THIRSTY CITY

THE CASE STUDY OF HAVANA

EPFL-ENAC-SAR 2015-2016
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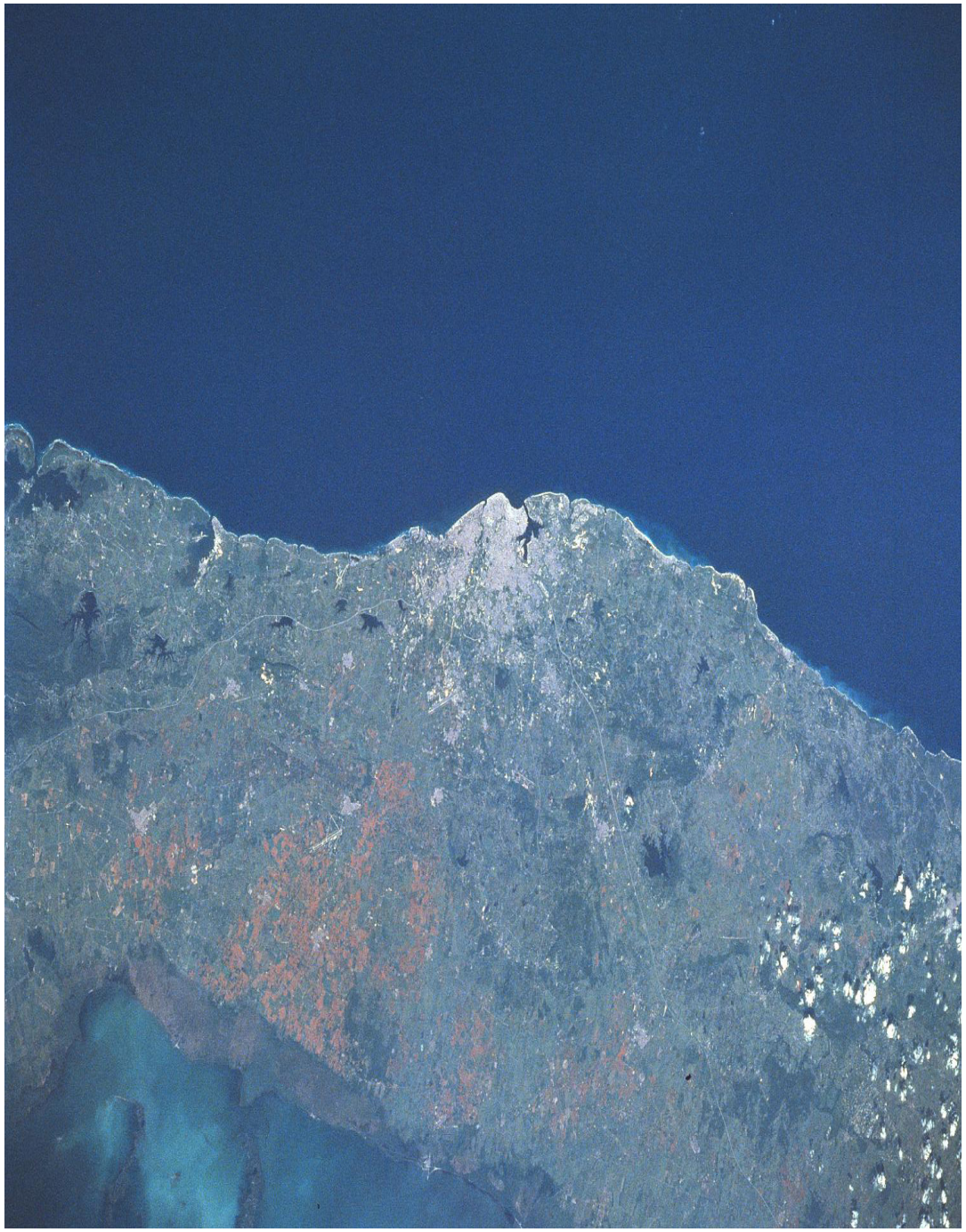
PREFACE

This work is a reflexion around the thematic of water and it's relationship with an urban context. Water is omnipresent in our environment but many people find themself in deficit, have no access to it, or its contamination level makes it unsafe to drink. It is the case in Cuba, in its capital, Havana. The main issue there is not directly linked with a lack a quantity, although water resources aren't excessive, but relies on the poor conditions of its aqueduct infrastructures, which serve the water distribution, the path that link the source to the consumer. The other major element concerns the constant and rapid degradation of their aquifers, which host the groundwater resources. This is due on one side by the high vulnerability of the island to climatic perturbations, and on the other by the anthropogenic effects of urban sprawl. Aquifers are the foundations of the regenerative cycle of water and a perturbation of there given structures and conditions can be very harmful to the whole ecosystem. Those damages are often irreversible.

Meanwhile, water is necessary for agriculture, industrial processes and human health. With the population growth, those factors are under constant development and the pressure on environmental resources is increasing. Water scarcity is already affecting many parts of the globe. As actors of the urban planning and development, we need to establish a positive interaction between our cities and their environments. For that we need to have a clear understanding of the many factors that composed the relationship between a resource and its exploitation. Infrastructures have to be part of the urban environment and have must improve it.

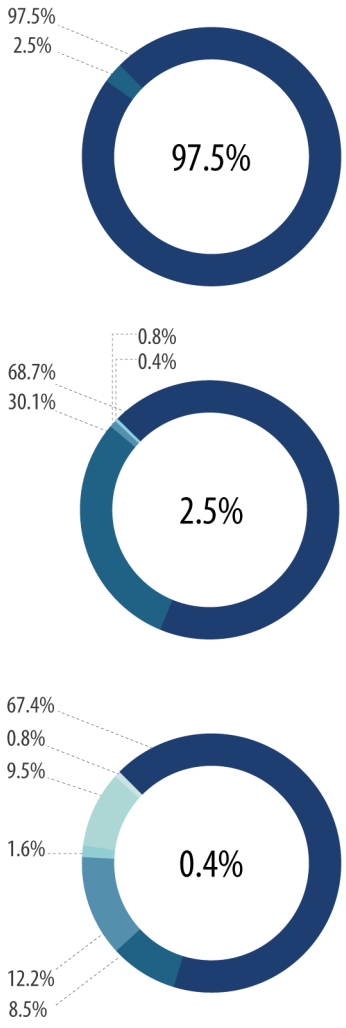
This work will attempt to describe the condition of water in an urban context, with the case study of Havana. It will point out the many interactions that exist between those two physical elements, but also explore the many potentialities for water to improve an urban context. This document will serve to establish an architectural project, in coherence with the current situation of water in the city of Havana, its needs and potentialities.

CONTENTS



Source: Nasa, Satellite view oh Havana

1. INTRODUCTION



SALTWATER

- Oceans
- Freshwater

FRESHWATER

- Glaciers
- Groundwater
- Permafrost
- Surface and atmospheric water

SURFACE AND ATMOSPHERIQUE WATER

- Freshwater lakes
- Wetlands
- Soil moisture
- Surface and atmospheric water
- Rivers
- Atmosphere
- Living organisms

Source: greenfacts.org

THE IMPORTANCE OF WATER

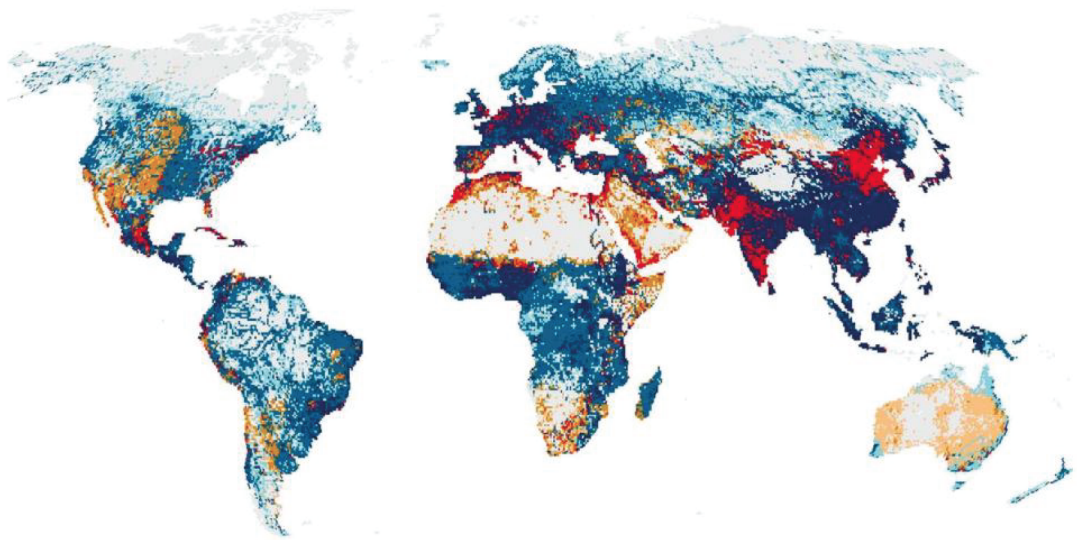
Every living organism needs water to survive, plants needs water to grow food and sanitation systems has provide to civilisation the ability to grow. By this way, water has influenced societies settlements but also religion, mythology and art. In Egyptian mythology, the Nu was the beginning of everything and represented water. It brought life to their people while drought produced chaos.

The world has an estimated 1.34 billion cubic kilometres of water but 97.5% of it is salty. Freshwater is still considered, as a renewable resource while less than 1% of this water on Earth is accessible for human consumption. This resource takes place in lakes, rivers and underground reservoirs. The rest is contained in the form of ice in glaciers and in the polar ice caps.

Water is a major driving force on our planet, it is in constant motion and explains the interactions between the atmosphere the hydrosphere and the lithosphere. Human civilisations has therefore settled near water sources, in the valleys of the rivers, and looked for humid spaces to build its habitat. Water availability was essential for the social and economical development of regions, countries and continent. This way, areas of hydrographical bassins began to coincide with the location and the morphology of big cities.

Dynamics interactions took places between Man and his environment. We found ourselves dependent of the constant regeneration of water, but lost control to maintain it in efficient conditions. Inadequate activities over the water bassins such as rapid urbanization, industrial water wastes and the use of pesticides in agriculture, for example, affects the permeable condition of soils, which is directly linked with the well functioning of the hydric cycle. Anthropogenic impacts on watershed and climatic changes are the main factors for erosion, flood, hydric and agricol droughts, diminution of groundwater reserves, soil infertility and water contamination. Water quality problems tend to be greater in lesser-developed countries, like Cuba where regulatory standards or relevant scientific data are rare or non existent.

In opposition, water has the given capacity to generate liveable environments, green spaces, healthy societies and to provide food security. The infrastructural aspect of its manufacturing can generate dynamic urban spaces. We have to understand its global condition but also learn to manage it inside our cities, were it is under constant pressure, in order to maintain the flow. Good water quality is very beneficial for a society, it reflects the condition of the surrounding 'natural' and man-made environment and prevent risks to human health.



>100 Unstressed
10-100
0-10
0-10
10-100
>100 Stressed

Population (in thousand) above and below the water stress threshold (RWSI=0.4)

Source: WWAP (2006)

WATER STRESS

«Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity and quality.»

European Environmental Agency

Water distribution on earth is not isotropic. This map shows populations living in water-stressed (red) and relatively unstressed (blue) conditions That inequality will inevitably lead to some tension in some part of the globe, where the needs are not reached. As the population grow the world's supply of clean, fresh water is under increasing demand for human activities. If present trends continue, 1.8 billion people will be living with absolute water scarcity by 2025, and two-thirds of the world could be subject to water stress. Water stress is not about running out of freshwater, but about reaching physical, economic, and environmental limits on meeting human demands for water in terms of availability, quality and use of freshwater resources. Water demand already exceeds supply in many parts of the world, and as the world population continues to rise, agriculture, industrialization and urbanization all serve to increase water consumption. Many more areas are expected to experience this imbalance in the near future.

Beside the humanitarian consequences, water stress may cause environmental degradation. Aquifers are pushed into their limits, and their over-exploitation have several impacts such as drying rivers, reduction of natural groundwater reservoirs and are more susceptible of receiving saline intrusion.

Source: «Nebel im Valle des Vinales, Kuba». CC BY-SA 3.0 vía Wikimedia Commons

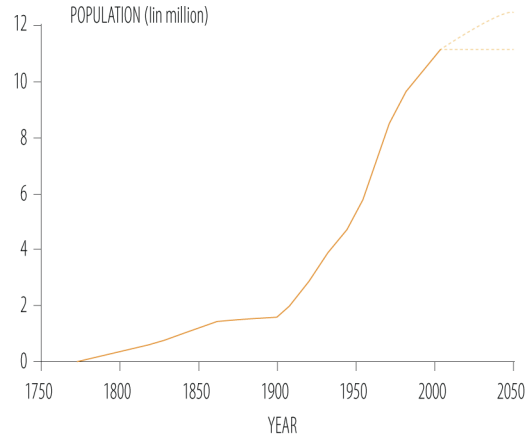
THE REPUBLIC OF CUBA

Cuba is the largest island of the Caribbean arc. It is well known around the world for its tumultuous political and economical history, such as the Cuban Revolution from 1953 to 1959 that leads the "26th of July Movement" to establish a socialist state after a succession of despotic leader. Strong characters such as Fidel Castro, Raul Castro and Ernesto "Che" Guevara became iconic for many civilizations that founded themselves under a dictatorship, a symbol of freedom. The country has since then, and until very recently, been economically and politically isolated by the United States. They began cooperation with other communist countries, and most notably the Soviet Union. Fidel Castro has been the President in charge from the Revolution until 2007, and is brother Raul Castro has then replaced him as Acting President. In 2016, Cuba remains one of the few officially socialist states in the world.

In 2015 the dialogue between Cuba and the United States moved forward as U.S. President Barack Obama announced plans to re-establish diplomatic relations with Cuba. The first visible signs was the re-opening of the US Embassy in Havana, after more than fifty years of inactivity, and American tourists are again welcomed to visit.

Other aspects that gave to Cuba its world known reputation should be found in their innumerable very talented musicians, artists and writers, but also for it's unique climatic conditions and paradisiac landscapes. For those reasons, tourism has become a significant part of their economy. Cobalt, nickel, chromium and copper are among their principal resources and they export a majority of coffee, sugar, tobacco, nickel, fruit and fish. Their major trading partners are Canada, China, Mexico, and Russia.

With the recent improvements in the relationship between Cuba and the US Government, the amount of visitant could augment drastically if regular flights connections are established, knowing the physical proximity between those two countries.

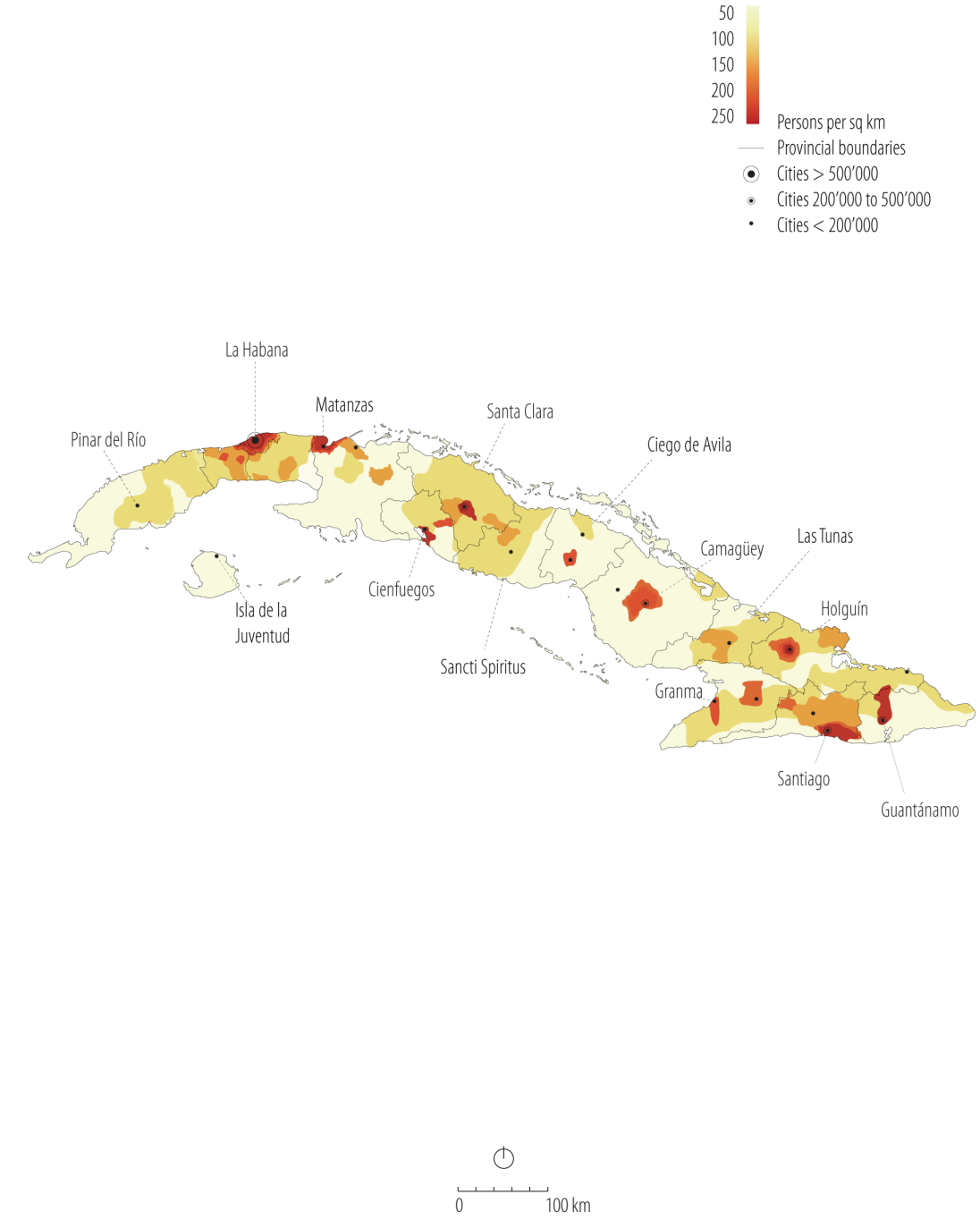


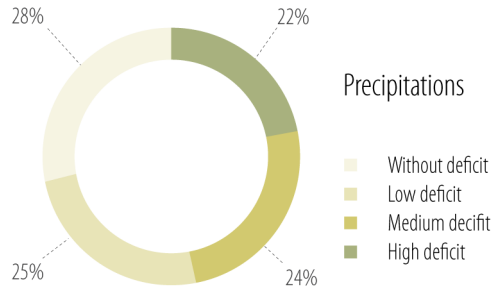
DEMOGRAPHY

The population stood at 11.217 million inhabitants at the end of 2000, of wich 75% reside in urban areas, and 25% in rural areas. It has 3 IWarge cities; Havana, Santiago de Cuba and Holguin, and 25% in rural areas. 20 % of the population lives in the capital region, Havana. The country's average population density is 102 inhabitant per square kilometers.

The population has increased steadily from de eighteenth century, until the early twentieth century, with a pupulation of nearly 2 million inhabitants, and it has accelerated to reach 5 million inhabitants in 1950. In the last five decades the population has doubled, One of the notable reason is the good sanitary system established by the Communist Party.

Source: Encyclopedia Britannica, INC (2005)





DROUGHTS

The situation is being classified as "critical" in Cuba, where rainfall levels is too often insufficient.

The areas most affected by the drought are the provinces of Pinar del Rio and Havana, in westernmost Cuba; Cienfuegos, Villa Clara and Sancti Spiritus, located in the central part of the island; and the eastern provinces of Santiago de Cuba, Granma, Camaguey, Ciego de Avila and Las Tunas.

More than soil errosion, that effect the reservoirs that are, on average level, at 25% of their capacity and that causes major shortage on water distribution. Water trucks are being used to supply water to some of the people affected by the drought.

Source: Systema Nacional de Vigilencia de la Sequia, (SNVS) 2014-2015

59% of the most contaminant source releases their pollution into the Cuban environment without any treatment.

20% receive limited but inadequate treatment before being discharged.

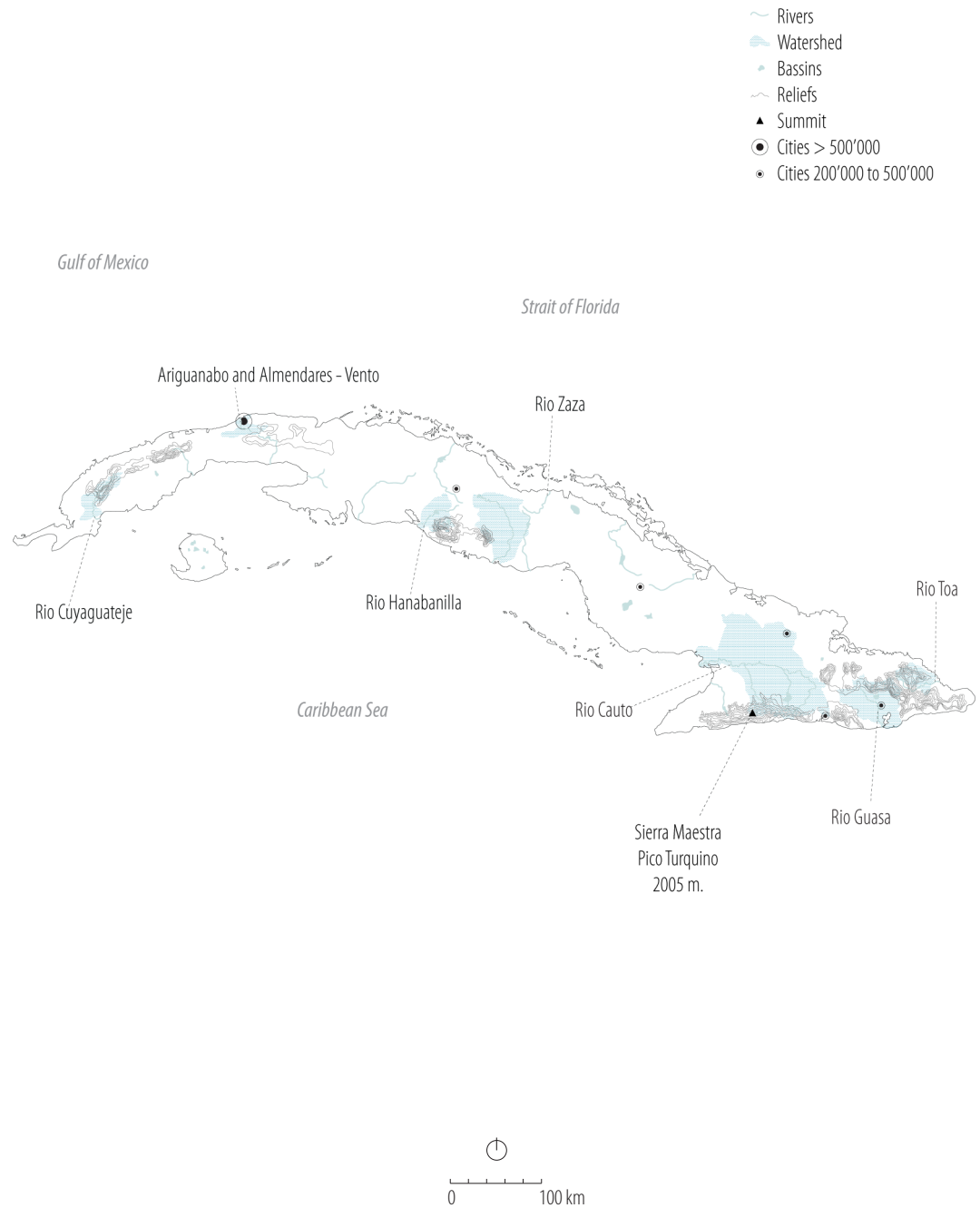
17% of urban sewage receives any treatment before discharge into Cuban waterways.

HYDROGRAPHY

Cuba has a central watershed that divides the territory into two sides, north and south; it determines the length of its rivers. Rivers are almost always shorter than 40 km and 200 km2. Their potential water resources reach 38.1 km3, broken down into 6.4 km3 of groundwater resources in 165 hydrogeological units.

The usable water resources are estimated at about 24 km3 per year, of which 75% are groundwater and 25% remaining surface water. Those amounts vary depending on the regions, in Havana for exemple the usable water resource is 90% from groundwater. That represents an average rate of 1'220 m3 water per year per capita. Knowing that the UN minimun desired level is 1'500 m3/year/capita, the cuban government has to manage its hydrological resources with precaution. The average water supply per inhabitant is 604 litters per day, meanwhile a tourist can consume up to 1'000 litters a day.

There are 6 watersheds that are considered of nation interest. Among those, the Almendares-Vento which feeds the city of Havana, and the Cauto plays a central role as they host 40% of the Cuban population and are part of 60% of its economy.



Source: United Nations Environmental Program (UNEP)

Photo: Tom Frohnhofer-Flickr

PROBLEMATIC OF WATER IN HAVANA

Havana has a privilegied geagraphic situation; its has a natural harbour, the soils conditions are among the most fertiles in the cuban archipelago, the underground resources of water where, at a time before urban sprawl and other contaminants, the best in the country and the air temprature is very pleasant dur to the proximity with the north american continental area.

The potential of hydrographical resources in the Province of Havana is about 430 hm3, on which 68% are from groundwater and 32% from superficial water. The exploitable amount is today at 323 hm3, on which 90% are from groundwater and 10% from superficial water. We can note the large proportion of groundwater in both cases. With the urban sprawl occurring in the capital city urbanization is arming the aquifers that host this groundwater. In order to prevent avoid contamination and a possible diminution of the given stock, the city has to act and look for sustainability by managing its interactions with the water cycle.

The Almendares River and its watershed called the Vento have for long provided the city with potable water supply. From open canals to an elaborate aqueduct network build at the end of the 19th century by Francisco Albear, various infrastructures have allowed the connection between the stream and the population. The problem is that today 19% of the population (400'000 inhabitants) are still relying on the supply from the Albear aqueduct, which was designed for half of this capacity (200'000 inhabitants) and has suffers from major degradations since its construction.

Networks from 8 different sources supply the remaining population with the most recent infrastructure constructed in 1970. In total 98.9% of the inhabitants relies on aqueduct infrastructures. The deterioration and the obsolescence of the pipes have as consequences the lost of around 58% of the transported water, which cause deterioration of the streets and the reduction of the working hours of the supply system. Access to water is not constant. As the water supply is also related to climatic conditions, such as precipitations, any perturbation can have severe repercussions on the availability. In the summer of 2011, Havana suffers the worst drought in its history, from which followed 5 days without water.

Even if quite every house are connected to the water network still many citizens are supplied by trucks, or must proceed to self treating processes in order to drink a decent quality water. Streams are contaminated by untreated water effluent, as only 4% of the wastewater is treated before disposal. Today, 36% of the city's potable water runs directly beneath the polluted Almendares. Its affects also the Havana Bay where the untreated sewage of over 42,000 people is throw directly to Havana Harbour and coastal waters.

Source: Guamo Embarcadero, Rio Cauto western Cuba

2. RESOURCES

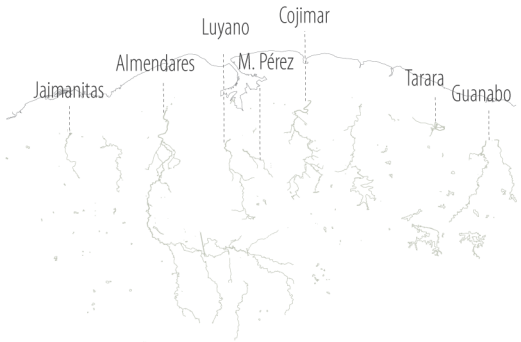
TOPOGRAPHY

Havana's relief is relatively flat, some low hills on which the city lies rise gently from the deep blue waters of the straits. A limestone ridge has an elevation of 60 meters that slopes up from the east and culminates in the heights of La Cabaña and El Morro, the sites of colonial fortifications overlooking the eastern bay.

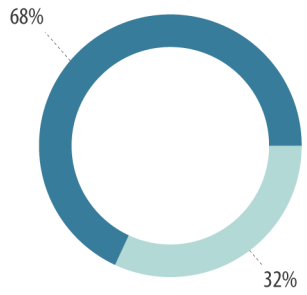
Another notable rise is the hill to the west that is occupied by the University of Havana and the Prince's Castle. Outside the city, higher hills rise on the west and east.

Watersheds

Rivers



Reservoirs



Potential hydric resources

- Groundwater
- Surface water

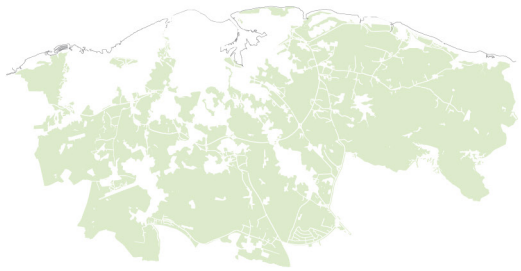
HYDROGRAPHY

The province of Havana counts 7 principal watersheds. The most important, in terme of size and volume capacity is the Vento watershed. It is located directly under the Almendares river and marks the limit between central Havana and the western part of the city.

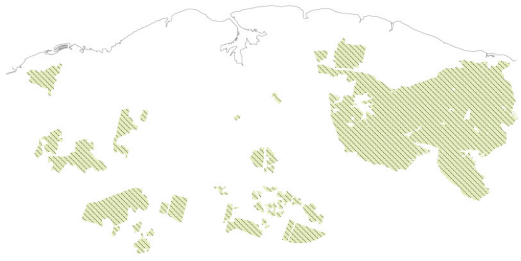
The Luyano and de Martin Pérez rivers flow directly into the Havana Bay, and form one unique watershed.

The reservoir Ejercito Rebelde contains the water from the upper side of the Almendares river. The quality of this water is improper for direct consumption and needs to be treated. The reservoirs located on the eastern part, La Cara, La Zorza and Bacuranao contain freshwater and a simple filtration makes it potable.

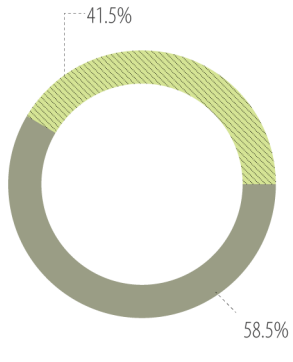
Green belt



Agricultural areas



Parcs and forest



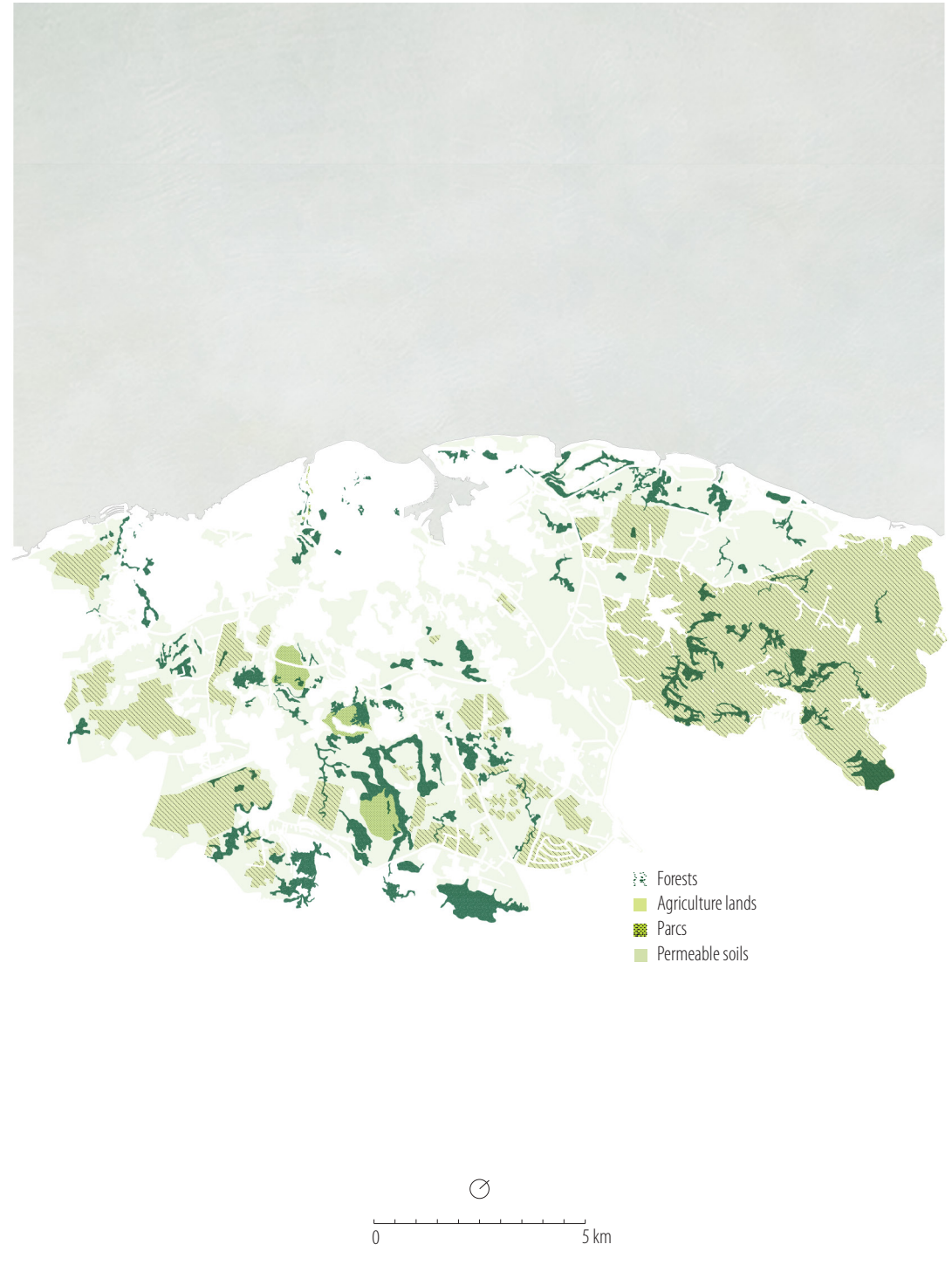
Land use: Havana

- Cultivated
- Constructed

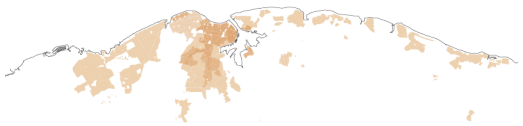
SOILS CONDITIONs

Havana has the particularity of having very fertile soils. With the urbanization of the city the quantity of arable lands have diminished but stil represent 41.5% of the province. In comparison Cuba has 62.5% of cultivated areas. The grren belt that sourrounds the city was part of a master plan dating from 1960-1970.

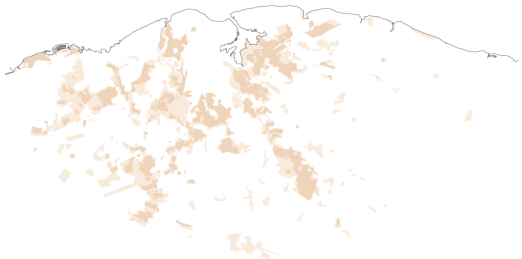
The Almendares river generates a green corridor which connects the south part of the city and the sea side, and allows recreational and agricultural areas to be part of the city. At the end of that corridor we find the 'Gran Parque Metropolitano'. It's parc of 700 hectares that host a botanic garden and a unique biodiversity for this urban area.



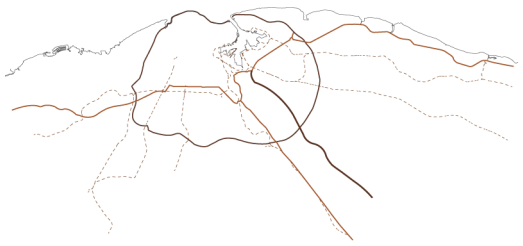
Urbanization 1900

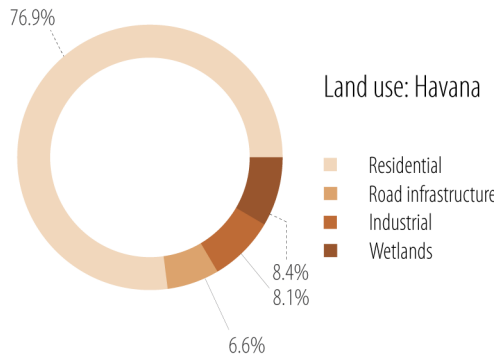


Urban sprawl of the 20th century



Transportation axes



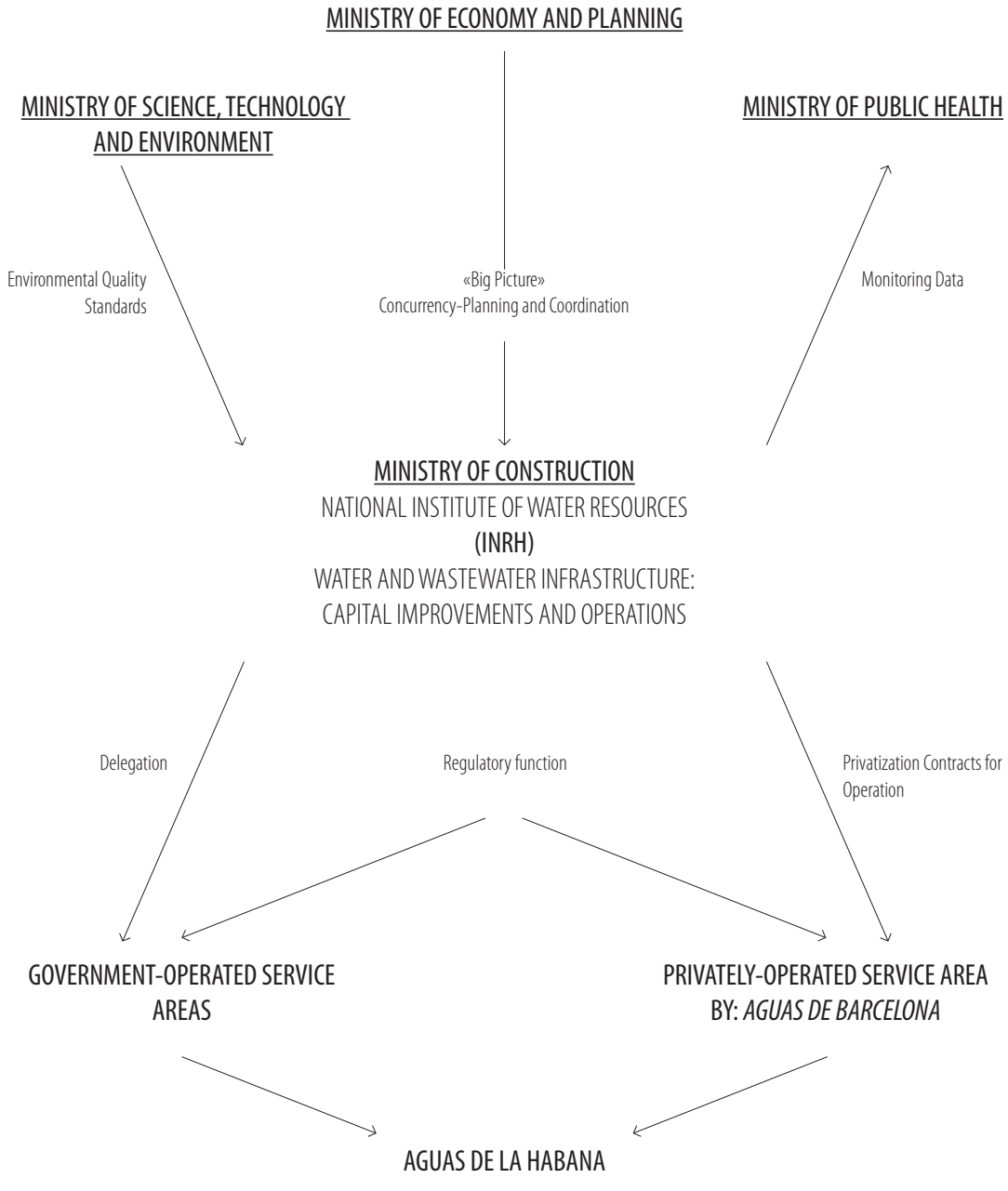


URBAN FABRIC

The superficy of the city is 727 km2 and that represent 0.7% of the national territory. It's population is 2.2 millions of inhabitants correspond to 20% of cuban the population. After a quiet expension between the fifteenth and the eighteenth century, a time when the city was used as a fortification, the city begans to grow first along the coast, on the east and the west sides. In the beginning of the twenteenth century the city grew assively and its development shifted to the south, along the valleys, without particular orgnisation. In the mid century they strated to densificate the city center with the apparition of hise rise building along the Malecon, the sea side of the city. At this time, the peak has been reached, and since the end of the Revolution in 1959 the urban expension has slowed down.

Palatino reservoir; Photo: José Raúl Robleda

3. INFRASTRUCTURES



INSTITUTIONS

The main institution managing the hydric resouces in Havana is the National Institute of Water Resources (INRH). It was created in 1989 and is in charge of directing, executing and controlling the application. It is part of the Ministry of Construction wich works in correlation with the Misitries of Public Health, Economy and Planning, and Science, Technology and Environment. In 2000 it was restructured to focus on business management. The INRH group now includes 4 enterprise groupings and 5 independent enterprises. One of the enterprise groupings covers 19 regional water and sanitation companies. Majority of those enterprises are state-owned socialist, centrally planned Cuban economic system. One of this entreprise is a mixed public-private company with partial foreign ownership. The company is called Aguas de la Habana, it provides water and sanitation services in 12 of the capital's 15 municipalities under a 25-year contract signed in 2000, while the infrastructure remain publicly owned. In addition of operating and maintaining the systems, it also carries out engineering studies and executes works.

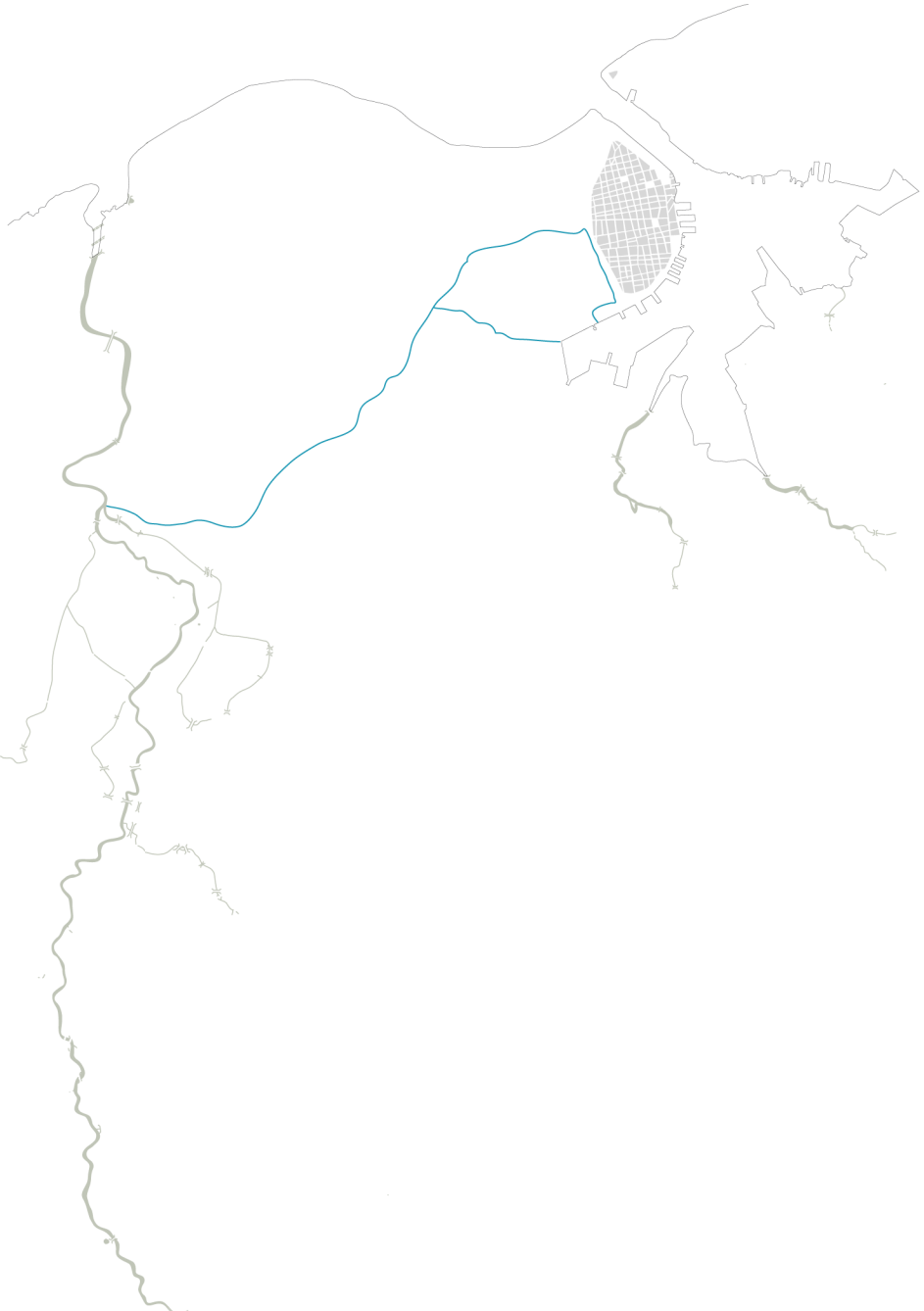
WATER PRIVATIZATION

Since January 2000, the socialist government of Cuba created a mixed public-private company, in association with foreign private company (Agbar) in order to manage some of the water infrastructures, such as sewer and stormwater drainage system.

It serves 1.25 million inhabitants in the municipalities of Old Havana, Central Havana, Cerro, Plaza de la Revolución, 10 Octubre, La Lisa, Playa, and Marianao, which together are home to 60 percent of Havana's population.

The company, called Aguas de la Habana, has a capital of 8 million USD and is owned by the Cuban state through the National Institute for Water Resources (INRH), the Spanish private company Aguas de Barcelona (Agbar) and the Spanish family firm Grupo Martinon. The contract foresees that ultimately the entire population of Havana will be served by the company.

Other foreign investment seeks to be make in near futur, as Havana is still in need of betterment in water managment systems, and some city residents are still supplied by tanker trucks.

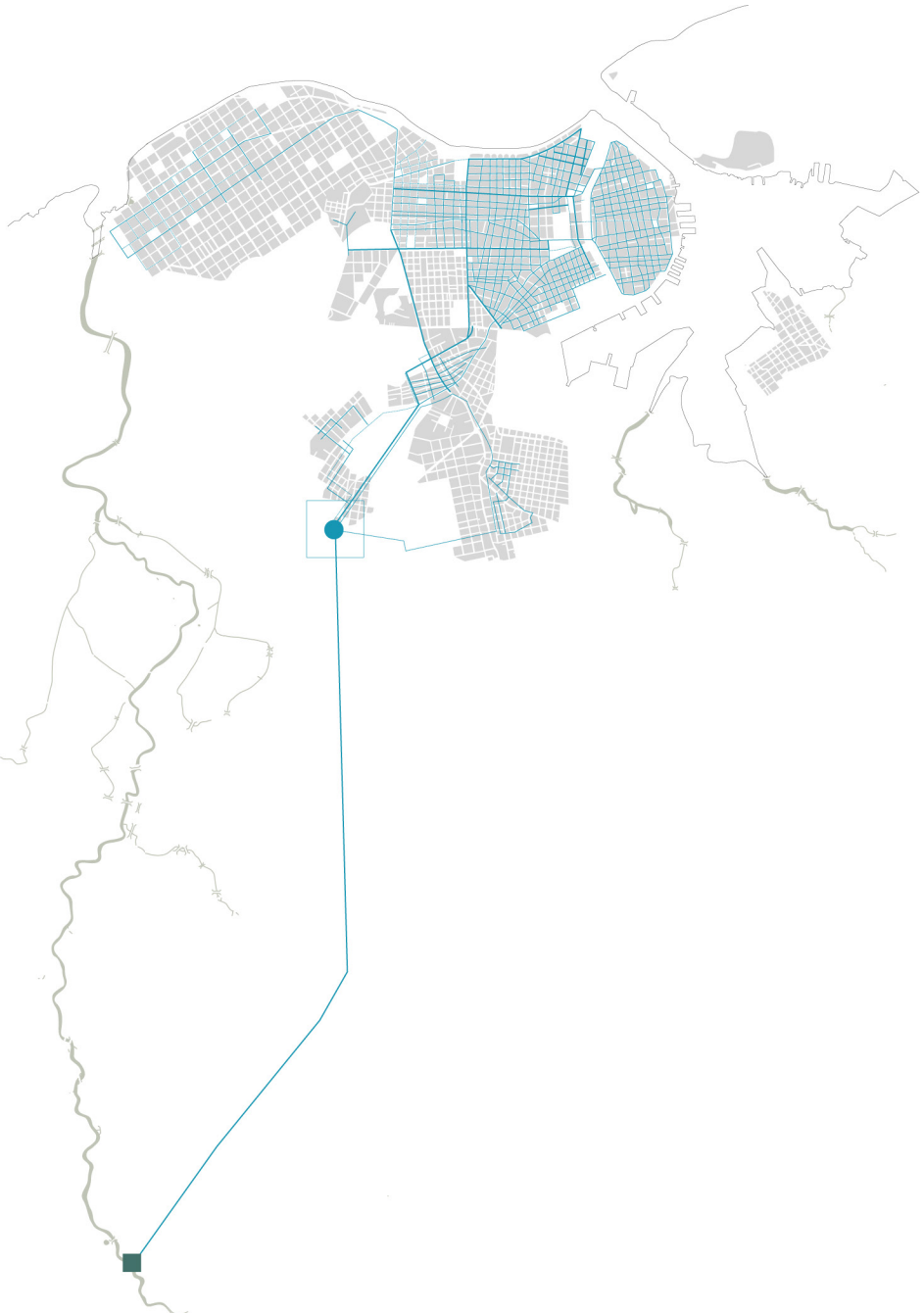


THE ZANJA REAL CANAL

The Zanja Real was the first aqueduct to be constructed within the city of Havana, in 1592. It is a derivation from the Almendares river. The spanish have choosen to settle in the bay of Havana for its unique natural port situation, but the access to fresh water was laking. They started the construction in 1566, under the engineer Bautista Antonelli. The canal is 13 kilometers long and served the population of havana until 1835, when the construction of the aqueduct Fernando VII tooks place. It was still use until the XX century for some sector of the city, notably for the elimination of industrial wastes. The canal became obsolete when the Albear Aqueduct was constructed in 1893.

Today some of the acceses are still visible on the Old Havana.

Source: https://commons.wikimedia.org



THE ALBEAR AQUEDUCT

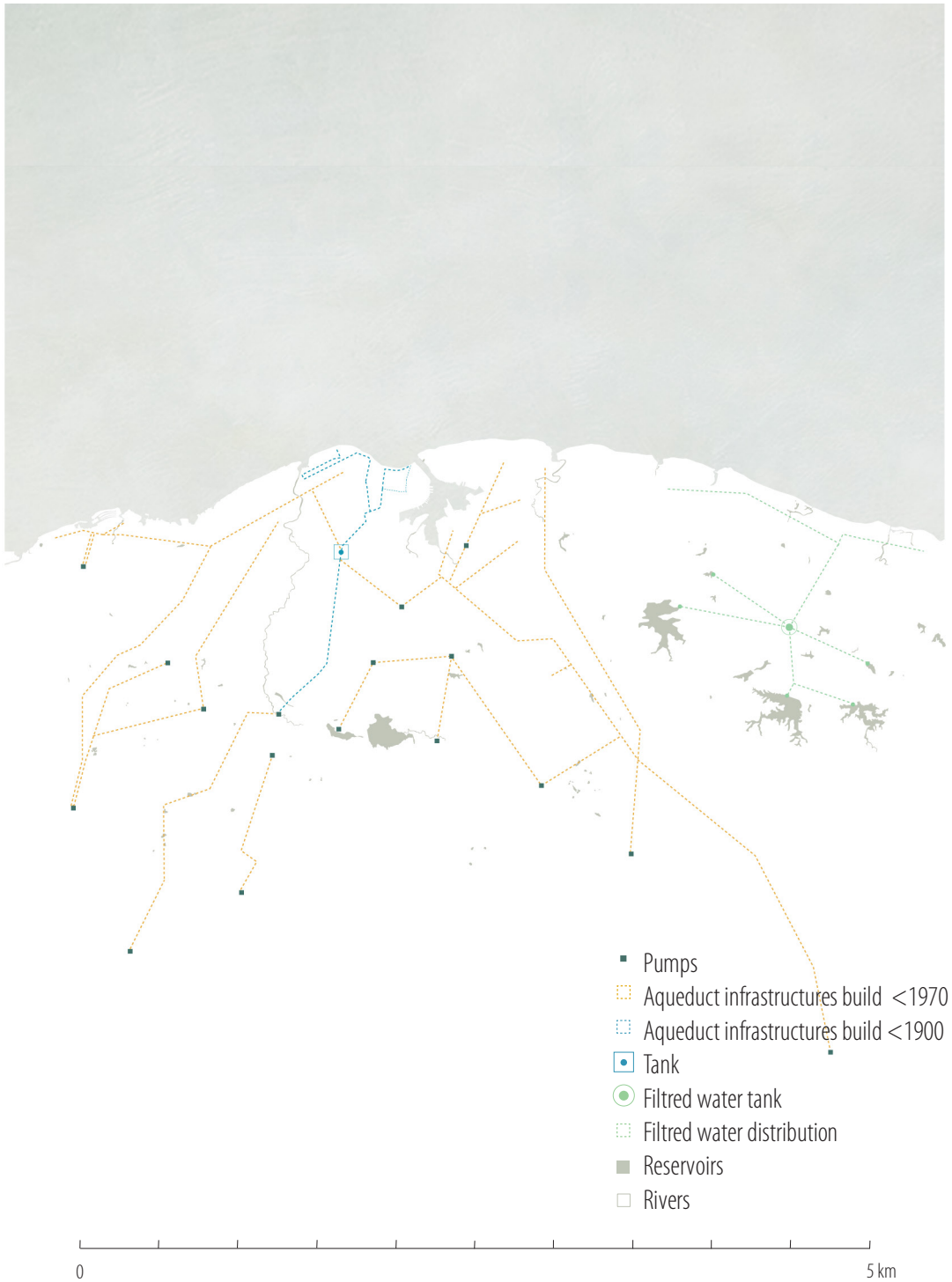
The Albear Aqueduct is one of the mastepiece of the cuban engineering society. It was completed in 1893, 45 years after its commencement. At this time it was one of the most advanced water system in the world. It has served the population of Havana with water supply since then. It was designed to distribute water to about 200'000 residents, the population of Havana at the end of the XIX century, at a ratio of 200.000 m3/day.

Today, there is still 20% of the population (400'000 hab.) relying on this system, in the municipalities of Centro Habana, Habana Vieja and Plaza de la Revolution.

Though called an aqueduct, the project presented by De Albear is complex water supply system, including the following components:

- Dams for the creation of storage ponds for the water of the springs
- Hydraulic structures in the Vento gully
- De-silting structures
- Tunnel for the crossing of the Almendares River
- Canal for conveyance of water to the city
- Water treatment plant
- Water storage tanks and water towers
- Water distribution network in the city

Source: snipview.com



WATER DISTRIBUTION

The principal income of freshwater for the city of Havana comes from six groundwater sources (El Gato-Cunenca Sur-Ariguanabo-Paso Seco-Cosculluela-Canal de Vento). It represents 63% of the overall extraction (364 Hm3/y) and serves for 82% of the population (1'788'449). Those sources contains potable water, but with the large distance of pipes and conducts necessary to bring it till the customers, the infrastructural deterioration , and the discontinuity in its service, that doesn't rule for 24h, lots of contaminents intrusions make its unsuitable for direct consumption. It has to be treated and desinfected.

The network used in Havana composed by 401 km of conducts and 3158 km of pipes. With their long years of services, it is estimated that only 11% of the pipes are still efficient, while 42 to 62% are nearly obsolete.

The actual sitation is that only 15% of the aqueducts were built after 1959, 65% which only give a few hours of water per day and the 20% per cent just carry the water to collection tanks. (Cereijo ed. 1992)

Above we can see the representation of the first aqueduct infrastructure that what used to transport water into the city, and a photography of a water pipe today.

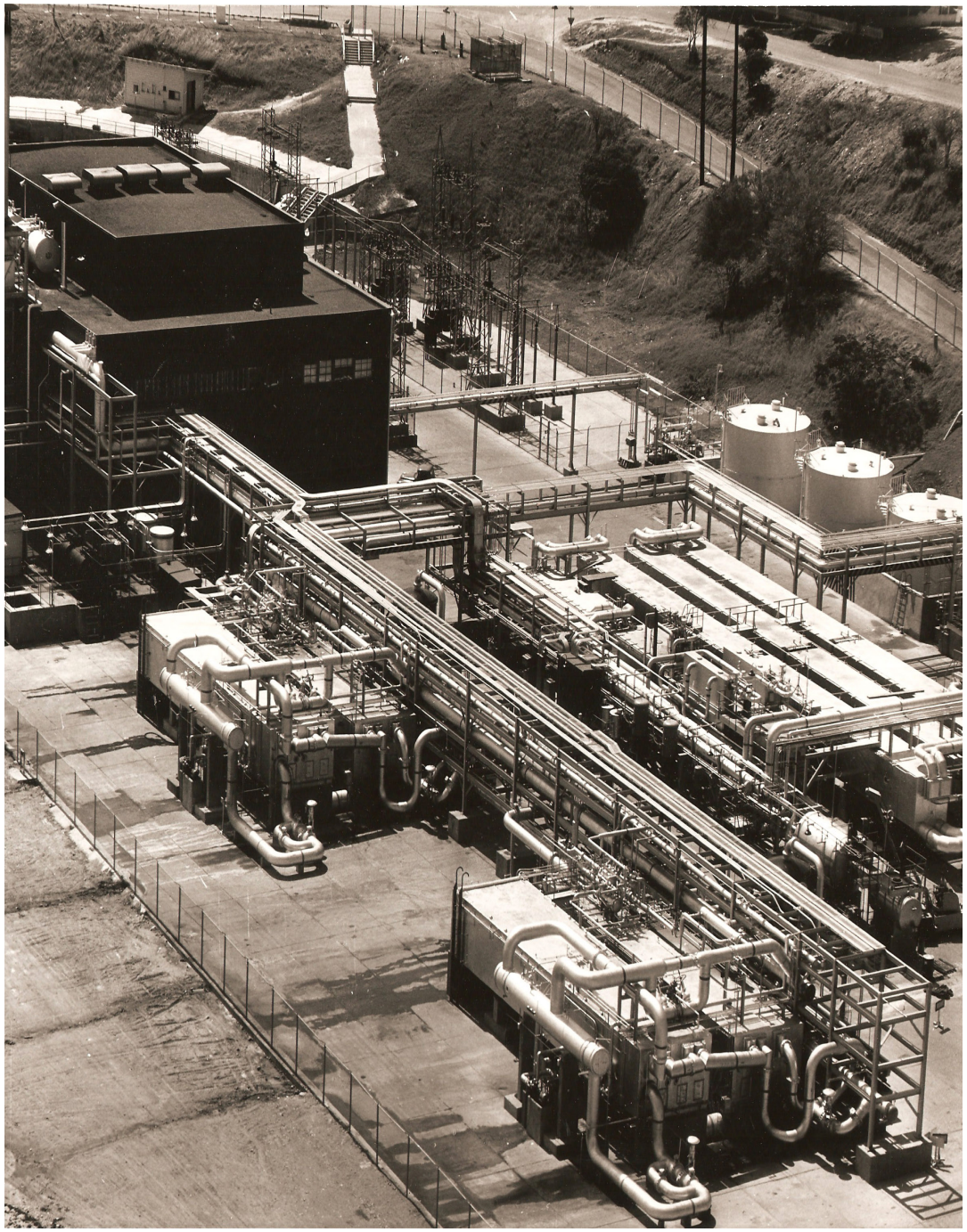
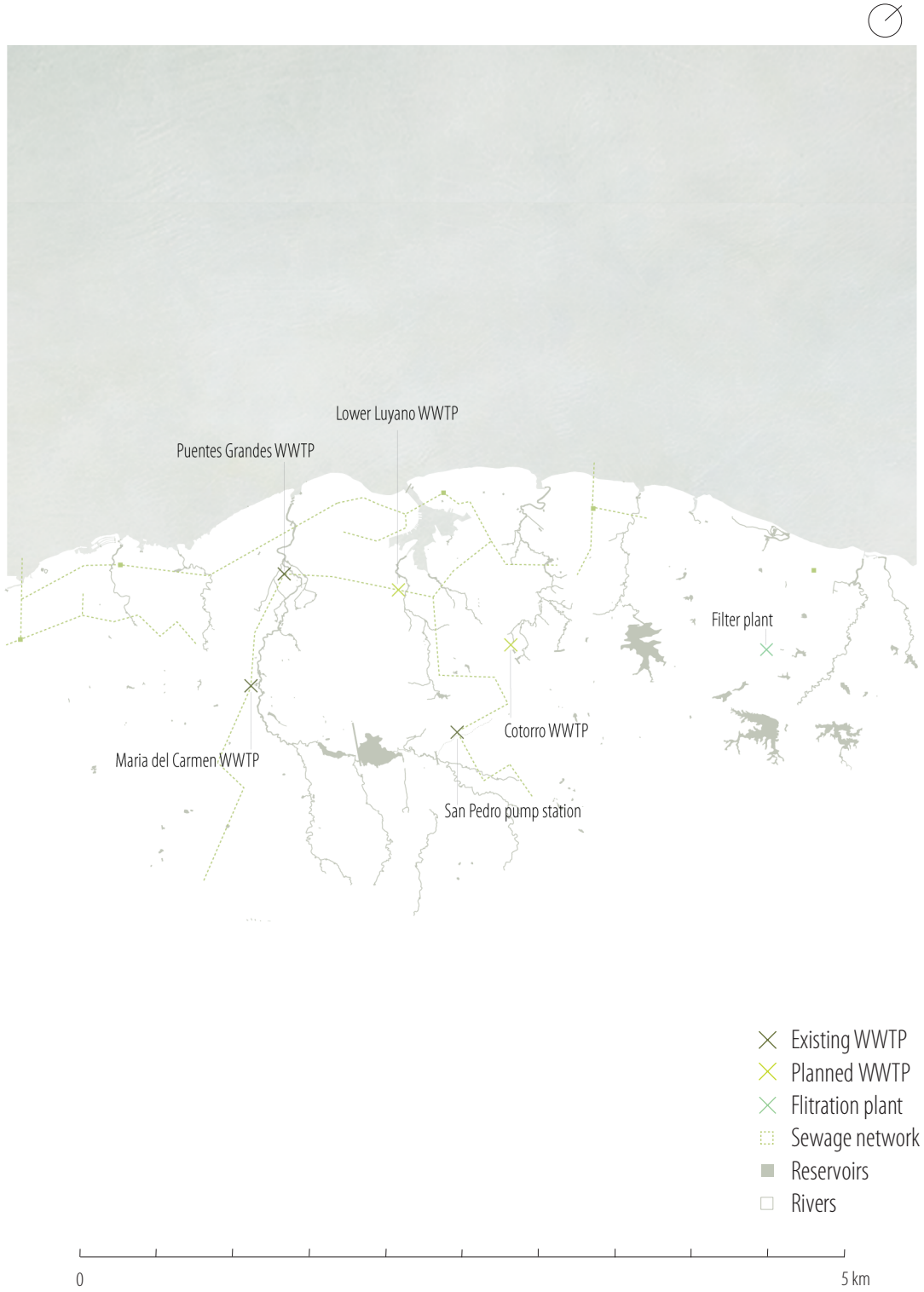


Photo: U.S. Navy Seabee Museum-Flickr

4. MANUFACTURES



WASTEWATER COLLECTION

The wastewater treatment plants serve two of the six existing collection networks. These six networks consist of more than 1570 km of sewer mains and laterals. Originally built for almost 1.2 million inhabitants many years ago, these six major collection networks serve approximately 55% of the city population of over 2.2 million people. The sanitation coverage for the rest of the population is managed by septic tank coverage (26%) and smaller wastewater collection networks (12%). The remaining 7% of the population in the nation's capital does not receive any type of sanitation coverage.

(Alonso Hernandez and Mon, 1996).

IMPROVMENTS

The infrastructure of water and sanitation are beyond the breaking point and are close to catastrophic failure. Havana's sewer system, which was built almost a hundred years ago, has been due for major repairs for almost five decades and is serving over two million citizens, well beyond its design capacity of 400,000.

It is a urgent need for a sustainable development of the city of Havana to improve their sewage facilities to collecte the watewater, then to better the water distribution in order to minimize the lost and prevent infrastructure's degradation. In absolute, they need to redefine the cycle of water production.

TREATMENT FACILITIES

There are three conventional wastewater treatment plants Maria del Carmen, San Pedro and Puentes Grandes in the City of Havana. In the western part, a filter plant makes the connection between the potable water reservoirs and the population served. The current state of those treatment plant is alarming. Only one of them, Maria del Carmen is still partly working, but does not have an adequate wastewater collection networkand throws untreated sewage to a tributary of the Almendares River, while the two other are yet obsolete.

Two new treatment plants were planned, in the lower Luyano area and in the municipality of Cotorro, the feasability studies have been done but witout outcome.

Google Image

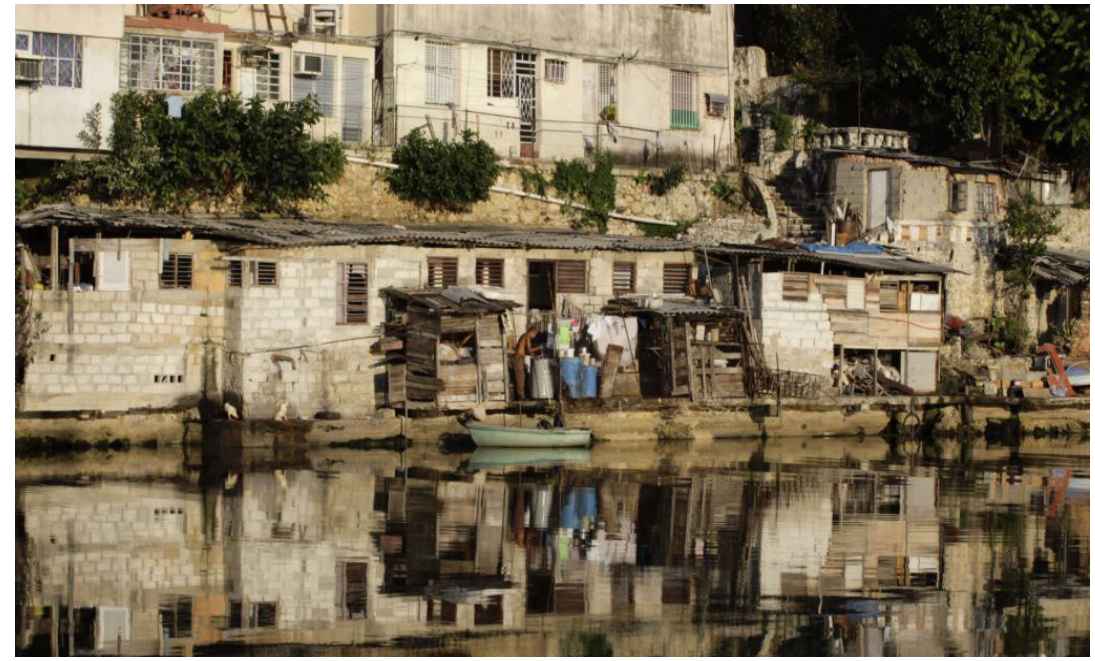
5. READING

- Industrial areas
- Watersheds
- Urban sprawl over aquifers
- Most contaminated rivers
- Reservoirs

SPECIFIC FOCUS

In order to establish a strategy for the water management in the city of Havana, a specific focus will be make on the most sensible areas. The first criteria is the fact that the Vento watershed stands on a karsatic aquifer. Those are the most vulnerable to urban pollution due to the porosity of their texture. It hosts a large amount of the population and must be taken into serious consideration. Another fact is that the Luyano and the Almendares river are among the most contaminated rivers in the world. We can note the large concentration on industrial areas standing along the Almendares and around the Havana's Bay. For those reasons, the strategy will focus on the lower Vento watershed, where urbanisation is mostly concentrated, and on the Havana's Bay watersheds, that regroup the Luyano and the Martin Perez rivers.

0 5 km



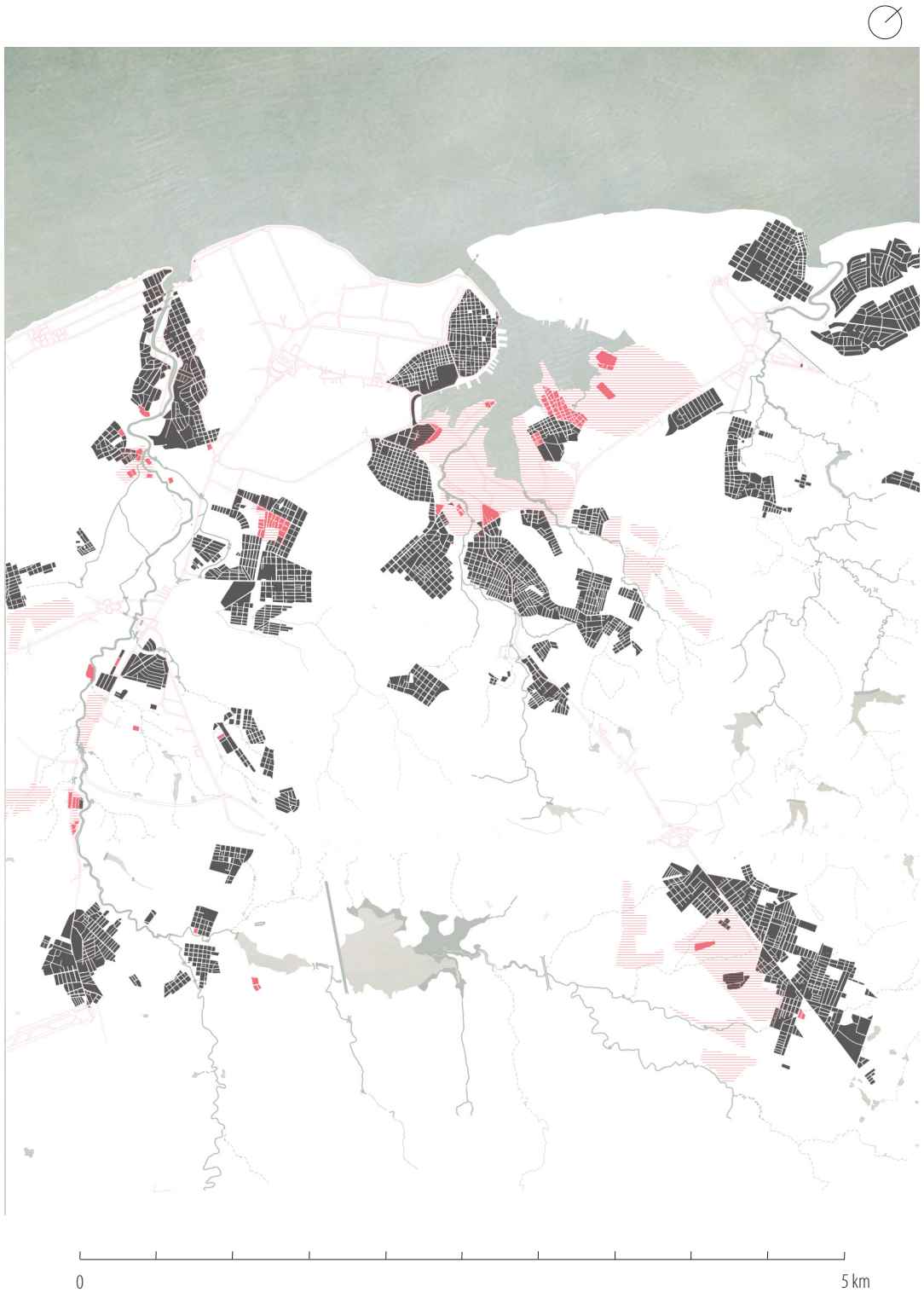
FLOODING RISKS

The relatively flat topography, the imprevisible rain water precipitation level and the lack of a decent sewage system, alle serve to accentuate the risk of flooding around the streams.

Some habitations find themselves under the threat of instability in those flooding zones and might be damaged in the case of an unpredictable event such as a huricane.

Sea level rise is also a threat along the coast and in the Havana Bay.

- Reservoirs
- Overflowed
- River flooding areas
- Salt water intrusion
- Sea level rise
- Topography



- Reservoirs
- Rivers
- Urban pressure
- Industrial areas
- Industries
- Roads

MAJOR CONTAMINANT

Urban sprawl of the recent decades has seen many neighborhoods establishing themselves very next to the rivers.

As for industries, in order to have a direct connection to freshwater, that is used in manufacturing processes, many are located very next to a water source, notably along the Almendares river and at the end of the Luyano river.

Those two elements have lead to the construction of many road infrastructures that affect the soils permeability.

Knowing that only 4% of the industrial waste of water is treated, those areas are contaminating the rivers at a rapid rate.

Photo: El Río Almendares-Reuters

- Reservoirs
- Overflowed
- Rivers
- Parcs
- Forests
- Agriculture fields

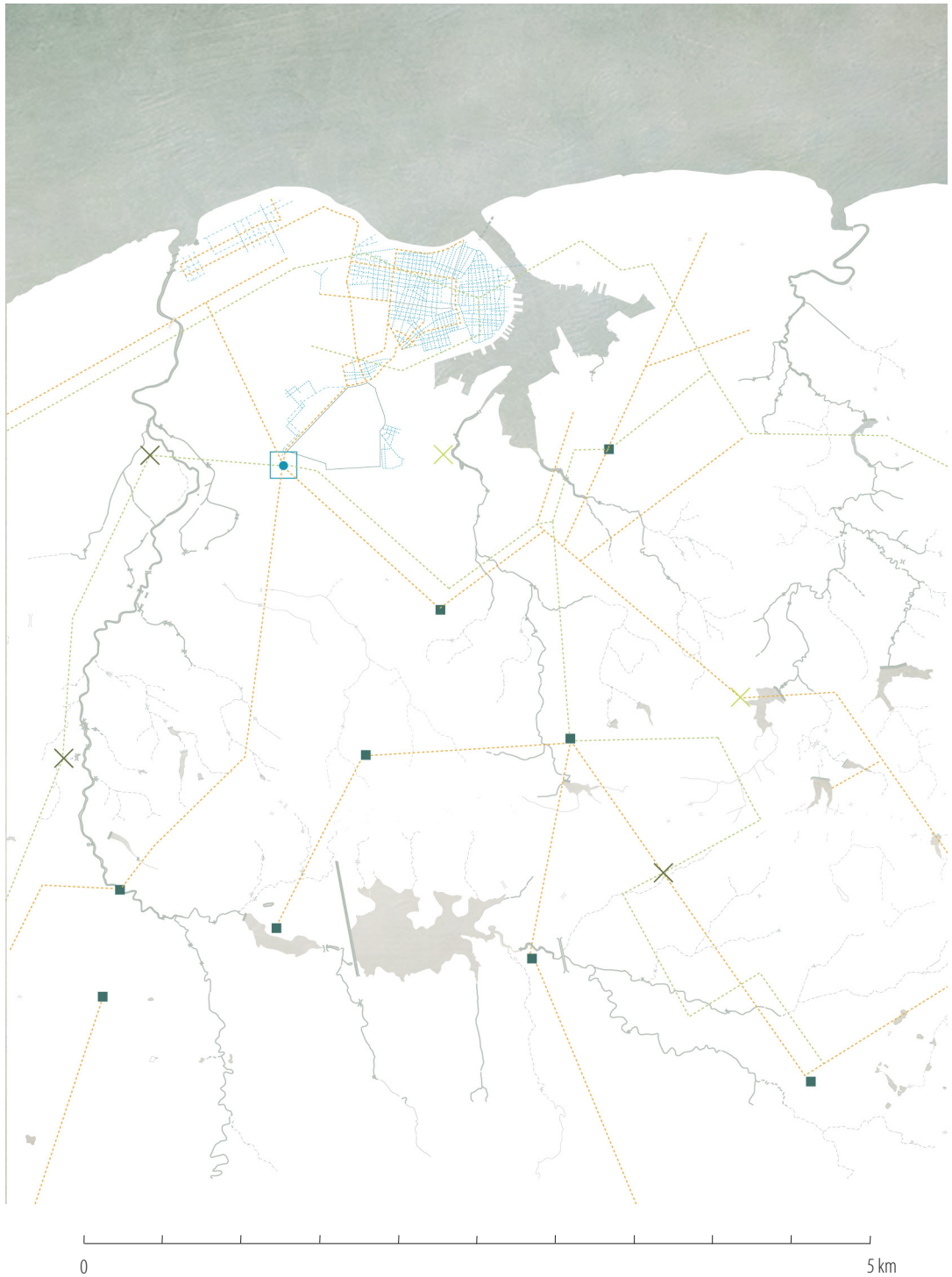
GREEN SPACES

As we can see on the map, the relation between water and green spaces is very direct. The parcs, the forest and arable lands are always next to a water source.

The city development, from the coast to the south, has pushed those areas to its periphery, with very few green spaces within the living areas, beneath the presence of water.

An exception stands at the end of the Almendares river, where the major parc of the city, the 'Gran Parque Metropolitano' stands.

Gran Parque Metropolitano, Photo by: Calle primera, photonucket



WATER NETWORK

- Pumps
- Aqueduct infrastructures build <1970
- Aqueduct infrastructures build <1900
- Tank
- Existing WWTP
- Planned WWTP
- Sewage network
- Reservoirs
- Rivers

The Albear aqueduct was elaborated with a lot of precision and highly technological features at the time it was build. The ingenieer had a great knowledge of the topographiy and the morphology of the territory. Its outcome of water would, at the time exceeds to demand. Time has past, and the following infrastructures that were build during the twenteenth century did not had this «big picture» in their planning dispositions. It was more made by addition of particular operations.

The result is that today the network can't cop anymore with the demand and a lot a discontinuity is arming the strenght of its possibilities.

6. STRATEGY

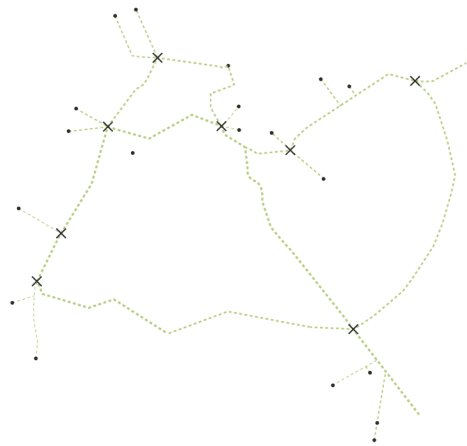
THE PATH OF A CLEAR WATER STREAM

After an overview of the problematic around water in Havana, this strategy aims to look at the water management as one big ensemble in order to enforce the potentiality in its application.

The idea is basicly to find alternative source to bring drinking water in the city and with that, considering a possible amelioration not only the sanitation system, the economy and the environment, but to generate new urban spacialities.

The first step will to decontaminate the rivers and their direct environments. To do there is an urgent need to recollect the watewater from both industrial and residential outcomes. So no more «dirty water» will be injected into the streams. The direct environment of the rivers needs «protection». A buffer zone will take place along the rivers and their flooding areas. A series of natural filters, like trees or special plantations will serve as a natural filter between the water and the urban fabric. It will then offer the possibilities of new recreational areas, parcs and urban agriculture fields.

The rivers could then become a new source for water distribution as it's quality would be largely improved. Those effort will also tend to purify to polluted bay of Havana, by fresh and clean water injections from the Luyano rivers.



RE-COLLECTION

The new sewage and treatment system's structure follows the geometry of the existing road infrastructure. The reason for that is the underground context of the pipes. To establish such a network could demand a lot of work and digging. This would not be in adequation with the effort of maintaining a maximum of soil permeability around the watersheds. Moreover, the majority of the industrial areas are located along those existing infrastructures.

The result is a circular sewage network armed with water purification and treatment plants on strategical locations regarding the water circulation.

Collection points
Sewage network
WWTP
Urban pressure
Industrial areas
Industries
Roads

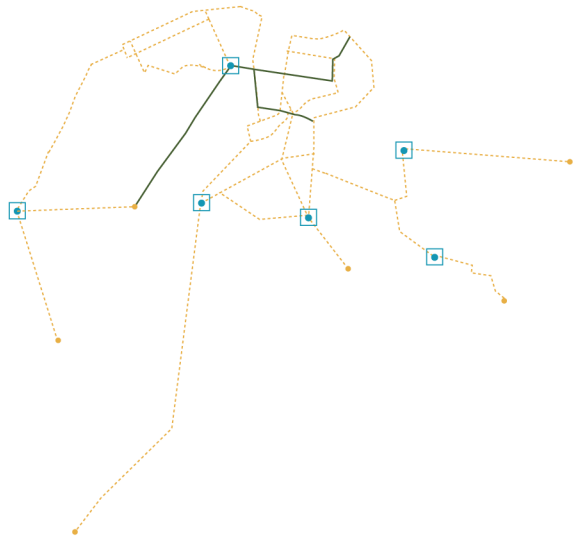
PROTECTION

To avoid external contamination of the rivers, a buffer zone plays as a parfect actor for a natural filtration. It will protect the flood's vurnerable nieghbourhoods as well as keeping the water clear of pollution. It will offer new forest areas, which will be a continious path from the south side to the sea side.

The trees are beneficial for the soil fertility and could in a second step offer new productive surfaces nera the city center.

In areas very next to an urban context, near the ocean for exemple, the buffer zone could take form of a parc, in which various activites could be developed such a freshwater fishing for exemple.

Reservoirs
Overflowed
Rivers
Parcs
Forests
Agriculture fields
Buffer zone
New forest areas



DISTRIBUTION

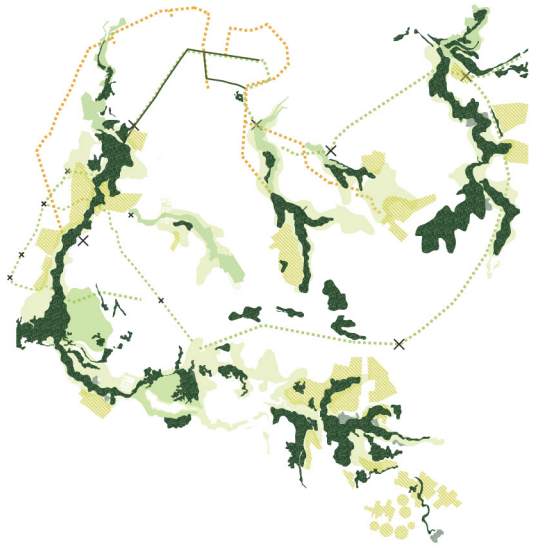
From the decontaminated water streams, new purification plants will allows to augment the capacity of the supply,, and will run constantly.

New storage tanks will take places in some of the main «plaza» of the city in order to establish a connection between the main attractive and historical locations of the city, between de lands and the seashore.

One surface aqueduct system, connectiing the Almendares river and the municipality of Old Havana, will bring new urban opportunities to the city center and will also bring the people knowledge and experience of water the management.

Aqueduct infrastructures
Surface aqueduct infrastructures
Tank
Water purification plant
Urban
Reservoirs
Rivers

7. VISION



THE FUTURE OF HAVANA'S WATER

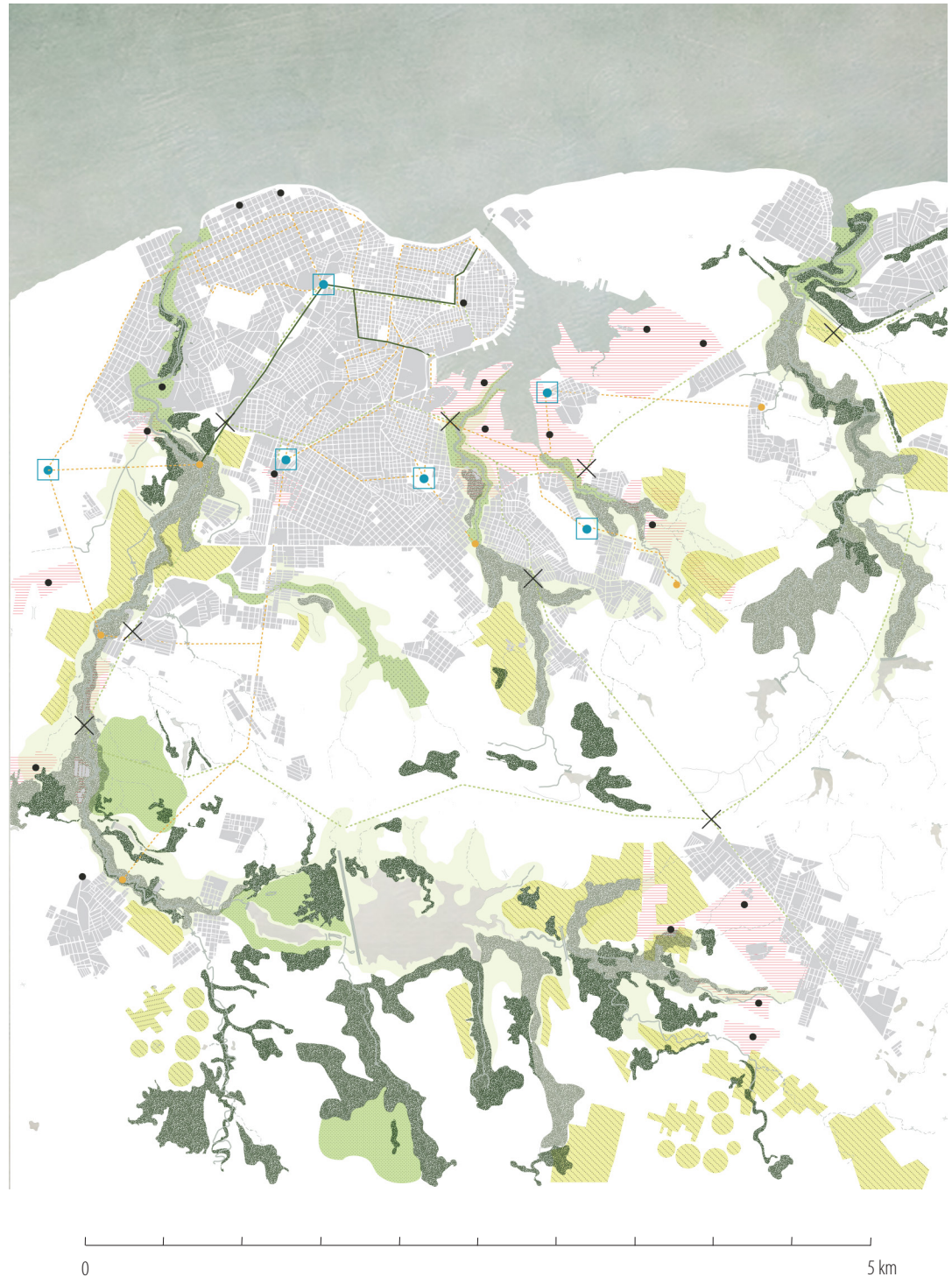
Water in urban contexte has the potentiality to generate green spaces, agriculture fields, recreation areas, and potable water distribution.

The emergence of a new urban form stands in the circular shaped network, composed very distinctive elements, from a sewage pump to a new forestal area, but all focus to strengthen the relationship between the city and its hydrological resources.

As for water, the system function better as a close cycle, but is very dynamic in the way that it has the ability to generate urban transformation.

Water is central for architecture for all those reasons.

- Aqueduct infrastructures
- Surface aqueduct infrastructures
- Tank
- Water purification plant
- Urban
- Reservoirs
- Overflowed
- Rivers
- Parcs
- Forests
- Agriculture fields
- Buffer zone
- New forest areas
- Collection points
- Sewage network
- WWTP
- Industrial areas



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