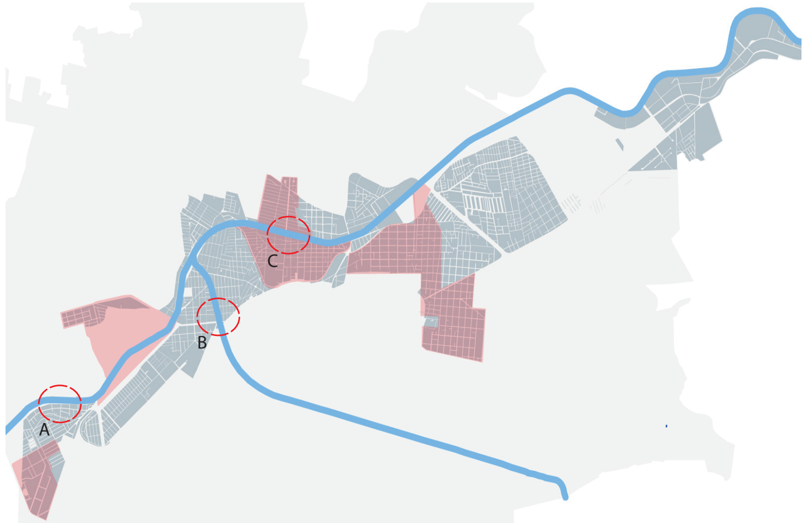

5
4
3
2
1
spot 1
spot 2
spot 3
spot 4
spot 5
spot 6
spot 7
spot 8
complexity
disturbance
coherence
stewardship
imageability
visual scale
naturalness
historicity
ephemera

APPENDIX II DESIGN SELECTION AREA



Problems

- Housing sewage is drained to river Grande (partially treated water)
- Housing sewage is drained to river Chico and it connects to river grande (water is not treated)
- People throw their house waste in the river.
- Flooding problems in rainy season




A


B


C

Evaluation

A
- Bad smell
- Discontent of the people
- Reduction in economic services (eg. food services)

B
- Bad smell
- Poor perception towards the river
- Fragmentation on the relation between inhabitants - river

C
- Bad smell
- The wall protect against flooding
- The wall breaks the human relationship with the river

Objectives

- Reduce odor pollution
- Improve water quality
- Limit risk flooding

Strategy

Sustainable drainage urban system

Work with natural systems to militate against flooding and polution

SUDS...

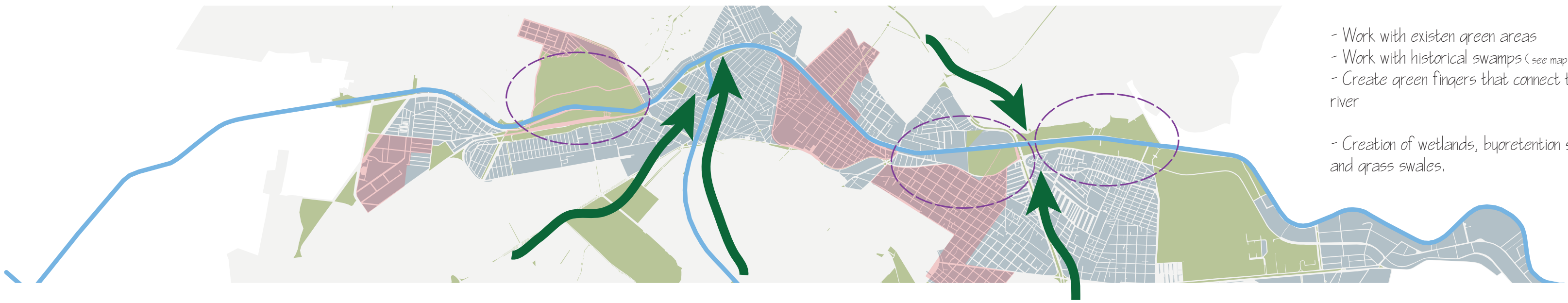
... provide a passive treatment to collected surface water before discharge onto a watercourse (SEPA 2000)

...reduce the quantity of runoff from the site

...slow the velocity of runoff to allow settlement filtration and infiltration

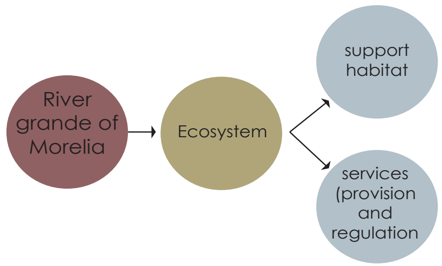
Mission and vision

SUDS as a tool to improve the regulating functions of the River Grande de Morelia



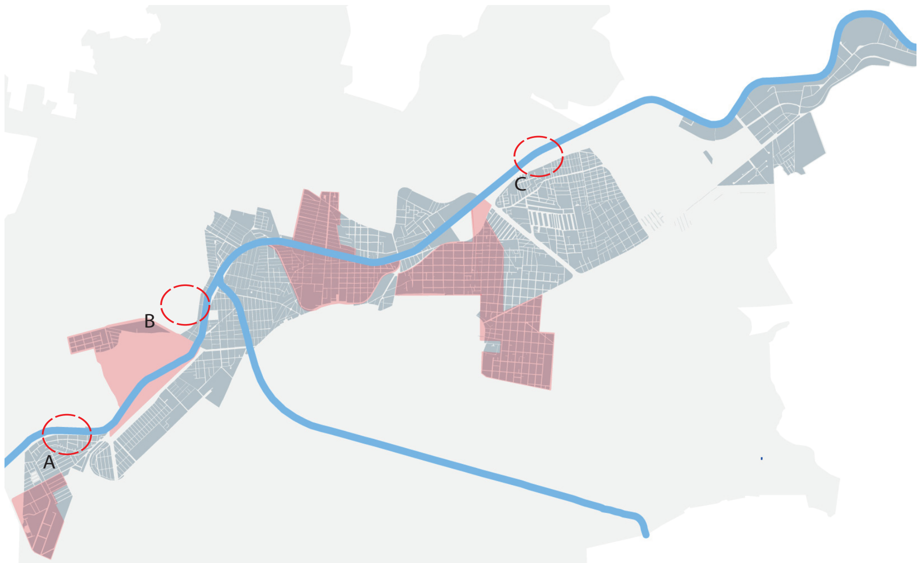
- Work with existen green areas
- Work with historical swamps (see map 1888)
- Create green fingers that connect to the river

- Creation of wetlands, bioretention systems and grass swales.



Problems

- Housing sewage is drained to river Grande (partially treated water)
- Housing sewage is drained to river Chico and it connects to river grande (water is not treated)
- People throw their waste in the river.



A

B

C

Evaluation

A
- Water eutrophication
- Increase of water temperture
- Decrease of oxygen on the water

B
- Water pollution that comes from springs with several species

C
- Water management against vegetation
- Low channel's maintenance

Objectives

- Improve habitat for species
- Improve water quality
- Improve the relation between vegetation and water managers (Ooapas)

Strategy

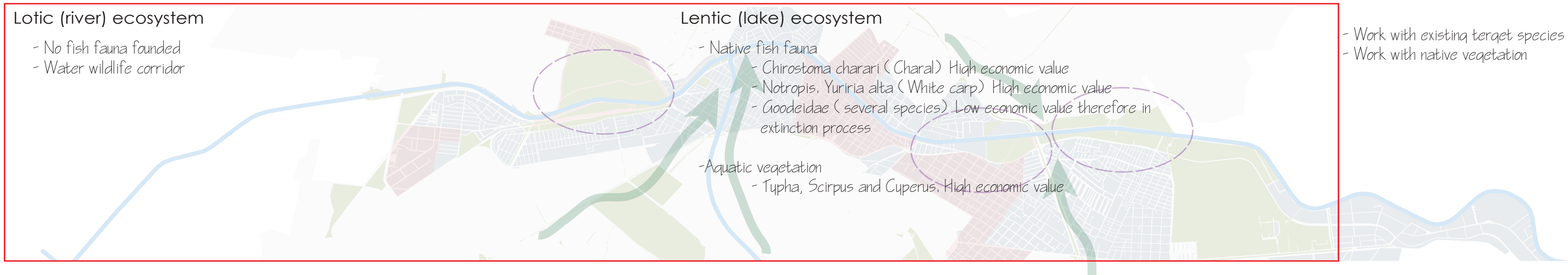
Target key species

Work with target species (fish) to improve their habitat

Working with target key species...
...helps to frame the type of solutions that can be provided

Mission and vision

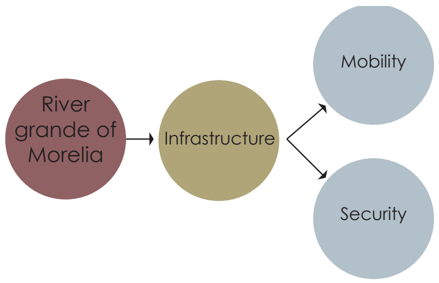
Target key species as a tool to improve the habitat and provision functions of the River Grande de Morelia



Lotic (river) ecosystem
- No fish fauna founded
- Water wildlife corridor

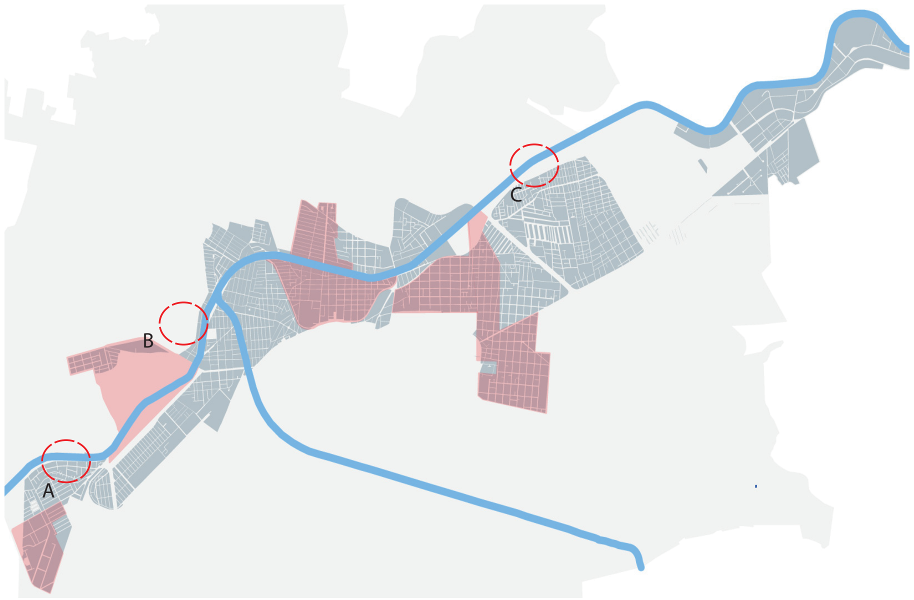
Lentic (lake) ecosystem
- Native fish fauna
  - Chirostoma charari (Charal) High economic value
  - Notropis. Yuriria alta (White carp) High economic value
  - Goodeidae (several species) Low economic value therefore in extinction process
- Aquatic vegetation
  - Tupha, Scirpus and Cuperus. High economic value

- Work with existing terget species
- Work with native vegetation



Problems

- Deficient road and cross connections
- Unattractive and unsafe rail road
- Lack of walking or biking paths
- Unattractive and unsafe bridges



A

B

C

Evaluation

A
- No relation between the public space and the river
- Is not attractive
- No proximity appearance

B
- The train increase the perception of Non-place

C
- Insecurity perception on bridges
- The river do not has walking paths

Objectives

- Improve the aesthetic perception of the area close to the river
- Improve the perception of safety
- Improve the relation between inhabitants, mobility and the river

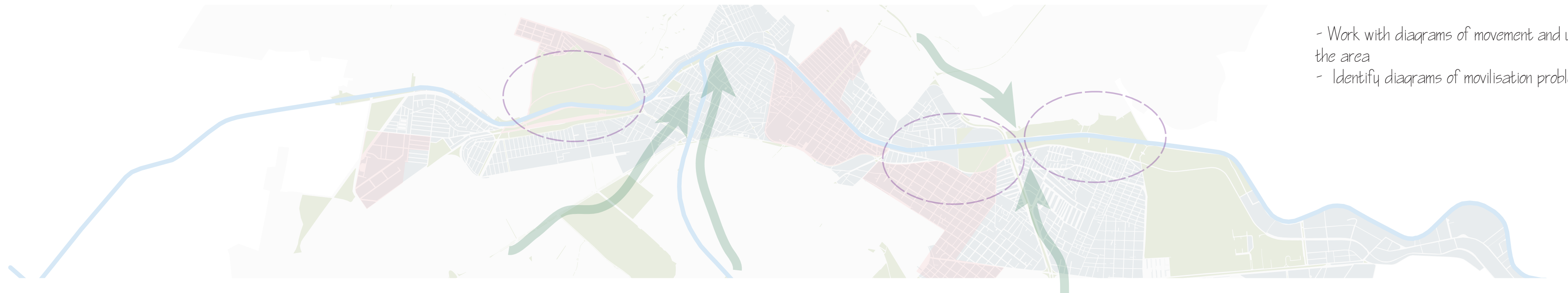
Strategy

The mise en scène (Eisenstein) in acupuncture river landscape points

Work with acupuncture points and the method of mise en scène By Sergei Eisenstein, helps to frame design areas.

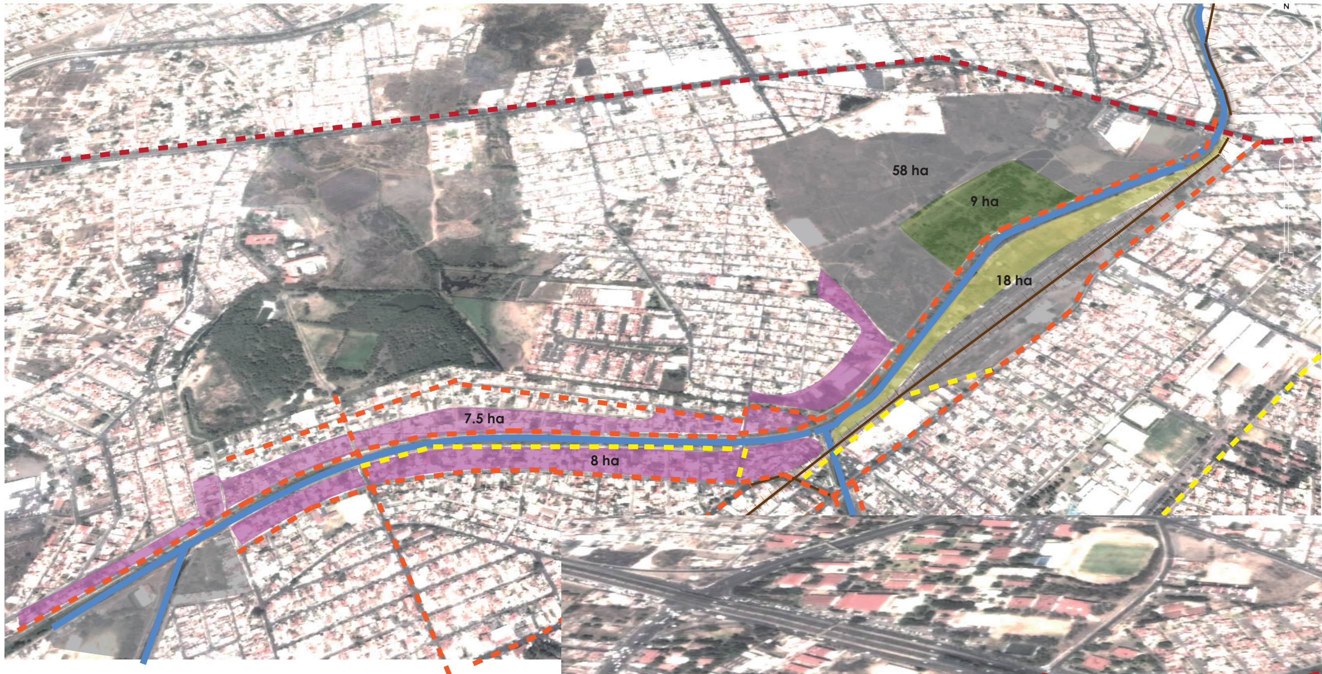
Mission and vision

Work in acupuncture with designs that include the uses and traditions of a place help to improve the cultural and amenity functions of the river.



- Work with diagrams of movement and use of the area
- Identify diagrams of movilisation problems

BOTANIC GARDEN SECTION	RIVER CHIQUITO SECTION	URBAN FOREST SECTION
SURFACE 27 ha HOUSING high density & industry TYPE OF SOIL aluviol	SURFACE 3 ha HOUSING high density TYPE OF SOIL aluviol	SURFACE 43 ha HOUSING high, average and low density TYPE OF SOIL aluviol & basalt
STRENGTHS some flood plain area conserved	STRENGTHS connection point	STRENGTHS high flood plain area conserved at the final part of the urban river
WEAKNESS at the entrance of the city	WEAKNESS Not enough flood plain	WEAKNESS housing and streets
OPPORTUNITIES connection to the botanic garden	OPPORTUNITIES -	OPPORTUNITIES connection to the historical centre, the urban forest
THREATENS fast urban growth	THREATENS High housing density	THREATENS fast urban growth

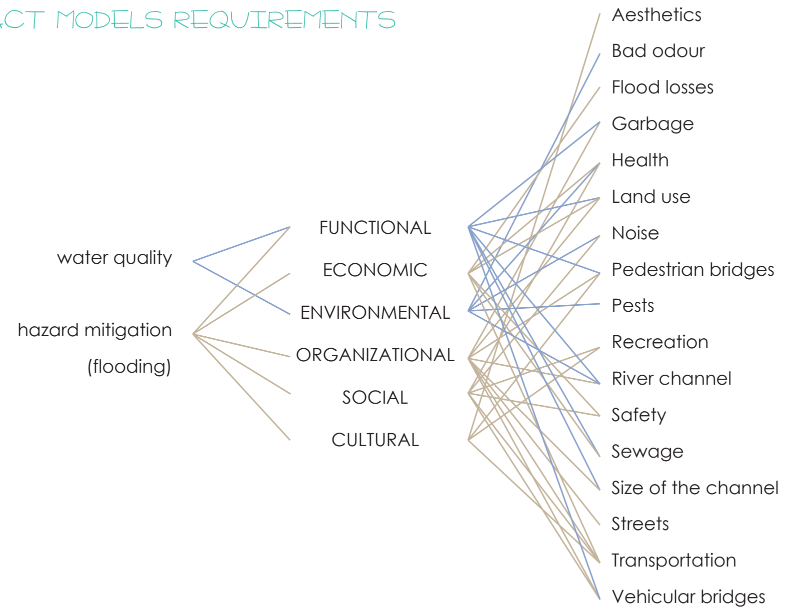


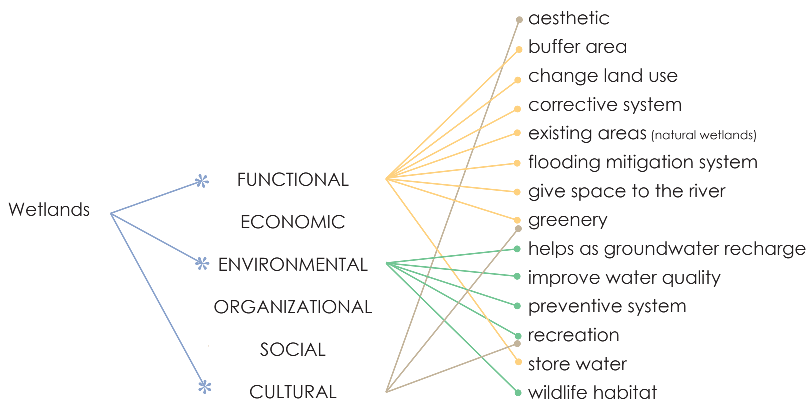
NODE 1
IMPACT MODEL

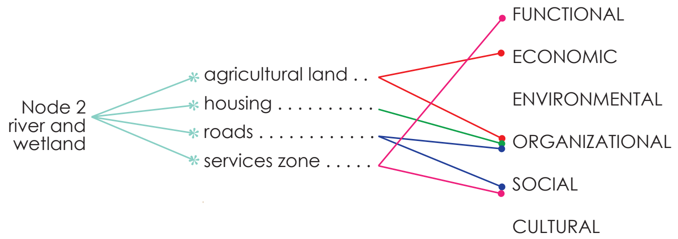
NODE 2
IMPACT MODEL

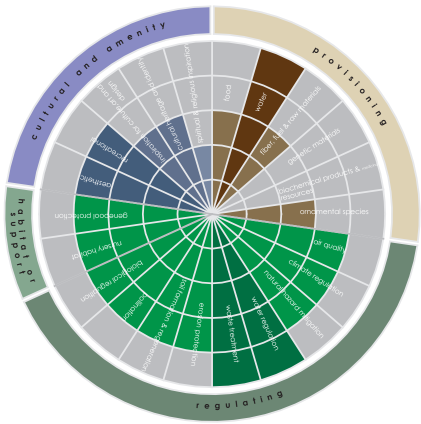
protected wetland
invades wetland
housing high
services
train rail
roads 3 lanes
roads 2 lanes

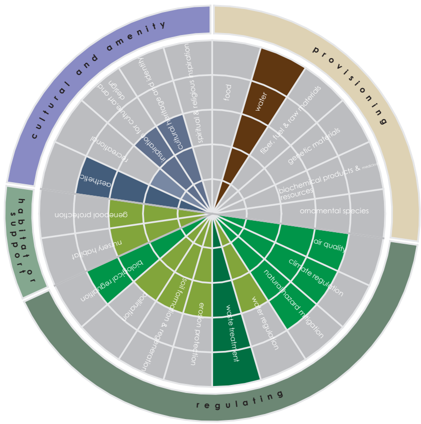
APPENDIX III IMPACT MODELS REQUIREMENTS







pattern / process	attributes	service	benefit
floodplain and wetland	Quantity 2% catch area 47 ha	water provision water quality hazard mitigation	
	Quality floodplain grassland wetland	water regulation waste treatment	
	Location	aesthetic cultural inpiration and heritage recreation nursery habitat	
	Timing rain season retention 5-15 days	air quality climate change genepool protection soil formation hazard protection waste treatment	

pattern / process	attributes	service	benefit
green infrastructure / storm water sewage	Quantity water catch area 237 ha	water provision	
	Quality trees on street green corridors swales	water regulation waste treatment	
	Location	aesthetic cultural inpiration and heritage	
	Timing rain season	water regulation hazard protection waste treatment	

APPENDIX V NATURAL PROCESS OF RIVER GRANDE AND AFFECTED ECOSYSTEM SERVICES

	Rural	Dam		Urban		Rural	Lake
Natural river flow	The river originates at the municiplaity of Patzcuaro	The river feed the Cointzio dam at the municiplaity of Morelia	The river is channeled into Morelia's city (Cienega drein, 4km)	The River Chiquito joins to the River Grande of Morelia (Cienega drain - Rio Chiquito, 3,5km)	The (urban) river croos the city and arrives to the Atapaneo's treatment plant (Rio Chiquito - Atapaneo, 15km)	The (rural) river cross the valley of Morelia - Querendaro (agricultural - irrigation fields)	The river feeds the lake of Cuitzeo
Economic process		-Water urban provision -Water irrigation provision		-Water urban consumption		-Water irrigation and housing consumption	-Natural water provision
Social process		-Water recreation consumption		-Water sewage production -Waste production		-Extraction of groundwater -Agricultural waste production	
Ecological process	-The river wash away the waste on its riverbeds (TEEB, 2005)	-Eutrophication of the dam		-Pollution of the water, high turbidity and suspend solids, loss of oxygen		-Decrease of water levels	-Habitat for several species -The lake contribute to climate regulation of the basin

Ecosystem services	Rural	Dam	Urban	Rural	Lake
-Food	Ecosystem services	Not apply	Not apply	Ecosystem services	Ecosystem services
-Water	Degraded	Degraded	Degraded	Degraded	Degraded
-Fiver, fuel and raw materials	Ecosystem services	Not apply	Not apply	Ecosystem services	Ecosystem services
-Genetic materials	Not apply	Not apply	Not apply	Not apply	Ecosystem services
-Biochemical products	Not apply	Not apply	Not apply	Not apply	Ecosystem services
-Energy	Not apply	Degraded	Not apply	Not apply	Not apply
-Air quality	Not apply	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Climate regulation	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Degraded
-Hazard mitigation	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Water regulation	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Degraded
-Water treatment	Ecosystem services	Ecosystem services	Degraded	Degraded	Degraded
-Erosion protection	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Degraded
-Soil formation & regeneration	Ecosystem services	Not apply	Degraded	Ecosystem services	Ecosystem services
-Pollination	Not apply	Not apply	Not apply	Not apply	Ecosystem services
-Biological regulation	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Nursery haitat	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Genepool protection	Not apply	Ecosystem services	Degraded	Degraded	Ecosystem services
-Aesthetic	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Recreational	Not apply	Ecosystem services	Degraded	Not apply	Ecosystem services
-Inspiration for culture	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services
-Cultural heritage	Not apply	Ecosystem services	Degraded	Not apply	Ecosystem services
-Spiritual inspiration	Ecosystem services	Ecosystem services	Degraded	Ecosystem services	Ecosystem services

● Ecosystem services ● Degraded ecosystem services ● Not apply ▭ Hydric ecosystem services

N

APPENDIX VI WATEER QUALITY DIAGRAM