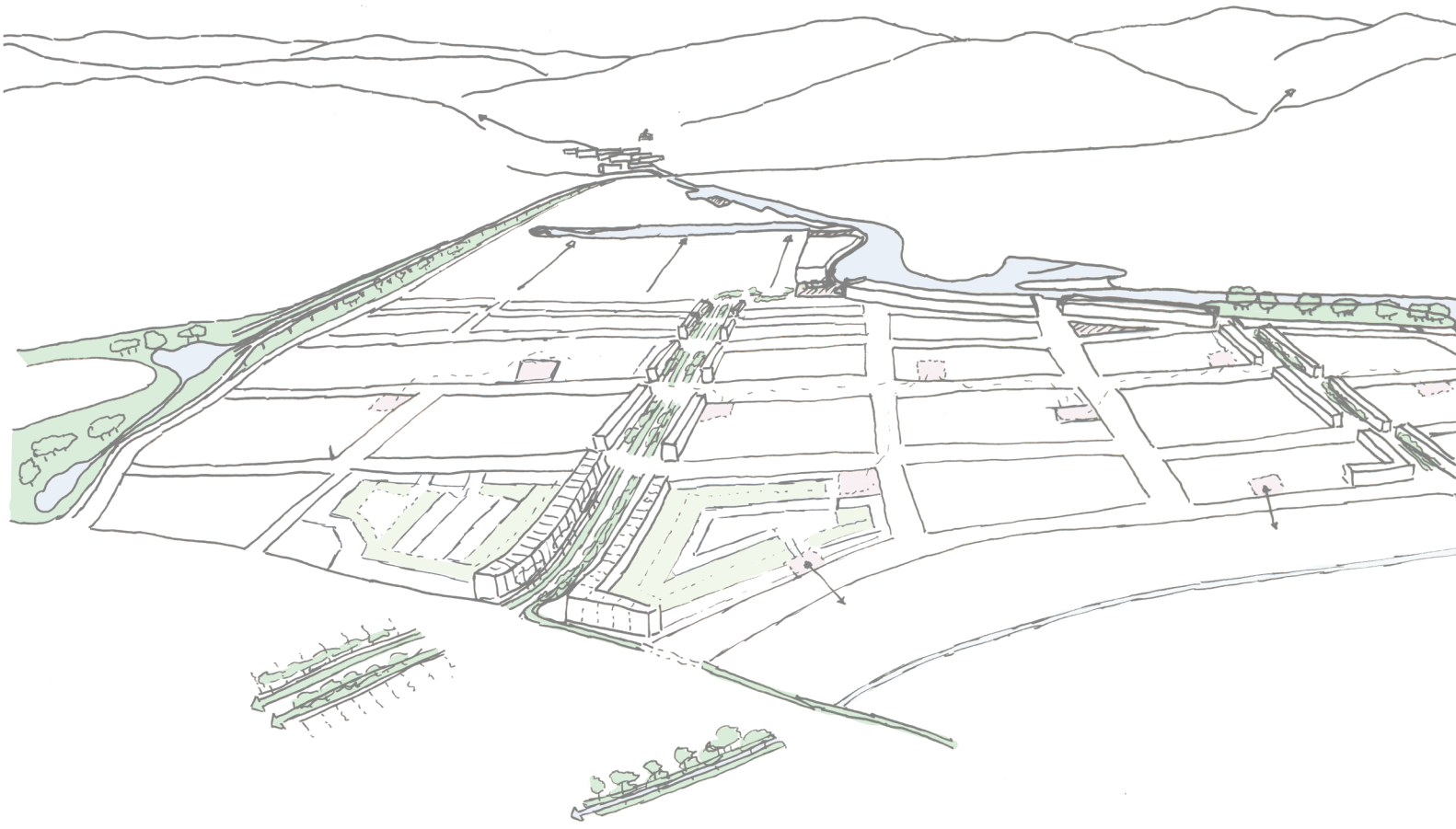
Adaptation by Design: San Rafael Canal District

'Keeping water out, and people in'



Master Thesis

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Delta Interventions graduation studio

Adaptation by Design: San Rafael Canal District
- 'Keeping water out, and people in'

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Preface and acknowledgements

A small minor in water management, a SUET course, Aqua Terra and one amazing project in Sao Paolo with the Smart infrastructure and mobility course. All steps toward the graduation studio Delta Interventions. A personal fascination with water is just a part of it. As an Urbanist you can not ignore the problems of the future, and climate change is a big one. Combined with the rapid growth of our global population, the problems seem to stack up. Tackling two of these problems in one project might have been a bit too much, but I have tried.

This booklet is the final product of my graduation year, the final product I will produce as a student. A long road, that started at the wrong study at the TU Delft, only to bring me back years later.

I want to sincerely thank all the faculty members of the Urbanism department for providing a great master track. Special thanks to Louisa, Birgit and Paul for exceptional guidance during the first year of the master, and to Taneha and Fransje, for nourishing my interest in Delta Urbanism.

I would also like to thank my graduation mentors. It was an honor to be guided by two professors, together more experience and wisdom then I will manage to gather during my lifetime. Han Meyer, his brilliance would sometimes daze me. But I have learned more from him then I have been able to show in this thesis, and I will probably continue to do so for many years to come, because it will take years to read all the work he has produced regarding delta urbanism. And Wil Zonneveld, the most enthusiastic teacher I have ever had. From the first conversation I felt inspired to look into delta interventions form a governance perspective. Thank you both for your support and patience.

Finally I would like to thank my parents, my brother and sister. Without their endless support I would never have been able to do all the things I have done in my years as a student.

And in a final acknowledgement I would like to confess that I would have been completely lost without the help of our modern society. Access to digital data and GIS systems make it possible for us to do analyses from the other side of the world, without these systems I project in the United States would not have been possible. And as an Urbanist, I can no longer imagine how to work without Google, maps, earth and street view opened up our world completely, thank you Google.

Abstract

Floods have become a regular appearance in our global system, though inhabitation of former marshlands and tidal flats, more people are at risk and this number is expected to grow. The people living here are usually the most vulnerable inhabitants of the local society. Flood risk areas seem to attract people with a low ability to recover from flood events. Resilience by design should not just be about spatial recovery, it should support the most vulnerable in the system as well.

San Rafael is an example of this combination of lower social-economic groups living in a flood risk area. In a very high density, these people struggle to maintain themselves. Lack of spatial quality, mobility options and isolation of the area are decreasing the potential for redevelopment of the area. Higher quality facilities, public spaces

Direct protection of the most vulnerable is almost impossible because of economic feasibility. People in low social-economic don't need spatial quality, they need the opportunity to develop themselves. They need higher quality facilities to reach this goal.

A design strategy created around a three-layer approach; mobility, urban patterns and social-economic development. These layers are separately analyzed and interventions are created that would benefit the specific layer. When all the layers are handled separately, they are integrated into a general scheme and strategy. The result is the creation of different networks in the different layers, all working on top of each other.

Through high-quality water management implementations, a spatial quality can be achieved that will attract higher income households. With enough density and a mix of different households in the area, higher quality facilities can be achieved to support lower income houses, giving them the ability to grow. By creating different sets of guidelines, both to guard the spatial quality and the position of the more vulnerable, resilience can be reached through design.

Contents

1. INTRODUCTION

1.1 Context

This year's focus of the Delta Interventions studio, is the San Francisco Bay, the location for the research by design competition 2017. The chosen site for this graduation thesis is San Rafael in Marin County, north of San Francisco. This site is chosen due to its relevance of combining flood risk with social-economic discrepancies.

At the start of the graduation year, the delta interventions studio aimed to work ahead on 2017's Resilience by Design competition, involving the bay area. After the catastrophic events of Hurricane Katrina in New Orleans (2005) and Hurricane Sandy in New York (2012), the government of California is attempting to preemptively act to the increasing risk of natural hazards in the bay area. For the competition, ten sites around the bay will be selected.

Worldwide over 40 million people are currently living in area's at risk of flooding (Nicholls, et al., 2007) and both the risk of flooding and the development of these areas continue to rise. The number of people at risk can run up to 150 million in 2070 if current trends continue. Currently about half of the people at risk are living in first world countries and the other half in developing countries, however, the most rapid growth can be found in the upcoming countries (UN Habitat, 2008).

Flood risk is often evaluated by economic standards; how much will the damages cost to our urban system? When we try to improve the urban fabric through resilience by design, we try to create a system that is able to quickly recover from natural hazards, like flooding. When looking at the system as a whole, that approach makes perfect sense. However, when we look at the smallest scale, the individual, we see a disturbing trend related to flood area's, they attract the lowest social-economic classes. This trend is not only occurring in the upcoming development countries but also in first world countries, Like the United States.

The economic situation in our global society has lead to a big divide between poor and rich people. Many European countries have a political system based on, or similar to, a welfare state. The poor don't have it easy, but they are provided for. In the United States, everything revolves around freedom and thus self-reliance.

The San Francisco Bay area has gone through an incredible growth in the last 30 years. Ever since the digital age began, Silicon Valley has been fuel for the development of the region. But this development has come at a price. The divide between rich and poor has grown and the costs of living are rising exponentially. The lowest social-economic classes barely get by and are designated to live in the area's where no-one wants to live, right in the middle of the flood risk areas.

Yet, water in the built environment can be a great tool when used in an integrated design with water management on the one hand and urban design on the other. Especially the value of water, expressed in spatial quality and measurable worth, makes water a powerful element to design with.

Due to climate change and the expected densification of our cities water management will become a more important topic in the years to come. For a sustainable future, both in the context of urban development and environment, water-related processes in our cities are essential and therefore the focus of choice for this graduation.

The San Francisco Bay provides an interesting case for this goal. The water-related urban design is an important export product for the Dutch as a nation. Continuing in this field might result in collaborations with foreign countries and possible projects abroad, an international project like the San Francisco Bay is an interesting experience as a first step to prepare for the future.

Water-related, the San Francisco Bay provides problems relating to all three possible causes of flood, open water, run-off and urban densification. In that way, you can see the bay area as a complete world as it comes to water problems. So a very interesting case study regarding water management in an integrated design.

The Resilience by Design competition for the San Fransico Bay Area started in the middle of 2017. The sites are known by now and interested parties have signed on for the competition. During the excursion of the Delta Interventions Studio, the ten sites were yet to be determined.

The San Fransico Bay is surrounded by 9 different counties, together they form the Bay Area (see fig. 1.1).

A: Marin County
B: Sonoma County
C: Napa County
D: Solano county
E: Contra Costa County
F: Alameda County
G: Santa Clara County
H: San Mateo County
J: San Francisco

The assumption was made that every county would provide at least one site. During the excursion more than 12 possible sites were visited briefly. From these visits, a list of most likely sites to be added to the competition was made.

1: San Rafael - Harbor town
Former marshland turned into urban area

2: Petaluma - Creek
Marshland transformation

3: San Marin - Harbor town
Former marshlands turned into urban area

4: Richmond - Waterside industry
Lack of coastal protection

5: Oakland Docks - Urban fabric
Densification of urban area

6: Oakland Coliseum - Urban fabric
Former marshlands turned into urban area

7: Hayward - Waterside industry
Lack of coastal protection

8: Alviso - Salt flats
Former marshlands turned into urban area

9: East-Palo Alto - Silicon Valley heart
Former marshlands turned into urban area

10: Foster city - Canal based housing
Low freeboard between canal and street

11: SF - Hunter's Point - Former docks
Lack of coastal protection

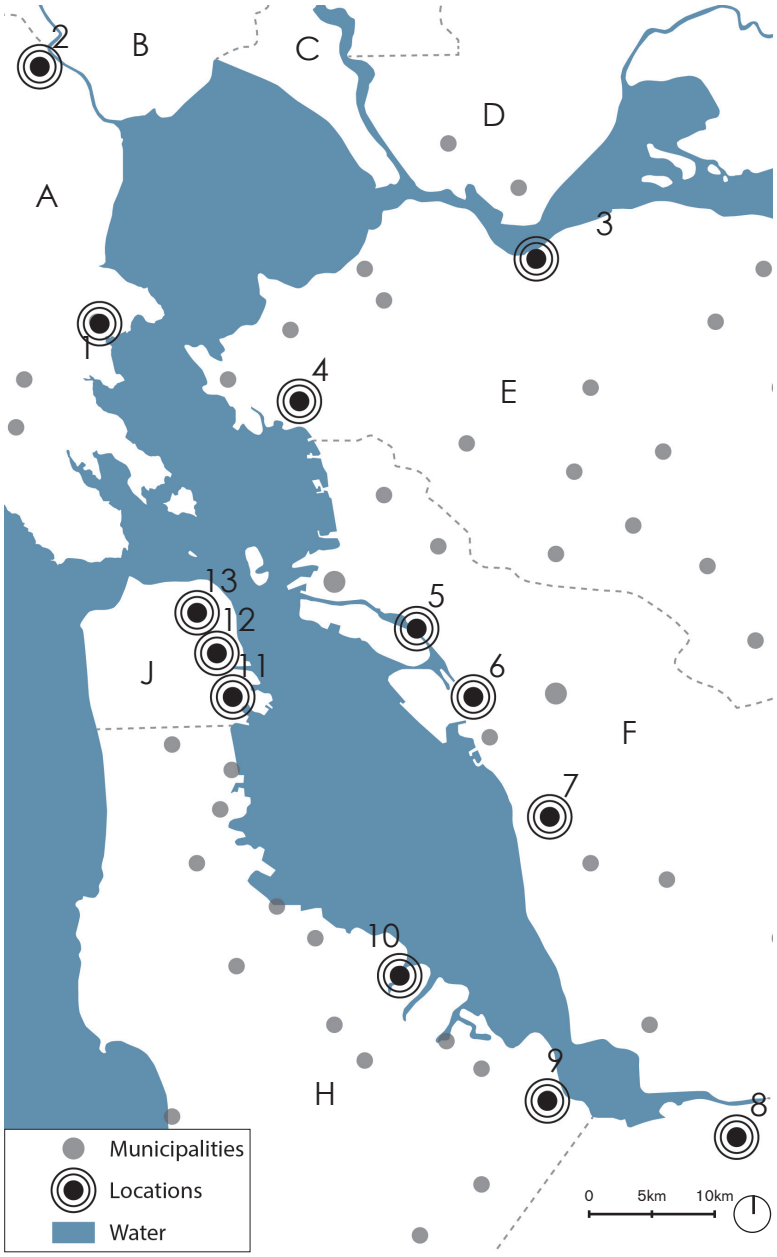

Figure 1.1 - San Francisco Bay Area

12: SF - Mission Bay - Former docks
Densification of urban area

13: SF - Embarcadero - Urban fabric
Densification of urban area

These sites became the focal points of the studio members. After a short study of the sites. They were picked and divided. Here the focus of this thesis became San Rafael, but not solely because of the interesting water problems, mainly due to the relation between social-economic development and flood risk.

1.2 Relevance

Flooding is a problem that occurs periodically, but the threat is always there, and with the expected climate change this threat will only increase. This permanent problem is going to affect our society for the rest of our existence, yet our political agenda's change every election period. Dealing with this kind of problems require long-term visions, a skill that is more familiar to the urbanist than a politician.

Henk Ovink, special envoy of international water affairs, warned us that we only have five years left to save the world, during a lecture at the TU Delft. He was referring to the 2015 Paris Agreement, a binding global climate deal that was signed by 195 countries. If these goals, to reduce global warming, are to be met, we have to take drastic actions in the next five years, or we will not make the change that's needed. During the election for the presidency, Donald Trump said he would 'cancel' the climate deal if he would become president (BBC News). With Donald Trump as the next president of the United States, one of the worlds biggest industries might do more harm than good in the years to come.

The election of Donald Trump is not the end of the world, but it does illustrate a problem of our society, we want to think ahead, safeguard our future in the long term, but policies change with power switch, every election. As Urbanists we can no longer wait for a solution to the problem of climate change, we have to start preparing for the problems of our future. We do not have to design for the worst, but make sure that we are ready for it to come.

With the global warming continuing, the sea level will rise and the risk of flooding will increase (see fig. 1.2). Simultaneously harder rainstorms will fall down on our cities. To prevent flooding of our Urban systems, we'll have to increase our protection against open water and improve or transform our rainwater system.

Transforming our existing fabric to implement these new systems, will come with great costs and are needed in area's where to lowest social-economic classes are settled. Investing in these area's usually lead to a gentrifying process where the current residents are pushed out. But with this threat happening on a global scale, in multiple countries, it's time to find a different approach. Implementing delta interventions in these underdeveloped neighborhoods in flood risk areas, while protecting the residents by offering them a future in the area they live, is a goal worth pursuing.

It's about answering the moral question, to what's worth more, the economic benefits, or the people. Chasing economic growth has triggered global climate change, maybe humility can save us, people.

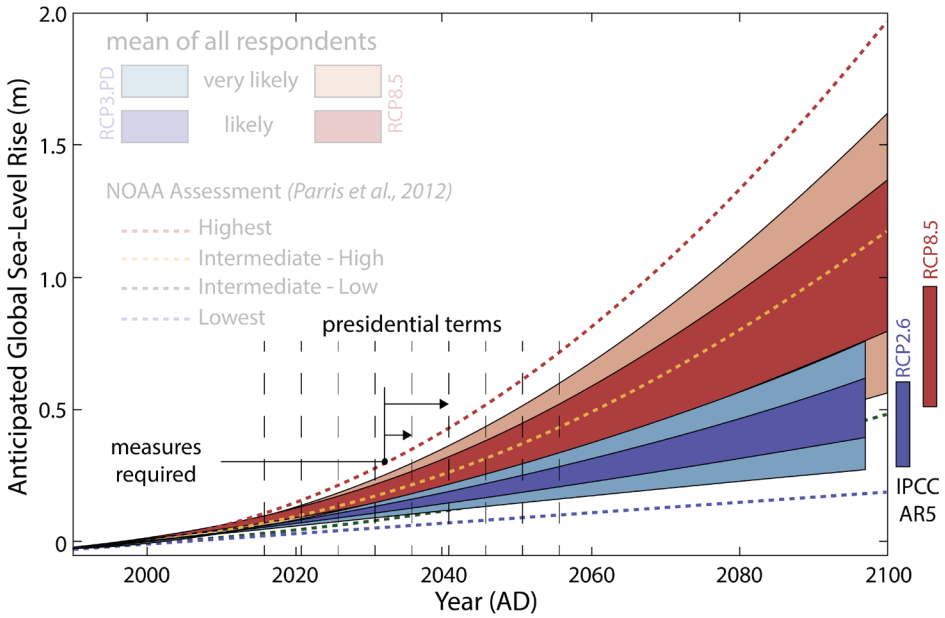

Figure 1.2 - Sea level rise predictions

The Threat that is facing the San Francisco Bay is a global problem (see fig. 1.3), and the threat to other, similar area's is even bigger. The flood zones of the San Francisco Bay expose around 200.000 people to a potential hazard, where other regions in the world, facing the same threat, are far more densely populated.

These upcoming countries grow so rapidly, that the threat, in the next 50 years, will expose three times the amount of people, it does today. In order to stop or prevent this threat, action is required fast.

So why would we start looking for solutions in a western developed area, like the San Francisco Bay? Well even though the development of the urban area's seems completely different from each other, they are both struggling with a similar topic. Not just Flood in general, but flood hitting the most vulnerable inhabitants of the system. The poor, uninsured and unemployed.

Because the systems of the upcoming, former third world countries are so different, we might not know how to intervene, but we understand our western society. If we are capable of providing a solution for the vulnerable in our society, we might learn how to deal with different areas with similar problems.

The solution for flood resilience is not just finding out how to keep the water out, it's also about how to keep the people in. If the people can't survive a flood because everything the owned was destroyed, there is no resilience.

When you combine the words 'flood' with any of the regions marked below, you'll find proof of a flooding in the last 10 years (see fig. 1.4 to 1.9). These floods often hit areas with a high concentration of people in lower social-economic situations. These areas, as a result, lack spatial quality due to the threat, or the repeating problems, of flooding.

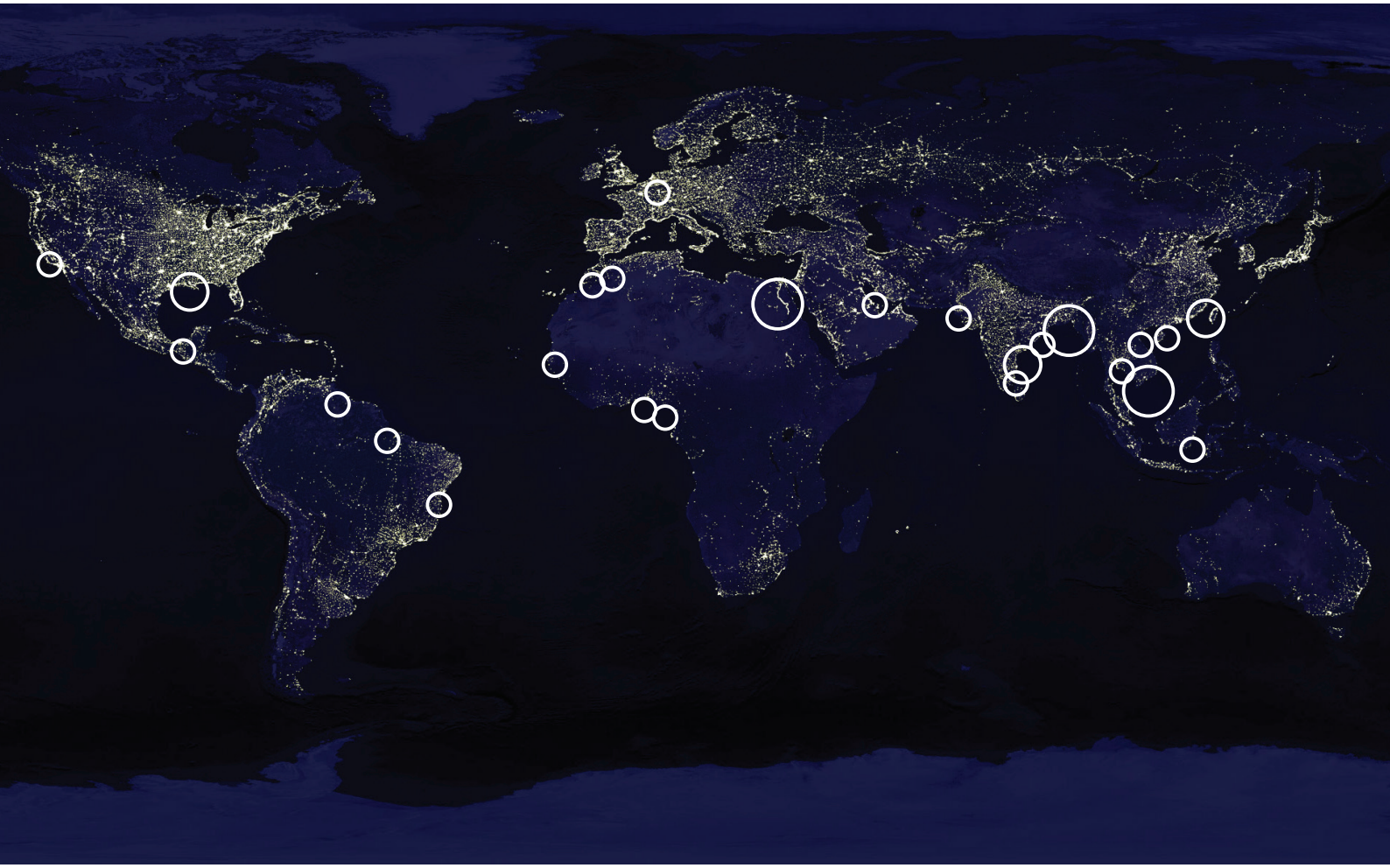

Figure 1.3 - World wide flood endangered regions

Figure 1.4 - Brazil, June 2010

Figure 1.5 - Egypt, October 2015

Figure 1.6 - India, August 2016

Figure 1.7 - South China, July 2017

Figure 1.8 - Pakistan, July 2010

Figure 1.9 - Bangladesh, August 2007

1.3 Project Location

From the start of the graduation project, the link between social vulnerability and flooding was the aim of this master thesis. Because of that the number of project sites were already narrowed down to 4 possible locations, San Rafael, Oakland - Coliseum, East Palo Alto and Alviso. San Rafael was eventually picked, the high density of the Canal district gave the break thought. The highest concentration of vulnerable people is the least resilience location for me. And therefore ideal to focus on, so let's find out where we can find the Canal district.

It's no wonder that the San Francisco Bay has at least 13 different locations you can focus on. If you look at the flood risk map of the bay, provided by the United State's Federal Emergency Management Agency (FEMA), you'll find that more than 50% of the bay's edge is at flood risk (see fig. 1.10).

Most of the risk is created by human intervention, by removing a fast area of marshlands, the Bay has a reduced capacity of handling the king tides. Combine this with current sea level rising, due to climate change and you'll find that the San Francisco is facing a serious threat in the years to come.

Within the flood risk area's, four locations were interesting for this thesis. On all four sites, you'll find a high amount of social-economic vulnerable residents. Ultimately I passed on Alviso, Oakland and East-Palo Alto and chose to continue with just San Rafael.

In the end, Alviso was too isolated, it was more a ghost town, where people just continued to live, then a location where people were forced to live. East-Palo Alto was the exact opposite, right next to the heart of Silicon Valley, there is a enormous economic pressure on the area. However, there is barely any water around, yes the area is in a flood risk zone, but only because of the low levies. There was barely any water quality to work with. In the end, Oakland and San Rafael are quite similar, with the only major difference being the water body the area is connected to. Oakland is directly connected to the open water of the San Francisco Bay through different harbors. The area purely suffers from rising king tides, where San Rafael has multiple sources of flooding, which seemed a more interesting challenge.

And so my primary study into the San Francisco Bay area brought me to the San Pablo Bay, the north side of the metropolis. The municipality of San Rafael, in Marin County.

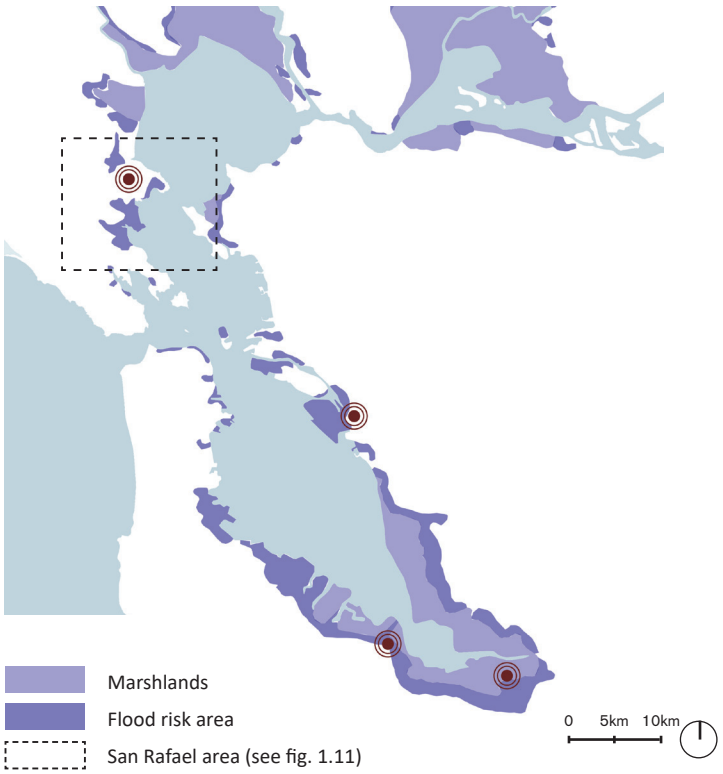

Figure 1.10 - San Francisco Bay, Flood risk area's

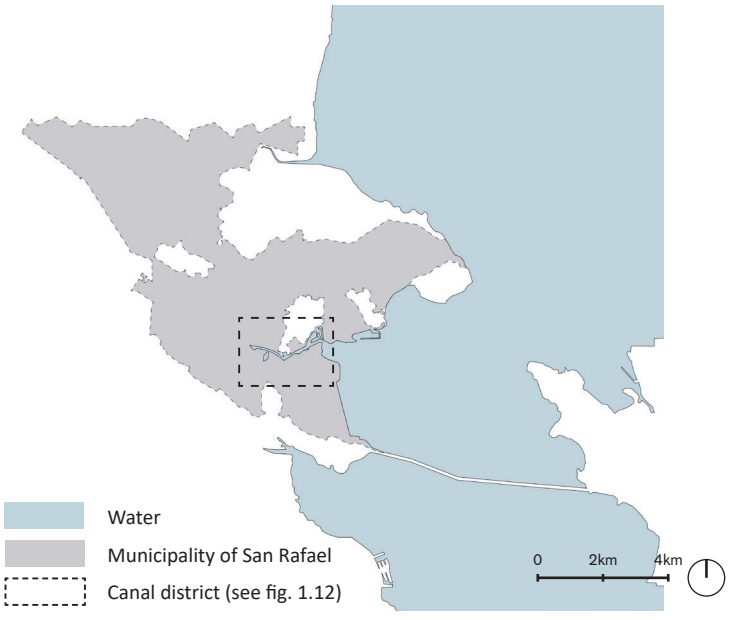

Figure 1.11 - The municipality of San Rafael

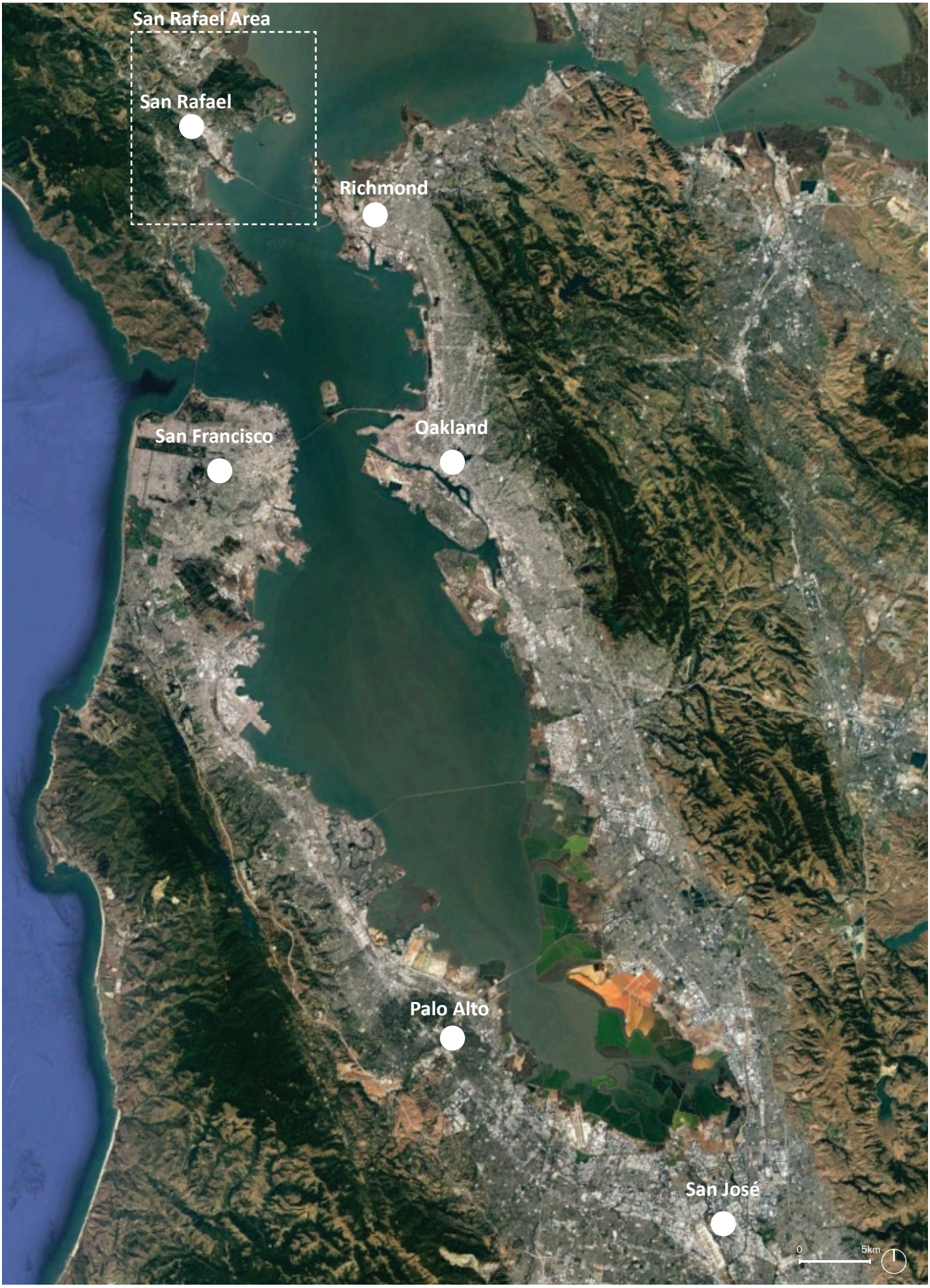

Figure 1.12 - San Francisco Bay Area

Figure 1.13 - The San Rafael Area

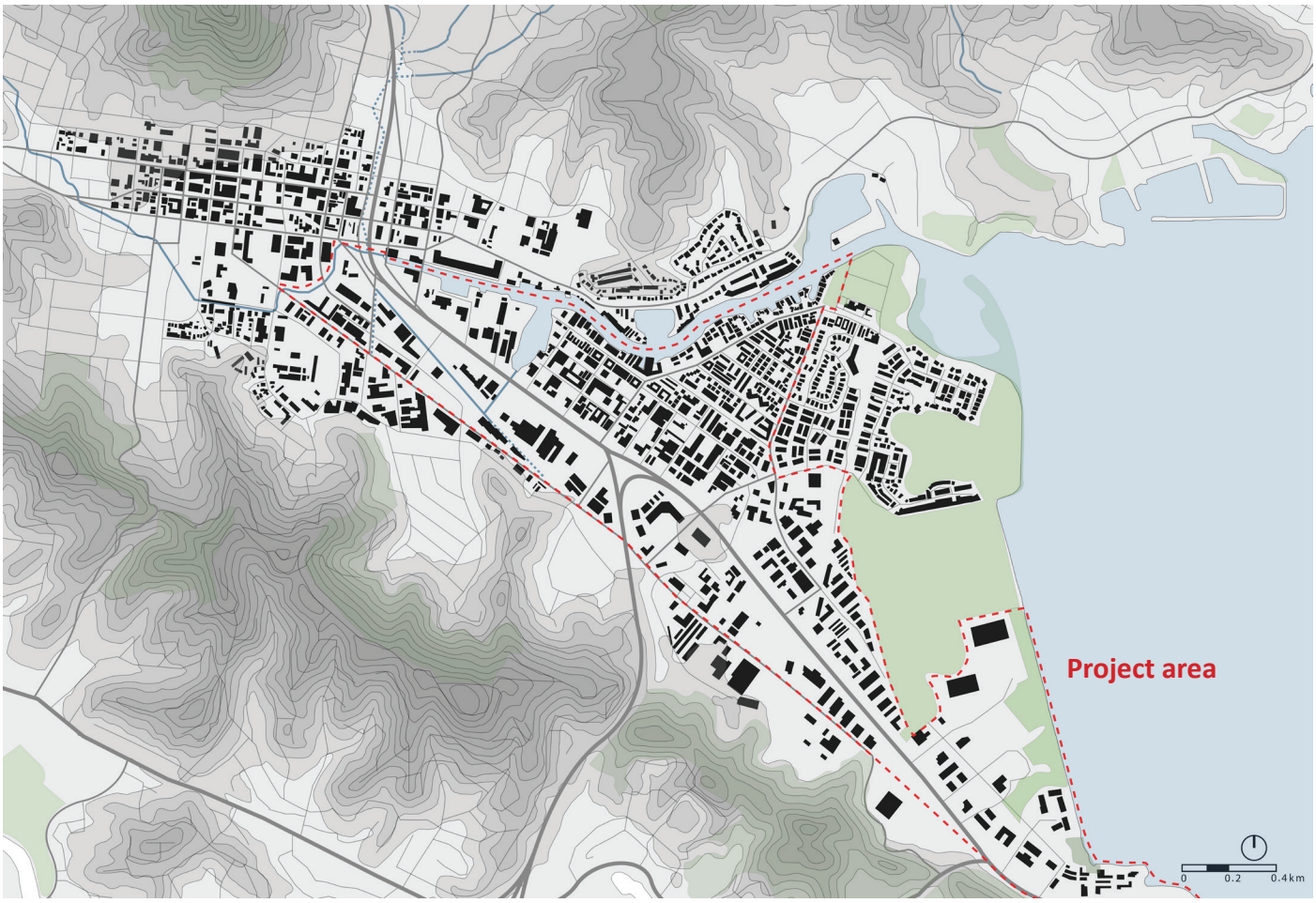

Figure 1.14 - South San Rafael

The municipal area of San Rafael is quite extensive, but a fast area of the surface is nature or low densely populated ground. The majority of the San Rafael Inhabitants live in the south side of the city, where the city was originally founded.

If you look at the boundaries of the municipality, you'll find numerous holes and interruptions. This is quite common in the United States. Some of these area's are nature, preserved by the county or the state, and therefore withdrawn from the municipality. But there are also 'special districts', in these area's the rules set by the municipality don't count. They do abide the rules of the county, state, national and federal government. Another common reduction of the municipal area, which also applies for San Rafael, is ground owned or reserved by the military. In this specific case the area is used as an harbor for drudging ships, controlled by the army corps of engineers.

In the heart of South - San Rafael, you find a canal, this was the original waterway, connecting the bay with the first settlement. The canal was formed to strengthen the San Rafael Creek, that arrives from the west of the city center.

Alongside the Canal, you find an area filled with industry, harbor activity and very low-income houses. In this area, you find the most densely populated neighborhood in San Rafael, possibly even in the whole San Francisco Bay. With almost 8000 people living in just 32.5 ha., the neighborhood has a density that belongs in cities like Shanghai.

Besides this small triangle, the canal district doesn't have much to offer, run down and abandoned industrial buildings and a lot of automobile industry. The Canal district feels like a neighborhood stuck in time, not able to grow with the rapidly expensing silicon valley, just south of the bay.

Figure 1.15 - The San Rafael canal district

1.4 Project position

The theme of the research problem finds itself on the edge between social-economic development and water management. There is a lot of acknowledgment for the threat of flood to lower social-economically developed area's, but no clear solutions. In this project, an attempt is made to bridge this problem by using tools and references from strategic planning aspects and from water management interventions in delta areas.

The field of Urbanism is not a clearly defined field, Urbanist find themselves surrounded by other specialists and usually work together with other disciplines in the field of Urbanism. Where all these fields of different disciplines overlap with or within Urbanism is hard to tell, but some do overlap with each other, and some rarely don't. Figure 1.16 is an attempt to simplify the field of Urbanism for this project.

The three main disciplines within the field of Urbanism for this project, are planning and strategy, social-economic development and water management. There are familiar examples for planning and strategy to overlap with social economic developments, and there are familiar examples of using planning and strategies with water management goals in Urbanism. Social-economic development and water management do not clearly overlap. Even though there is a lot of acknowledgment of problems when it comes water management threatening social-economic development. The UN habitat report of 2008 predicts an alarming increase to flood risks problems in third world countries. Flood problems that will hurt the least resilient residents of the population.

In this project, an attempt is made to address this problem by using the field of planning and strategy as a bridge between social economic development and water management. As a starting point tools and references are used from both fields.

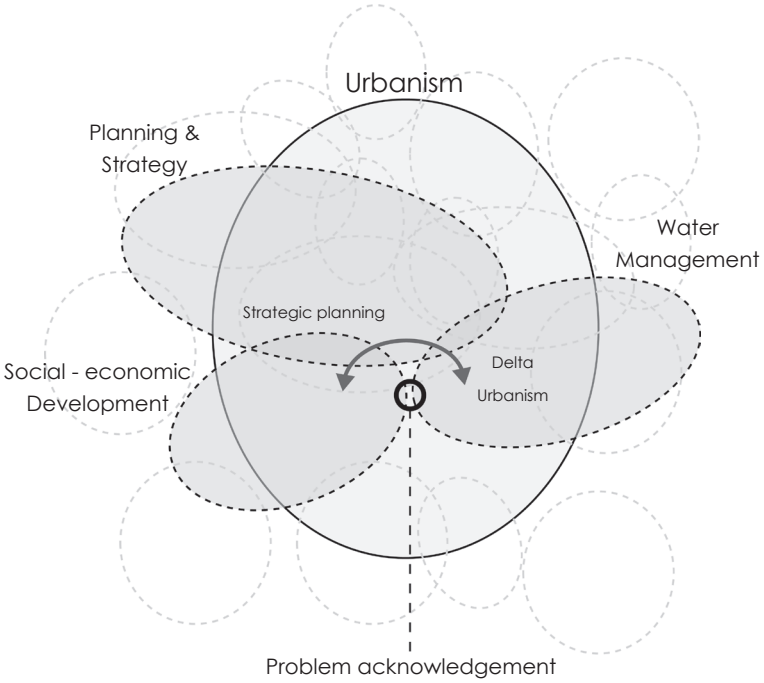

Figure 1.16 - Project position in the field of urbanism

The four-track approach by Louis Albrecht (see fig. 1.17) is a strategic approach that allows for different levels of governance and actors to work together through time and scale. The different tracks represent the different actors. The first track is the highest form of governance that works towards a long time vision, while in the fourth track the local actors are invited to participate in the realization of different projects. With the small strategic project on the lowest scale, you allow the local actors to benefit first before an area starts blossoming on a larger scale. Eventually, a similar effect to gentrification will be created within the neighborhood, but by allowing local actors to grow first, you give them the ability to grow and benefit from spatial improvement.

Participation of the local actors is needed to form them to improve their social mobility. A recent Dutch study of

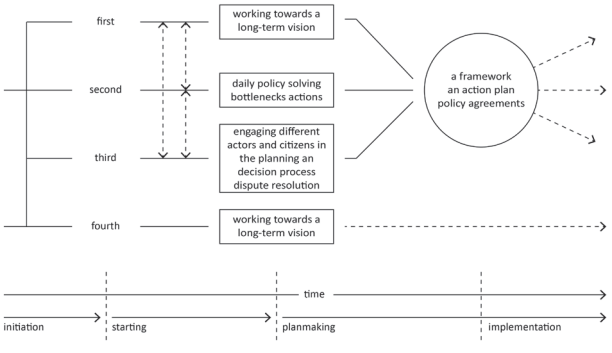

Figure 1.17 - The four track approach

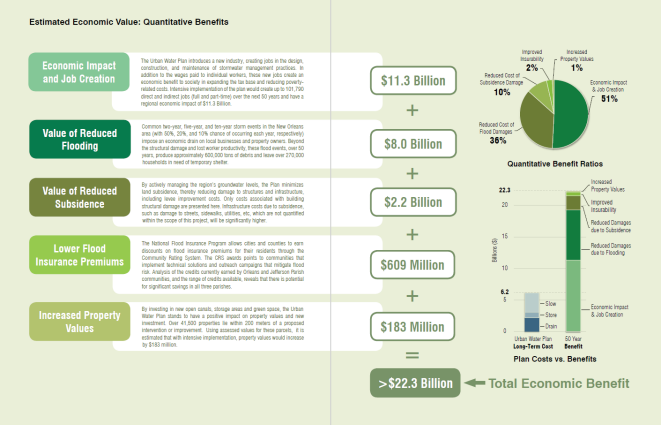

Figure 1.18 - Economic benefit for New Orleans

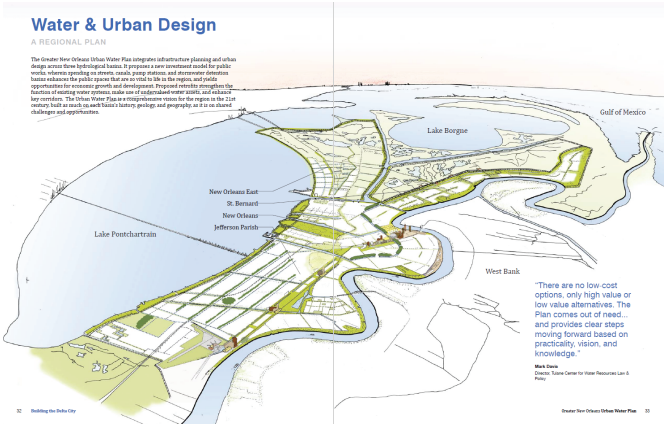

Figure 1.19 - The urban design for New Orleans

Figure 1.20 - Demonstration project East basin, New Orleans

the neighborhood Hoogvliet in Rotterdam South (Kleinhans et al. 2014), concluded that changing the physical quality of a neighborhood has barely any effect to the quality of life for its residents. The study, 15 years after construction, called the transformation a physical success, resulting in more spatial quality. But without additional jobs in the area or social stimulation, the position of the low-income households did not change at all. The resident would have been better off by investing all the funds in education and job creation. Social improvement does not happen from physical change alone.

One of the main reference project used for this graduation project is the New Orleans Greater Water Plan. This project was initiated after the disastrous destructing left by the Hurricane Katrina in 2005. The greater water plan exist out of different parts, there is analyses of the weaknesses of the New Orleans water system, a part of the implementation and a greater urban design split into multiple demonstration projects.

In the analysis of the existing water system, a lot of problems came to see the light of day, problems that were familiar by different parties, but without anyone having the final responsibility, all these problems together resulted in most of the destruction. The first recommendation of the greater water plan is to adopt a watershed system, like we have in the Netherlands, with a watershed authority that has all the information, and works as a guiding governance body to secure the watershed in the future.

Fixing the water problems to the water system would require a large investment (estimated $6.2 billion). A part of the implementation of the project calculated the benefits over 50 years (see fig. 1.18). The economic impact on the local scale would far outweigh the costs of the plan. Other benefits would be the prevention of future flooding and the reduction of insurance premiums. This is a great tool to open the eyes of investors for future opportunities.

The Urban design of New Orleans (see fig 1.19) is essential a network of different water management implementations that work together as one system. The system is similar to the Dutch polder system where the smaller systems lead to bigger systems, working as one. There is a lot of buffer room for extra water, these double as green networks for improving the vegetation in the area.

The urban design is a framework for additional projects that can happen within. In the greater water plan, 7 demonstration projects (see fig. 1.20) are included to show how the neighborhoods can be restructured using the framework as a larger tool.

Another important factor, highlighted in the greater water plan, is the gathering of funding. In the United States, projects like these are not just funded by government authorities. Big developers are interested in investing, but for social and ecological improvement, additional funding is gathered by lobbying. So implementing these factors in the design is also a tool to receive funding for the project.

After another hurricane, Sandy, the Resilience by Design competition was launched for New York. This competition split the city into smaller projects with different characteristics. One of the projects is the Living with the Bay project by The Interboro Team (see fig. 1.21). This location has some similarities with the San Rafael canal district, with including a marshland buffer. The guiding principles for the project do not start in the area itself. They highlight the problems upstream as a part of their design intervention. They include a warning for different levels of governance, smaller municipalities and special districts, that have to work together in order to achieve a solution for the plan area.

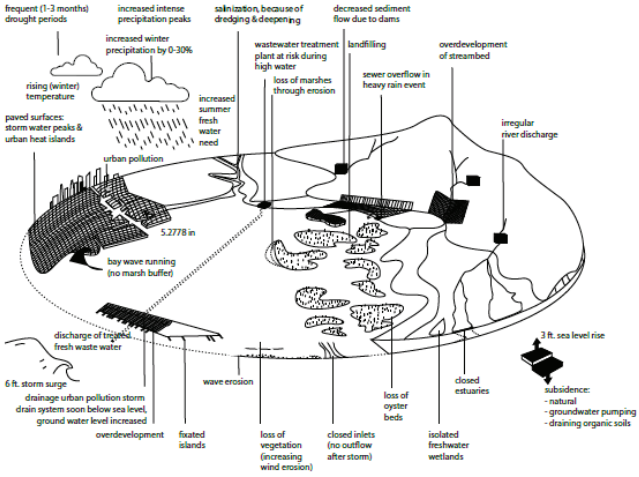

Figure 1.21 - Guiding principles 'Living with the bay'

Another waterfront that has been successfully transformed over the last decades is Hafencity in Hamburg (see fig. 1.22). Old docks and industries are transformed into a mixed residential neighborhood. The goal of the project is to create an active district with a 24-hour activity. It is high-density residential area combined with offices and public functions. By putting the public functions, like a university on the waterfront, a continuous use of the waterfront is insured. Combined with public open space, the waterfront has become quite successful. Additionally, the edge of the waterfront is designed in a way that it allows for the water to rise, and even overflow, this strengthens the connection between the water and the district.

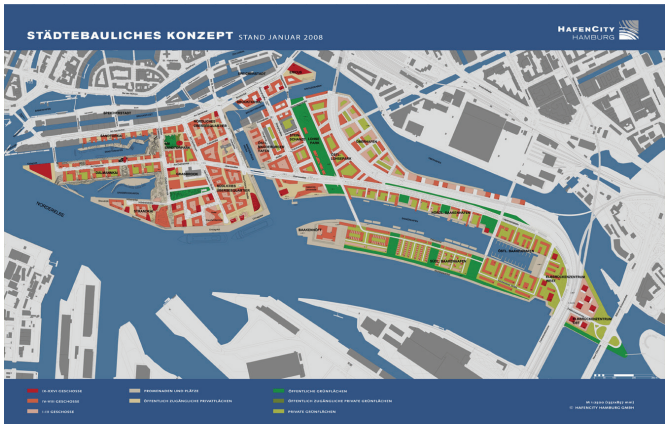

Figure 1.22 - Masterplan Hafencity Hamburg

The Dynamic Adaptive Policy Pathway Approach (see fig. 1.23) is purely a water management tool. It is designed to control and maintain large bodies of water. However, in its essence, it is a way to deal with the unpredictable future. It is based on tipping points when a certain level is reached, the policy has to change and a switch will be made to a next level. It is also possible to make this change before this tipping points, to prepare in advance.

These changes in policies require actions, and these actions could be combined with spatial interventions. Which means that this dynamic approach could be combined with spatial adaptation over time.

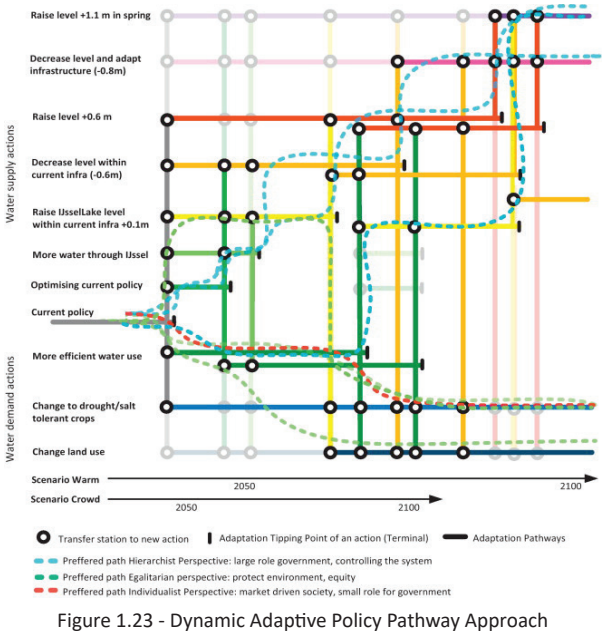

Figure 1.23 - Dynamic Adaptive Policy Pathway Approach

1.5 Problem definition

San Rafael can be considered as a miniature of the San Francisco Bay Area, all the problems you find in the bay, you find in San Rafael as well. Its position is like most cities, between the hills and the bay, born on dry land around the river banks. Just like the rest of the bay the city grew, at a slower pace than the south bay but with the same result. Now the cities barely have any room to expand while the problems of the densification start to emerge. The open bay, connected to the sea is a constant flood risk waiting to happen, but that might not even be the biggest threat. And those most vulnerable, have first row seats.

When looking at the general statistics for San Rafael, the city seems quite healthy. A population of 58.588, with a median age of 42. An average household income of $75,668, far above the median numbers of California ($62.000) and the United States as a whole ($54.000). As a whole, the city of San Rafael seems to be doing fine, but just like many locations around the bay, there is a big gap between the classes.

In the bay area, you find the rich, living in the villa's outside of the major cities or apartments in the city centers. People with incomes far above the national median, with houses worth over one million and a lot of security when it comes health, education or jobs. At the same time, you find the poor, not too far away, just on the outskirts of the cities, living in small apartments with multiple people. It is quite common to live in a house with eight people from different families. These people do not have any security when it comes to health, education or jobs. Most of them work just to pay the rent.

Because of this big gap between rich and poor, the pressure on the lower classes keeps increasing. Housing and rental prices continue to go up, food and clothing are becoming more expensive. For a lot of people, it's almost impossible to keep living where they are, but they simply have nowhere to go. Another problem is the big number of illegal immigrants living in the bay area, most of them are living with relatives or are sub-renting, because of this, the actual problem might even be bigger then it already is, more people might be living at risk.

They are living at risk because they are forced to live in flood risk areas. The houses constructed there are the most affordable because they are at risk. They can not pay the rent anywhere else, even if newly constructed social housing would be offered, it would likely cost more then what they are paying now. And because these people have nothing and are living in these area's at risk, they have the most to lose. They don't have the ability to recover, they are not resilient on their own. If a flood event would happen, the only solution that they have is to move out

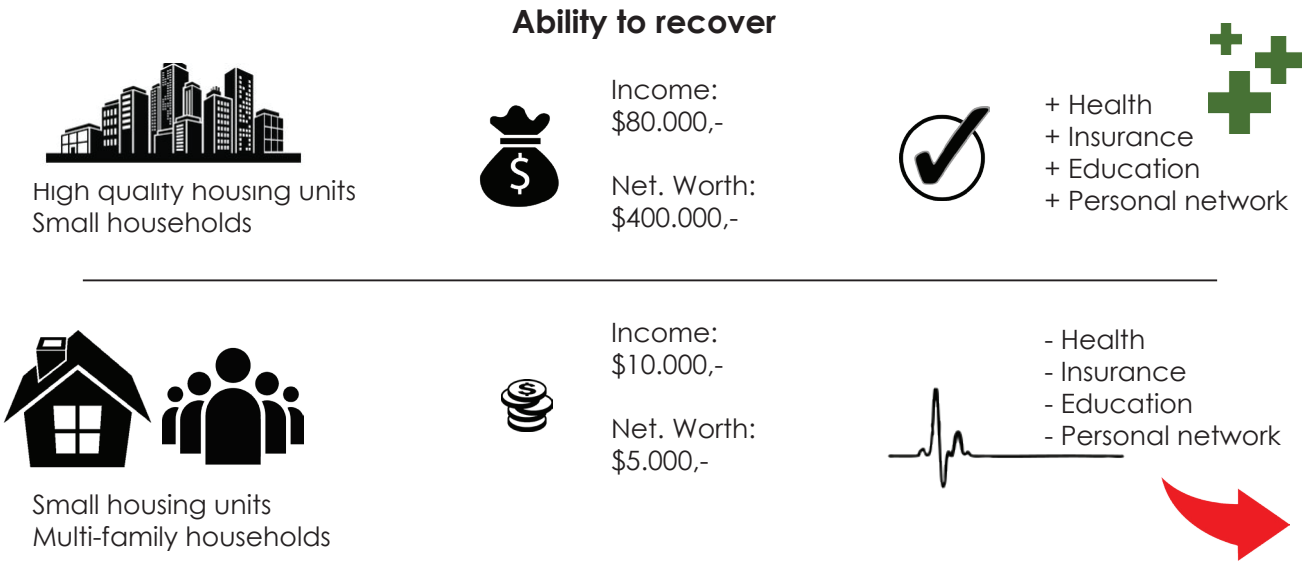

Figure 1.24 - Resilience, the ability to recover

We have been given five years to save the world. No, this thesis is not about the question how to save the world. In fact, it might not even be about how to save the San Rafael canal district, it is somewhere in between. It is using the city of San Rafael to find an answer to a global growing problem, the growing unhealthy relationship, between flood risk and social-economic discrepancies.

The relation between social vulnerability and flood risk area's is a worldwide problem. Most people see this as a problem that is limited to developing countries, but as this project highlights, it is also happening in our western cities. By finding a solution to the problem of San Rafael, I'm trying to create both awareness and a solution to this problem. Hopefully, this will lead to an approach that can be used in areas with similar situations.

Main research question

Can a spatial strategy, created out of the urgency of flood prevention, contribute to social economic improvement?

The main research question is attempted to be answered through the guidance of smaller sub-questions. These questions can be split into analyzing questions, used to guide the research during the graduation project, and design questions used to guide the design strategy.

The analytical sub-questions are:

What is the nature of the water management problem of San Rafael?

This question is answered through analyzing the origin of flood events and the development of the build-up area through time. By combining these factors it is made clear which factors are responsible for the flood threat and on what scale the interventions need to be made.

What is the economic impact of water (protection) in the United States?

Because of the low social-economic situation in the flood risk area's, there is a lack of incentive to do something about these areas. In order to understand if it is possible to change this kind of area's, it is important to find out what economic risk and benefits there can be found in water.

The design strategy is a reaction to the problems found in the analytical sub-questions. To shape the design strategy, design questions were formed to give a more intervention orientated input.

These design questions are:

Which water management options have proven to be a positive influence, in areas with social-economic discrepancies?

There have been made multiple attempts to change existing urbanized areas in flood risks areas. Some of these were areas with social-economic discrepancies. By looking into the design plans and strategy of these projects, positive interventions could be found as a base for the strategy

Which stakeholders could play a role in the (re) design process, what is their role now and what could it be in future developments?

Stakeholders in the United States play a different role then they do in the Netherlands. The responsibilities are completely different, they work on different scales and are executed by different government bodies. A large part of this question is to better understand the American system of governance.

Through different methods design input for the design interventions were gathered. These different design interventions formed the cornerstones or 'pillars' of the design. In order to reach the goal set in the problem statement, changes in mobility, land-use and social-economic stimulation have to be achieved.

The research question is attempted to be answered through an example of a design and/or strategy intervention. This design has been shaped through the input of three 'pillars' (see fig. 1.25) that are deemed necessary to guide the design outcome. These pillars are mobility, land use and social-economic stimulations. These are the factors that are deemed necessary to change, in order to reach the goals set in the problem statement.

The input for the design interventions of these pillars is the combination of research and analysis. The outcome of this research are the guiding rules for the design interventions. Different methods have been used during this thesis graduation to achieve these goals.

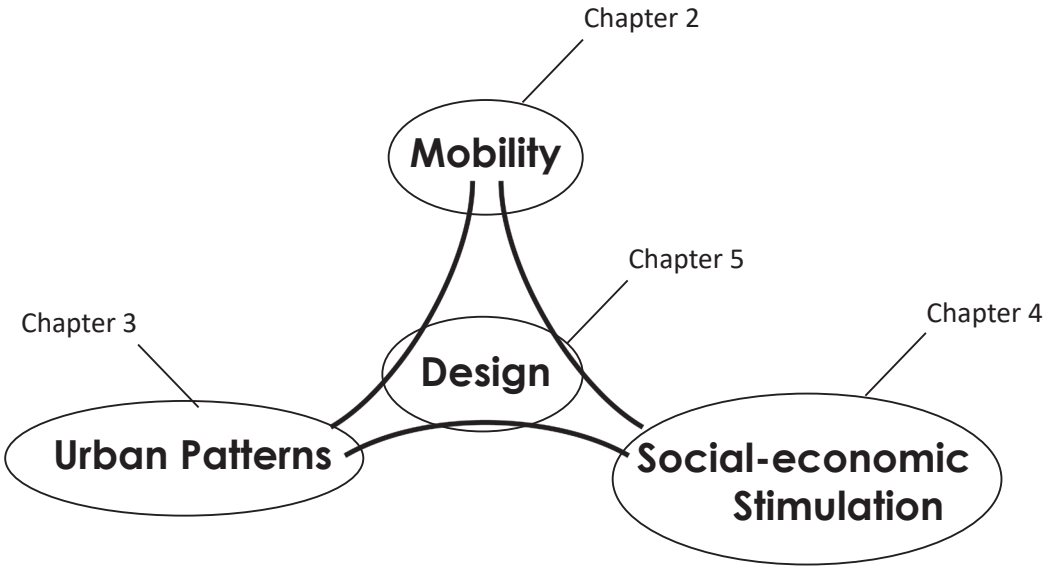

Figure 1.25 - Three pillars of the design strategy

Design to answer the research question

Can a spatial strategy, created out of the urgency of flood prevention,
contribute to social-economic improvement?

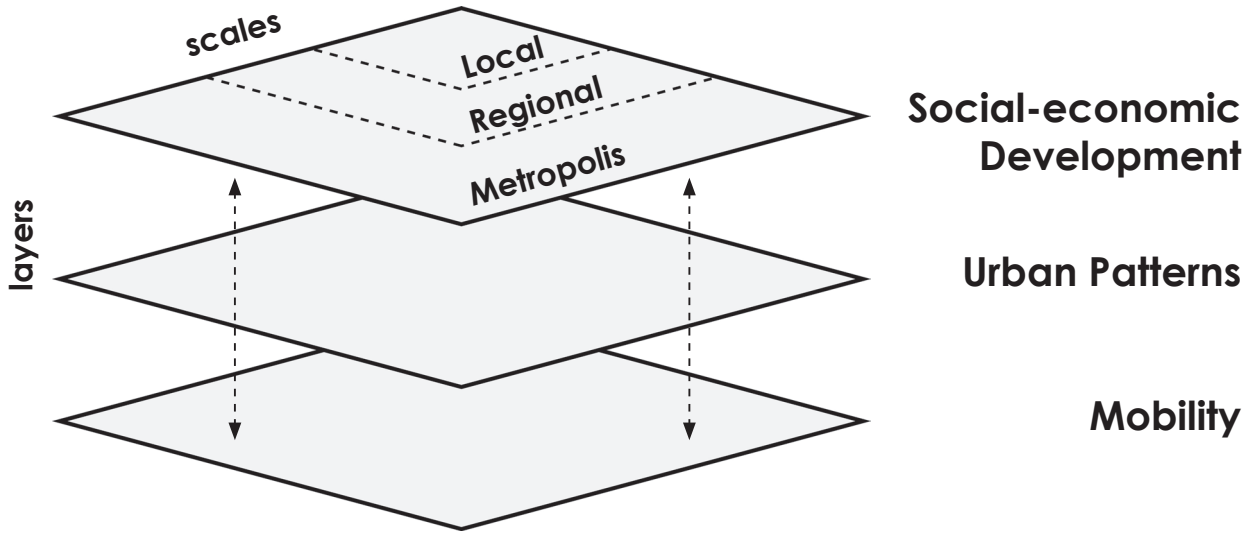

Figure 1.26 - Three layers of the design strategy

Essentially the main method used for the analysis and design strategy is a layer approach with three layers. These layers are Mobility, Urban Patterns and Social-economic Development. These were the three layers that were needed to analyze the problem and are also the layers in which change is needed to successfully adapt the canal district.

In the new world, mobility has been the driving factor for development. Connections stimulated developments and the lack of connection stalled it. By analyzing this layer the main problems with the connections to the canal district in relation to urban patterns and social-economic development are found and suggestions for change in this layer are made.

The changes in Urban Patterns over the last 50 years have created the main problems that are being faced today. This is not only an analysis of nature, but also of the ground, and the structures of the city. To understand the problem of the water the urban patterns are analyzed and suggested changes are made.

Working with three layers was inspired by the 3x3x3 approach executed in the Delta interventions studio. The main change between that analysis and the method used in this project is the social development layer. Conventionally this layers is seen more as building development, with the social-economic problems that San Rafael is facing, it is more important to focus on who is living in the neighborhood and what kind of homes it provides, rather than what kind of buildings are built.

The layers are analyses and solutions are suggested for all the different layers, but they keep interacting. The interventions all work together as an integrated design.

The layers will work on different scales, but they connected from local to the metropolis. However, not all the layers will be approached on these different scales.

1.6 Thesis structure

The chapters and subchapters are structures in the same fashion throughout the report. Every subchapter starts with a small abstract of the material discussed. After the final subchapter, a small conclusion of the whole chapter is provided on the final page. This subchapter provides an overview of the information discussed in all the chapters.

The three pillars and layers of the design strategy are split into three different chapters. Each of these chapters begins with an analysis of the problems relating to the topic of the chapters. Each pillar chapter ends with a sub-chapter called 'Interventions' in this chapter, the conclusions of the analysis are transformed into suggestions for interventions. After the pillar chapters, the chapter 'Integration' will combine all the different suggested interventions and combine them together in a strategy.

Some of the research methods used in this report covered multiple pillars because they showed a really clear connection between the different aspects of the area. The 3x3x3 analysis (see appendix) is an example of this. However, most of the research was done to find the information on one of the pillars. An overview of which methods were used to find the answers in the corresponding chapters.

2.1 Historic Development

In this chapter, the mobility of the San Francisco Bay and San Rafael is analyzed. A large portion of this analysis started by tracing maps. All available historic maps were put over each other to see changes in development over the early stages of the San Francisco Bay. The aim was to understand the driving forces of growth in the bay area.

The tracing was also used as a starting point for a 3x3x3 analysis, or the triple three layer approach. In this analysis, three different systems through three different scales are analyzed in three different time periods. The systems that were analyzed are infrastructure and mobility, nature and urban development. By looking at these systems in different scales, bay area (metropolis), county (regional) and city (local), relationships between the different scales are highlighted, to understand how these are influencing one another.

By putting the third time period in the future, 3x3x3 analysis can also be used as a forecasting tool. The relationship between the past development and now is made clear. What should change in the system to achieve the desired future scenario. That is why this approach is the most essential for the mobility chapter, a lot of the current undesired situation seems to be a tied to mobility.

Other data for the mobility pillar was found through data gathering. Especially trends and current developments in (public) mobility could result in a substantial change in mobility for the area.

2.2 Interventions

In the interventions chapter of the mobility pillar, suggestions are made to improve the mobility situation for the Canal district. Design scenarios are pitched for a connection to the greater public transport network. Together with the current developments and trends in private mobility, these changes are used to spatially change the infrastructure around the canal district, to make room for land use changes.

3.1 Historic development

The land-use pillars start with a historic development subchapter as well. Just like for the mobility pillar, the 3x3x3 approach was used alongside tracing. Unlike the south of the San Francisco Bay, the North Bay has a far stronger connection between development and nature, due to the hilly terrain. Additional tracing and mapping were done using flood maps and terrain to understand the local flood problem of San Rafael.

3.2 The Flood problem

The research question, what the nature of the water management problem of San Rafael is, led to an investigation of the local weather climate. More than 50 years of local climate data were collected and transformed into easy to understand tables and graphs. The full analysis can be found in the appendix, the conclusions are used in the chapter.

Another huge influence on flood risk is soil typology and permeability. The last one was analyzed and appeared to have a very clear relation with the built-up area.

3.3 Spatial Quality Aspects

The relationship between permeability and build up area demanded a closer look. There appeared to be a relation between typology of the public space and permeability. These were visible between the different part of the district on the permeability maps.

This leads to a street view analysis. With the location far away and no means to visit, analysis of the public space was done through street view. Quite similar to the layered approach of the 3x3x3, the street view sections were picked apart into similar layers, mobility, nature, constructions and furniture. The full analysis can be found in the appendix, some examples and conclusions are used in this chapter.

3.4 Interventions

In this chapter, the conclusions of the analytical chapters in the land-use pillar are countered by interventions that could prevent the main problem to the flood risk. These interventions have different scales but together work as a whole in the larger strategy for water safety.

4.1 Housing development

The pillar chapter Social economical development required, logically, more insight into the social and economic situation of the resident. The majority of this analysis was done through gathering and understanding demographic data. This data is easily made available, however, most data is summarized on the larger scale (mostly the whole city). To understand the severity of the local scale, data of smaller districts were collected through raw data files and GIS. The most important demographic.

For the subchapter housing development both demographic data was used, and local real estate websites.

4.2 Social threats

This chapter is a summary of the most shocking demographic variations and a tie into the housing development. The housing situation of the San Rafael canal district needed further insight into the problem of social housing. Alongside the collected demographic data, information about social housing initiatives in San Rafael and Marin County were used.

4.3 Interventions

The majority of the interventions for the social-economic development, or stimulation, evolve around guiding rules for future development in the area. These guiding rules are set for block typologies and put in the larger system.

These guiding rules are used in some examples for the redevelopment of certain locations along the canal. These are tied to some reference projects that have proven to have a positive effect on waterfront redevelopment in more urbanized areas.

5.1 General scheme

In the first subchapter of the integration chapter, the general scheme is revealed. Starting with a vision for the whole of the canal district, a new main structure of blocks and public spaces is visualized. In this scheme, all the interventions and conclusions set in the previous chapters are taken into account, together they should work as a whole.

5.2 The strategic plan

In this chapter, the elaboration of the strategy is highlighted. For the strategic approach, a spatial strategic strategy is used called the four-track approach. This strategic approach was one of the topics in my review paper (see appendix) and is attempted to be used in the spatial design strategy.

5.3 Water management policies

The American water management system is different then the Dutch, they have different levels of government that are overseeing different problems. However, they don't know a watershed authority like we do in the Netherlands. Because almost everything in the United States is privatized, a suggestion is done to create an alternative water management strategy, based on dynamic interventions.

The inspiration for this is the Dynamic Policy Pathway Approach, this was also a topic of my review paper (see appendix). Through using different investors for water management projects as the result of reaching a tipping point, the water management implementations could respond to the unpredictable needs of the future.

Conclusion

The conclusion of this report is the result of all the conclusions of the different analyses done in the pillar chapters. The spatial strategy that is created is part of the new design for the canal district. All the small interventions, as suggested in the interventions chapters, work together as a redesign of the urban system.

Appendix

In the appendix, some of the analysis done for the main chapter is explained an showed more extensive. All the information you find in here has been used to shape the discussion of the spatial strategy in this rapport.

All the sources for the images can be found in the appendix, these are organized by number. These provide both digital references as the information used to create the images.

Conclusion

Flood risk is a global growing problem, most of the flood risk area's are zones with a high amount of people in a low social-economic situation. This means that the most vulnerable people are living in the most dangerous areas. Resilience is the ability to recover from a certain event, vulnerable people have a low resilience on themselves and so the system as a whole is vulnerable.

True resilience for flood risk area's will require measurements to keep the most vulnerable people in. Therefore the focus of this thesis will be to protect the most vulnerable using water management interventions.

2. PILLAR: MOBILITY

2.1 Historic development

The development of the San Francisco Bay area happened in different stages, each resulting in different kinds of developments. Greater plans for the bay included a public transport system surrounding and connecting the whole bay. This system was never realized but could provide solutions to current problems, with the current public transport system falling short.

The development of the San Francisco Bay has changed between different time periods. The first settlement of San Francisco didn't actually take place in the bay, but a little north, on the coast of Marin County. The first maps of the bay area (around 1900), show the establish cities of San Francisco, Oakland and San José (see fig 2.1). To date still the three major cities. During that time, there was a clear infrastructure along both sides of the bay. During this period the main transport directions were from the south to the north, the supply lines to Oakland and San Francisco. Along these roads, small settlements were formed near fresh water sources, at the crossing with the creeks.

Between 1900 and the 1930's bridges were created between the sides of the bay east and west and San Francisco to Marin County. These bridges connected the settlements that were formed along the creeks (see fig. 2.2), these cities on both sides of these bridges were the cities that grew the most. Without these connections, these cities would not have had the development drive. Meanwhile, the bigger industries settled in Oakland, the land was flat and easy to build upon. San Franciso mainly grew as an urban city.

Between the 1940 and 1960, the car industry completely changed the urbanization around the bay. The dense city cores remained, but around them, new urban typologies were formed in the shape of American suburbs, through urban sprawl (see fig 2.3). In this same period, the connection between Marin County and Richmond was created, connecting Marin county to the south and the east now. This connection created new opportunities for the cities of Marin County, and after 1960 Marin county became really densified.

The demand for houses became so high that they chose the path of least resistance. Developments started to emerge in former marshlands, they were filled with sand. Building on this land was easy and cheap, and large sums of houses were created, making some of these former marshlands the most densified area's in the bay.

After the creation of the suburbs, the digital era began, and silicon valley was born. Between 1960 and today every available plot was filled and the demand for housing kept growing. Nature has been pushed back to a minimal and the bay area has become a mixture of concrete and asphalt.

Urbanization of the San Francisco bay

Figure 2.1 - San Francisco Bay 1900

Figure 2.2 - San Francisco Bay 1940

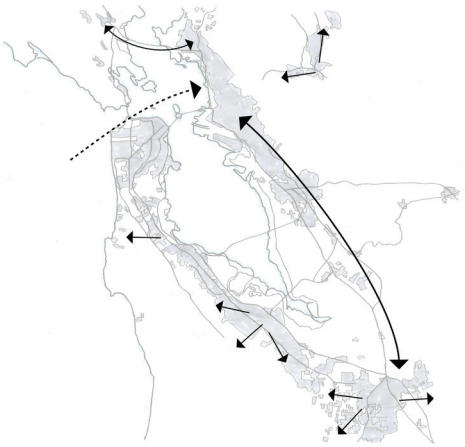

Figure 2.3 - San Francisco Bay 1960

The urbanization of the San Francisco bay grew parallel to the infrastructure. Roads were provided for mobility, and the roads because of the leading lines for building development. With the population of the bay rapidly growing, the infrastructure became inadequate. A plan was created to build a subway system around the whole bay (see fig 2.4), connecting all the major cities to one system. This was the birth of the BART subway system that is in place today.

The system was supposed to have multiple connections across the bay, accessing all the possible development sides around the bay. The development of the BART system created a subway system between San Francisco and Oakland (fig 2.7), and to date, it is the fastest way to travel between these two cities. But the system never continued to develop all around the bay. Instead, the highways were widened and additional highways were created.

The cities in the San Francisco Bay Area grew with this very car-oriented system, including San Rafael. Main roads that used to connect the cities (see fig 2.5) simply turned into the highways, even if they would run through the heart of the city, like in San Rafael (see fig 2.6).

New developments are no longer build in grid systems, suburban housing has become the norm for most housing developments, providing lots of space for cars, without public transport in mind.

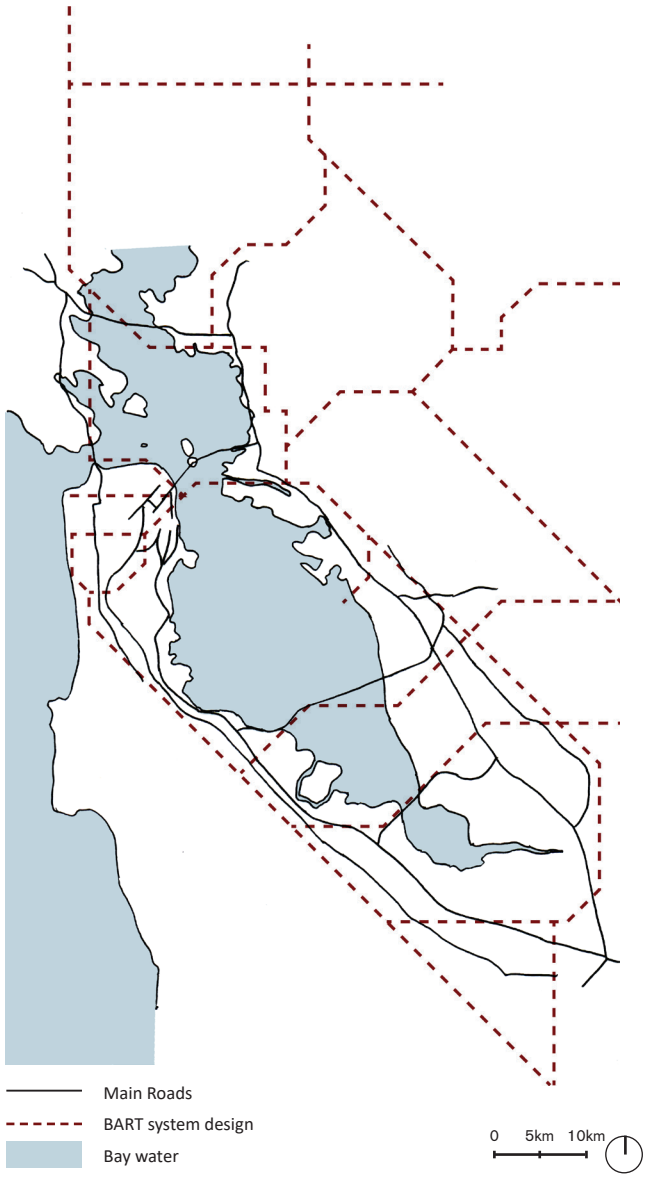

Figure 2.4 - San Francisco Bay main infrastructure 1965

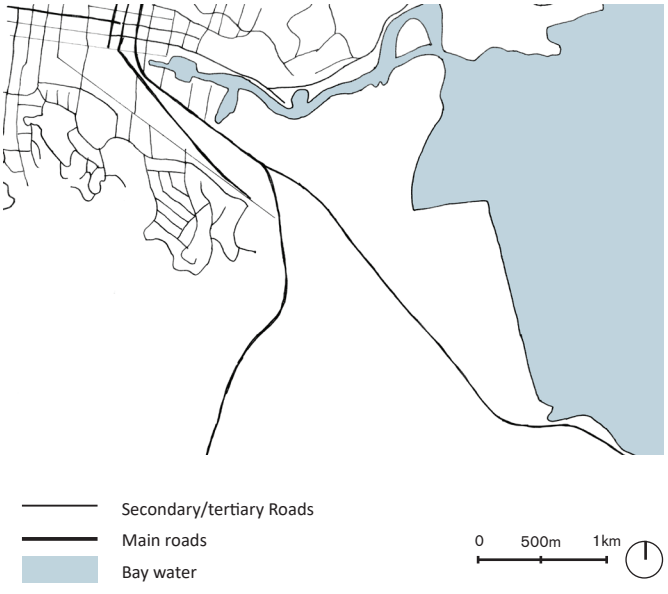

Figure 2.5 - San Rafael infrastructure 1965

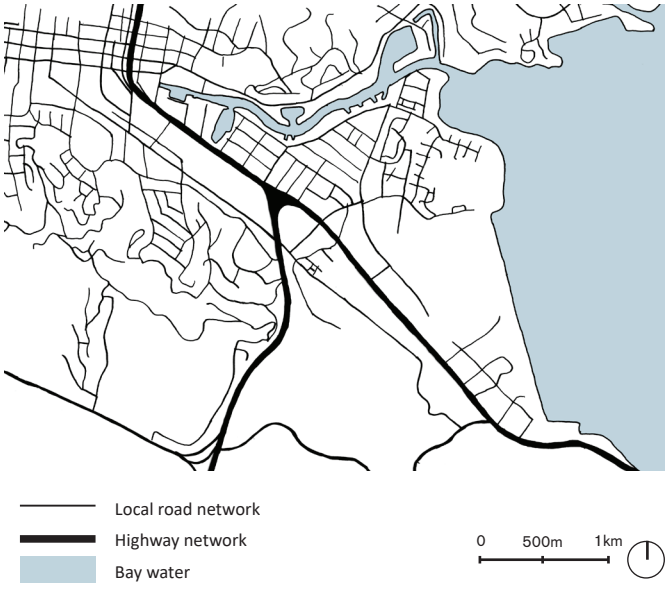

Figure 2.6 - San Rafael infrastructure today

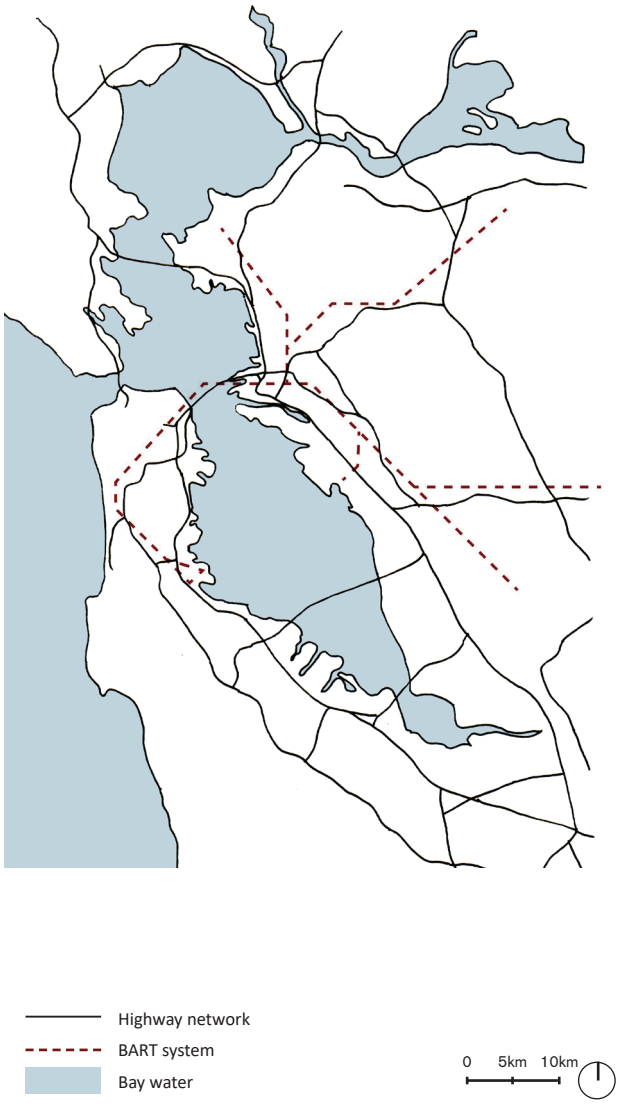

Figure 2.7 -San Francisco Bay main infrastructure today

There is public transport present the canal district, but it is lagging. Low-income households are usually quite dependent on public transport. As a governing entity, you can provide people with public transport discounts, you can't just give them a car. And jobs for lower income households are easier to find in larger cities than in a city as San Rafael.

If you look at the current mobility of the public transport system of the canal district (see fig 2.8), you can just leave San Rafael in one hour. From the downtown bus station, you get a bit further but it is no comparison to how far you would get by car. By car, you are able to reach all around the bay, even to silicon valley within the hour.

Because residents are able to get to their destinations much faster by car, the incentive to use the public transport system is very low. Currently, it will only be used by the people that really have no other option, a large proportion being the residents of the canal district. Another problem with the current system of mobility is the gasoline prices. With barely any taxes on gasoline, driving a car in America is really affordable, if you have one.

The low amount of people using and being reliant on the public transportation system, improving the system will be hard. Only when the system will change so drastically that it can compete with car mobility, investments could be worth it. These investments would be high, but could completely change the way how the city is used.

Around 1940 it was the connections across the bay that drove the developments of the cities. Revitalizing those connections could play a role in the redevelopment now.

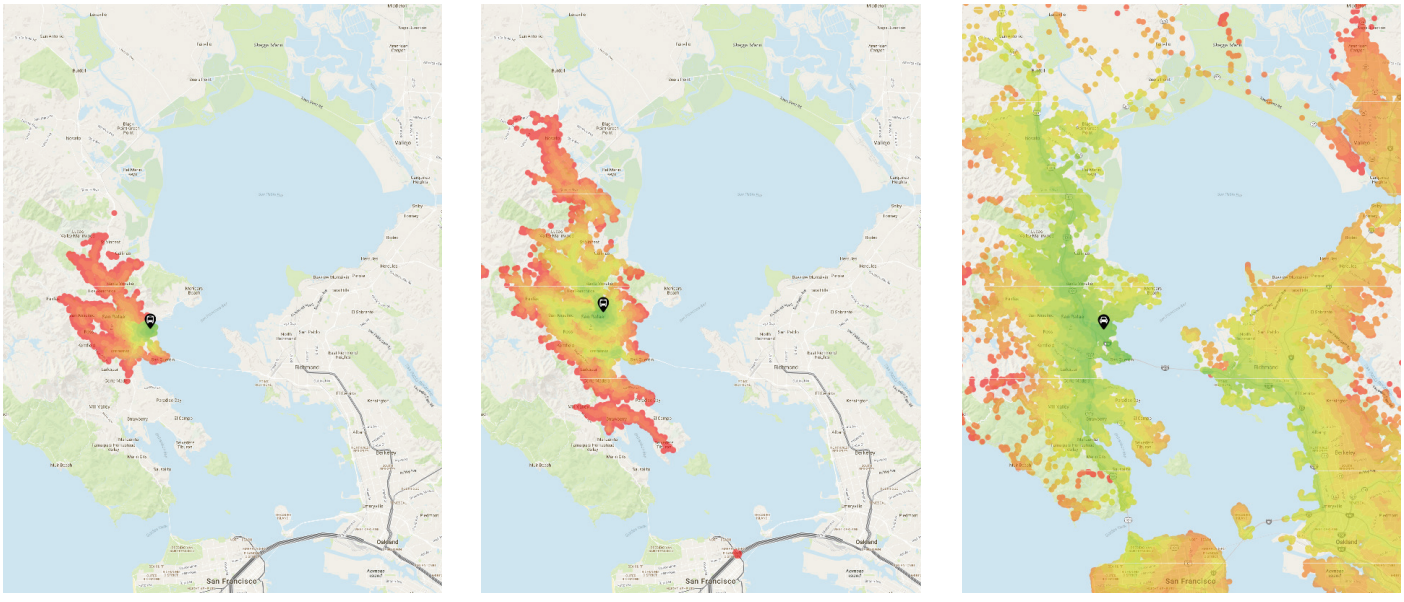

Figure 2.8 - Public and private mobility

2.2 Possible interventions

Based on the comparison between public and private mobility reach, the public transportation network of San Rafael is lacking connectivity. By strengthening the public transport system of San Rafael the city can become a hub in the larger network of the San Francisco Bay area. Combined with a shift in private mobility the accessibility of the canal district can be improved through spatial interventions that can reconnect the district to downtown San Rafael.

By improving the public transport connections of San Rafael, the city could become a hub in the bay area, connecting north and south, east and west. The SMART connection towards Petaluma is already scheduled to be implemented, by adding a BART connection between downtown San Rafael and Richmond, the connection would be complete (see fig!). This is not only in the benefit for the development of the canal district, it would put all the residents of San Rafael and other cities connected to the SMART rail on the public transport ring of the Bay, like the original plan from 1965.

Adding multiple stops along the Canal district would increase the potential of the district for a successful redesign, an easy to reach location, with a lot of development options.

With a development along the San Rafael canal, the city could reconnect downtown with the bay, regaining the identity of a harbor city. Making San Rafael, not just a hub, but also a destination. This connection along the canal would go through and alongside the canal district, providing the incentive for redevelopment.

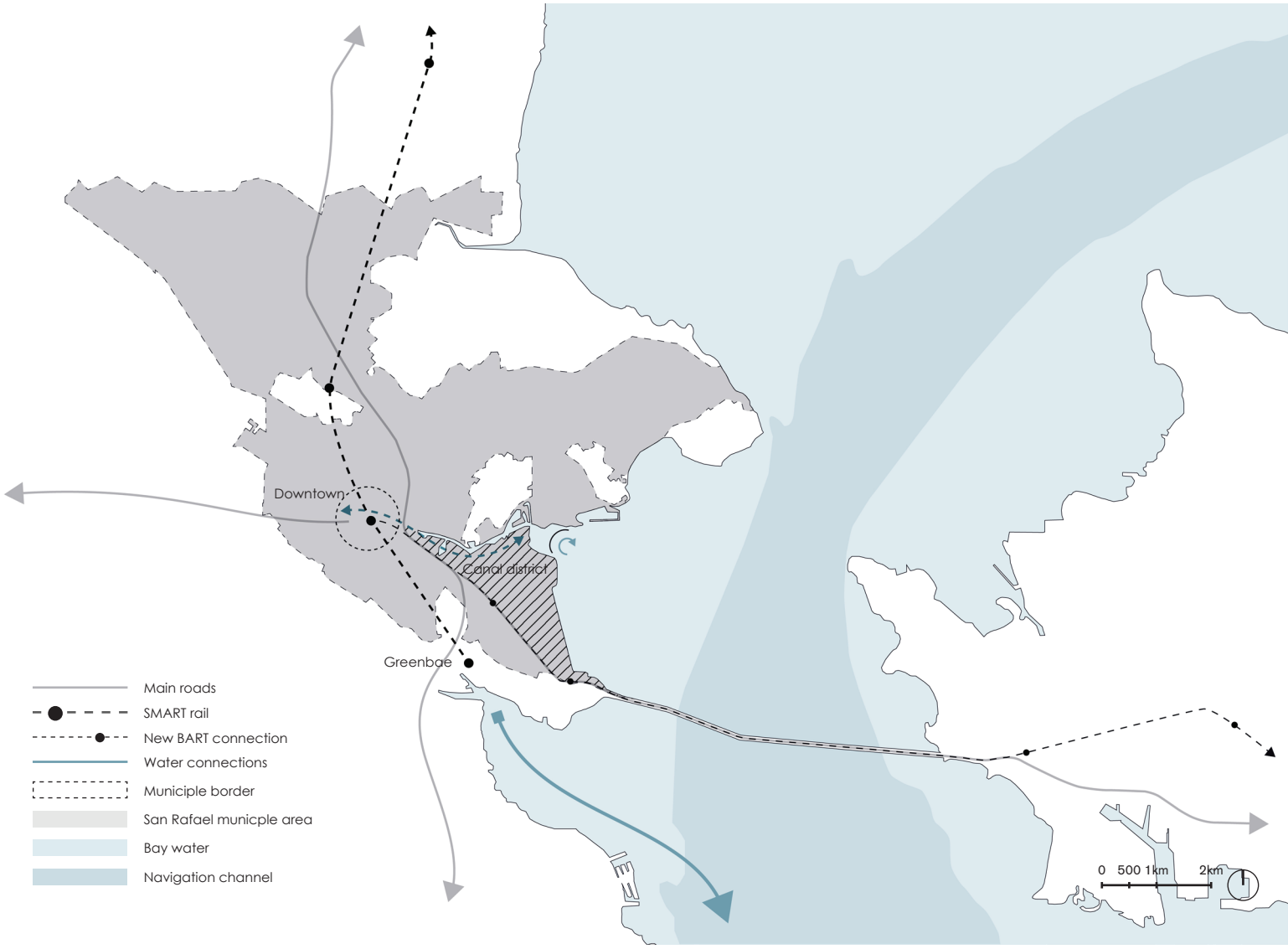

Figure 2.9 - Mobility vision

Figure 2.10 - Ferry alternative

Figure 2.11 - Water taxi alternative

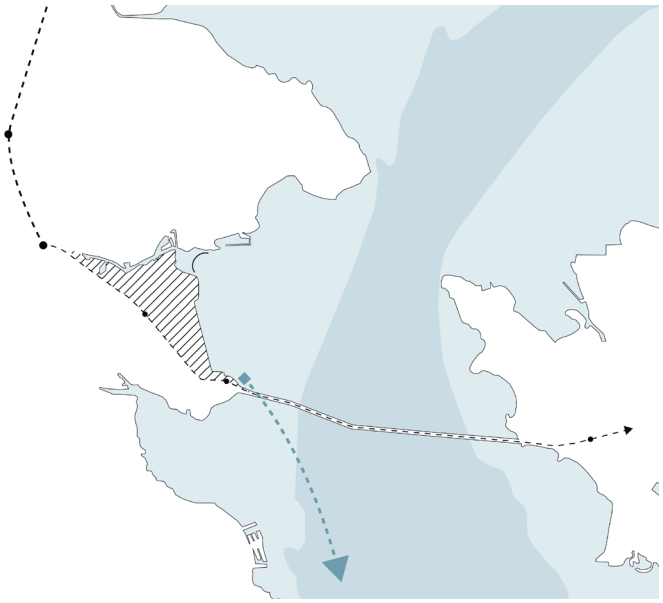

Figure 2.12 - New Ferry point

Expanding the BART system from Richmond to San Rafael would be quite an investment, especially crossing the water. The existing Richmond-San Rafael bridge could possibly be adapted to host a rail track, but this will also be quite an investment and undertaking. An alternative could be a ferry connection between San Rafael and Richmond (see fig 2.10). A fast reliable connection between downtown San Rafael and the bay, a ferry to cross the bay and an extended line of the BART system over land for direct connection.

With the aimed completion of the SMART rail to the Greenbrae ferry, Downtown San Rafael would become the cornerstone of the public transport ring San Rafael - Richmond - Oakland - San Francisco - San Rafael.

An alternative for a single ferry line would be a more dynamic form of water transport, like water taxi's (see fig 2.11). Ferry's are very reliable, but even over the short distance they usually go once every half hour or so. Ferry's need this time in between to reach a certain capacity without people having to wait in line. In order to compete with car usage, this waiting time for the ferry would be too much. Smaller units, like water taxies, could cross the bay with a smaller group, making it faster to travel. Additionally, they are more dynamic and could have multiple landing sides. They could even transport residents through the San Rafael canal.

The SMART rail to Greenbae is scheduled for the 'near future' but not yet in progress. The old rail line has completely disappeared and a lot of the ground around the line has been developed into other functions. Revitalizing this part of the SMART rail will need quite an investment as well. Alternatively, the SMART rail could stop at Downtown San Rafael. From here the BART line could take over and connect the two public transport systems. The connection that would be missing in this scenario is the connection between the SMART line and the Greenbrae ferry. This connection could be achieved by moving the ferry station from Greenbrae towards the canal district (see fig 2.12). Here the ferry line could be clustered with a BART station, establishing a fast connection to San Francisco. In this scenario, San Rafael is still the cornerstone of the public transport system, but on a different location. It does provide more incentive to establish a BART line between Richmond and San Rafael.

When looking into alternative ways to reach the same goal: a good public transport connection with the rest of the bay, the starting point should be to create a system that can compete with car usage. Easy to reach, fast connections will have a much higher success to create the needed demand for the investment.

Good investments in public transport could reduce the usage of cars in the San Francisco Bay area. However, it is not the only change we'll see when it comes to mobility. Currently, a major shift is already happening when it comes to people using transport. A lot of people don't even have to go to an office to do their jobs. More people in the city don't even own a car and completely rely on Uber drivers.

The number one reason Uber is investing millions in their company, without expected profits in the near future, is because they expect to bank big when self-driving cars are no longer a thing of the future (see fig 2.13). Currently, rules and safety seem to be the only reasons holding masses of self-driving cars of the road.

When that happens, we'll see a change in the usage of the street, self-driving cars are a lot smarter than the average human when it comes to driving. Especially when the car can communicate with each other. Simulations of completely automated systems show that there would be no traffic jams if we all had automated cars driving for us. So when the time is really there, we wouldn't need all those huge highways anymore.

But the question is, how many cars do we need at all. Cars on the road will never be able to match the speed of a subway, or even better, a hyperloop (see fig 2.15).

Chances are, we'll completely reinvent traveling in the next 50 years to come. Whether it is through the automated car or a new form of public transport. We should get rid of those concrete blocks ruining our urban fabric.

One of the reasons the canal district has become an isolated neighborhood in the city is the physical barriers created. The canal in the south, the bay in the east and the highway in the south. These barriers are currently impermeable and cut of the district from the rest of the city.

When it comes to mobility, the aim is to (re)connect the canal district to downtown San Rafael. Make the canal part of the city again (see fig 2.16). With the expected changes in mobility in the near future, our roads could be less dominant. Fewer cars will be using the main roads at any given moment, allowing for more open space around these roads.

The reduction of noise and exhaust gasses will allow for a more inviting atmosphere around the roads. Depending on the changes in mobility more space will be available to use around these structures (see fig 2.17). By raising these impermeable barriers, the isolation of the canal district can be broken and the district can be reconnected to the city. The space around the highways can change function and serve as a park providing storage and infiltration, together with a spatial quality.

Figure 2.13 - Uber's self driving cars


Figure 2.14 - The Mercedes concept

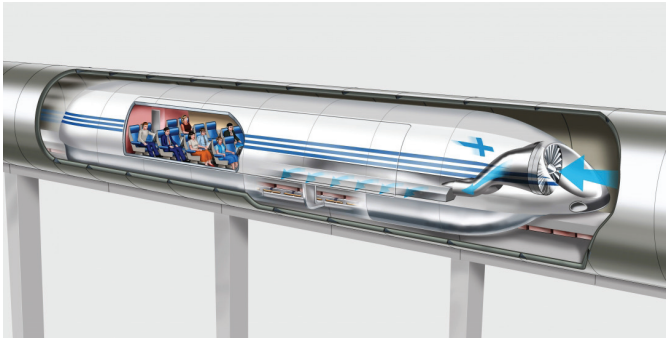
Figure 2.15 - Hyperloop

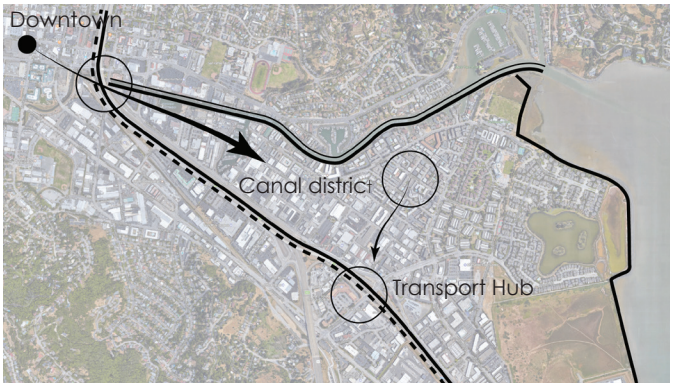

Figure 2.16 - Canal district isolation

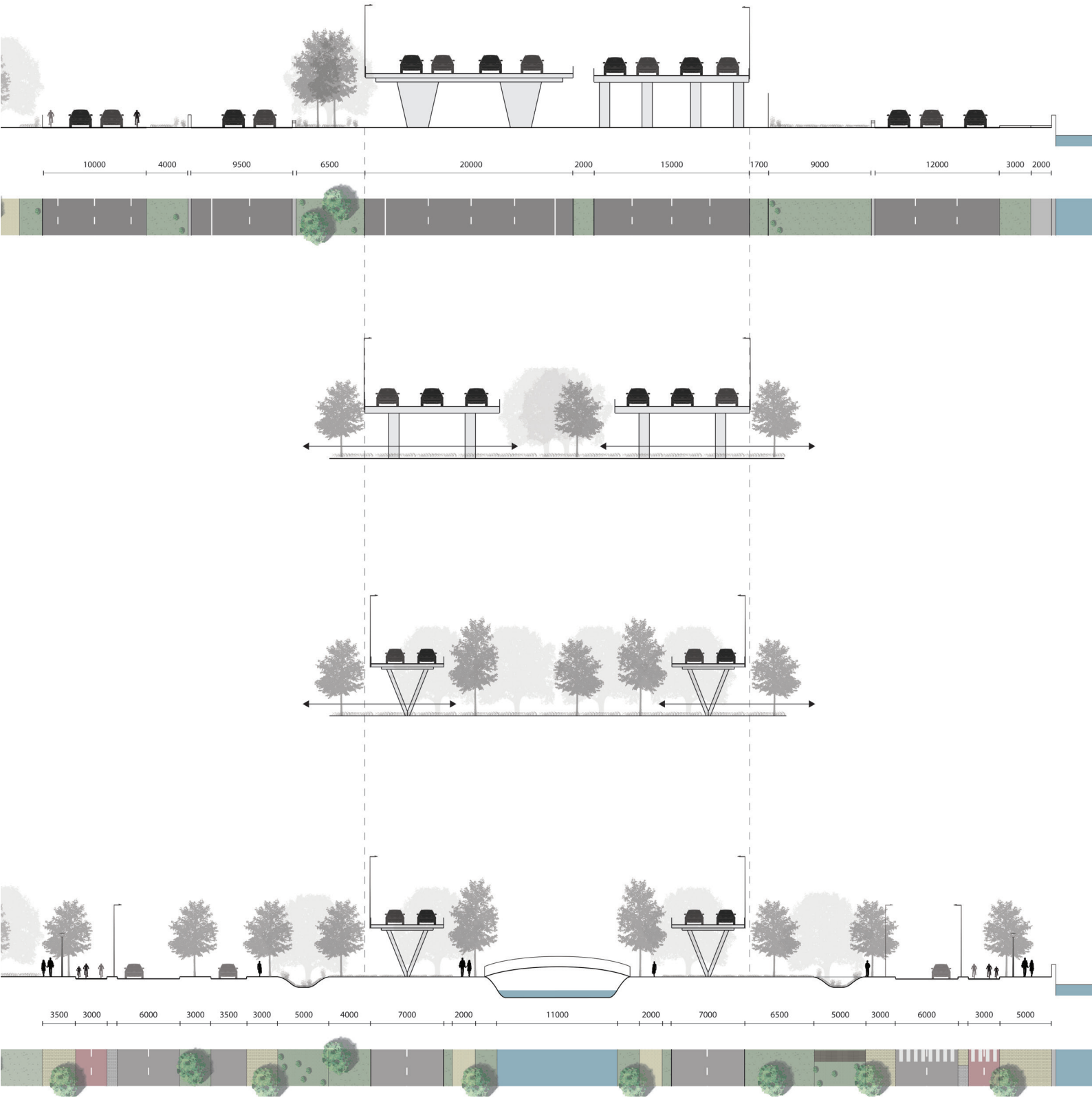

Figure 2.17 - Transformation of the highway system

Whether the future mobility system will be based on public transport or self-driving cars, the system will change for the better. There should be fewer cars on the road, that require less space. Which means that new space becomes available for another usage. The dominant highway structure seen today (see top) can change to a more open space, allowing for quality public space and water management options. A less dominant highway structure will allow for more movement incentive underneath. Transforming the reserved space into a parklike structure, with the highway raised over the entire length of the canal district, will open up the area and break the isolation.

Breaking the isolation of the canal district by making the barriers around the area permeable is not enough to reconnect to downtown San Rafael. A connection to the city center should be clearly visible, it should be guiding, invitational. Both from the perspective of the canal district as the perspective of the city.

To reach this goal the highway knot between downtown San Rafael and The canal district will have to be transformed (see fig 2.16). This knot is a combination of the current highway system and roads and railways structures that belonged to old systems and is now remnants (see fig. 2.18). The existing infrastructure network is capable of handling the traffic without these remnant road structures (2.19). By removing these, the space around the San Rafael Bus station is opened, showing the residents of the city that the city center is actually at the waterfront already. Currently, the water is completely hidden, by making a larger water body in front of the bus station, with a clear view on the water opens up the experience of being at the waterfront, as a city (see fig 2.20).

On the other side of the water, there will be a park, merged with the highway park under the new road structure. The park will become the new connection node between the Canal district's redeveloped waterfront and downtown San Rafael.

With the realization of the SMART rail and the extension of the BART rail in mind, this will become the new entrance to the San Rafael Canal district. The improvement in mobility will open up the district for a larger (commercial) audience.

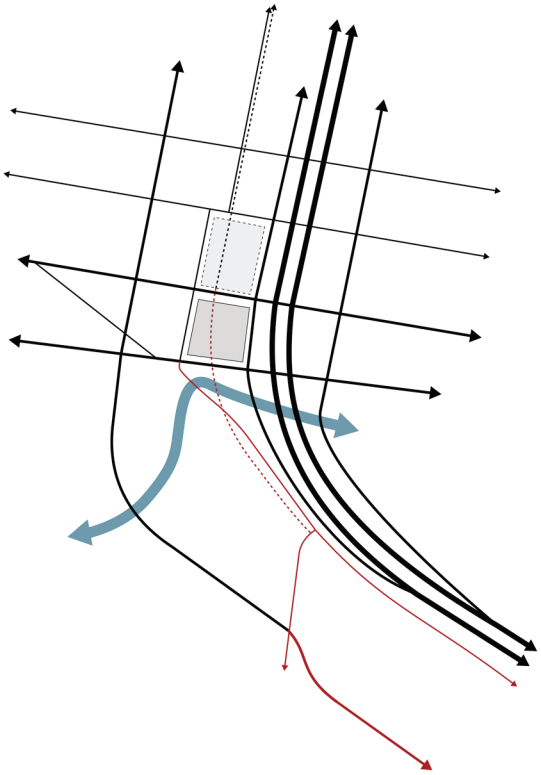

Figure 2.18 - Current infrastructure connections

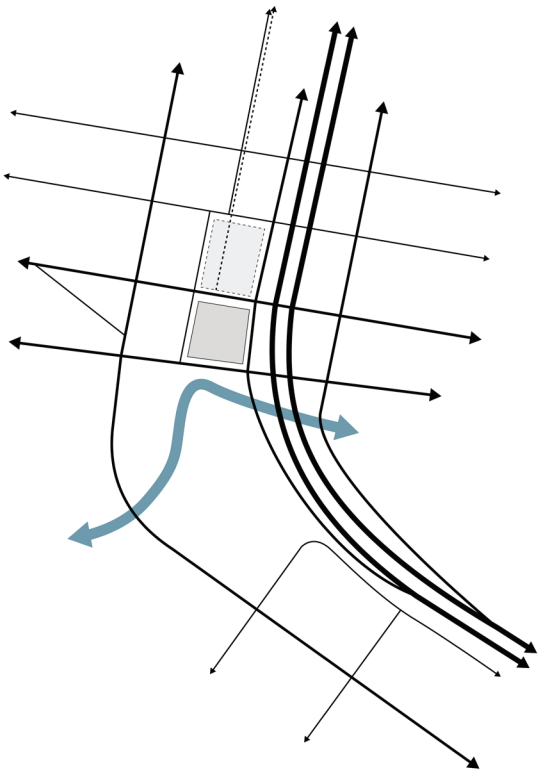

Figure 2.19 - Infrastructure intervention

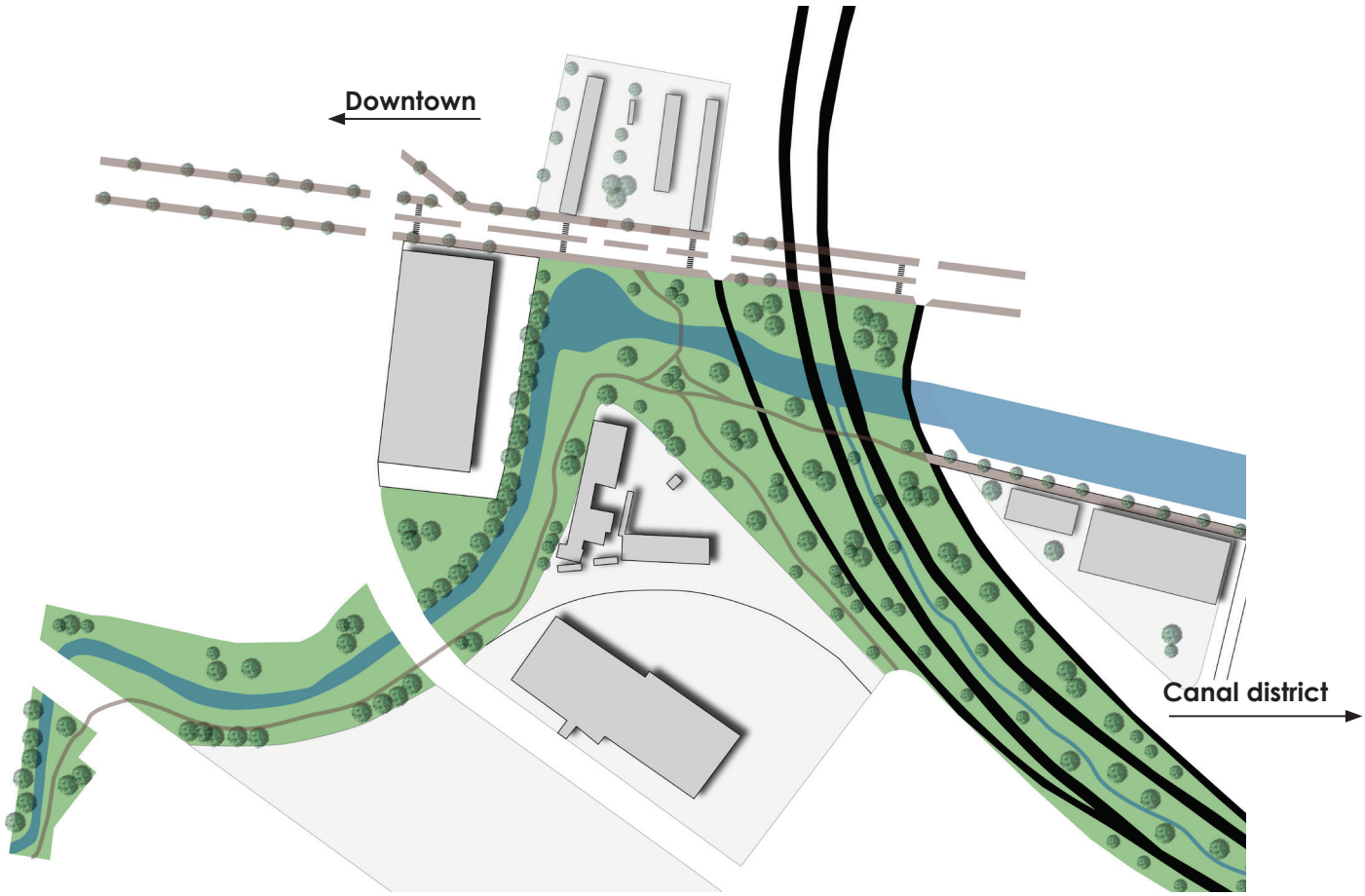

Figure 2.20 - Downtown San Rafael Reconnected

Conclusion

The historical development in the bay was driven by improved connections between cities. By improving the public transportation network, through expending the BART line from Richmond, San Rafael can improve its position in the bay area network. This provides the opportunity and stimulation for the canal district to redevelop.

Redevelopment of the canal district should start by improving the local connections, reconnecting the district with the city. Future developments in mobility could be used to reshape the traffic system, providing space for alternative landscape use.

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3. PILLAR: URBAN PATTERNS

3.1 Historic development

During the establishment of San Rafael, the natural landscape was taken into consideration. Ignoring the rules of the natural landscape, filling the former marshlands, San Rafael caused the flood risk problems they are facing today.

Marin County has a landscape filled with nature, the terrain is full of natural elevations, with Mount Tamalpais (see fig. 3.1) as the highest point at 785 m. This rocky natural landscape fills the majority of the county and it is the cause for many recreational tourists. These tourist choose this area for hiking and cycling, especially mountain biking is a big part of the recreational activities. Marin County and Mount Tamalpais specifically are considered the birthplace of modern day mountain biking (Marin museum of bicycling). The county supports these activities by protecting these areas by deeming them national recreation areas.

Figure 3.1 - Mount Tamalpais

The landscape may now be considered a quality, during the colonization of America, the land was considered unfit for larger settlements. These were formed on the shores that are now San Francisco and Oakland instead. The bay edge of Marin county consisted mainly of tidal marshlands, you still find these marshlands north of San Rafael (see fig. 3.2). Only after the formation of the major cities (San Franciso, Oakland, San Jose) and their harbors, small settlements were created in Marin County. These small settlements were built on the edges of the marshlands, right beside the creeks flowing into the marshlands.

Figure 3.2 - San Rafael's northern marshlands

For San Rafael this was the San Rafael Creek, it provided the settlement with fresh water and a connection route, while the Marshland provided protection from the tidal waters of the bay. The growth of the city in the last 100 years ignored these basic principles, changing the land-use of the city drastically. The creek has been transformed into a canal and the marshland has been completely paved and developed (see fig 3.3).

Figure 3.2 - The Canal district, former marshland

Even though the original settlement of San Rafael was founded before 1900, due to the lack of bridges across the bay, the city was only directly connected to the north side of the bay. The city was a final station, only for those who lived there (see fig. 3.4).

After the golden gate bridge was built (see fig. 3.5), San Rafael became a node in the connection between San Francisco and the North-West coast of America. From that point on slow developments towards the hinterland began. The roads and developments followed the natural terrain. And more settlements in Marin County were formed.

The development of San Rafael was hindered by the natural terrain, marshlands in front of the city, hills at the back. Until 1950 (see fig. 3.6) nature guided the development, the construction of the Richmond-San Rafael Bridge, opened in 1956, ended these guidelines. In a way San Rafael became an extension of Richmond, creating a labor opportunity for the residents of San Rafael and a housing opportunity for the residents of Richmond. The growth that followed resulted in a demand for housing that was answered by cheaply build housing on the former marshlands.

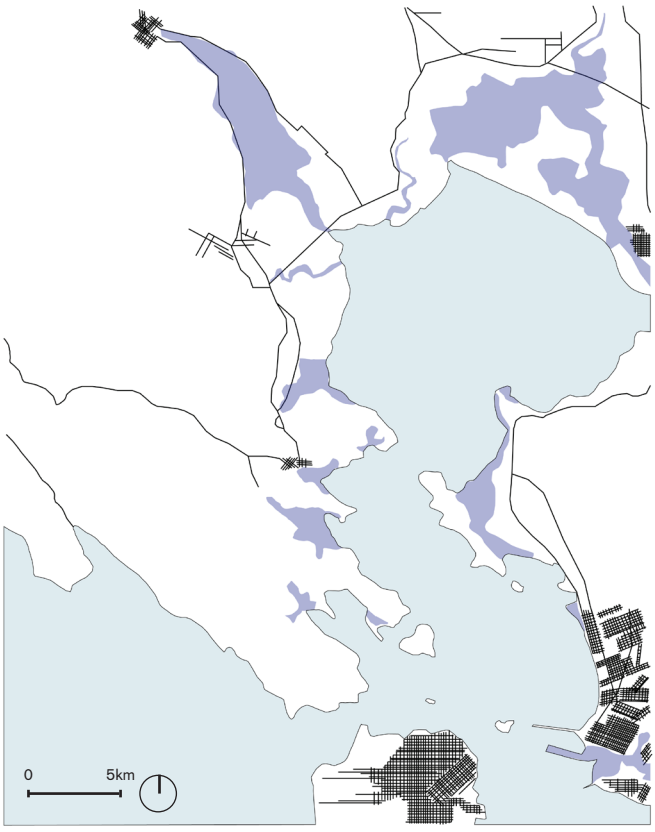


Figure 3.4 - North Bay 1900

Roads
Marshlands
Bay water

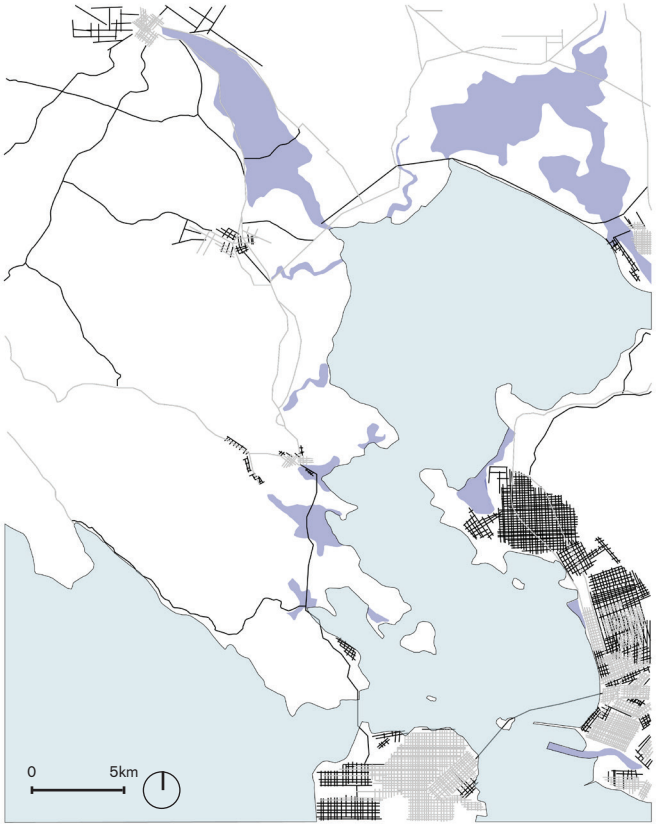


Figure 3.5 - North Bay 1930

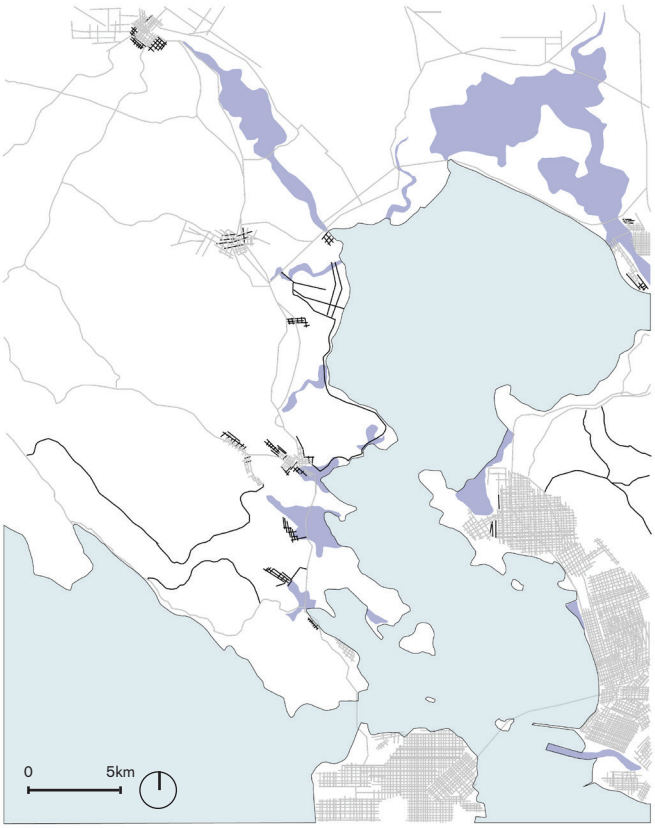


Figure 3.6 - North Bay 1950

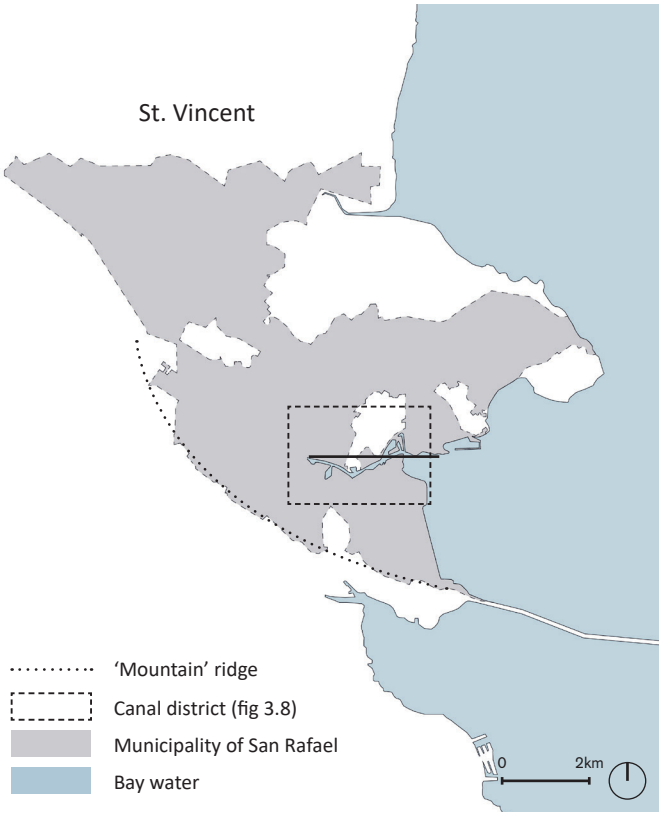


Figure 3.7 - Municipality of San Rafael

The city of San Rafael has different kind of borders on all sides. As a rule, municipalities at the waterfront control half of the water, so that's where the eastern border is set. The south-west border is natural, in the shape of the hillsides And north the city stops when the city St. Vincent begins (see fig. 3.7).

Within San Rafael, you find special districts that are not governed by the municipality itself. These districts have their own set of rules and regulations on a smaller or higher governance level. These areas are the result of preservation on a county, national or federal level. Alternatively, a piece of land can be owned privately or collectively and operate as an unincorporated community.

One of the challenges when dealing with municipalities like this is creating a set of rules that can be bound to the geographical location rather than the municipal outlines. Some of these special districts are part of the watershed, if you aim to address the water problem of the canal district, you need the cooperation of the whole area between the source and impacted area.

Figure 3.8 - San Rafael Canal district

Looking at the modern map of San Rafael with only adding the contours of the hillsides and the former marshlands, the original settlement (see fig 3.9) was a very logical location. Easy access to the land by water, fresh water and dry land. From this location, the hinterland was easy to access through the valleys and locations like these would have had plenty of natural resources.

With the water being the main transportation line, the creek was turned into a canal and industry resided on the shores. For a long time, the marshlands were respected as a natural barrier between bay and land. But the flat dry land was extremely limited and construction up the mountain expensive. It was an economical decision to fill the marshlands and construct housing(see fig. 3.10). The great expansion of the whole bay area let to a housing demand that was answered by cheap and easy build houses. With a landfill, the marshland was turned into construction ground and the majority of the marshland became filled with buildings.

The remaining marshland in the canal district is now protected for environmental preservation. But these marshlands are cut off from both the bay and the creek and as a result, they miss their original natural diversity.

The FEMA flood maps show, that in case of a stormwater event, the entire former march land will be flooded, and then some (see fig 3.11). The storms are calculated on rising bay water in connection with a rainwater event. Where the rising water from the bay can only get so far, due to the natural elevation, ponding and shallow flood will occur all the way up to the valleys.

The rising bay water, due to climate change effect, might appear to be the direct threat to the canal district, but this is only true in relation to a rainwater event. The natural resilience of the marshlands has disappeared and all the water has to be disposed of in the San Rafael canal. This canal is no longer able to handle this amount of water, especially because the rising bay water limits the capacity of the canal.

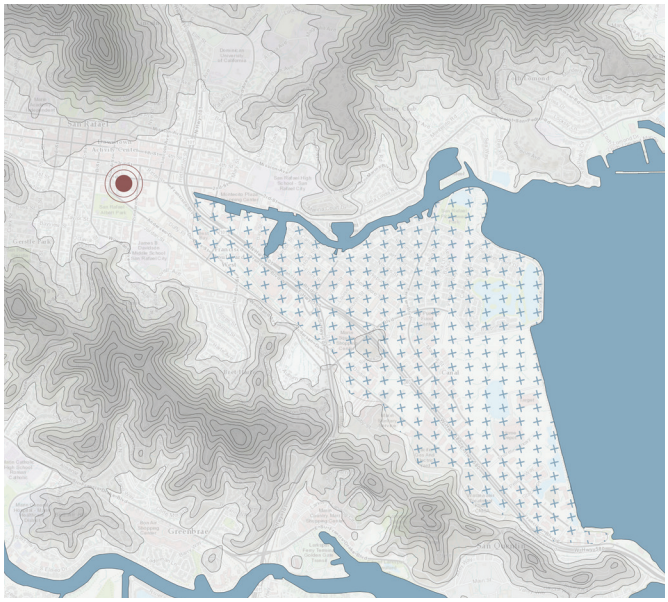


Figure 3.9 - Original settlement

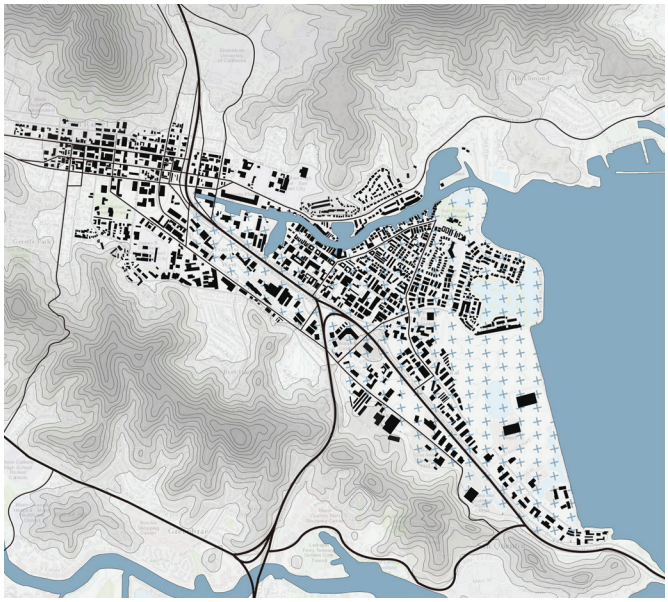


Figure 3.10 - Urbanization of the marshland

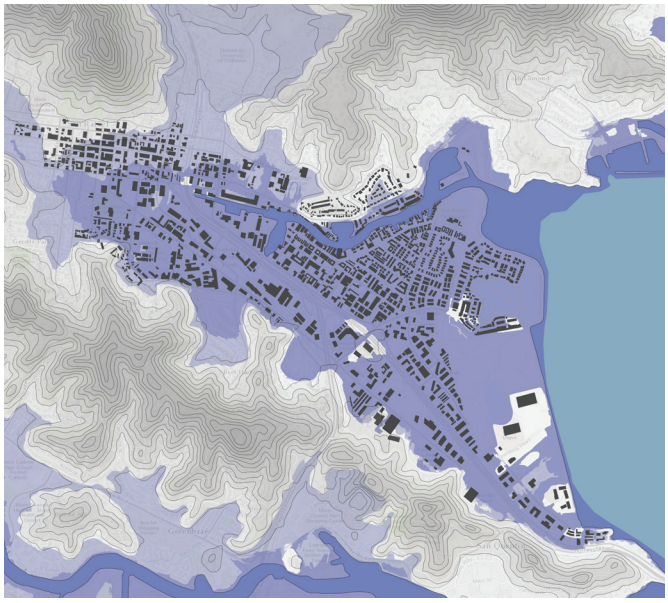


Figure 3.11 - Current flood risk

3.2 The flood problem

The San Rafael climate is quite unique, the geographical location is cause for more rain than any other city in the bay area experiences. On average just short of 900 mm of rain falls each year, all the surrounding areas have numbers of 200-300 mm below that. This amount of precipitation puts more stress on the water system, which is not able to handle these kinds of amounts, due to the lack of permeability and open water.

Rain is a bigger threat to San Rafael than any other city in the Bay Area. California as a whole has quite a dry climate, north is a little wetter but the south is completely dry. San Rafael has it's own climate (see fig. 3.12). Due to the unique location of mountains at sea (see fig. 3.11. Even though California is considered one of the warmer states, the Pacific is ocean and its air is quite cold. The changes in temperature on land are usually a cause for rainwater to fall (the urban heat island effect). Because of the surrounding area of San Rafael, these differences in temperatures are more extreme, resulting in more extreme rainfall events locally.

As a result, San Rafael on average annually receives up to 300 mm more precipitation than any other city in the region. This amount falls in a short period of time, only the months November to March are considered as rainy months. The other months are extremely dry. In addition, the precipitation usually falls in a few rainwater events. In some 24h rainwater events, more precipitation will fall then is usual for that month (see fig. 3.14).

For more data, the extreme events and annual numbers, see the climate analysis in the appendix.

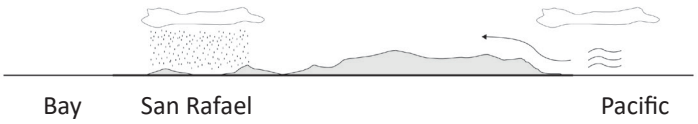


Figure 3.12 - Geographic influence precipitation

Figure 3.13 - Annual precipitation San Francisco Bay Area

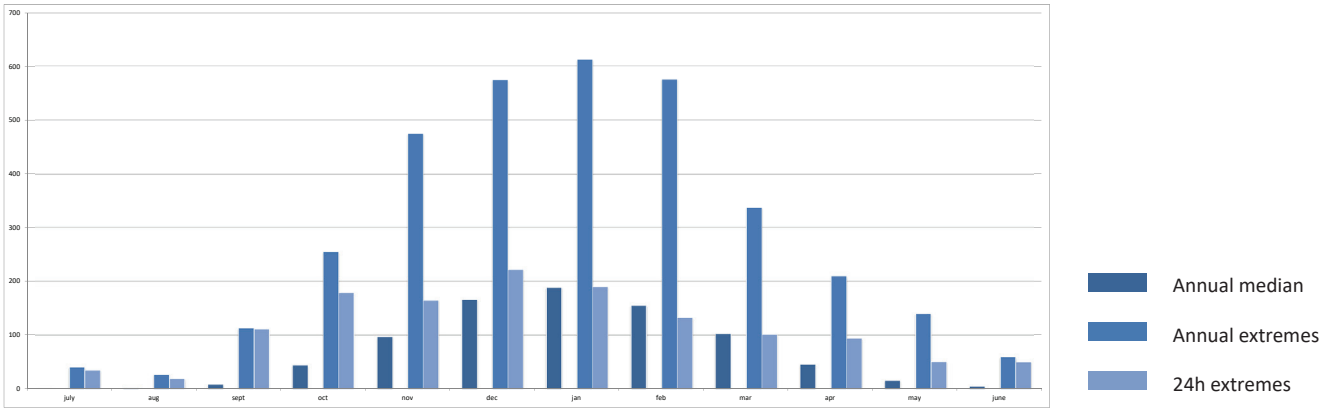


Figure 3.14 - Annual precipitation San Rafael

With an extraordinary microclimate and the threat of rising sea levels through climate change, San Rafael has water-related threats coming from multiple directions. The water is coming from north, east, south and west, from bay and hills.

The municipality of San Rafael has two watersheds, one covering the northern part of San Rafael and the Gallinas Creek, and the San Rafael Creek watershed in the south (see fig. 3.15 and 3.16). The watershed is shaped by the natural environment of the hills, the edges on land are connecting the hilltops surrounding the south of San Rafael.

The edge of the watershed on the bay side is protected and regulated by the army corps of engineers, like all the edges directly facing open sea water. In the past, they were responsible for the dredging of the canal as well (Marin county watershed program). Inside the watershed, the central Marin sanitation agency deals with the collection and treatment of the waste and rainwater. But there is no government body that is responsible for the surface in the watershed.

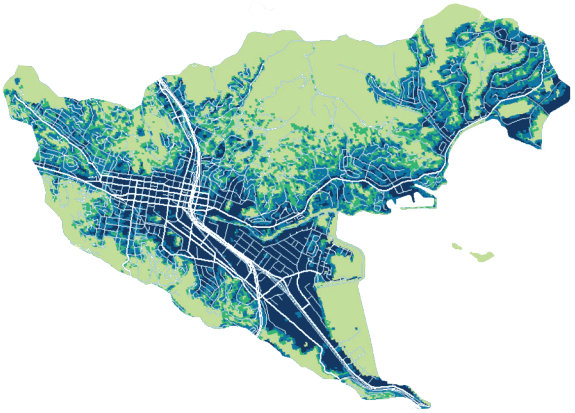


Figure 3.15 - San Rafael watershed

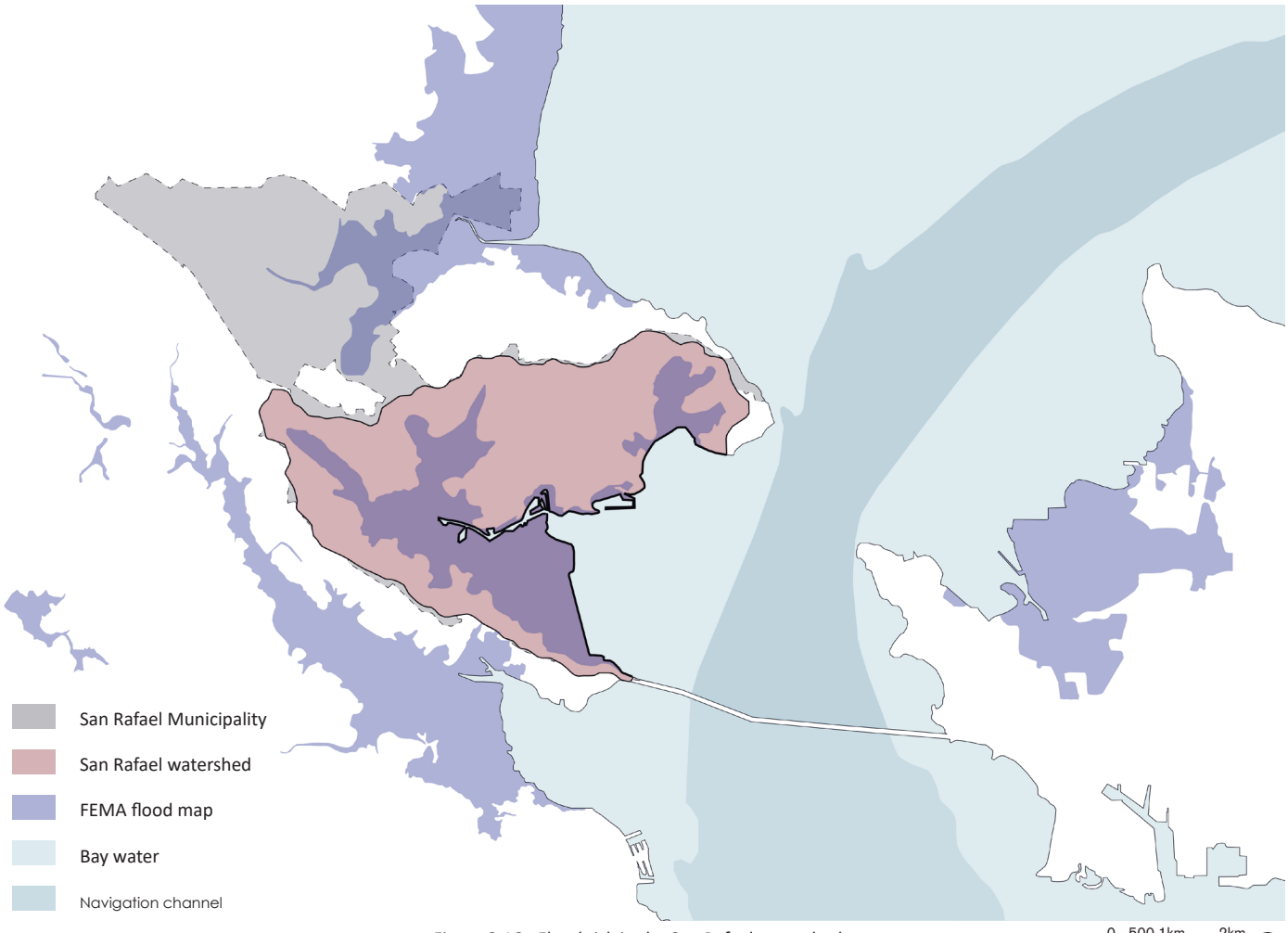


Figure 3.16 - Flood risk in the San Rafael watershed

Figure 3.17 - High permeable ground

Figure 3.18 - Permeable ground

Figure 3.19 - Low permeable ground

Figure 3.20 - very low permeable ground

80% of the watershed is developed (Marin county watershed program) the majority of these developments can be found at the lowlands of the watershed, including downtown San Rafael, and the canal district.

Looking at the permeability of the watershed surface (see fig. 3.17 to 3.20), all the unbuild and the rural area still has an infiltration capacity capable of handling a major rainwater events. But the city center, downtown San Rafael and the complete canal district, including the industrial zones are completely densified. These areas are not capable of handling rain showers on their own. Together with rainwater run-off from the higher part, this area completely relies on the sewer system and storage capacity of the San Rafael canal.

The Marin County watershed program calls for a 43% open space ratio to be able to handle with the rainwater in the San Rafael Canal district. Currently, this ratio is far from possible due to the highly densified area. Not only the construction of building development is cause for the lack of permeability, the materialization of the area plays a big role in the infiltration capacity. Current materialization mainly exists out of concrete and asphalt.

The materialization and high density of buildings result in a bad permeability preventing the area to cope with the rainwater on itself. In addition, the low geographic location of the canal district will result in addition water run-off entering the area. When you look at the map of the bad permeable ground, you see the exact contours of the FEMA flood map. The risk of flooding is a sum of rising sea water, lack of permeability and additional run-off from higher geographic locations. Three sources of water management problems, that all have to be addressed.

3.3 Spatial quality aspects

The spatial segregation between the neighborhoods in the Canal District is a segregation that is visible in the spatial quality of the different streets. Streets with a higher spatial quality can be found in the better neighborhoods, the main reason behind this quality is the presence of green, a factor that also provides better infiltration options.

The canal district was developed after the construction of the Richmond-San Rafael bridge, however, this happened over a period of multiple decades. You can see the stages of development when you look at the area from above (see fig. 3.21) or street level. The first housing development in the 60's answered to a high demand for cheap housing. The result was a very dense neighborhood with small housing units and barely any open space.

The neighborhoods in the 70's built with a more suburban area in mind, the houses are built like villa's on their own plot or are surrounded by open space. The latest addition, the neighborhood build in the 90's, continued this trend and completely let go of the existing grid structure and is a clear example of the suburban American housing.

The housing developments of the 70's and 90's provided the area with more open space for infiltration, on the permeability maps (see fig. 3.15) these neighborhoods light up as areas with light permeable ground to high permeable ground. At the same time, an increase of permeability creates a spatial quality that can be seen on street level (see fig 3.22 and 3.23).

The full street view analysis can be found in the appendix.

Figure 3.21 - Spatial quality structure of the canal district

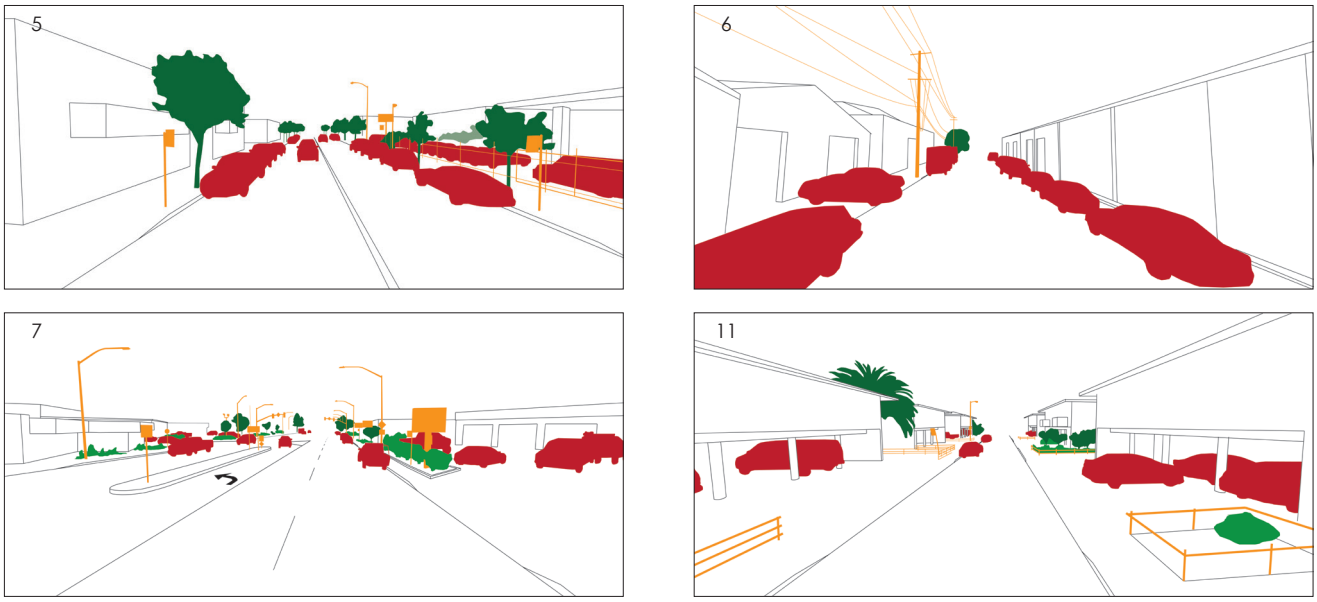


Figure 3.22 - Canal district street view analysis

The streets in the 60's neighborhood are completely paved with asphalt and concrete tiles (see fig. 3.22). The amount of green is minimal, especially if you look at the percentage of open space the green has. All the patches of green are singular and not connected, there is no room to flourish.

The streets in the 70's and 90's neighborhoods show a lot more green and a large diversity of green (see fig. 3.23). The green has more room to expand and flourish. Economically there is a huge difference between the residents of the 60's and 70's-90's housing. This difference is not only visible through demographics, it has a clear reflection on the spatial quality of their neighborhoods as well.

This difference between the neighborhoods doesn't only show the social-economic segregation reflecting on street level, it also shows that providing a neighborhood with an infiltration capacity through open space can have a positive effect on spatial quality.

Providing the canal district with water management solutions that are paired with spatial quality, could solve the multiple problems the district is facing.

For the full street view analysis of all the 20 streets throughout the district, see appendix.

Figure 3.23 - 'south-east' San Rafael street view analysis

3.4 Interventions

The water strategy deals with the three threats of water for the canal district, sea level rise, run-off water and lack of permeability. It is a combination of larger interventions, like the closing of the bay and creating a natural network, and a set of rules to be implemented in new developments providing the area with an improved infiltration capacity and spatial quality improvements.

The water strategy (see fig. 3.24) deals with the different sources of the canal district flood problem, found in the weather and permeability analysis. It can be narrowed down to three different interventions; closing off the canal from the bay, preventing rainwater run-off and increasing the permeability.

The backbone of the canal district will be a green network that connects the San Rafael canal to the marshlands through multiple routes. This network's main function will be storage and infiltration of precipitation but also functions as a natural corridor that will benefit the vegetation of the original marshlands.

New sets of regulations for development and the changing of materialization in the neighborhood will provide for a more permeable ground, allowing a big percentage of the rainwater to naturally infiltrate. The more densified area's, existing and new, will also focus on water storage interventions, holding the water for regulated discharge.

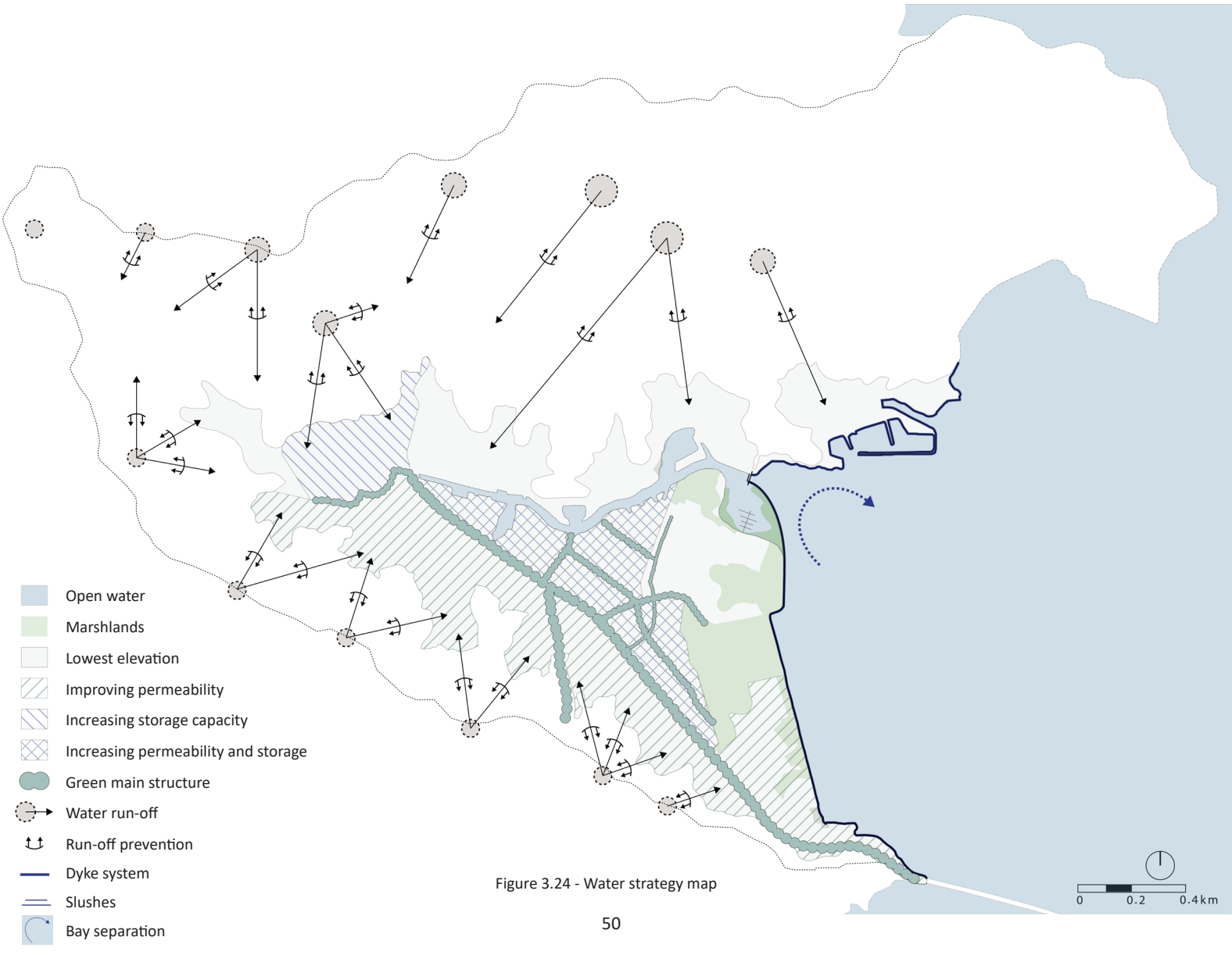


Figure 3.24 - Water strategy map

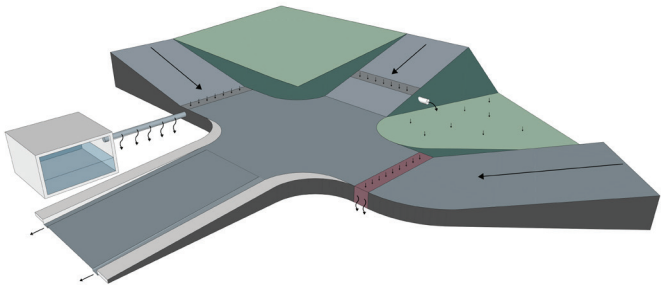


Figure 3.25 - Rain water run-off prevention

The main problem with the rainwater run-off is the lack of interruptions. No matter if the water runs off to the sewer or down the street, the water will lower the capacity of the system below. Instead, the focus should be on retaining the water uphill, through storage or infiltration (see fig 3.25). Instead of parallel sewer systems, the water should be interrupted using the width of the road. Crossings are an ideal location for this, allowing for water to be stored in the open space, in storage units or infiltrated.

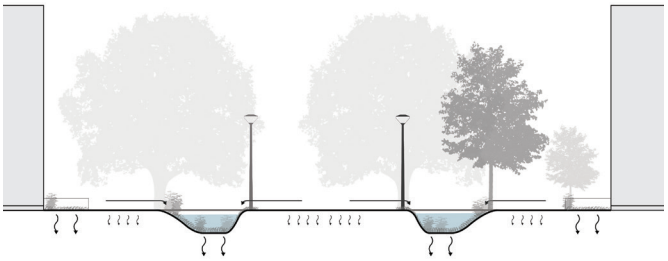


Figure 3.26 - Urban wadi system

The natural backbone of the canal district will be a wadi system (see green main structure fig. 3.24 and 3.26). Wadi's will provide a huge storage capacity and are able to infiltrate. In a climate that knows just as many days of draught as it knows rain, a wadi is a better choice than a canal. At the same time, these wadi's will form a network with the existing marshlands, allowing for a growth in biodiversity.

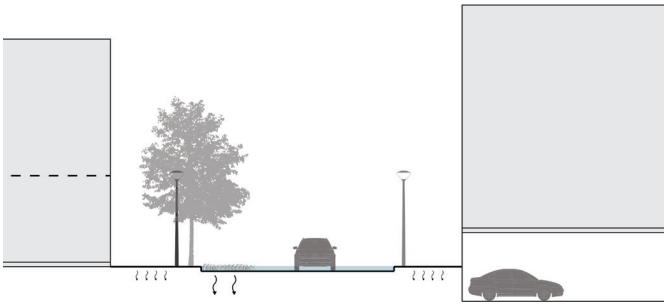


Figure 3.27 - Infiltration through materialization

Wadi's are not the only infiltration methods implemented in the canal district. By changing the surface material from asphalt and concrete into absorbent and infiltration capable pavement, a lot of water can be guided into the ground (see fig. 3.27).

Figure 3.28 - Bay-canal separation

With climate change in mind, you have to expect the sea level to rise above a level that is sustainable with an open water system. Therefore the bay will be separated from the canal by a new levy (see fig 3.28). This allows for some new marshlands, and possible a small marina. In the beginning, the system could stay open and only close in case of an incoming king tide. With increasing sea water levels the system could be changed into to slushes.

This separation between bay and canal is to provide the maximum storage capacity for bigger rainwater events. A permanent barrier does have a massive effect on the flora fauna of the bay, marshland, and canal. Without continuous mixing of sweet and salt water, in due time salinization of the bay might become a hazard.

San Rafael is quite familiar with extreme rainwater events, during the wet season the monthly amount usually falls in a few days, a 100 mm of rain is not unusual. On average San Rafael should be experiencing a rainwater event of 92 mm a day (see fig. 3.30). They have the sewer capacity to deal with this amount of water and the problems of flooding are usually kept to a minimal. The problem is the more extreme cases, like the 222 mm a day from 1995. This created flooding throughout the whole canal district and downtown San Rafael.

Expected changes in climate suggest that these events will happen more frequently and with larger amounts of rainfall. This will require an additional amount of storage capacity for the area.

Using the ground permeability of the watershed an estimation will be made of the required storage capacity when a rainwater event perceives the sewage capacity for San Rafael. However, the capacity of the sewer system is depended on the depletion rate of the system. So the amount of rain that can be handled in one day, is depended on the previous days. So a rainwater event of 100 mm might not cause any problems, two 100 mm rainwater events back to back will.

With the expected problems growing, an estimation will be made to store 100 mm additional runoff water in the project area, following the water strategy.

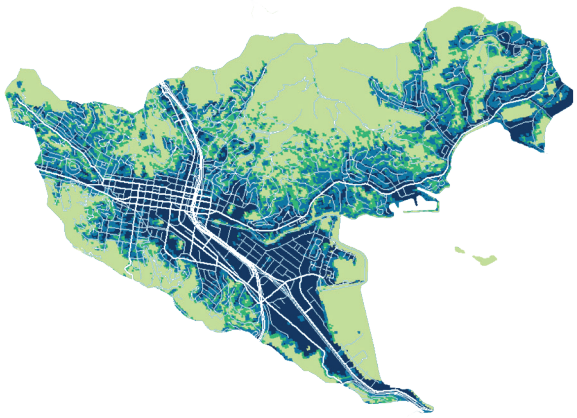


Figure 3.29 - San Rafael watershed

Ground permeability	Area	Run-off c.:
High permeable	10,6 km2	0.1
- Marshlands	1,1 km2	0.1
Permeable	3,7 km2	0.25
Bad permeable	4,0 km2	0.5
Very bad permeable	6,4 km2	0.95
Non permeable	3,5 km2	1.0
Water	0,2 km2	0
	28,5 km2	

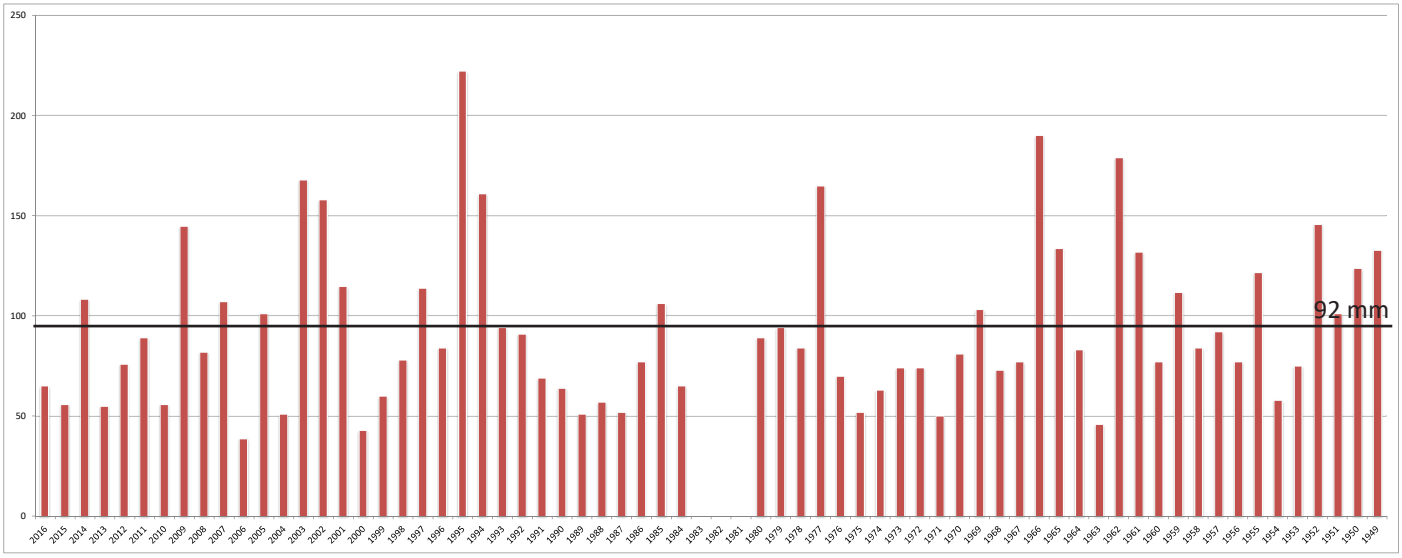


Figure 3.30 - Annual extreme 24h event

The soil composition of the high permeable and permeable ground is mostly sand. Which means that these areas have an infiltration capacity between 240 and 480 mm a day. These lands contain a lot of vegetation as well, which would increase the absorption and infiltration. However, for a surplus, the run-off coefficient will be used.

High permeable ground:
0.1 x 0.1 x 10.600.000 m2 = 160.000 m3
Marshlands:
0.1 x 0.1 x 1.100.000 m2 = 11.000 m3

Permeable ground:
0.1 x 0.25 x 3.700.000 m2 = 92.500 m3

These grounds, with the exception of the marshlands, are located in the higher areas of the watershed. In accordance with the water strategy, this would mean that 241.500 m3 of water will have to be caught, slowed down and infiltrated locally.

Bad permeable ground:
0.1 x 0.5 x 4.000.000 m2 = 200.000 m3

The bad permeable areas find themselves on slopes, the rundown towards the canal district should be prevented, with limited room for infiltration, storage options should be implemented in the urban fabric. Small storage tanks and blue roofs could reduce the stress on the larger system.

Very bad permeable ground:
0.1 x 0.95 x 6.400.000 m2 = 604.000 m3

Non permeable ground:
0.1 x 1.0 x 3.500.000 m2 = 350.000 m3

80% of this area is directly connected to the canal district, storing this water in the district would require a storage capacity of 763.200 m3.

Currently, the canal is the only storage room present in the area. Potentially the water itself could hold 200.000 m3 with a freeboard of 1m. An additional 100.000 m3 could be stored along with the water in the small marshlands. However, during an extreme rain event, the capacity would be limited by the rain falling on the water itself, reducing the capacity to 240.000 m3.

Additionally, the flood risk of the area is a combination of king tide in the bay and an extreme rainwater event. When this happens, storage in the canal is extremely limited or not possible at all, which would result in flooding of the canal district.

Which is one of the main reasons, for the suggestion, to create a separation between the bay and the canal. During the wet season, slushes can prevent the canal filling up with water from the bay. The suggested interventions in the water strategy even create additions marshlands and a larger water surface of the canal. Creating a buffer for 320.000 m3 rainwater.

The remaining water will have to be stored within the area of the canal district. The total length of the streets with wadi systems is 3km. With a wadi on both sides of the street that will be the length of 6km in total. With a capacity of 2m3 per meter, the wadi system itself can store 12.000 m3. But the true objective of the wadi system is to connect the marshlands with the open water of the canal. The wadi system will connect to the eastern marshlands, 0,5km2 lowered natural land, a storage capacity of 250.000 m3.

Separated canal: 320.000 m3
Wadi system: 12.000 m3
Marshland: 250.000 m3

A remaining amount of 195.000 m3 will have to be stored and infiltrated within the canal district area. The soil of the canal district is former marshland, raised with sand, so infiltration in the area is possible. Replacing the majority of the nonpermeable surfaces in the district, by replacing concrete and asphalt with bricks and semi-permeable surfaces, the run-off from the non-permeable ground will be limited. Especially parking spots should be replaced with materials that accelerate infiltration.

The last basin that will be created for storage is the highway park, depending on the need for water storage at the time of transformation, this park could be a wadi system, focussed on extra infiltration, a marshland to promote the vegetation in addition to a water basin, or an additional waterway, connected to the San Rafael canal.

The canal district is part of the very bad permeable ground, adding additional rules to building developments, like green or blue roofs or internal water storage will further reduce the water run-off in the area and work towards flood prevention. By implementing a bigger network in cooperation with new rules for the redevelopment, a storage capacity should be reached that can keep water out during future events.

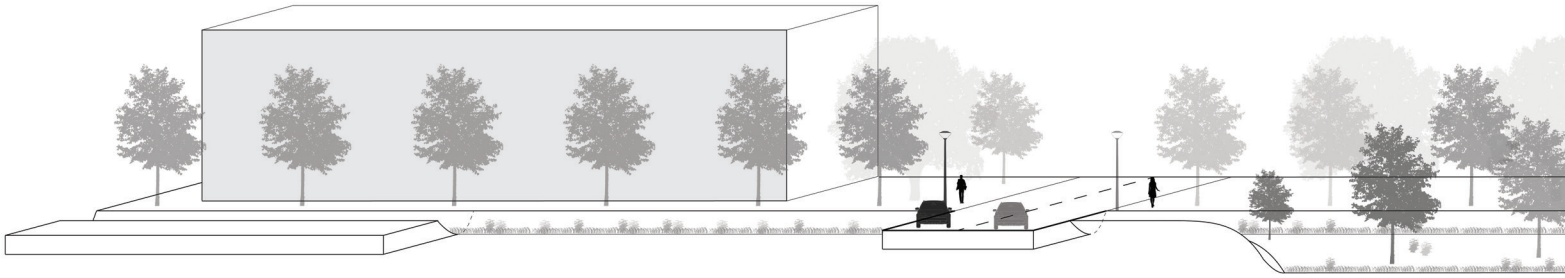


Figure 3.31 - Wadi connecting the wetland

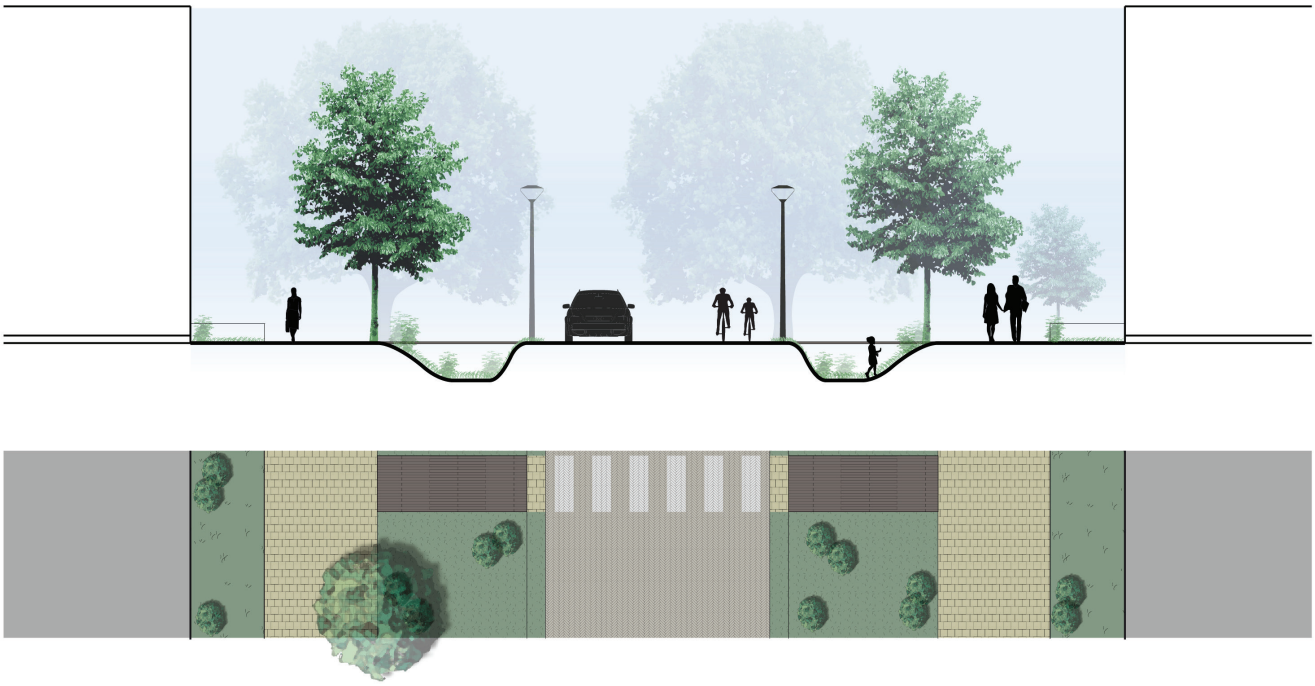


Figure 3.32 - Section of street with wadi

The backbone of the green network through the canal district will be a continuous wadi system (see fig 3.31). The wadi system should be a connecting factor between the canal on one end and the protected marshlands on the other.

The streets that contain a wadi will be a contrast with the 'normal' streets you'll find in the neighborhood (see fig. 3.32). The streets will be wider and filled with nature, they are there to remind the residents of the original nature of the area. The wadis will not only serve the streets and district as a water management implication, it will also function educational and recreational.

The houses on these streets will likely be used for higher market housing, by connecting public spaces and commercial functions to the streets with wadi's, they will also be a quality improvement for other residents in the area.

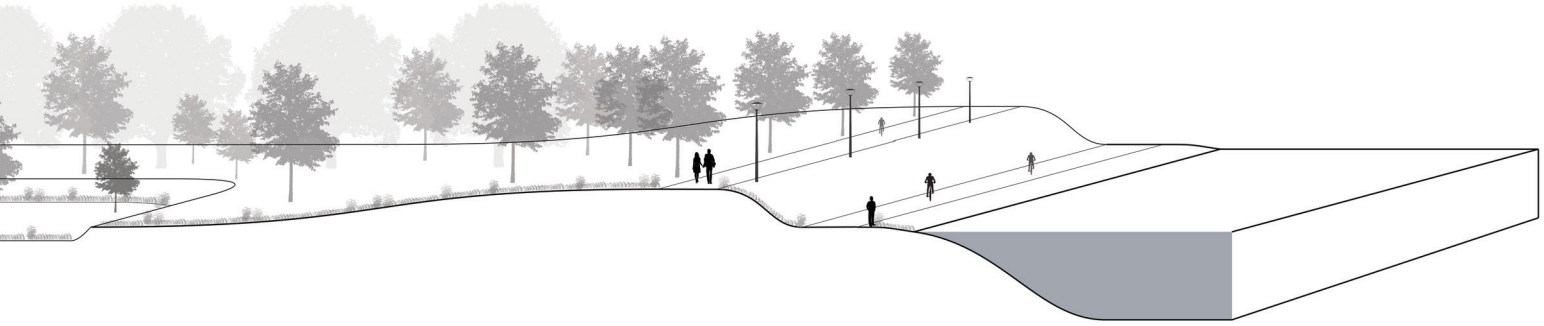


Figure 3.33 - Possible wadi vegetation

The current marshlands of the canal district support a few special-status plants (Marin County watershed program), one of the goals for the green network is to stimulate the biodiversity of the marshlands. The wadis should be able to support the growth of these plants, just like the marshlands does. These wadis will have a more robust appearance and will remind the residents and visitors of the origin of the land, the marshlands. The wadi will be the home to the type of plants you'll find at a marshland (see fig. 3.33), plants that will grow and flourish in both sweet and salt marshlands.

The low permeability of the Canal district has different causes, one of them is the usage of the current plots. Especially the more industrial plots are completely paved, often used for parking space. Preventing future flood events will be a challenge that have to be fought as a community. For that reason, building developments will have to follow a set of rules to improve the permeability and the storage capacity of the district.

One of these guidelines will be the usages of blue or green roofs (see fig. 3.34). Blue roofs will be preferred over green roofs in the district, the local climate consists of a long period of drought, green roofs will dry and wither during these periods. Blue roofs are able to provide the same amount of storage and require less maintenance.

Another guideline will be to keep the ground within a block as permeable as possible. Parking options should be either paired with blue roofs or infiltration systems.

Public areas will be used for both storage and infiltration. Larger networks of green are able to hold and infiltrate more water, the wadi system (see fig. 3.35) should really remain continuous. Adding green to the streets should always be in balance between water management and spatial quality.

Larger public places, like squares, should double as a storage option (see fig. 3.36)), by creating different height levels the water can gather here. As long as the space for these public spaces is reserved, they could change over time, increasing the capacity of storage by lowering the ground level.

During the redevelopment of the area, developers will be asked to deal with most of the water of their own plot. Al the transformations together should provide the protection against flood events that the canal district needs. However, there is always a level of uncertainty when it comes to predictions. In the case of extreme events, emergency storage spaces could provide additional protection. (semi-) Underground parking facilities (see fig. 3.37). Stimulating investments like these could prove to be very helpful. Extreme rainwater events are normally predicted days in advance, and measure can be taken to minimize damage. With the predicted change in mobility in mind, parking solutions now could be the answer for future water management problems.

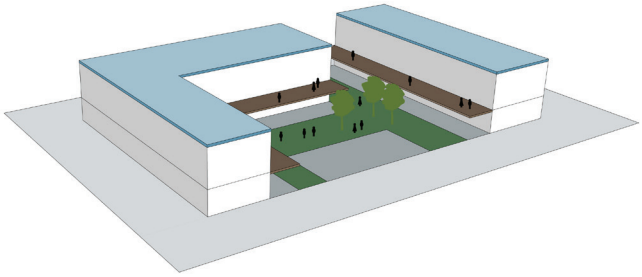


Figure 3.34 - Blue or green roofs

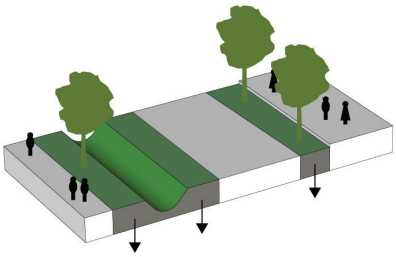


Figure 3.35 - Wadi's and green zones

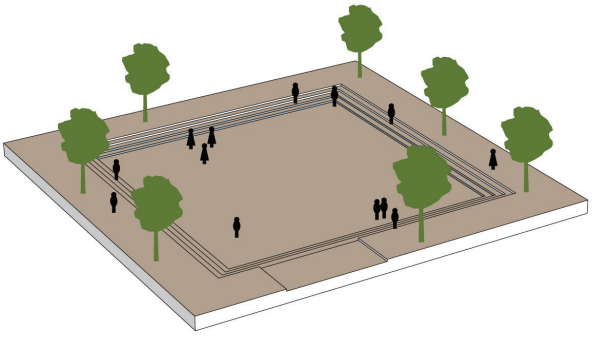


Figure 3.36 - Public spaces

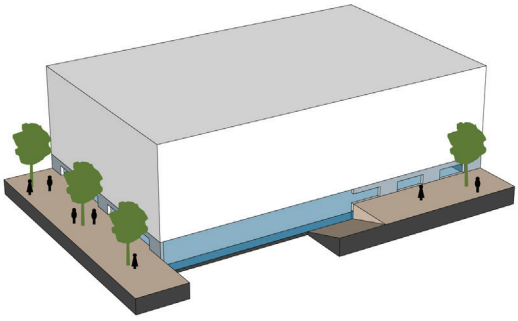


Figure 3.37 - Emergency storage

According to the Marin County watershed program, 43% of the canal district would have to be open space in order for the area to regain the infiltration capacity it used to have as a marshland. By adding wadi's, public spaces and a highway park this percentage will go up, but not to 43%. A lot of the public space can't be completely open because it will be used for movement or activities.

Other ways to improve the permeability of the district will have to be implemented as well. Currently, the two surface materials used in the district are asphalt (for the roads) and concrete (for the pavement). These surface materials have almost no absorption or infiltration capacity. By replacing these materials by more absorbent pavement, a large percentage of the rain can seep through the top layer and enter the ground. Just plain bricks have a higher absorption rate then asphalt, there is a wide variety of bricks with increased absorption and infiltration that even provide more infiltration capacity. And these materials give streets a completely different appearance, by transforming from asphalt to brick you can create a neighborhood instead of a drive through.

Another example is the TTE (see fig. 3.38) infiltration system, a system with multiple gradations. Its foundation is a raster in the ground, you can fill up with bricks or grass. The system is strong enough to carry cars. It can be used to change parking lots of asphalt into green fields while providing a water management solution by infiltrating in a natural way.

By applying this system to new parking facilities in the street or within building blocks, a quality is added to the streets that are now missing. With the expected changes in mobility in the future, cars will cease to rule the street, allowing for the green to take over, green that is already present through the TTE system and able to grow.

There is will be exceptional streets in the district, there will be a hierarchy of main streets and secondary streets. These main streets will be the supply routes for the commercial industries and require a more robust road. Brick roads will suffer under heavy transport traffic, for this kind of roads Asphalt would actually be an option. Streets like these could be compensated by infiltration systems in or on the side of the road. Granular drain systems (Amsterdam Rainproof) are able to completely take over the function of a sewer system.

Adding infiltration and absorption systems and materials will provide for a significant increase in permeability while improving the spatial quality by adding a more diverse street view through esthetic materials.

Figure 3.38 - TTE Infiltration system

The complete set of interventions guarded by the rules that will be set for developers should provide the canal district with the resilience to handle large rainwater event. The increase in permeability will return some of the function that the historic marshland had. The new green network should stimulate the biodiversity of the current marshlands enough to maintain.

In the end, all the interventions to improve the water management system are actually interventions to improve the spatial quality of the area. They are necessary from the aspect of flood prevention, but they are wanted from the aspect of spatial development.

However, improving the spatial quality of a district is not enough to improve the social quality of its resident. In order to improve more than the spatial quality, a different, additional approach is needed.

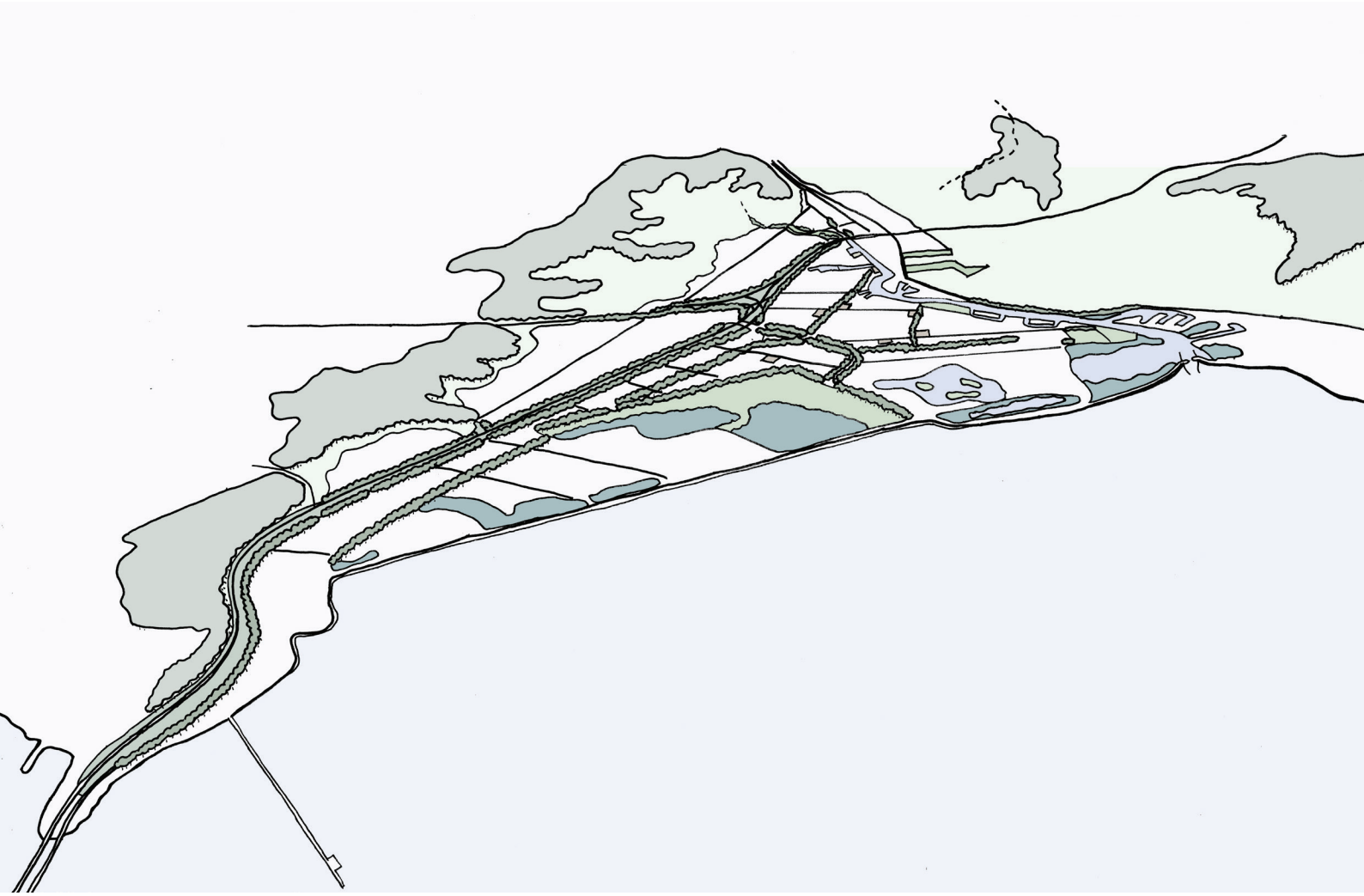


Figure 3.39 - The new green network of San Rafael

Conclusion

Developing the original marshland into an urban area created an imbalance between the amount of precipitation and the infiltration and storage capacity. San Rafael has a unique climate, that results in more rainfall, this is the main reason for the flood threat. In order to protect the canal district from these flood events, additional storage and infiltration have to be created to compensate for the missing marshland. The closing of the canal from the bay will maximize the storage capacity of the canal, while run-off interventions will minimize the additional water the canal district will have to deal with.

There is a lot of quality to be found in water management solutions, adding green, changing materials to improve permeability. These qualities can reshape the district redevelopment, from a point of water management solutions. To achieve this, set of rules will be necessary, for all stakeholders involved.

These small interventions, starting from the scale of materialization changes, are a link in the chain for the greater change towards a water management solution for the canal district. Together with the wadi system, it will provide the needed permeability and infiltration. While simultaneously, measurements on the higher scale, like run-off prevention and bay-canal separation, will reduce the flood threat from outside the district.

4. PILLAR: SOCIAL-ECONOMIC DEVELOPMENT

4.1 Housing development

The housing prices in the San Francisco Bay are at an all-time high. With no major new housing development, the prices will continue to climb, with severe social and demographic repercussions.

The whole San Francisco Bay area is rapidly evolving, powered by the steam engine that is silicon valley. When the American housing market collapsed in 2008, the prices in the bay area started to re-rise the next year. While most housing markets are still recovering from the blow of the global economic crisis, the housing prices in the bay area are higher than they ever were before (see fig. 4.1).

This growth on the housing market is visible for both house owners and renters, in 2016 the average rent for the free market sector grew with €400,- (see fig. 4.1) and continues to rise in 2017. For property owners, this is great news. But only 53% of the people in San Rafael does own a house (census), the remaining 47% is renting, for an increasing amount of rent.

San Rafael is considered one of the wealthier municipalities of California. With a median household income of $77.294 (data USA). However, this household income is a bad representation of the median population. The percentage of high-income households is a lot higher than the national median. And this percentage keeps growing, from 2013 to 2015, the households with $200k+ alone grew from 13,5 to 15,3% (data USA). This shift towards the higher income households is likely the effect of migration. People with lower household incomes move out of the city and households with higher incomes take their place. In a way, there is a high-end gentrification taking place in the city because the lower households can no longer afford to live in the area due to the increasing housing values.

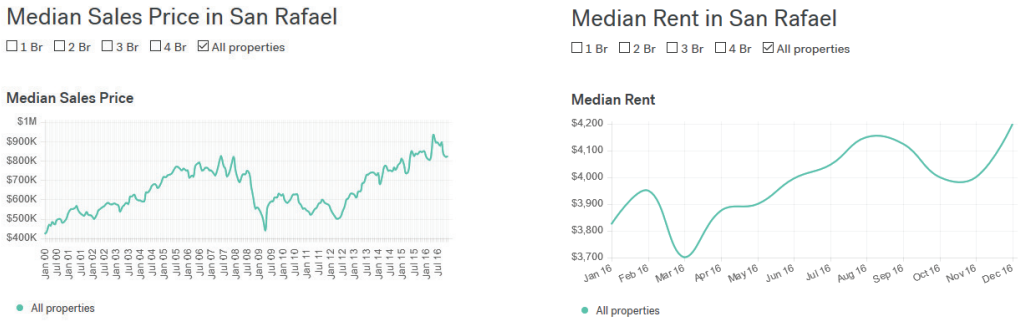


Figure 4.1 - Market development San Rafael

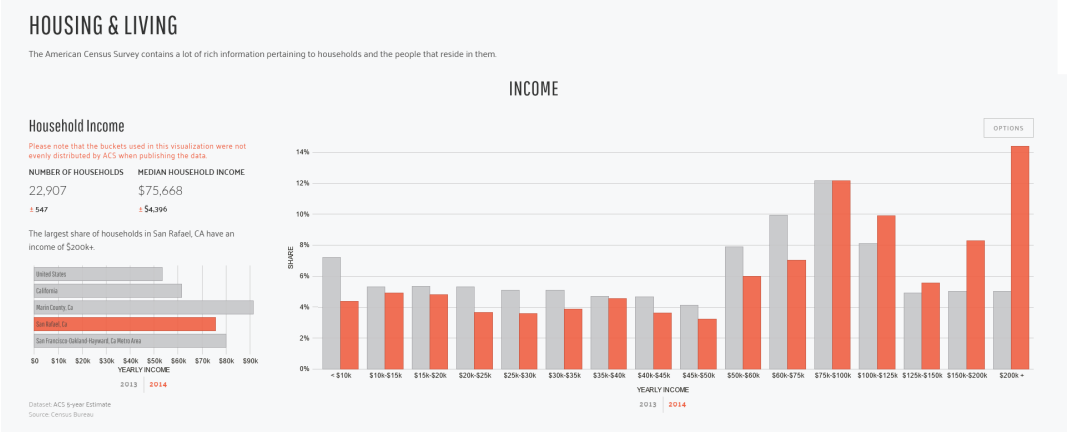


Figure 4.2 - Housing prices San Rafael

4.2 Social threats

The residents of the canal district earn far below the poverty line, and as a result, they are living in higher concentration, multiple families sharing houses. Of the 7809 people living in poverty, the majority will be found in the canal district. However, without stimulation of new housing development, more people will fall under the poverty line, increasing the problems for residents of San Rafael.

Many of the lower household incomes live in the canal district, the median income in the canal district is the lowest in the city (see fig. 4.4) with many households in poverty. These households are struggling to maintain and without change, they are most likely to disappear from the area or end up on the streets. When this happens, the problem doesn't stop, it will only move to the next group of people that are next in line.

Around 47% of the San Rafael population lives in rental units. Because of the stress on the housing market, the prices for rental units keep increasing as well. Almost half of the households renting are paying more rent than 30% of their household income. Marin county states, that households in that situation have the right to social housing, but currently, there is no social housing available. So the current economic situation is not only threatening the residents of the canal district, everyone who is renting, is next in line if the housing shortage continuous (see fig. 4.3).

There are different ways to get into a social housing unit. There is a limited amount of units constantly available (city of San Rafael), these were built by real estate developers and they will stay available as social housing. There is also a voucher you can apply for (Marin Housing). Housing owners that are willing to rent their house under market price, will rent their house to these vouchers owners. However, with the current market, not a lot of house owners are interested in this system.

There are other county-, state- and national programs for affordable housing, but most of these programs have a waiting list, which are sometimes even closed. Or the program will move you to a completely different city or state. In other words, there is a serious shortage of available rental units on the local scale, and so the prices keep rising. There is a shortage of social housing units, and so more people enter financial problems.

The only way to break this is to create more housing units. Buying new houses is almost impossible for the people who are currently renting, so a majority would have to be made available for rent, both social and free sector. The houses that will sell could be very profitable and used to finance other housing units.

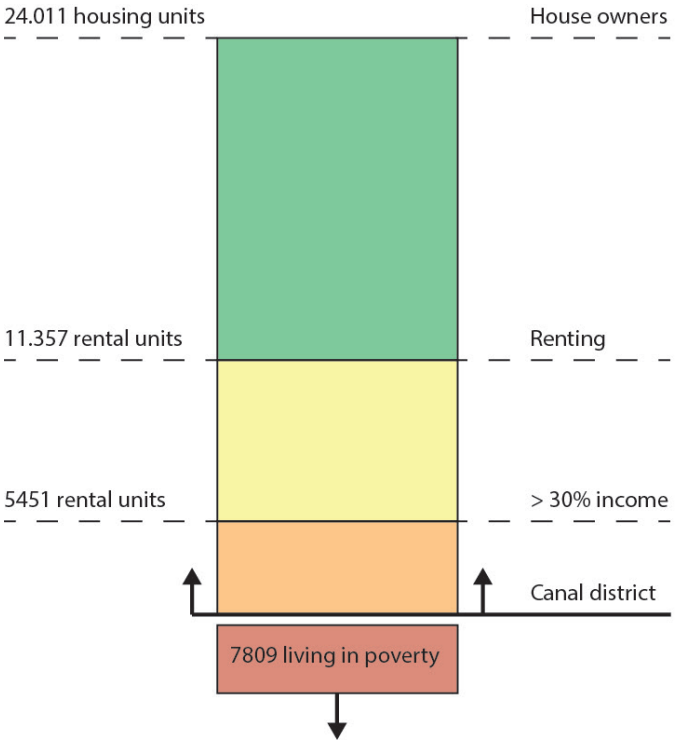


Figure 4.3 - The housing problem

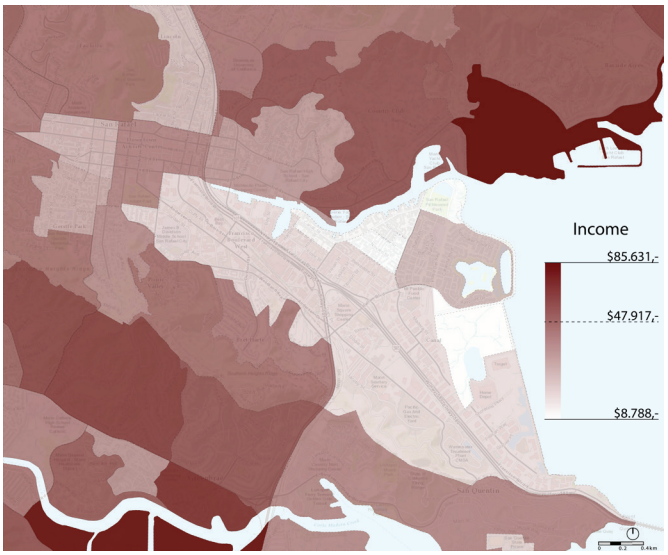


Figure 4.4 - Income San Rafael

Both per capita and per household, the inhabitants of the canal district have by far the lowest income in San Rafael, $8.788 (see fig. 4.4). In 'south-east' San Rafael adjoined to the canal district, you find an income per capita of $28.415, quite a difference between a couple of building blocks. In downtown San Rafael, the only location where you can also find a high density of social housing units, the average income per capita is 46.288, close to the city median.

With the high rental prices in the city, the only way to keep living in San Rafael is to share a house. The household size in the canal district is with 5.1 per household, far above the 2.4 city median.

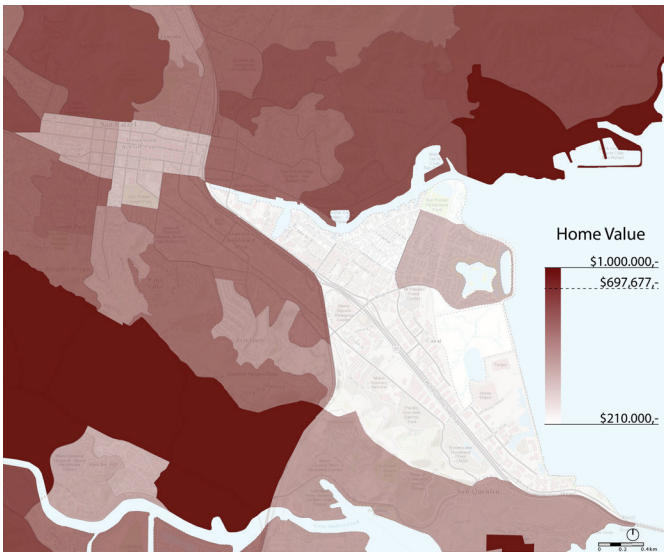


Figure 4.5 - House value San Rafael

With the pressure of the real estate market, there are multiple districts in San Rafael with an average home value of above 1 million dollars. In these area's you find large houses with their own private open space.

In downtown San Francisco you find a median home value of $411.667, below the city average of $697.677 but almost twice the price for a house in the canal district ($210.000, see fig. 4.5).

Redevelopment of the whole district, to create more housing units, could prove to be very lucrative. A mix of houses with their own open space and apartments could provide housing for different prices and different households.

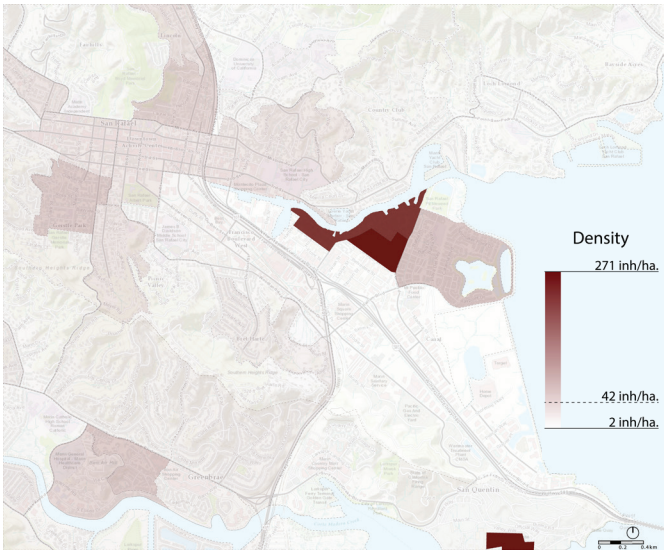


Figure 4.6 - Density in San Rafael

The extreme density of 271 inh/ha. (see fig. 4.6) is the result of sharing a house. It is done to keep living in San Rafael affordable. The median inhabitants per hectare is only 13,7 (data USA).

One of the higher populated area's in San Rafael is the downtown area, with a density of 57 inh/ha. Here you find a combination of social housing, free sector rental housing, and homeowners.

If you would build up the whole Canal district area, available for development (232,6 ha.), with a density equal to downtown San Rafael, the area could provide housing for a population of 12.800. With an average household size of 2.2, potentially 2180 houses could be developed, combined with commercial, businesses and light industrial facilities.

4.3 Interventions

The interventions regarding social economic development, are guidelines for redevelopment of the area. These guidelines are providing general rules for different kind of plot development, including; free sector housing, social housing, commercial industry and business and light industry. These guidelines are used in examples of redevelopment in the area.

Free sector housing:

- 1:1 development; for each house build in the free sector, the developer will have to contribute to the realization of a social housing unit.
- Solid housing line; the district will be redeveloped in the urban character that is equal to Downtown San Rafael, therefore the houses will be adjoined, moving away from the suburban preference.
- Public entrance; houses in the free sector will have direct access to public space.
- Private space; Each housing units in the free sector will have its own private open space.
- Infiltration or storage; if there is no option of infiltration in the private open space, there has to be a storage capacity. Housing units will have to deal with the rainwater falling in their own plot.
- Profitable; the free housing units will be established on the more attractive plots for maximum profit, along with the main green infrastructure and the canal for example.

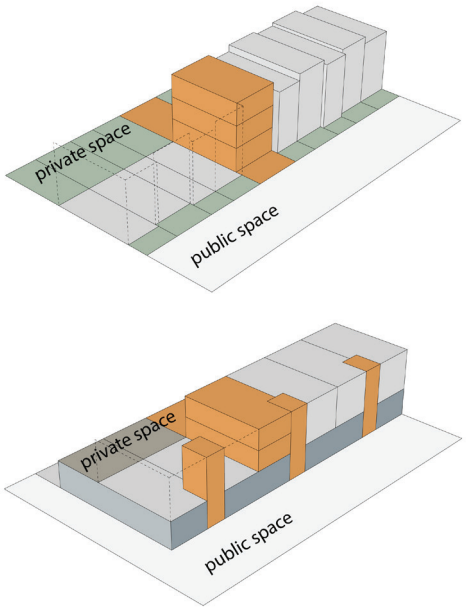


Figure 4.7 - Block rules free sector housing

Social housing units:

- 1:1 development; the social housing units will be financed through housing development in the free sector, for each house in the free sector, a social housing unit will be constructed.
- Additional stories; adding social housing to a block will allow for an additional story above the 10m city limit.
- Collective entrance; the social housing units can have their entrance away from the public space, adjacent to collective space.
- Integrated parking solution; combining parking solutions into the blocks will maintain the spatial quality of the streets. These solutions could also be used for free sector housing as a co-finance.
- Integrated water storage; Water falling on the plot should be stored on the plot. Blue roof or storage tanks should hold water for later discharge.
- Contribute to public space; each plot should contribute a % to public space (see fig. 4.10) multiple blocks could provide a larger open space in a cluster of social housing. These open spaces will function in a network through the district.

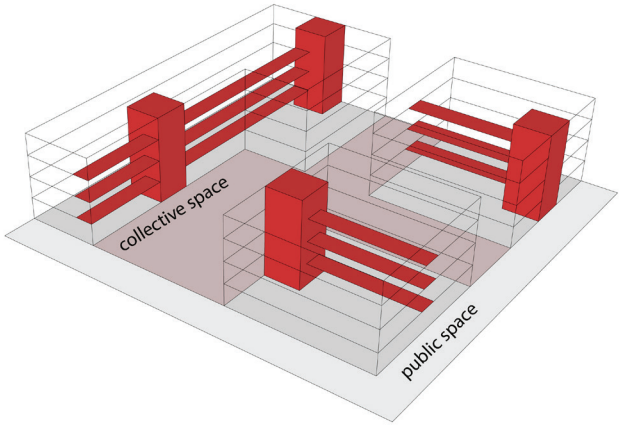


Figure 4.8 - Block rules social housing

Figure 4.9 - Free sector development interest

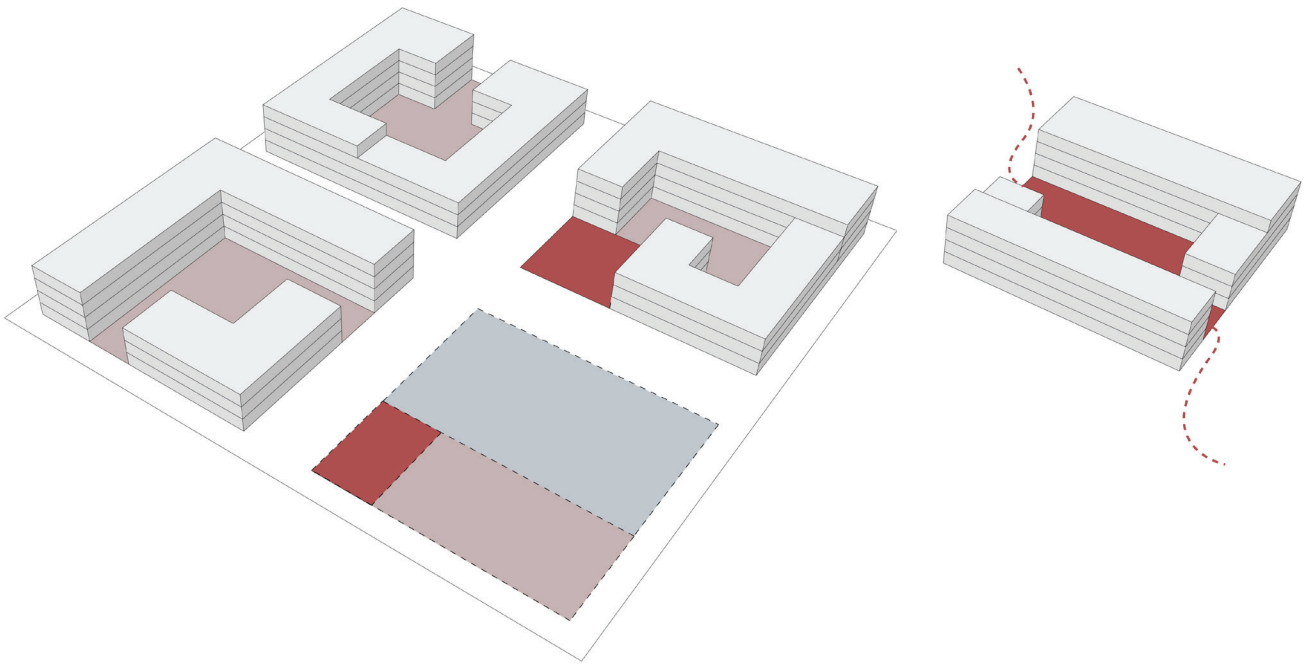


Figure 4.10 - Network of open spaces

Business clusters:

- Reservation for businesses; on these plots the ground floor will be reserved for businesses and small industries other functions may (temporarily) occupy these plots, but the rules for business clusters remain.
- Combined building plot; the plots will have to be combined with residential functions, adding social housing will allow for an additional floor about the 10m limit.
- Multiple stories; business spaces can use more than only the ground floor, as long as there is a combination of residential units.
- Raised ground floor; the ground floor has to be raised by at least 1 m, a raised second floor is allowed, not mandatory.
- Integrated parking solutions; parking facilities related to the building will have to be integrated into the building plot.
- Mobility; the business plots will be connected to the main infrastructure lines, for visibility and maximizing their potential (see fig 4.13).
- Business clusters are allowed to fill the whole plot area but will have to provide options for water storage as a countermeasure. This can be done by retaining water on roofs or storage tanks.

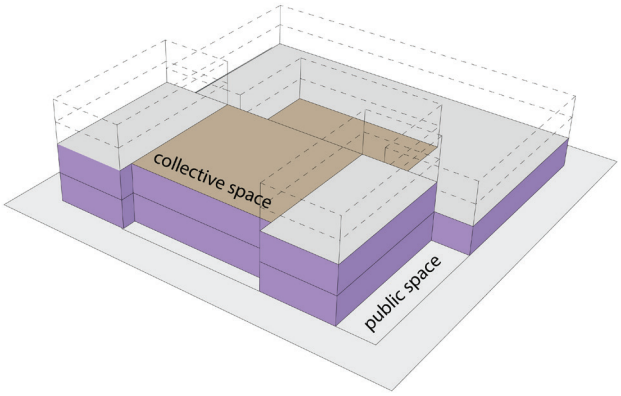


Figure 4.11 - Block rules business clusters

Commercial clusters

- Reservation for commercial use; these plots are assigned for potential commercial use, they can (temporarily) be used for other functions, but will follow the rules for commercial buildings.
- Combine functions; commercial buildings plots will be multiple stories high but only the ground floor will be commercial. The aim is to create a combination of residential units and commercial use. One function only plots will no longer be allowed.
- Raised ground floor; The ground floor of the commercial buildings will be raised by at least 1m., even if there is no commercial function available, the reservations for commercial use will remain.
- Attractive plinth; at least 50% of the plinth adjacent to the public space will have to be kept open.
- Network with public transport; the viability of commercial functions as related to mobility. The clusters of commercial functions will be nearby transportation hubs (see fig 4.13).

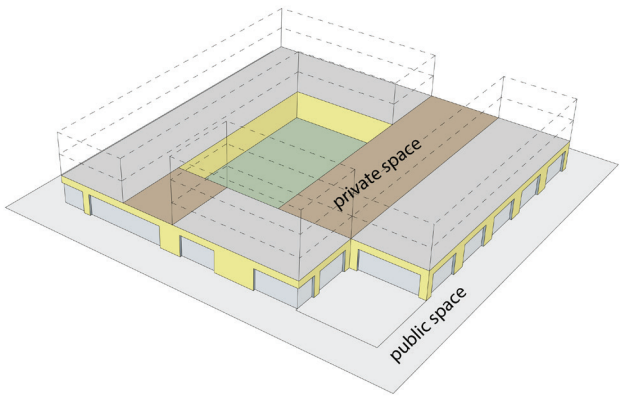


Figure 4.12 - Block rules commercial clusters

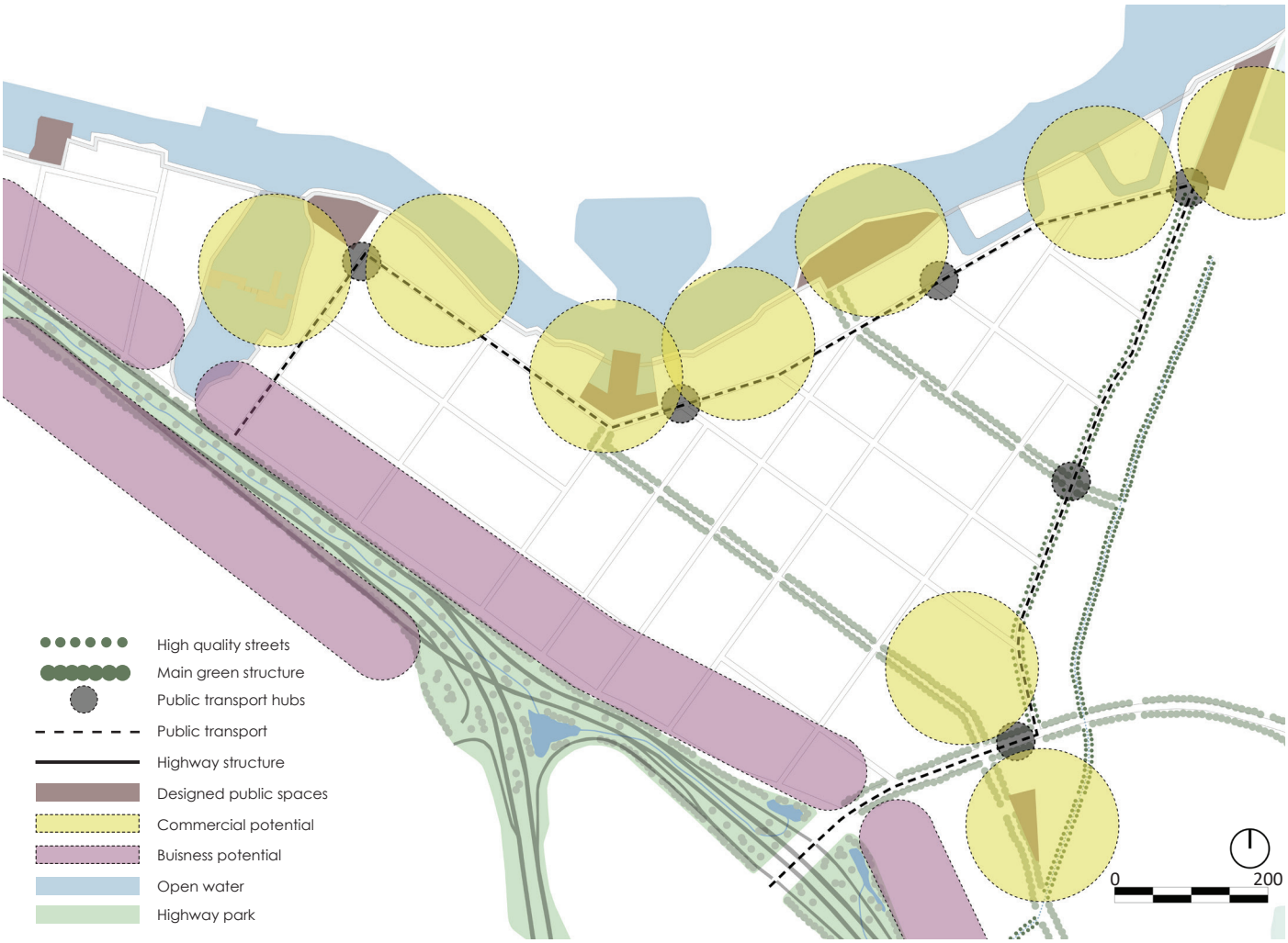


Figure 4.13 - Commercial and business locations

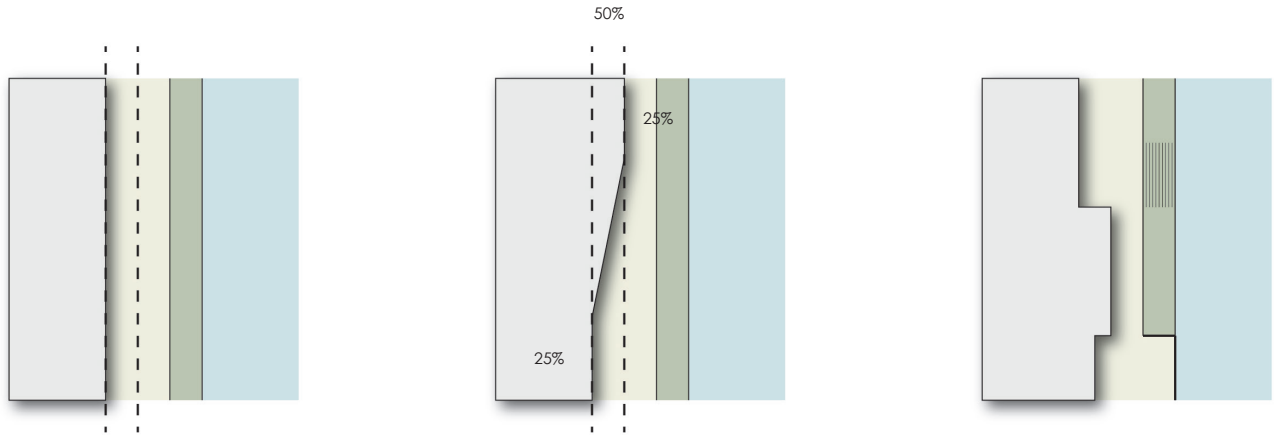


Figure 4.14 - Waterfront spatial guideline

For the commercial industry along the waterfront, additional guidelines will be set. The waterfront should be a great potential for economic gain. To create an interesting waterfront, the buildings along it, will have to contribute to shaping the public space.

The buildings will have a five-meter width area in which they can variate their building line. 50% of this space is allowed to be filled, but the building line has to be a variance. By establishing a minimum percentage (25%) of maximum and minimum alignment, interesting spaces will appear.

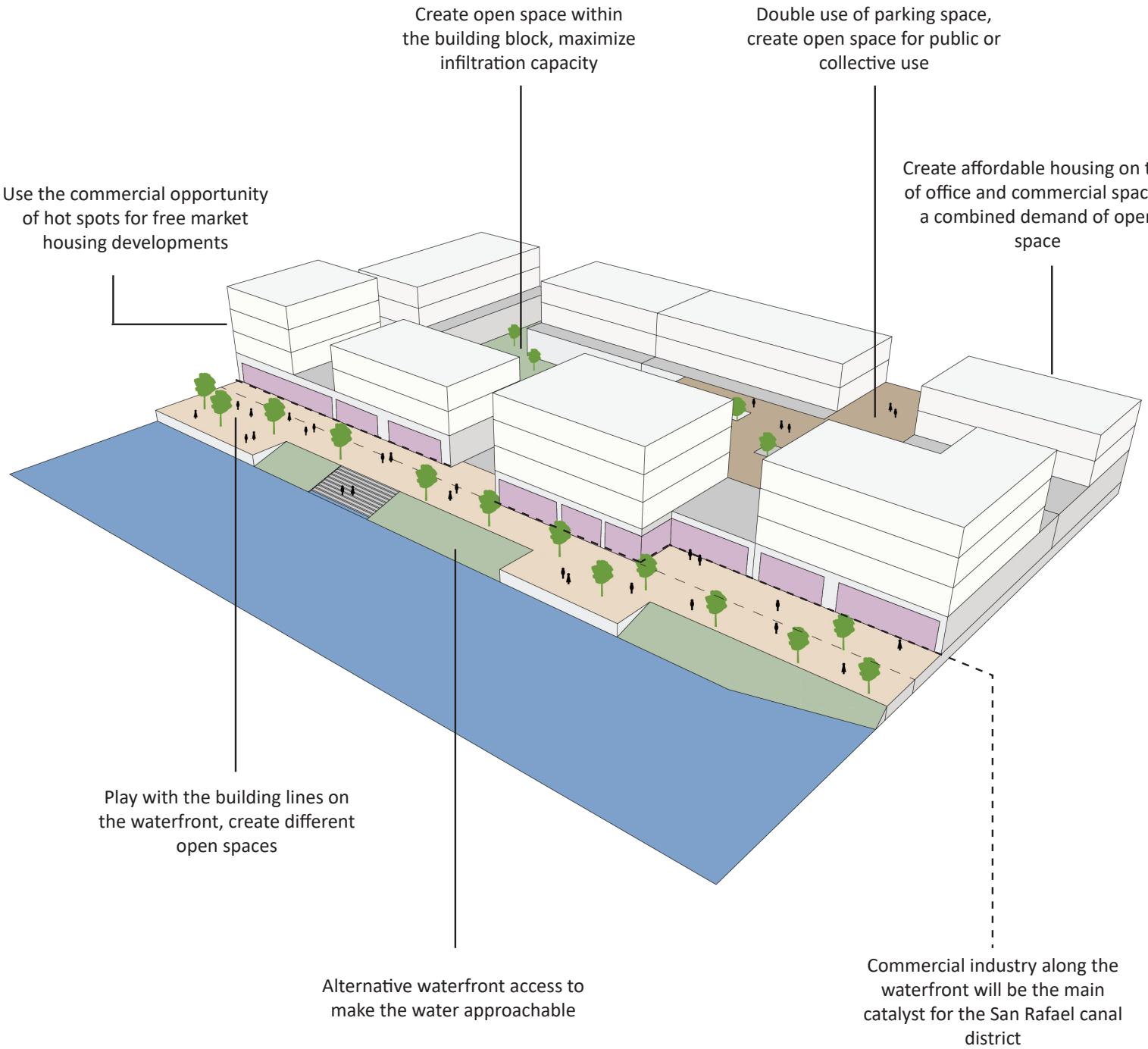


Fig 4.15 - Waterfront development

This new design for the waterfront is an example of combining the different functions in the district (see fig. 4.15). Along the waterfront, there should be plenty opportunity for commercial functions. But for shopping and recreational purposes.

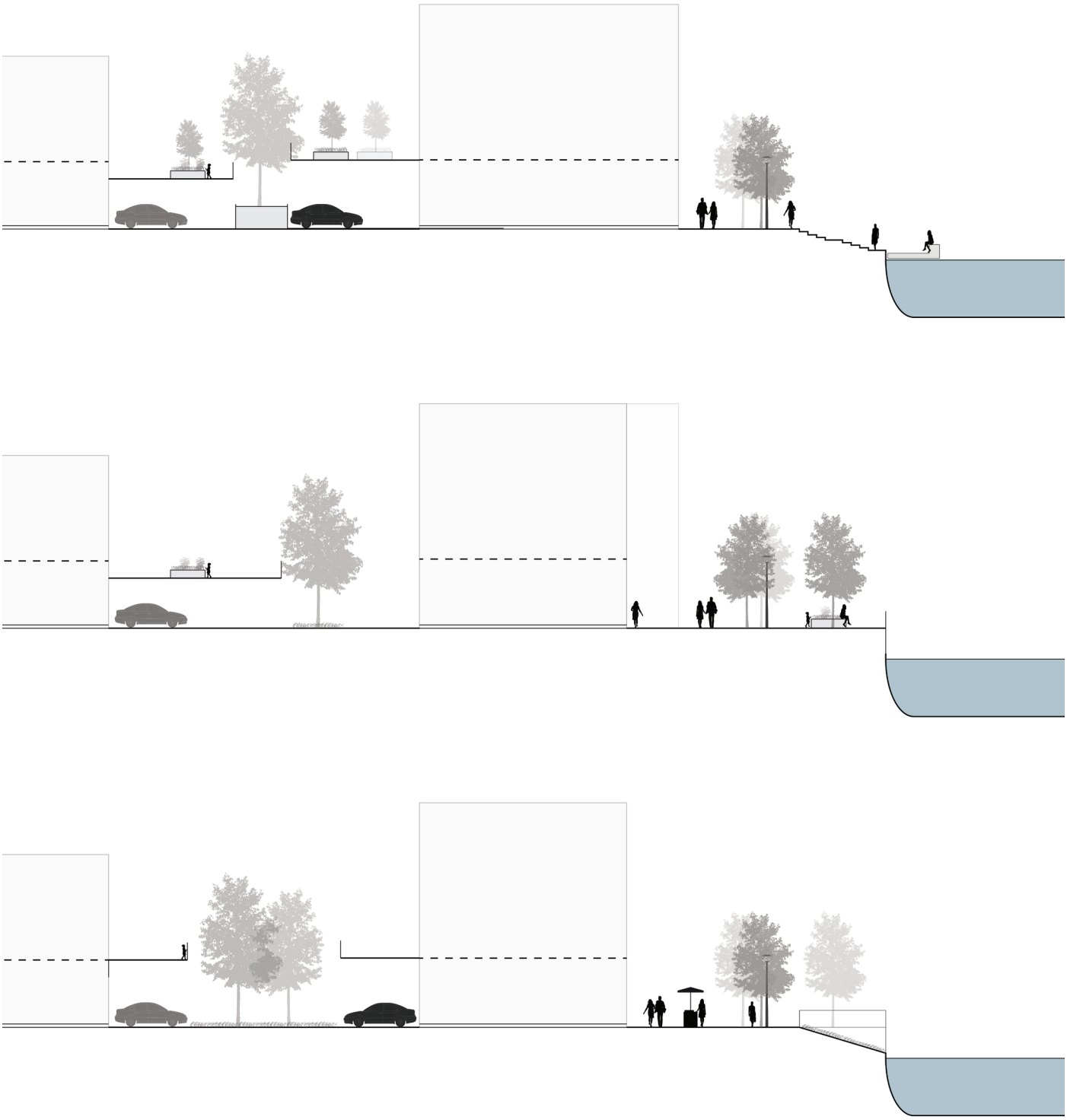


Figure 4.16 - Waterfron sections

The waterfront is a big impact intervention to stimulate redevelopment of the whole canal district. It will be the red carpet running from downtown San Rafael to the Bay. A combination of different open spaces and a commercial attraction for locals and recreational visitors (see fig. 4.16).

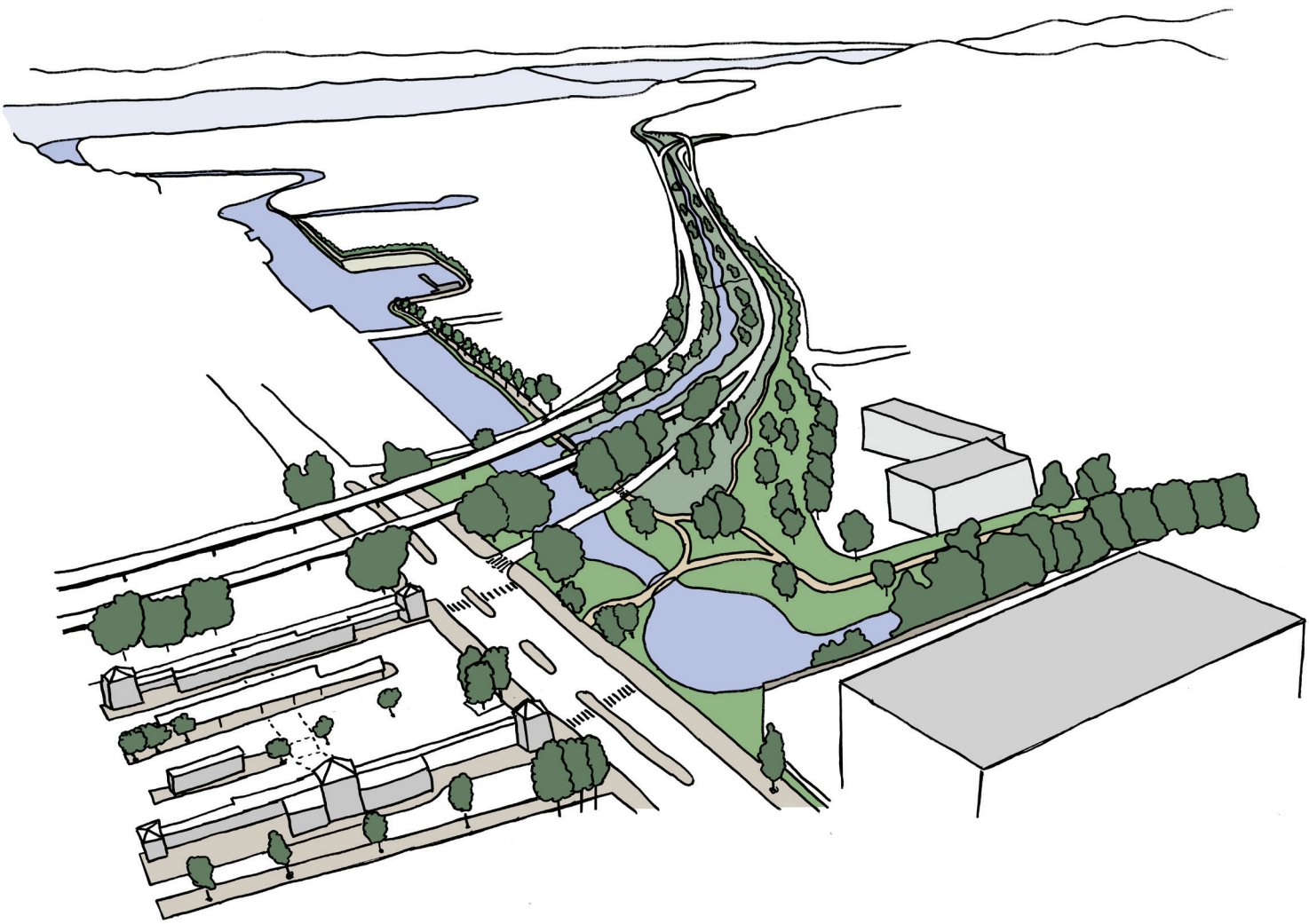


Fig 4.17 - Downtown-canal hub

In order for the canal district waterfront to be successful, the area should be easily accessible from downtown San Rafael. Due to the changes in mobility (see mobility chapter) and the redesign of the highway knot, downtown will have a park on the water that serves as the entrance to the new waterfront design (see fig 4.17).

By these interventions, San Rafael will regain it's identity of a harbor city, with a city center at the waterfront. Growing interest in the area will attract a mixture of different households, instead of a pure concentration of households in poverty.

Fig 4.18 - Canal district marina

The marina of the Canal district will be opened up from multiple sides (see fig. 4.18). It will be connected to the waterfront walkway as an extension of it. It will also form a link between the highway passage and the waterfront.

Even though the district is alongside the water, the marina's are very private areas. By opening up this marina, you draw people to the water and create commercial opportunity on and off the water.

An idea for the marina would be to create a floating dock in the middle of the marina, like the dock in Hafencity, Hamburg (see fig. 4.19). With a simple open and close bridge system. This way people can enjoy the marina from the water and cross the marina.

Fig 4.19 - Hafencity, Hamburg

Another example of opening up the neighborhood for more interaction between its residents is the street separating the different neighborhoods in the canal district. These are the neighborhoods build in the 60's and the 70's. The difference between these two neighborhoods is visible in the street view analysis (see appendix).

A survey of the municipality of San Rafael revealed that the separation between these two neighborhoods is so huge, that the people opposite of the street prefer to be called residents of 'south-east' San Rafael rather than residents of the canal district.

Neighborhood forming within a city is unavoidable according to Jane Jacobs. Neighborhoods will form itself. What you should not do, is emphasizing the edges between neighborhoods. In the current situation this particularly streets does exactly that.

The street separating the neighborhoods has a bank in the middle of the street, filled with a line of trees. Because of this line in the middle, the street can only be crossed on the crossing, this negates free roaming through the neighborhood and connection of residents (see fig 4.20).

By redesigning the street with a green line on both sides, you keep the character of an avenue but you allow for crossing. Simultaneously, the room requirement for a two-way street is less than a one-way street. Allowing for more pedestrian room (see fig. 4.21).

To stimulate interaction between these two neighborhoods, in the length of the avenue, public places on both sides should be created. By creating these on alternative sides, you invite people for interaction, without forcing them into it (see fig. 4.22).

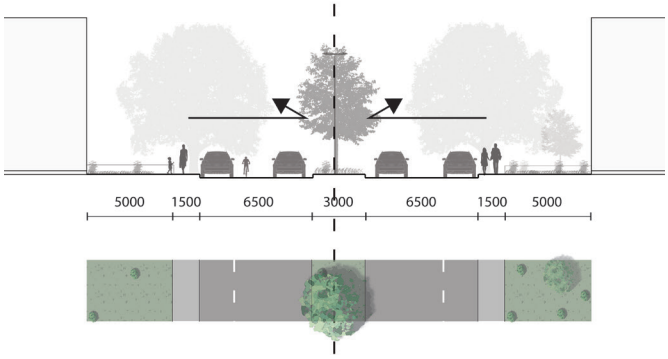


Fig 4.20 - Blocking interaction

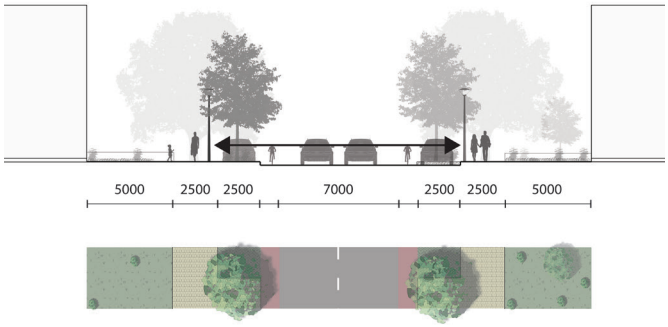


Fig 4.21 - Stimulating interaction

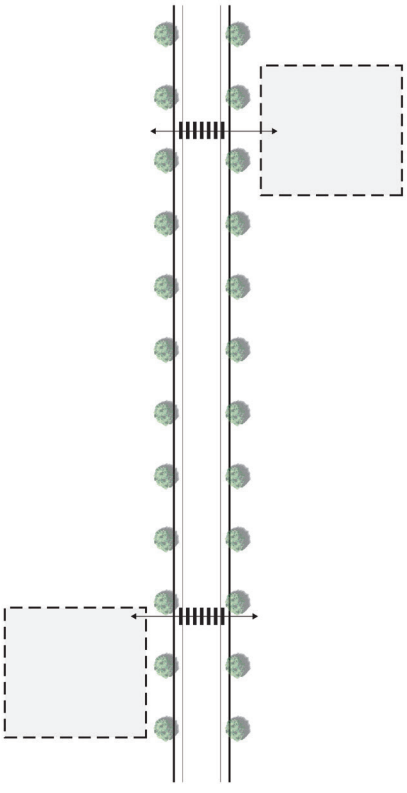


Fig 4.22 - Inviting interaction

Conclusion

Above all, the whole bay area desperately needs more housing units. Most of the area is completely filled and development options seem scares. But area's like the canal district can easily be transformed into more densified areas. By keeping the functions in the area, but combining them with housing units, most of the space can be used more efficiently then it is now.

By adding more quality and more open space to the district, commercial potential possible financial gains will attract residents in a higher social-economic situation. Mixing these different groups of people in the area, but not forcing them to live together, can be the catalyst the canal district needs.

5. INTERGRATION

5.1 General scheme

The interventions in the previous chapters are the ingredients used in the general schema. They are addressing the different problems that can be found in the Canal district; the isolation of the area, the lack of permeable surface and poor spatial quality and the high concentration of people in poverty due to a high housing market. The possible interventions for these problems are the building stones for the redevelopment. The general scheme is the guiding hand from a vision perspective.

The vision for the canal district started from the perspective of two points. The first was spreading out the resident of the canal district neighborhood over the whole area, giving them the space they need. The seconds was to create a green infrastructure through the area, connecting the canal with the wetlands.

This resulted in two different networks in the area, one network of green, as a water management solution. A network that would bring a spatial quality into the district. The other a network of public spaces, connected to commercial functions.

These two networks should cross each other and strengthen each other when met (see fig 5.1).

The different edges of the area need transformation, the waterfront will need to be accessible, visible to use it's economic and spatial potential. By having one site of the water focus on the commercial use and the other on water activity, both the water and the waterfront would be an interesting place to beat.

The strong separations in the neighborhood will have to be addressed and removed or transformed to improve the mobility and connectivity between the neighborhoods.

This vision leads to a spatial design with public area's at the waterfront, a restructured street system, and a highway park (see fig. 5.2). The block suggestions will be filled in according to the set block rules.

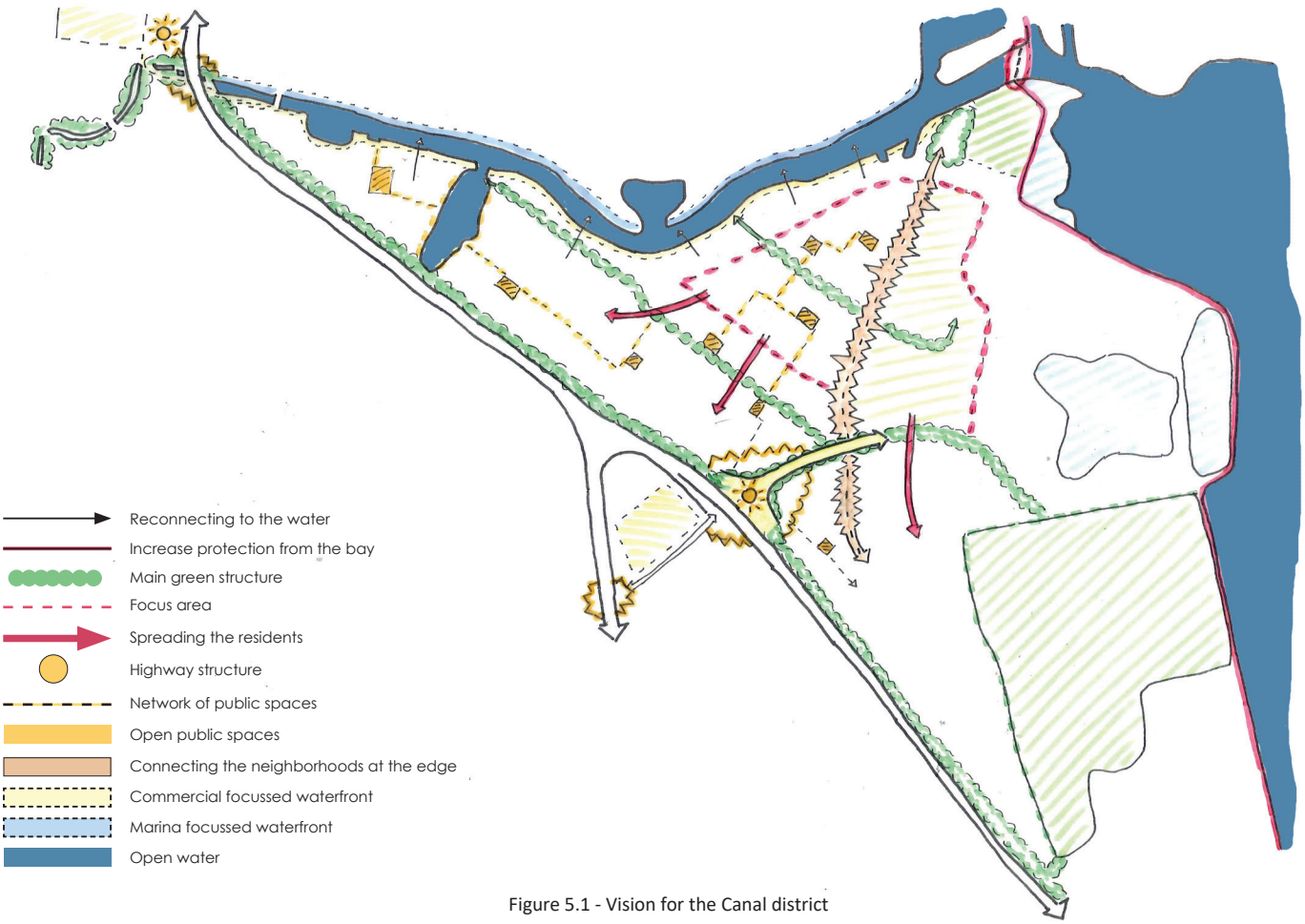
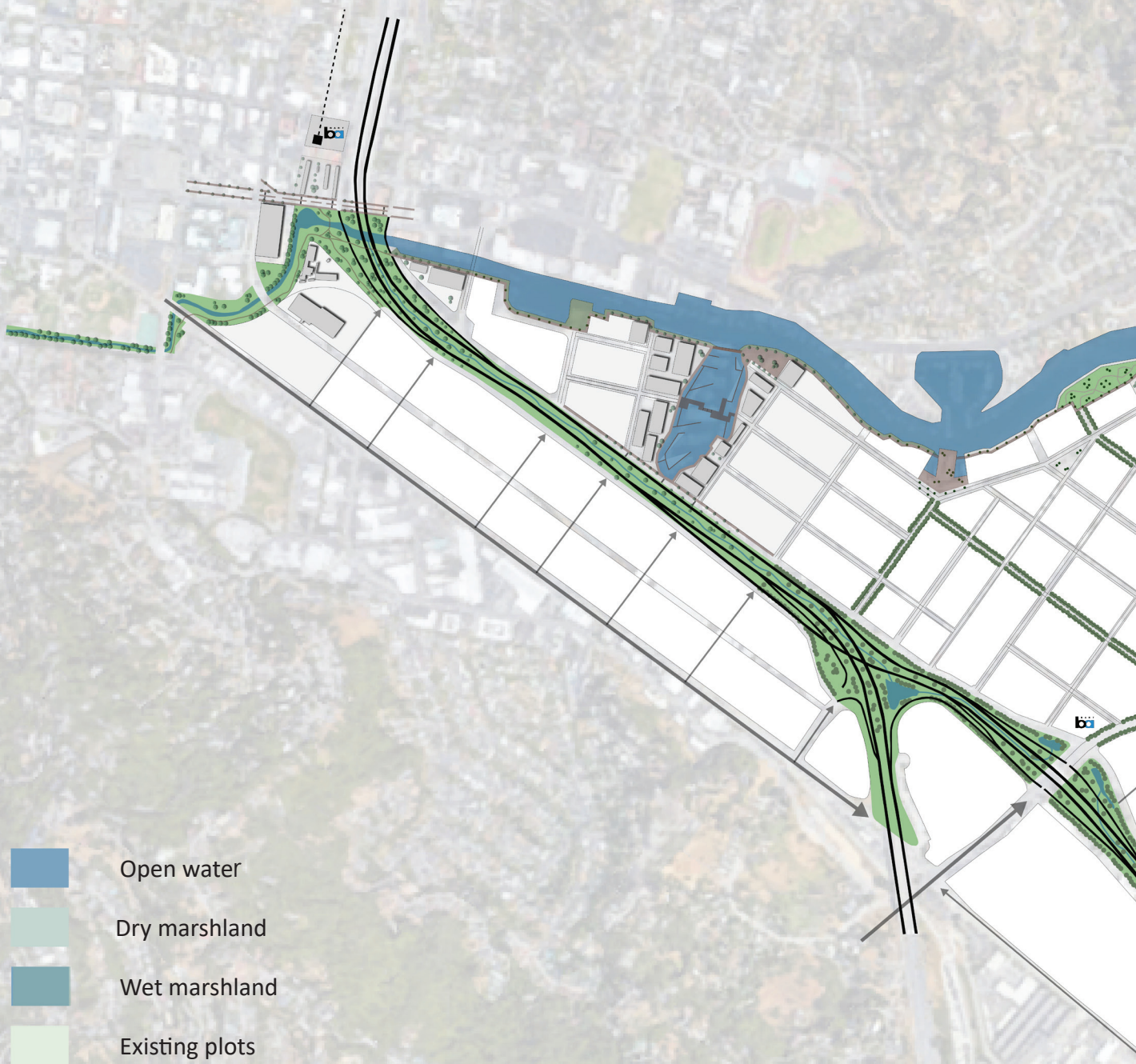


Figure 5.1 - Vision for the Canal district



Open water

Dry marshland

Wet marshland

Existing plots

'Highway park'

Public waterfront

New / alternative plots

Building suggestions

Wadi network

BART Stations

SMART Station

New / alternative roads

Highway connection

Figure 5.2 - General scheme


0
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5.2 The strategic plan

The strategy of the redesign evolves around attracting actors willing to invest in the neighborhood. By increasing the potential of the neighborhood with big impact interventions that will be noticeable on a larger scale, the area shall put itself on the map. By guiding the developments, through governance agreements to create social housing units along with free sector housing units, both an economically attractive neighborhood will be formed and a home for its current residents.

The main inspiration for the strategy is the Four track approach from Stijn Oosterlynck (see fig. 5.3). The idea behind this system is that you work on different levels with different layers of governance and actors.

The first track is about a long-term vision and maintaining the course of this vision. Normally this long-term vision is purely based on a spatial desire. For the canal district, this first track will consist of a vision evolving around water protection for the area. The projects as a result of the strategy work toward protection of the area.

On the second track, the municipality of San Rafael acts as the regulator. They make sure that the set rules are followed. The public space interventions will be done from the perspectives of water management solutions, improving the spatial quality of the neighborhood.

The third track is where the different actors meet. Investors interested in developing the area, but also property owners and (commercial) industry already present. This way actors from outside and inside the area will work together towards a desired future for both.

The last track is where most of the canal district residents find themselves. It's about socially disadvantaged groups being able to participate in the planning process. Their input should shape the public spaces to their needs.

When the different actors of the tracks come together, they create an action plan or come to policy agreements to reach an outcome that benefits all. These lead to strategic projects.

There are three factors that contribute to the success effect of strategic projects:

- Projects are executed on a small scale but serve as a catalyst and impact on a larger scale. It's about mobilizing new actors that can tag along to the first track.
- By bringing together different actors from different positions in the economy, together they can build the economy that is most suitable for the area.
- Strategic projects can be small-scale and more feasible. When implementing first the local society will benefit before influencing on the larger scale.

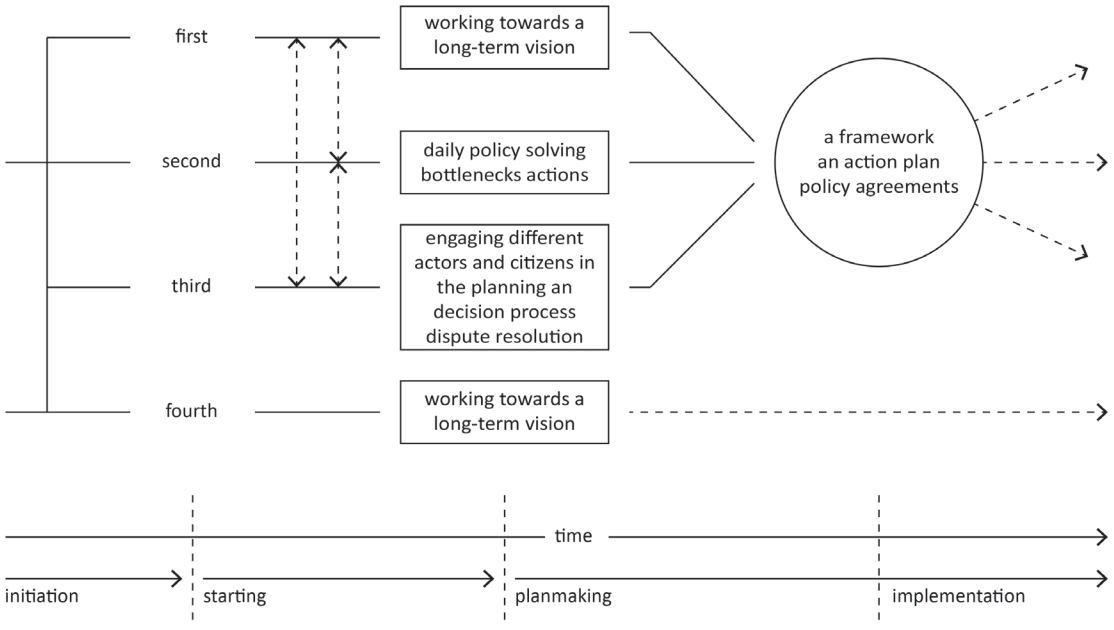


Figure 5.3 - Four track approach

With the four-track approach in mind, the first actions that will be taking are the spatial interventions along the waterfront. One by one the open spaces along the waterfront can be realized, creating a local opportunity for commercial spaces along the water and improving the relationship with the water. The building development along the waterfront can follow the spatial interventions of the public places.

Combining the new waterfront with downtown San Rafael will change the relationship between the city center and the canal. As soon as this connection is established, residents from all over the city might walk into the canal district, driving the interest of the area. In the time it could attract residents from the whole bay to visit San Rafael and the waterfront.

An incentive from the higher level of governance (the first track) to stimulate the development would be to guarantee the flood prevention. By creating a new levy with an option to close off the bay, developers would be more interested to invest in the area.

The redevelopment of the area could start with the densification of the more industrial zones. The different actors, both outside investors, and local (commercial) industry owners, could work together towards the realization of new housing units, both for the free sector and social housing. These developments will again be guided by the municipality.

At this stage interest from a larger scale is to be expected. Residents from outside the area looking to settle in the canal district. By connecting downtown San Rafael to the BART system at Richmond, the city and the canal district will become part of the metropolis of the San Francisco Bay.

Transforming the current canal district neighborhood will be a larger investment, this area will need thorough redevelopment. Waiting with this area till the interest is grown to a higher scale is crucial. In the redevelopment of this area, the focus will be more on redeveloping towards the free sector. Due to the expenses of demolishing and rebuilding.

In time, depending on the rethinking of our current mobility system, the highway structure will be completely revisited over its entire length. The economic gains from the housing development can be used for this spatial intervention.

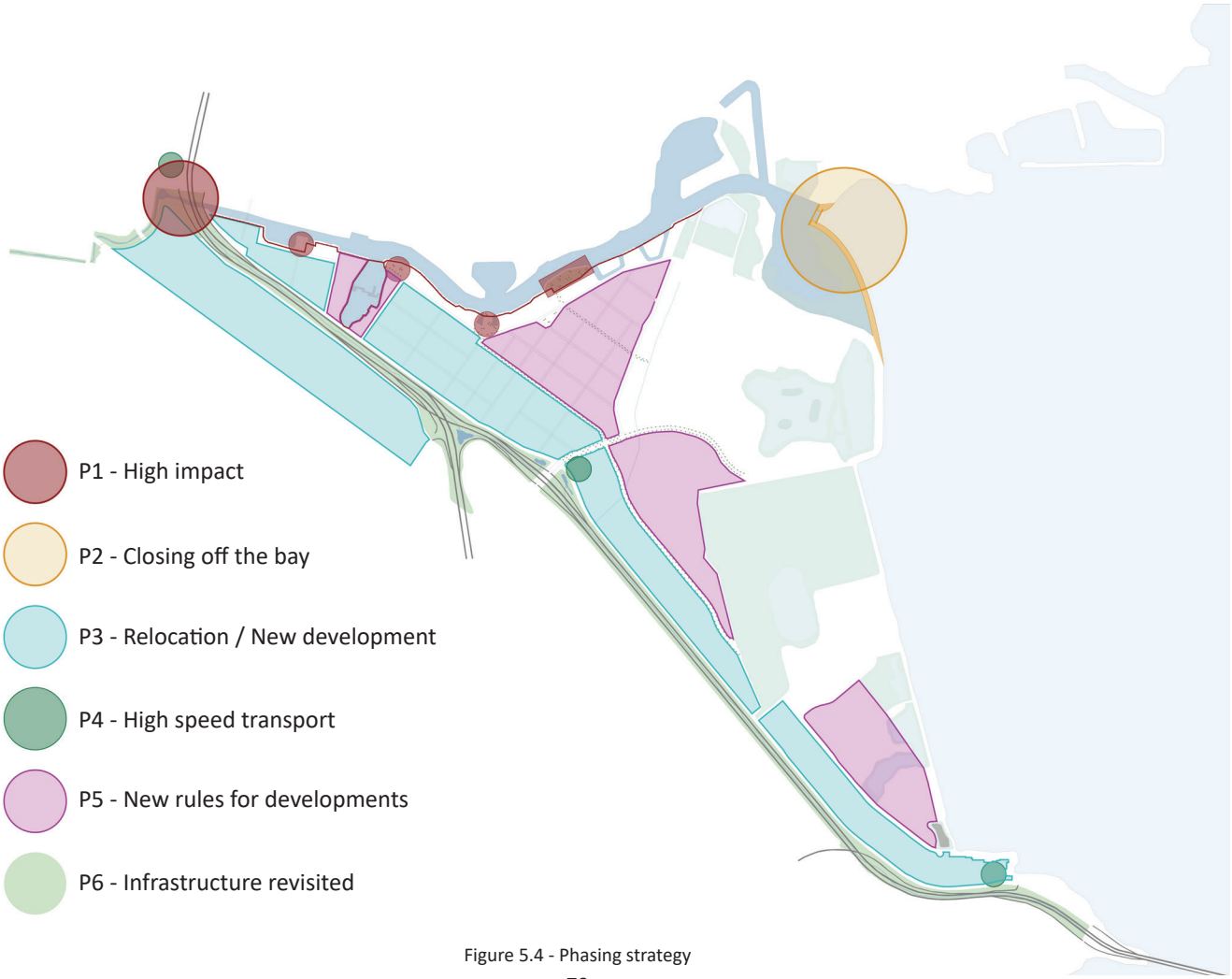


Figure 5.4 - Phasing strategy

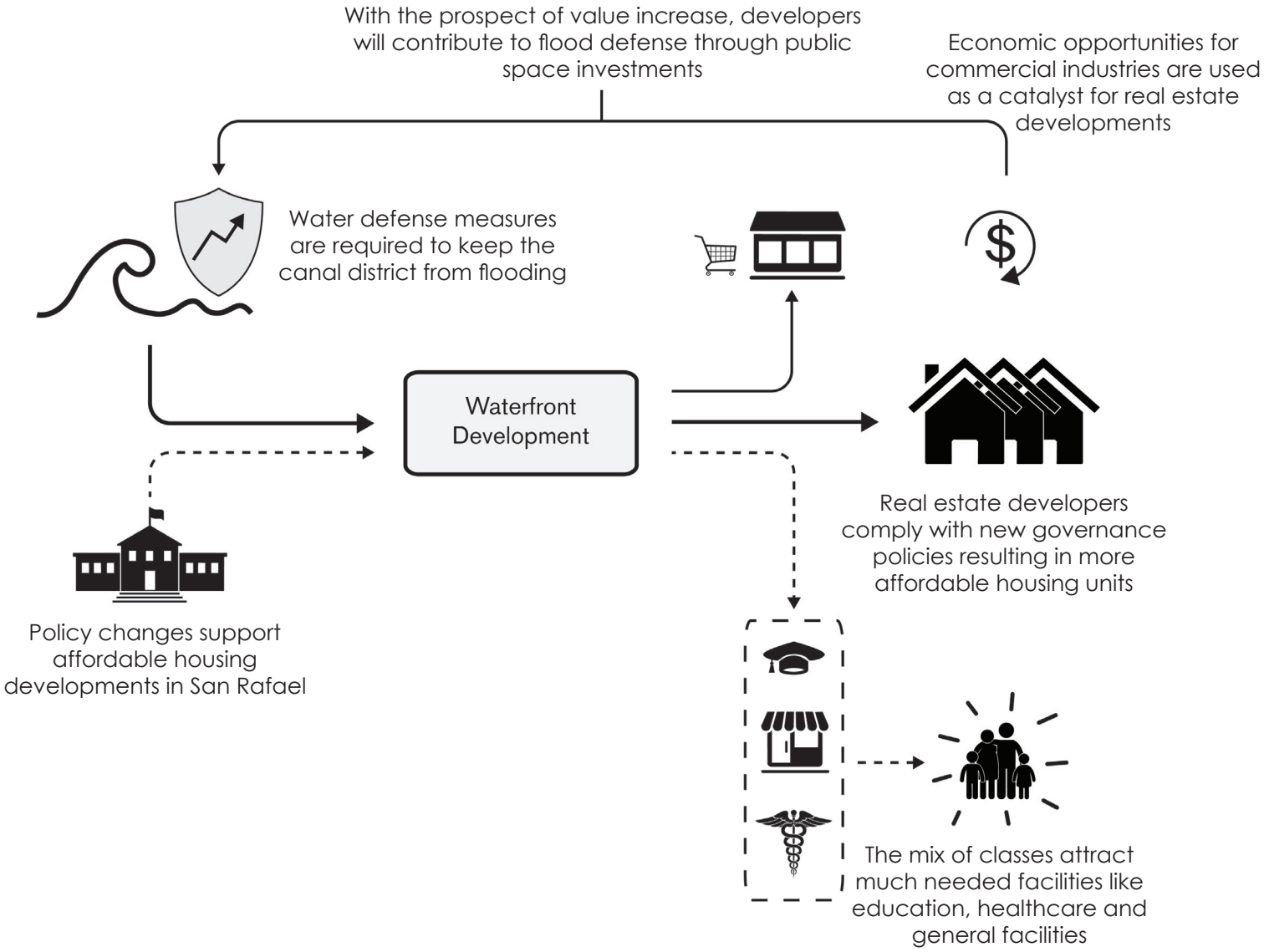


Figure 5.5 - Double interest scheme

A big part of the strategy is providing the current resident of the neighborhood with needed facilities like proper education and healthcare. By inviting the residents, as the fourth track in the Four track approach, they become actors in the redevelopment of the neighborhood and are able to steer developments in their benefit.

However, the driving force of the strategy will have to be the economic gain, from the potential of the area. By protecting the area from water, and implementing water management solutions with a high spatial quality, real estate developers will be willing to invest in the area.

At first, an investment will be needed, by allowing for developers to redesign the area in return for water management solutions, a start can be made. As indicated before, most of these water management solutions have a desired effect on the spatial quality, increasing value to the area.

Developers will start to make a return after the construction of property, making them able to invest in larger water management investment, like the wadi system. Again this brings a quality and returns their investment in time.

Along the development of the water management options, policies for more affordable housing are in place, making it able for the current residents to remain in the area. The mix of classes, both the current resident and the newly settled residents will create a demand for public facilities of high quality. These are the kind of changes that are needed for the current residents. The facilities together with a place to live will allow them to maintain themselves in the area or even better themselves.

The parcellation of the blocks within the area (see fig. 5.6) correspond to the set guidelines in the social-economic development interventions (see chapter 4).

The waterfront should be viewed as an extension of the city center, along the whole waterfront should be room for commercial spaces. Another center of commerce is the main entrance to the canal district.

Even though the change in mobility should result in less car traffic along the highway, it is still the most interesting location for businesses, with a future park underneath the highway it is both a good spot for business and living.

The harbor in the canal district will be strengthened by improved mobility towards the waterfront. Surrounding the harbor facilities supporting water and waterside recreation will remain.

The center of the canal district will remain residential, with opportunities for commerce and recreation in all directions.

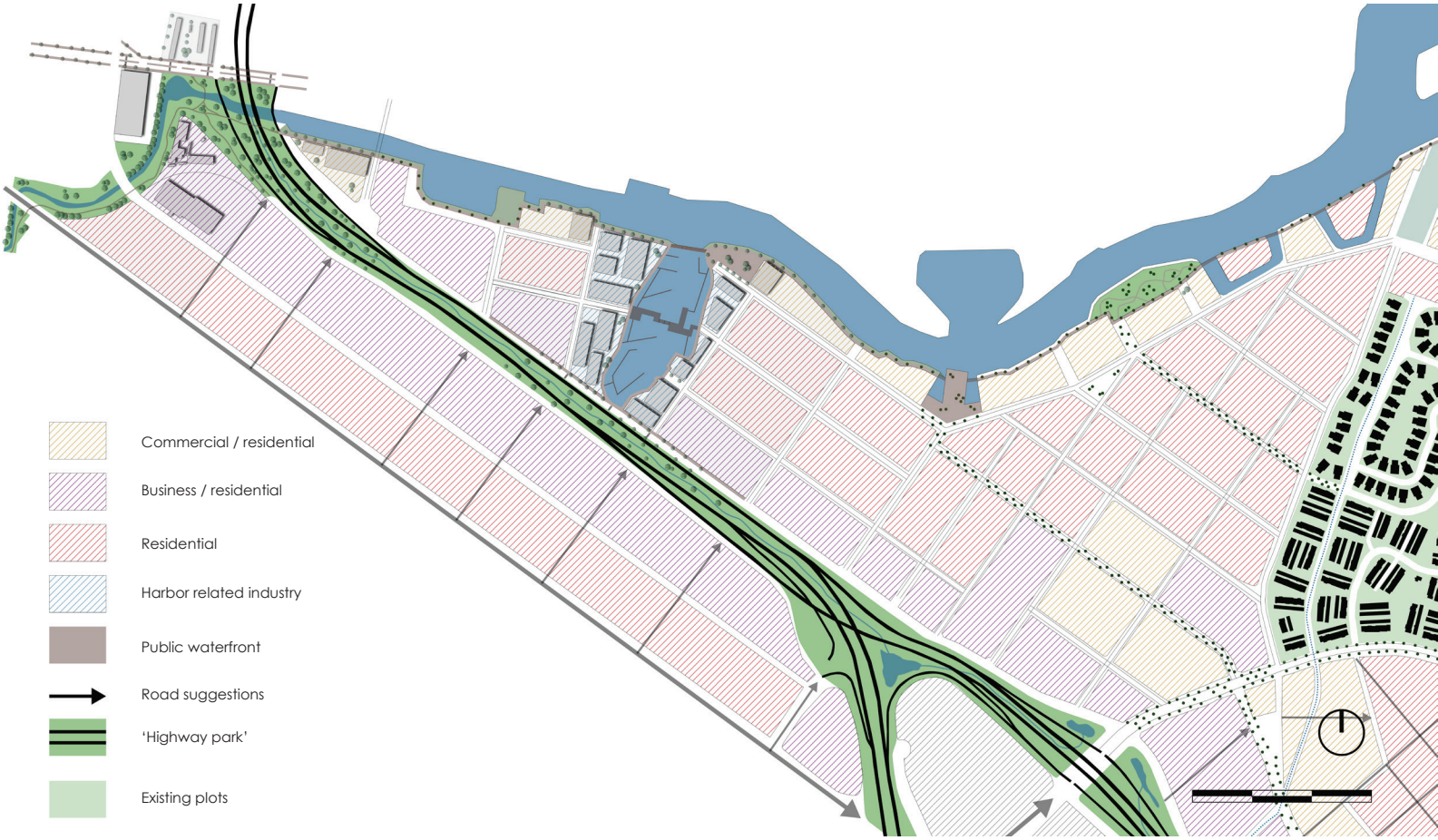


Figure 5.6 - Parcellation

Redeveloping the neighborhood with governance policies as guidelines will change the governance situations on multiple levels of government. From the federal government to local actors participation and action are required. This is an overview of the most important changes in governance that is required to make the redevelopment of the canal district a success.

Federal Government

- Coastline:

Current situation:

The Army corps of Engineers is responsible for the coastal defense, this includes the open San Francisco Bay. They maintain the levees in the district but not the edges of the canal. These are currently not maintained at all.

Governance intervention:

The Army corps of Engineers should construct the new levy that separates the Canal and the Bay. This separation could be done by sluices, or it could be a pure floodgate, only used during king tides. The maintenance and the responsibility will lay with the Army corps of Engineers. This creates more security for developers and does not create unwanted responsibilities for waterfront developers.

The state of California

- The Bay:

Current situation:

The San Francisco Bay Restoration Authority is tasked with the revitalization of the coastline around the bay. They work on restoring former marshlands. As a government authority, they have the power to intervene in developments on and near the bay edge.

Governance intervention:

The proposed wadi system is a flood measurement, but it also provides the opportunity to revitalize the former marshlands. By including the SFBRA in the planning and design progress, additional funding might be possible, and they might even provide maintenance towards the benefit of the marshlands.

Marin County

- BART and SMART:

Current situation:

Marin County has revitalized the old train tracks and the SMART rail is being used from San Rafael Downtown to Sanoma county airport. In a future phase, a connection between the smart rail and the Larkspur Ferry is planned.

Governance intervention:

By connecting the SMART rail with the BART network, the public mobility from and to Marin county will greatly increase. This will create an economic opportunity for tourism, jobs and development opportunities.

- Affordable housing:

Current situation:

According to the rules set by the county, households that spend over 35% of their income on rent, should be eligible for affordable housing. Almost 50% of the households renting are spending more than 35%. Development rules currently state that real estate developers have to create one affordable housing unit per 20 houses.

Governance intervention:

More housing units are needed to relieve the stress of the real estate market, but focussing on smaller housing units and affordable housing, residents can move out of the houses they can no longer effort and these come free on the market. New real estate developments should create close to 50% affordable housing. These housing units can later be changed to rental units when the residents have the change to grow with the economy.

- Watersheds:

Current situation:

Marin County has multiple watersheds that lead from source to marshland. Many of the developments alongside the marshlands are threatened by flood risk

Governance intervention:

Marin County should consider implementing watershed authorities. There are a lot of special district and municipalities sharing one watershed. By the creation of a watershed authority, the responsibility of maintenance and planning is more clear.

Municipality of San Rafael

- Buildings

Current situation:

San Rafael has a building restriction in height, 30 feet for single use buildings and 36 feet for mixed-use buildings. Which means that a building at maximum height will have 3 stories. Downtown San Rafael has additional rules for building, adding a story of parking or social housing units, will allow for an additional story.

Governance intervention:

With the canal district becoming a physical extension of downtown San Rafael, the same building guidelines should be adapted to the neighborhood. Allowing for higher buildings in combination with affordable housing will increase the number of housing units.

- **Waterfront:**

Current situation:

The waterfront is filled with buildings that have their back towards the water. High-density housing units with barely any spatial quality.

Governance intervention:

The waterfront will be completely redesigned, which means that the municipality will have to buy up most of the land. These costs will be returned by developers who are allowed to build high-end housing along the water.

- **Guidance:**

Current situation:

The building restrictions for new developments in San Rafael are very limited, other then a zoning plan and a maximum height, developers are left free, resulting in most suburban neighborhoods.

Governance interventions:

When it comes to the canal district, the municipality will have to be hands on. Both the policies for affordable housing as the policies for water management will have to be enforced. The economic success depends on the prevention of flood and the social development on the presence of housing units.

- **Landowners**

Current situation:

The buildings in the district old, single or two stories and most of the public spaces are used for parking.

Governance intervention:

The landowners, developers, and municipality should work together on the project, they are the first, second and third layer in the four-track approach. For landowners, there is a financial gain by creating more space on the same piece of land.

Developers

- Buildings:

Current situation:

Developers create a series of housing units, only if they exceed more then 20 houses, they'll have to create affordable housing units.

Governance intervention:

In order to develop real estate in the district, developers will have to build an equal amount of free sector units and affordable housing units. These don't have to be on the same plot. The more expensive locations will be used for the free sector houses, to compensate the developers for their contribution.

- **Public space:**

Current situation:

Developers build on the plot, the public space is financed by the municipality.

Governance intervention:

One of the main goals is to create a network of public spaces throughout the neighborhood. The guidelines regarding the social housing units include public or collective spaces, these will have to be included in the development of the plots.

- **Funding:**

Current situation:

The area is not really worth investing, the spatial quality is poor and the interest in living there is not high.

Governance intervention:

Together with the municipality a plan will be made to first address the water management problems, and by doing so creating a spatial quality worth living around. Developers willing to invest in those first actions will be rewarded with the development of the more lucrative locations later on.

- **Residents**

Current situation:

The average income per capita in the canal district is far below the poverty line. Job security for these people is low and there is no economic improvement in sight.

Governance intervention:

Invite the local residents to participate in the planning and realization of the district. They know what kind of public spaces they need, and what facilities are most needed in the neighborhood. Bringing them around the table will benefit them in the long term. Redevelopment of the neighborhood will take a long time, and provide a lot of job opportunities. By actively trying to use the local residents they can economically benefit from improving their own neighborhood.
all directions.

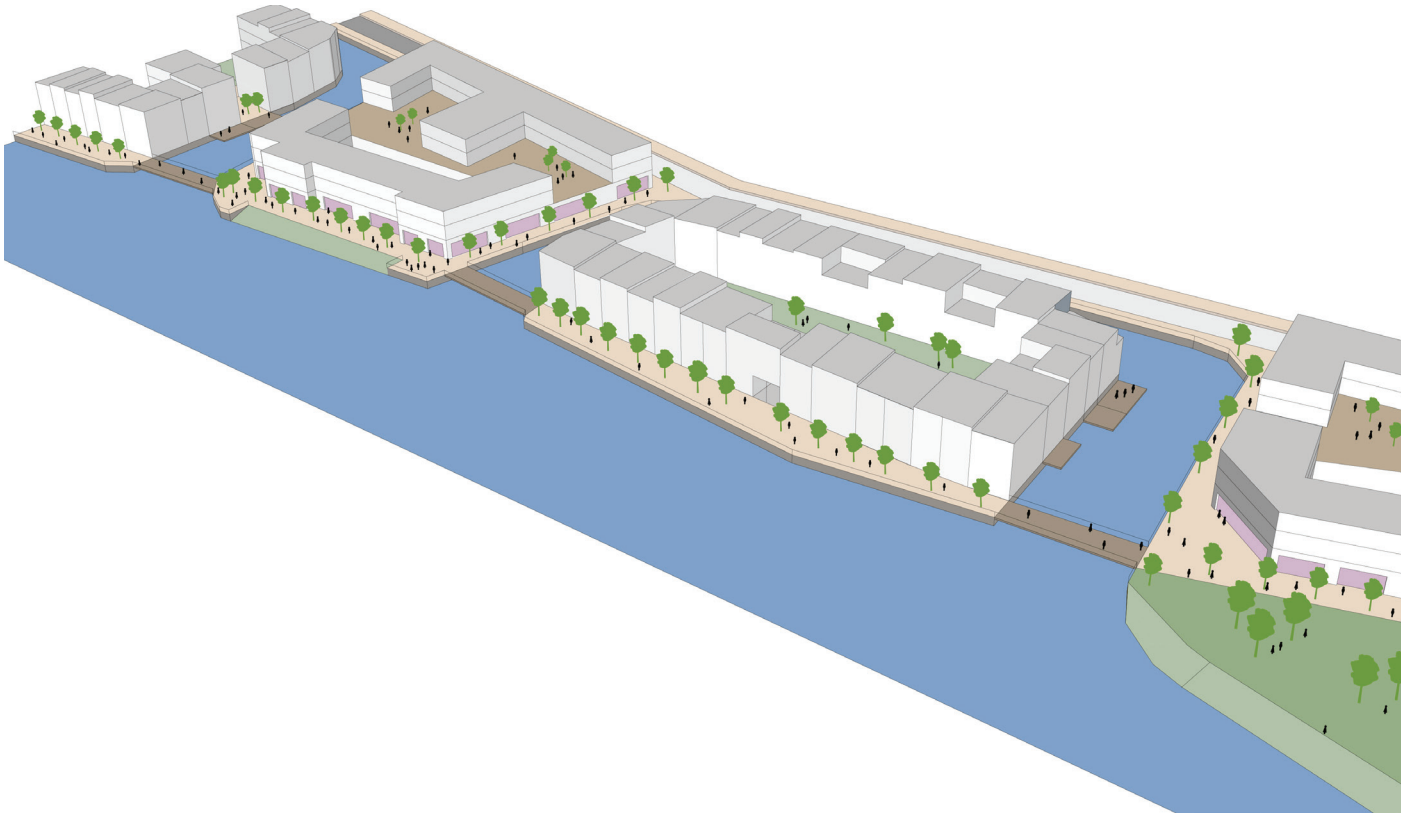


Figure 5.7 - Canal islands

In the canal, two small waterways will be created, forming two small islands in the canal (see fig. 5.7). These little bays can be traced back to the oldest maps of the city, it seems like the water always wanted to make the move around.

The island will be reachable by bridge, but not by car. The commercial buildings around the island could provide for parking.

Where the housing units around the commercial clusters will be more focused to social housing units and affordable free sector units, these houses could be a more financial gain for the redevelopment of the whole area.

Creating larger houses, available for sale, on a location like this, could be part of a strategy to make housing development pay for the waterfront investment.

Figure 5.8 - Canal island section

5.3 Water management policies

As an extension of the strategic plan, the water management solutions proposed in the intervention chapters could also fit in the Four track approach philosophy. The proposed interventions are on a small scale, working towards a larger solution. By putting private investors in charge or creating these interventions, the burden of flood prevention can be shared. Changes to the system can be made when needed, dynamically at tipping points.

The American system doesn't contain a watershed authority like we have in the Netherlands (see fig 5.9). Protection from coastal waters is regulated on the federal level and executed by the United States Army Corps of Engineers (US ACE). This means that the levy between the canal district and San Rafael is maintained by the Army Corps. A system to (temporary) close the connection between the bay and the canal would execute by them. In the San Francisco Bay, the San Francisco Bay Restoration Authority (SFB RA) operates on the scale of the state of California. But their jurisdiction is only in a limited coastal area.

There is no Authority that oversees water management problems in the watershed, on land or in the canal. In the past couple of years multiple organizations recommended the creation of such an authority, this was done in both New Orleans Greater Water Plan and by designs from the Resilience from Design competition: New York.

An authority like this could set rules, maintain the water management implementations and steer the municipality and water company to act when needed. But in America, the dream is to have everything privatized, which means that everyone could start their own business and execute their own profession.

Because the suggested water management interventions are all small scale, they could be executed by small private parties. The Municipality would have to strengthen their role as the daily policy solvers (their track 2 role) and guide private investors in which actions to pursue.

By tying developers to both real estate development and public space transformations, a large part of the suggested interventions can be achieved.

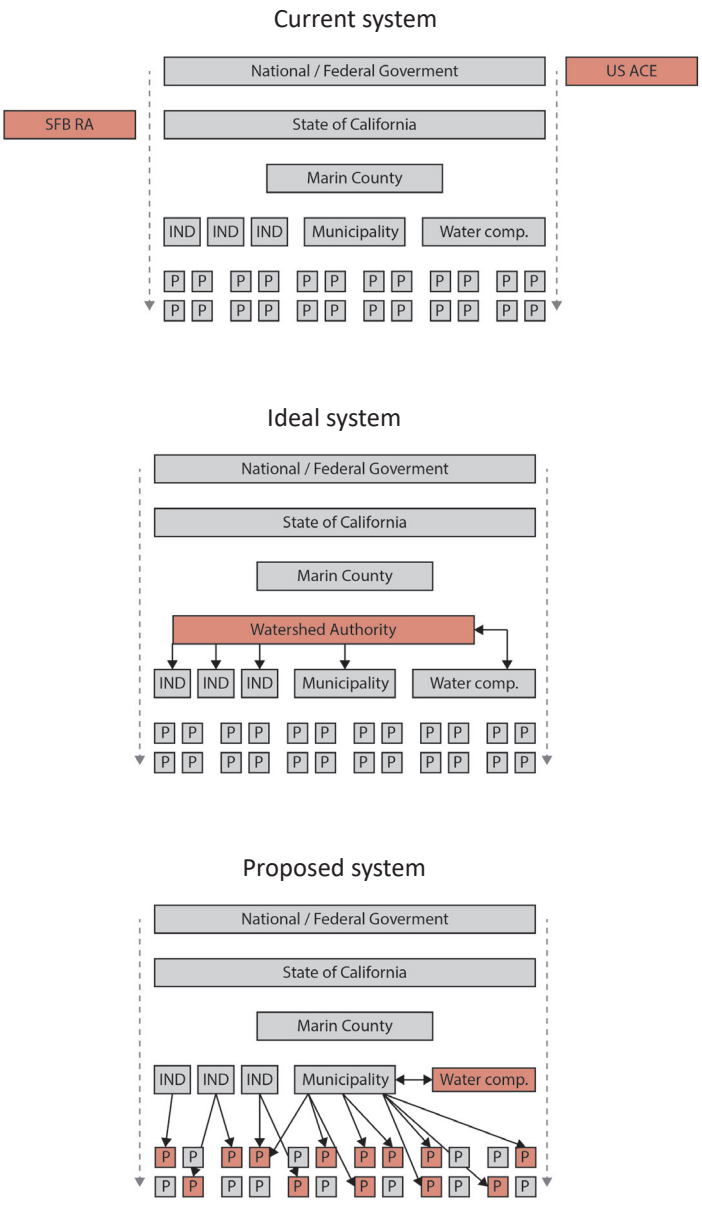


Figure 5.9 - Canal island section

The Dynamic Policy Pathway Approach (DPPA) was developed as a pure water management tool. It is a way to deal with preparing for an uncertain future. The system is based on a set of interventions that can be utilized. At a certain point, the current policy is not enough to maintain the system, a tipping point is reached (see fig. 5.10). At this point, an intervention is needed. The choice can be made to go one policy higher or more.

A system like this is not only effective for reacting to changes in time, it also allows for interventions to be done when the funds are there. Especially when working with smaller actors like private investors, their interest would not always be continuous.

To adopt a similar system as a spatial strategy tool as well as a water management policy, spatial change will have to be predicted ahead of time. By creating an intervention that could be transformed to a higher level of water management protection (see fig 5.11), the current policy could reshape the existing situation without a complete change.

Adopting the suggested water management interventions for San Rafael in a Dynamic Policy Pathway Approach would look something like fig. 5.12. With the unpredictable future, all the pathways are a possible scenario paths, but it makes it possible for actors to think about their implementations ahead of time.

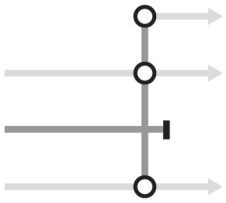


Figure 5.10 - Dynamic Policy, tipping point

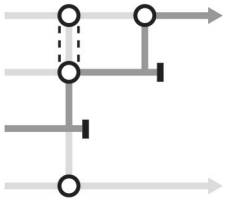


Figure 5.11 - Dynamic Policy, changing interventions

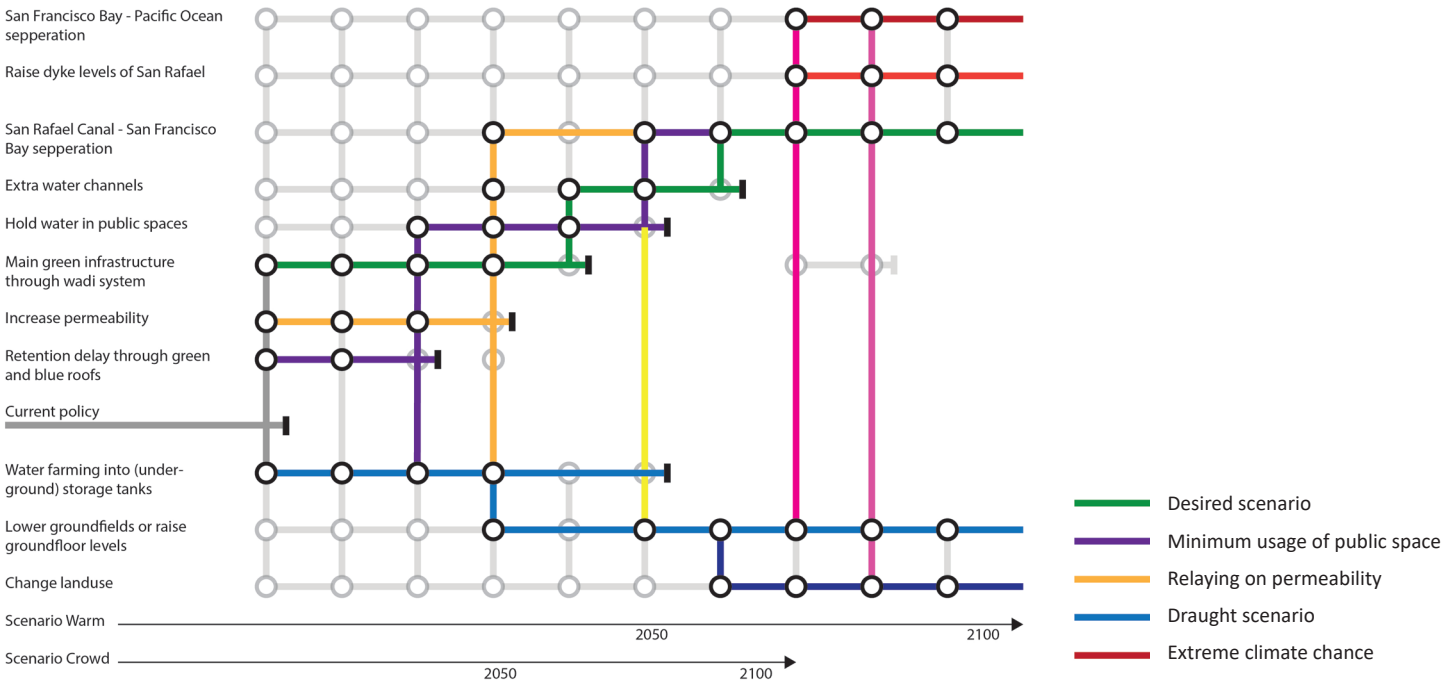


Figure 5.12 - Dynamic Pathway Policy, San Rafael

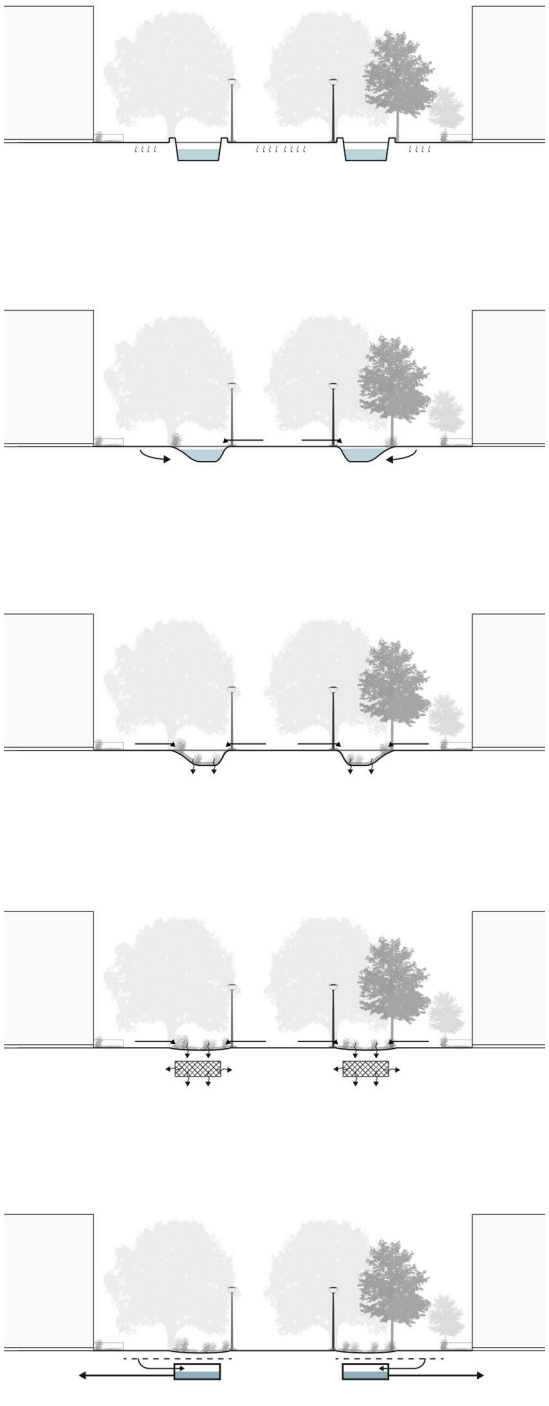


Figure 5.13 - Wet or Dry wadi system

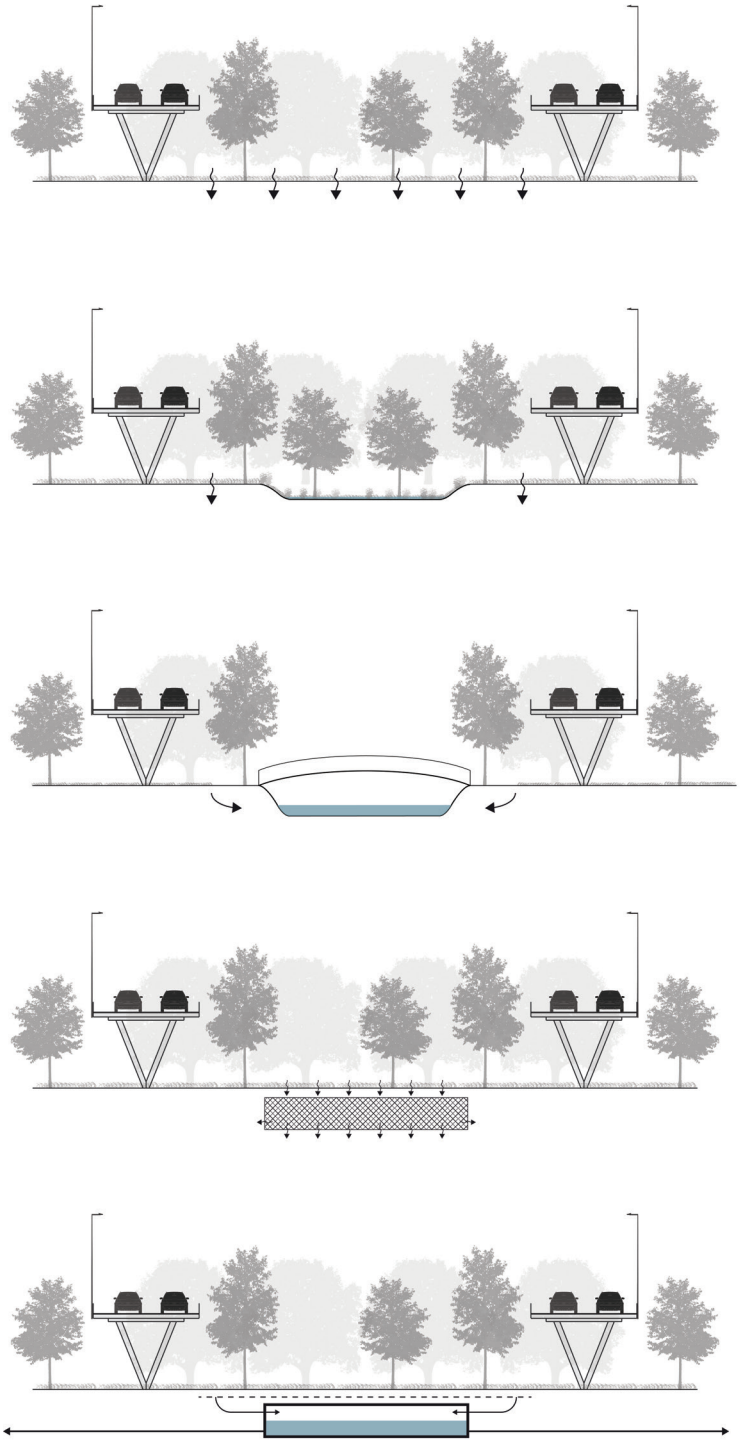


Figure 5.14 - Wet or Dry highway park

As an example, the change from the predicted wadi system to another water management structure. How the designed wadi system could transform to a canal system in a wet scenario or a park system with underground storage capacity in a dry scenario.

A similar kind of intervention can be done for the highway park. There might be the need for storing peak rainfalls in the dry season, making an extension of the marshland more suitable than a canal. But a possible future can also be extreme drought, creating a demand for water storage.

When it comes to spatial interventions, that is always the question of available space. Changing the water management policy, creating interventions is only possible when space is there.

The three main pillars of the strategy for the San Rafael district are Land-use, Mobility and Social-economic development. The latter will be influenced by the first two, but there is no real friction. There is friction between mobility and land use.

A lot of the interventions suggested depend on a shift in mobility, this in return will open up the space that can be used to create water management solutions. If there will be no shift in mobility, or if the current mobility system will demand even more from the public space, change in land use is not possible.

So when relying on a system like the dynamic policy pathway approach, these frictions should be taken into account. It is possible that due to a change in mobility, other water management solutions become possible, allowing you change to a more desired policy at the time. But it is also possible that change in mobility will require changing before the tipping point.

Alternative forms of transport will benefit a scenario where there is water in abundance. The land-use changes can provide additional storage and infiltration. In return water shortage and forced local water storage due to lack of space also work in the same kind of policies.

Eventually, the system will have to adapt to the climate, depending on both land-use and mobility change a water management policy will be executed. Implementing the suggested water management interventions over time to protect the San Rafael Canal district from flooding.

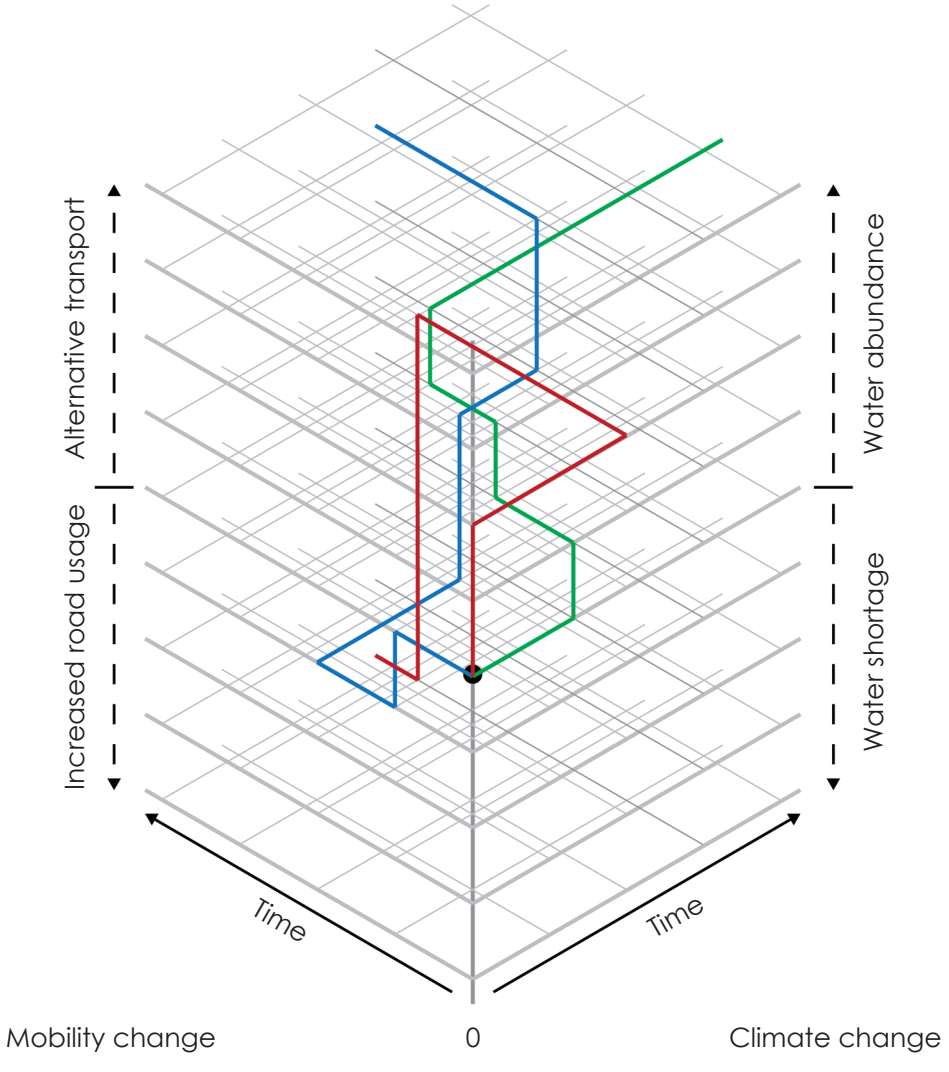


Figure 5.15 - Friction for public space

Conclusion

The leading strategy for the Canal District is to create an impact on the larger scale by implementing small-scale interventions. In this, the water management solutions are used as a tool for spatial quality. By firsts activating actors on the local scale, high impact interventions along the waterfront will be realized. These will first provide an opportunity for the local resident but will work as a catalyst for development interest in the area.

Through development guidelines and interaction between the actors of different economic levels, new facilities and housing units will be added to the area. Alongside the building development, water management solutions will be implemented on the small scale.

Depending on the need for strong water management solutions, through a dynamic policy approach, existing or future development can anticipate on this need and implement these before the tipping point.

6. CONCLUSION

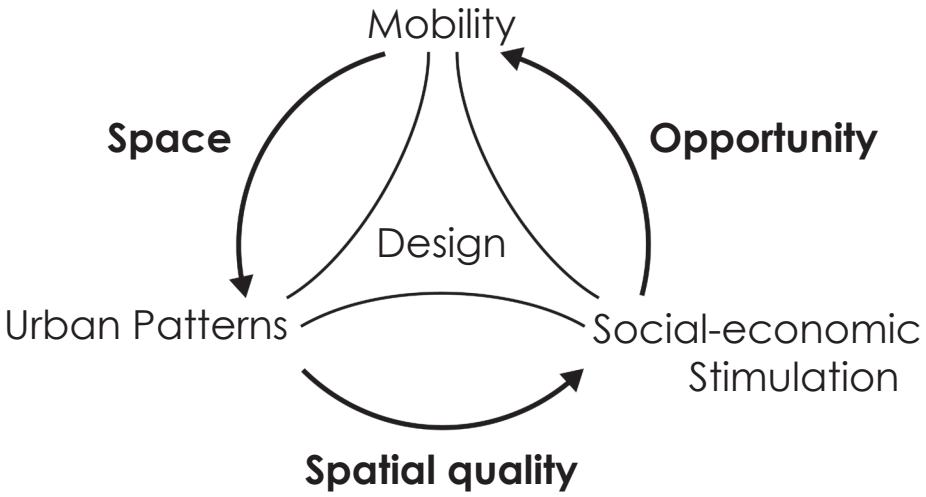


Figure 6.1 - Relationship between the pillars

Main research question

Can a spatial strategy, created out of the urgency of flood prevention, contribute to social-economic improvement?

Preventing flood in a flood risk area does not automatically improve the social-economic situation for its residents. Social-economic change is not the result of spatial change, but can be the effect of a changing district. General facilities like proper education, accessible public transport and healthcare are more important for people living in poverty.

To gain these new facilities a mixture of different social classes is needed in the area. By spatial improvements of the neighborhood, you will peak interest in new settlers for the area. There is a lot of quality to find in water management solutions. Especially since the main flood problem is the lack of permeability in the area. By creating more open spaces, you create more green in the area and bring a quality to the canal district.

A series of water management implementations can result in a strong network of green structures with a spatial quality. Through these interventions, you create an incentive for external actors to settle or invest in the area.

By increasing the mobility and connectivity of the area, the canal district can reach a larger area, creating a neighborhood with a high density and a mixed program.

The changing program will benefit the lower social-economic population. There is a higher potential for work and education. But without the protection of their housing situation, improving the neighborhood might lead to gentrification, which will eventually drive them out of the area. Alongside the water management system, guidelines and policies will have to be put in place to stimulate and maintain affordable housing in the neighborhood. A mixed housing offer should allow for them to grow within the neighborhood, but there should always be an affordable solution

The three pillars that support my design strategy; Mobility, Land use, and social-economic stimulation, are necessary tools to improve the district. The three factors strengthen each other. Changing the mobility will create the option for land use change, which can be used to improve the spatial quality, which will lead to attracting new residents with a higher social-economic situation. The current residents will at the same time profit from an improvement of mobility, it creates an opportunity for better connections, widens their potential work area.

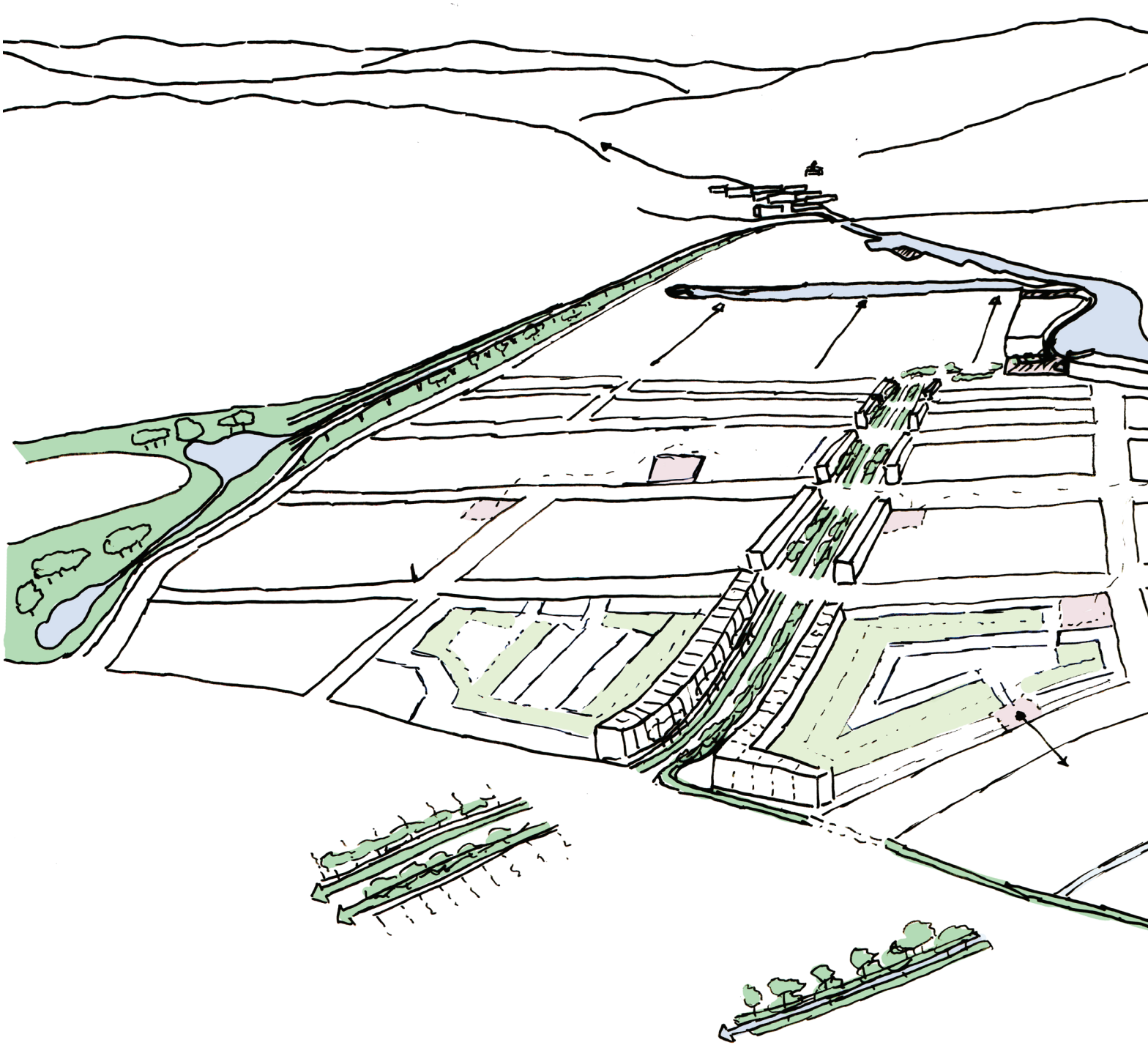
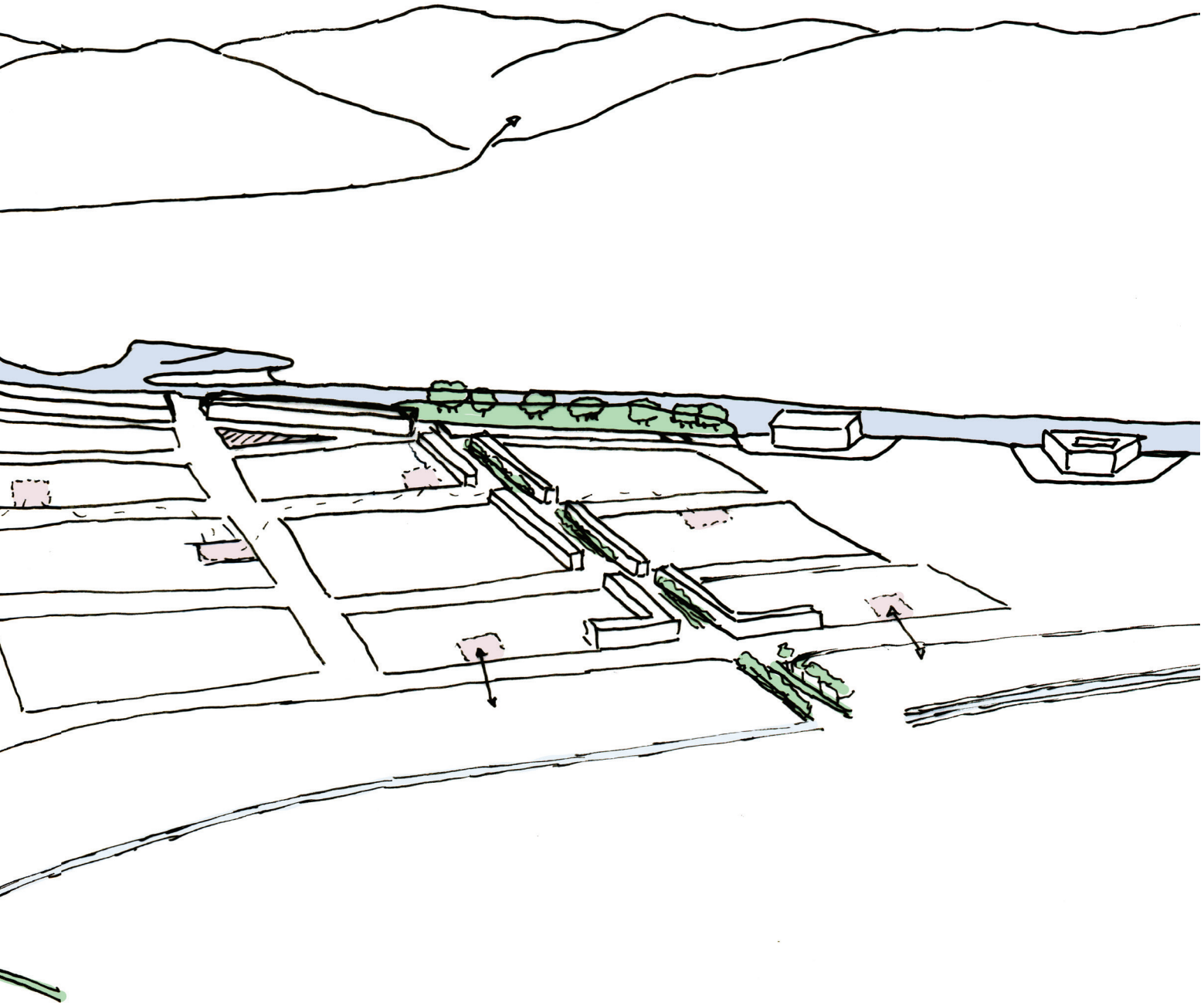


Figure 6.2 - Green and public networks



The design strategy is based on the creating of a framework for the district, this framework is created out of the necessity of water management implementation. This green infrastructure, paired with guiding principles for public space is providing a new spatial quality in the neighborhood. At the same time guiding principles for the creating of affordable housing is creating a second dynamic framework within the area.

These interventions, in the interest of the current residents, can be made through a finance strategy in which the more interesting plots will pay for the realization of social housing units. The mix of population created through these interventions will provide the necessary means for social economic growth opportunities.

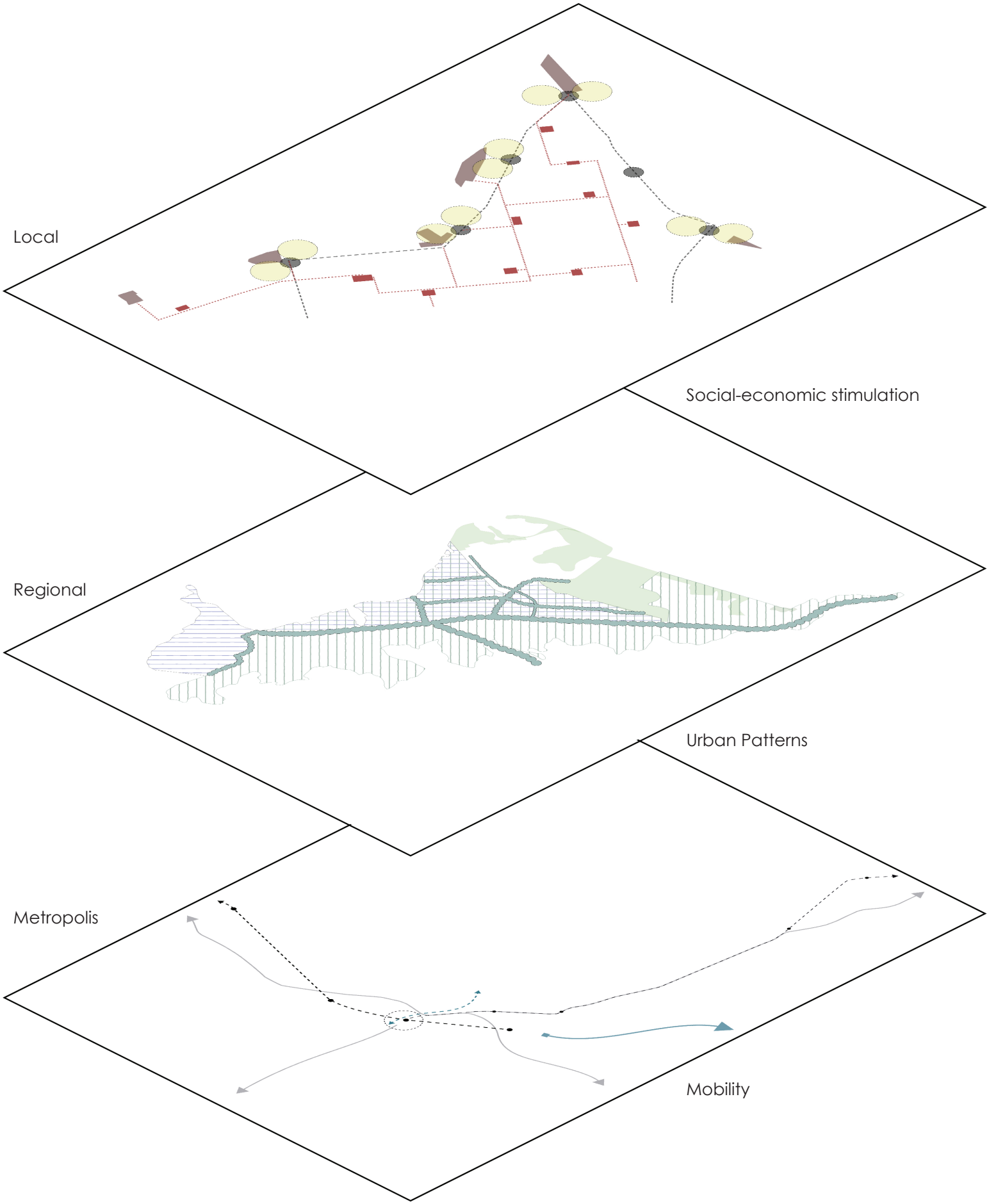


Figure 6.3 - Three layers of networks

In this project, the interventions are based on current situation and future expectation of San Rafael. The main threat to the future is climate change and what this will do with our delta regions. Even though the whole world will be affected by climate change, it will cause different results in different parts of the world. Understanding the local situation and how climate change will affect the area should always be the first step. This information is needed to find fitting solutions for the problems. There are multiple ways to use water management implementations as a spatial quality, but you will have to fit them in the situation.

When dealing with similar cases the same kind of layer analysis can be used to find the problems in Mobility, Urban patterns, and social-economic development. By creating a framework of interventions and strengthening the network the relation between the layers can be emphasized. Even though there will be a connection through the scales, the important aspects of the layers have different scales.

Mobility is a driving factor for development, a good mobility network increases the reach for job opportunities and it connects a district to a larger audience. By strengthening the mobility to an area, you connect the residents to the world and the world to the area. Making a district a link in a network, rather than a drive-through or a final stop will create economic and social opportunities. So the mobility layer should be looked at on the larger scale, a metropolis, county or province.

Changes in the urban patterns and the creation of a green network should also be done on the larger scale. However, this scale is decided by the origin of the flood problem. It is impossible to only deal with flood problems locally when they are not being handled on the larger scale. Ideally, the network and change to urban patterns are done on the scale of the watershed. If this is not possible, an attempt should be made to store or slow down run-off water threatening area's that are suffering from floods.

Social-economic stimulation should start on the lowest scale level, on the local scale. The projects to improve spatial quality and job opportunities should start small, allowing for local residents to participate in these processes. Eventually changes on the local scale, both spatially and commercial will reach a larger audience.

The combination of these different networks on the different scales will provide the opportunity to redevelop the area, by creating interest on a larger scale. By starting off with small interventions and protecting local resident through policy guidelines, the social-economic situation of the area might improve.

7. REFLECTION

The Delta Interventions research studio had set its focus on the San Francisco Bay Area because the state of California has made the initiative to proactively act against flood threat, by bringing the research by design competition to the Bay Area. Around the bay, flood risk threatens a variety of area's ranging from the heart of San Francisco to ghost towns in the south bay. However, a similarity is also to be found, of the 200.000 people actually living in the flood risk area, the majority lives in poverty or in a poor economic situation. And this is a trend you also find on the global scale; there is a relationship between flood risk areas and social-economic discrepancies. Redesigned area's after big flood events, like New Orleans, have the ability to improve themselves during this process. With the proactive approach of dealing with a flood threat, my research attempts to proactively improve the social-economic situation of these areas by using water management interventions as a tool for spatial improving.

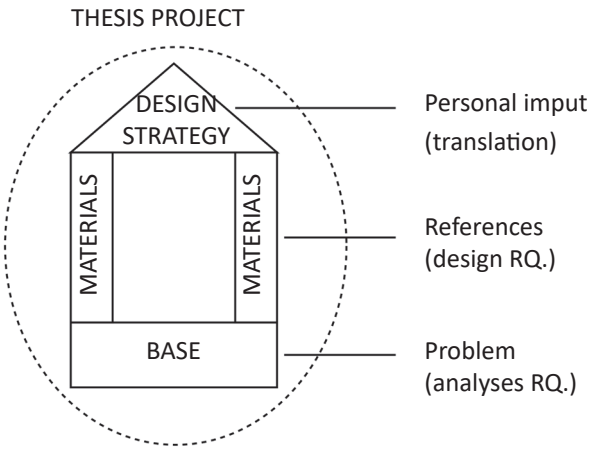


Figure 7.1 - Relation of research

At the start of the graduation process, my aim for the kind of research was clear, I needed to find the answers to the origin of the current problems on my research location and I wanted to find water management solutions that have been proven to work. You could simplify this approach by stating that I was looking for a base and materials that, together with my personal input and finding, would shape my strategy/ design in the final product (see fig. 7.1). With the base being the more analytical research questions and the materials being the design research questions aimed at interventions. In urbanism, the relationship between research and design isn't always a clear line, especially when you are using your design as a form of research, there is a lot of back and forth. In this project, that was not the aim. The goal was to have a clear set of research outcomes starting with the design process. Therefore, my methodology chart (see fig. 7.2) was a linear line with time on the one axes and process on the other, moving from an interest- to a research- to a design-driven approach (see fig. 7.3). During the research phase, there was expected to be a slight overlap with the design-driven approach because designing has become a second nature in our line of profession. During the research phase, you easily come across information you instantly want to transform into design elements, which also happened during the process of this project.

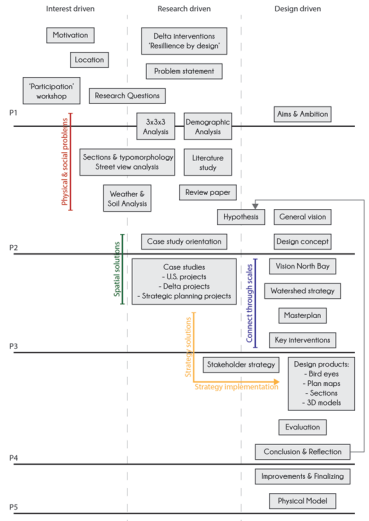


Figure 7.2 - Methodology planning

For the basis to build upon and the materials to be used, different research methods were used. One of the main research methods that were used, was the mandatory method of the research studio, the triple three-layer approach (3x3x3). A research method in which three different systems, infrastructure, nature and build up area, are compared with each other on three different scales, in three different time periods. This method was used to highlight the relation between these different systems and the scales they are working in. It provided a better understanding how the systems influence each other, and which role the design would play on these different scales. A big part of this method

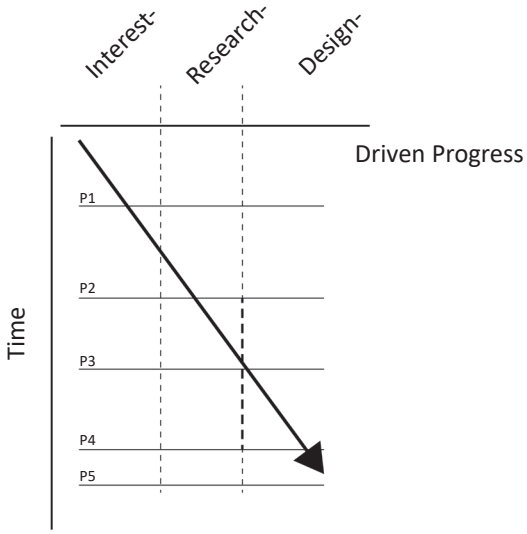


Figure 7.3 - Linear expected design progress

was tracing maps, tracing is not just a tool for analyzing, it is an essential part of research in learning to understand an area. By tracing the same lines over and over again, on different scales at different times, the area was explored. This method highlighted some of the major issues that are present in the Bay area today, and how these problems all came to be in the last 50 years of development. Initially, the method was used purely as an analyzing tool, with the last time period set on the current day. After a suggestion by a mentor, an alternative approach was used, the last timescale would be set in the future, turning the method into a forecasting design tool, alongside its analysis potential. A similar kind of tracing was done on the lowest scale possible, a street view analysis. This was again a great way to understand the area better, which wasn't otherwise possible with the location being half a world away. This analysis highlighted some of the more local problems and at the same time inspired solutions as a result.

Other base research questions, especially the water management and social-economic problems had to be answered through desk research. Gathering as much data as possible and analyzing this data, uncovered some of the major problems in the project area. The problems revealed here were the problems that the design/strategy is trying fix and prevent.

For the more design driven research questions, a combination of desk and literature research was used. The aim was to find similar situations and locations were flood problems were solved with a social-economic benefit for the local population in return. The research provided a lot of acknowledgment for this problem but not a lot of input for solutions. Individually there are a lot of projects where a spatial strategy was used to improve the local social-economic situation and there are multiple examples of flood protection with economic benefit, but these problems together are rarely combined. This was also one of the reasons why I started on this topic in the first place. The desk research did provide with standalone elements that could be used to either benefit the water management situation or the social-economic situation. By combining these in the project, I tried the one to strengthen each other. But hard lessons from the previous projects were missing.

By the time the research phase was supposed to end, not all the research questions felt answered, which meant that there was not enough input for the design/strategy to build upon. Because of this, attempts were made to go back into the research phase to get the desired answers. This unwanted back and forth (see fig. 7.4) between the research and design phase caused a lot of stagnation and struggle for the project in the end. In hindsight, there should have been a reevaluation of the research before entering the design phase (see fig. 7.5). The research that was done did not supply the

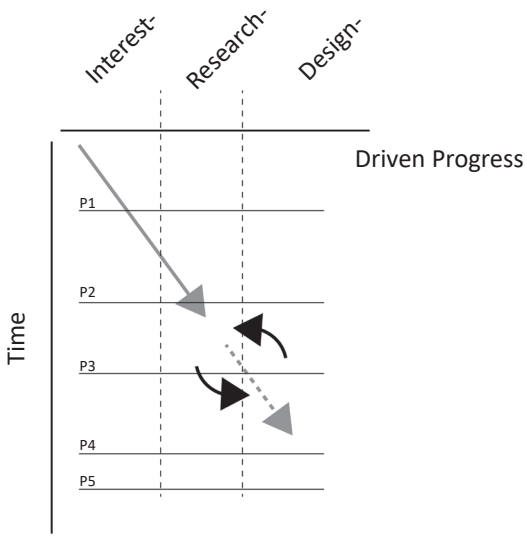


Figure 7.4 - Unexpected back and forth

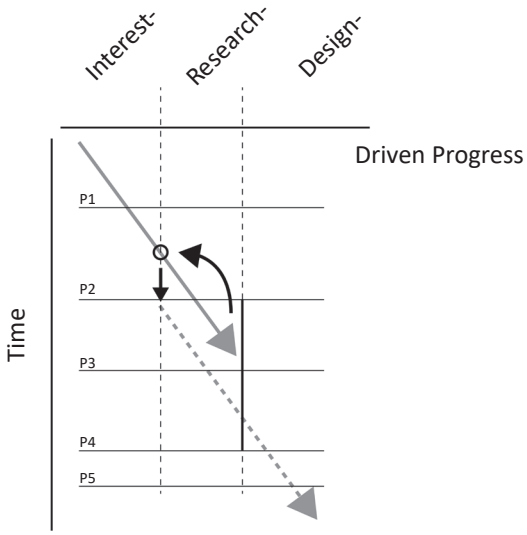


Figure 7.5 - Re-evaluate the research before design

desired outcome, so at this stage, the research should have been redone through a different method, or the research questions itself should have been recalled. Without finding clear answers in literature, a completely different approach should have been used. For example an in-depth case study comparison between a function and non-functional area with the desired composition outcome of this project location.

With the intended research questions not clearly ended, the base of the strategy/design wasn't solid. The project is build up with different materials that could reach the desired effect but the outcome is not strong. Individually for both the water management problem and the social-economic situation, a solution is provided. These kind of

measures are presumed to work, however, if they work together is not something you can test theoretically. Because the research did not provide the desired information, a large part of the conclusion is based on the assumptions. A strategy/design based on research should be built on facts. Because the research failed, the outcome of the project can also be considered a failure. It does provide a lesson, individual parts of these project could work, and personally, I have learned that it is better to completely reevaluate your research method and research questions than to try and keep continuing with it.

Even though the solidity of the project outcome is doubtful, in the end, a strategy was formed. In this reflection, the outcome of this project has been described as strategy/design multiple times, because it might be either one of them or both. This project started with an aim to find a strategy for redevelopment of the area that would benefit the current population. A part of this strategy is creating a strong framework of high-quality water management measures throughout the area. Creating a network like this is more of a design intervention, but you could also see this intervention as the strategy itself. A design sounds like a fixed project, and in many projects, this has been true (especially in the very privatized United States), but our current way of developing requires a more dynamic approach because we barely get to work with a tabula rasa anymore. Urban designs have become more guiding projects then fixed urban expansions, perhaps all urban designs are strategies now.

The suggested strategy in this project might work as a whole, but that would need testing. A solution for this project would have been to interview all the different actors, to understand if they would participate and what demands they had. With the project being in San Rafael this was simply impossible, if it would have been a similar location in The Netherlands, this could have been achieved, making the project much stronger.

Regardless, if a strategy like this would be implemented in the area and it would result in the desired outcome, it could be implemented in other flood risk areas with similar social-economic situations. For those locations, a local analysis would have to be done to understand the flood problem and you'll need to create suitable water management solutions. But the strategy to use these water management solutions to attract a mixture of people with a higher social-economic status would result in the same outcome. In that way, utilizing water management implementations as a spatial quality tool combined with governance policies to maintain the local population, the project could be used as a stepping stone for a larger global problem. Again, this is mainly based on a lot of assumptions.

Doubts about the realization

Even if the strategy would work on its own, there are still a lot of developments that could completely counter all the interventions done. Climate change is not the only unpredictable factor in the equation of the project. An assumption is made that there will be a shift in mobility; this is supported from different angles, strong believers in automated driving and fast public transport systems. However, there is a chance that this won't happen or the infrastructure might even become more dominant. Without these kinds of changes, the presented strategy won't work.

Another vulnerable point of the strategy is the developer participation. The lack of social housing is a result of low feasibility. Developers are currently working around the rules, avoiding that they have to create social housing units. Asking them to participate in this project in return for development rights is doubtful. They are fully aware, that without participating, the project would never work and in time the land would be made available for another kind of development.

But there is even a bigger problem when it comes to this area; it has been completely ignored for this project because it is almost impossible to design for it, earthquakes. The San Francisco Bay area hasn't had a major earthquake for many of years, and statistically, they are due for one shortly. It is one of the reasons that flood protection is not their primary concern; one earthquake could completely destroy a water management system. If it is impossible to create water management that can resist floods during an earthquake, area's like the San Rafael Canal district should be abandoned. And in that case, restoring former marshlands would be the best possible solution for these locations.

Bionic Team Research

By now the Resilience by Design competition has started and the team working on San Rafael has a lot of overlap with larger suggestions made in this report. Their focus is not on the social-economic aspect but purely based on flood protection and recovery. They have accepted that flood can occur and try to redevelop the area in a way that it is more robust then adaptive. However, the larger interventions they are suggesting should have the same effect in creating a catalyst for larger redevelopment. With a improvement and change in mobility and a redeveloped waterfront.

The suggestions made by the Bionic team could spark the same interested in the area, attracting developers and actors to participate in redevelopment. With guidance from the municipality, similar policies can be added to secure a future for the current residents.

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3.30
Data from:
U.S. climate data. (s.d.)
on 13-12-2016, from:
https://www.usclimatedata.com/climate/san-rafael/california/united-states/usca1011

Figure 3.33:
The piedmont Environmental Council. (2008) *Wetland plant guide.*
on 24-09-2017, from:
https://www.pecva.org/library/documents/Resources-Publications/Publications/Plant-Wildlife/WetlandPlantGuide.pdf

Figure 3.38:
TTE systems. (s.d) *groene parkeerplaatsen.*
on 23-09-2017, from:
http://www.ttesysteem.nl/projecten/parkeerplaatsen.html

Figure 4.1:
Trulia. (s.d.) *Real estate data for San Rafael*
on 13-12-2016, from:
http://trulia.com

Figure 4.2:
DATAUSA. (s.d.) *San Rafael, ca.*
on 13-12-2016, from:
https://datausa.io/profile/geo/san-rafael-ca/

Figure 4.3 to 4.6:
Data from:
Census. (s.d.)
on 03-04-2017, from:
https://census.gov/search-results.html?q=san+rafael&page=1&stateGeo=none&searchtype=web&cssp=SERP&search.x=0&search.y=0

Figure 4.19:
KCAP. (s.d.) *Hafencity*
on 21-09-2016, from:
http://www.kcap.eu/en/projects/v/hafencity/

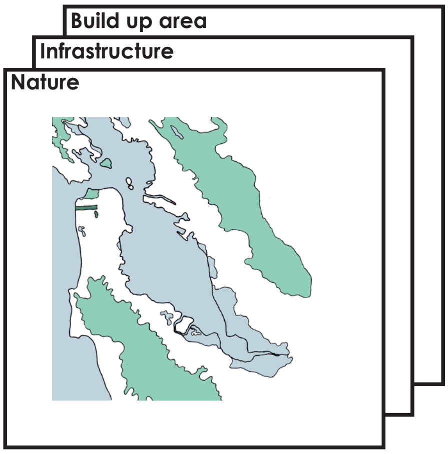
Figure 5.3:
Recreated from:
Oosterlynck, S., Broeck, van den, J., Albrechts, L., Moulaert, F., &Verhetsel, A. (Eds.). (2011). Strategic Spatial Projects; Catalysts for change. New York, NY: Routledge.

Figure 5.12:
Inspired by:
Haasnoot, M., Kwakkel, J., Walker, W., & Maat, J. Ter. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change, 23(2), 485-498.

3x3x3 ANALYSIS

A2 3X3X3 ANALYSIS

During the triple three-layer approach (3x3x3) we did an analysis of the bay area, the north bay area and San Rafael. One of the earliest conclusion is the dependence on mobility. The original settlements are all created by logical natural dependencies like fresh water, shelter, and dry feet, but as soon as mobility became an objective, everything followed the road structure. Sometimes the roads were even built long before the urbanization. The roads were created, urbanization followed and nature was slowly pushed back. The same progress is noticeable in all the scales.



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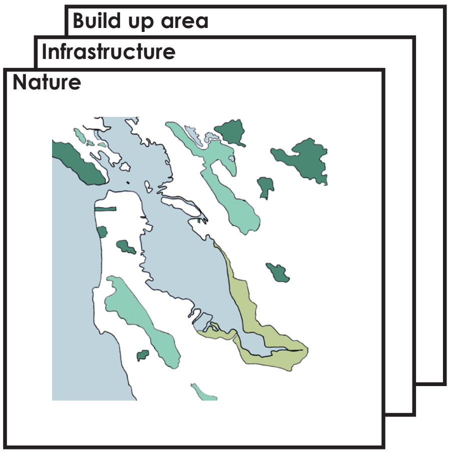

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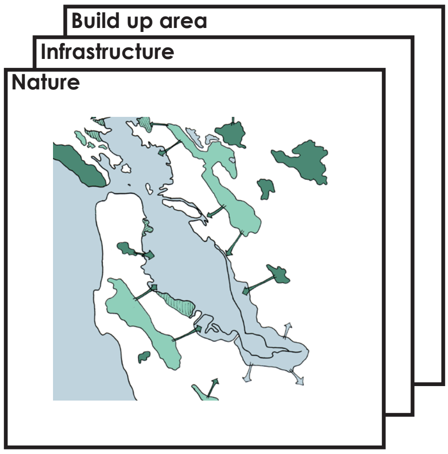

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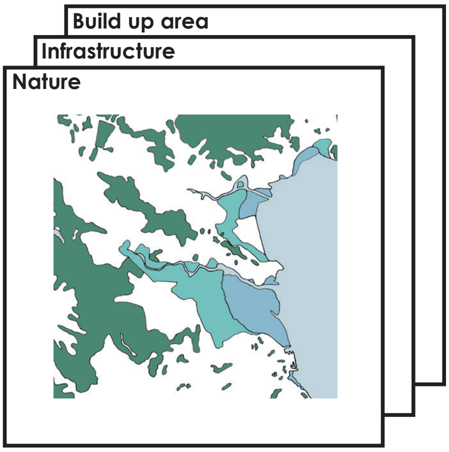

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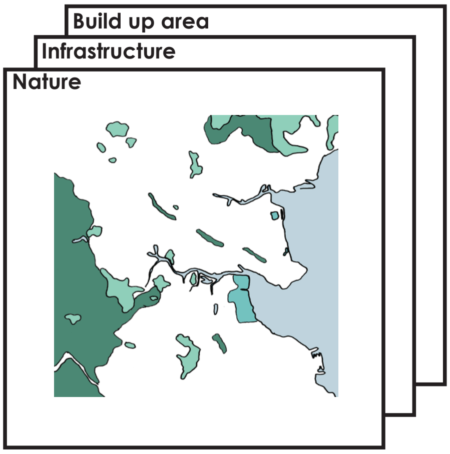

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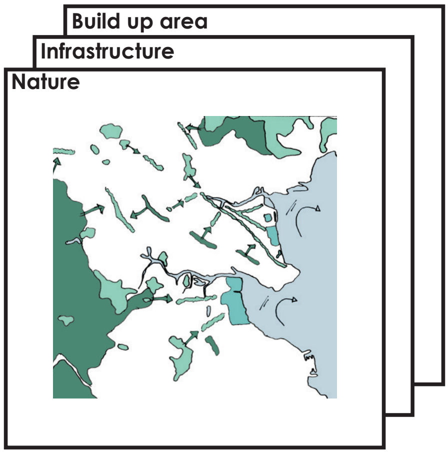

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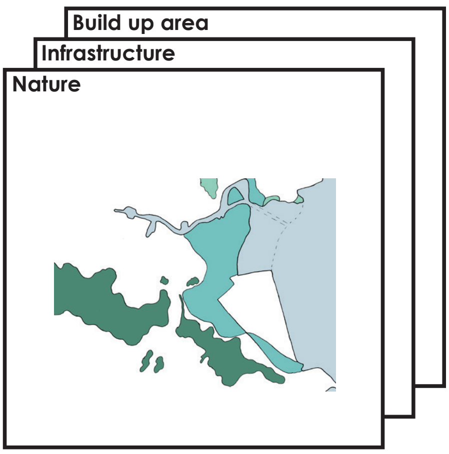

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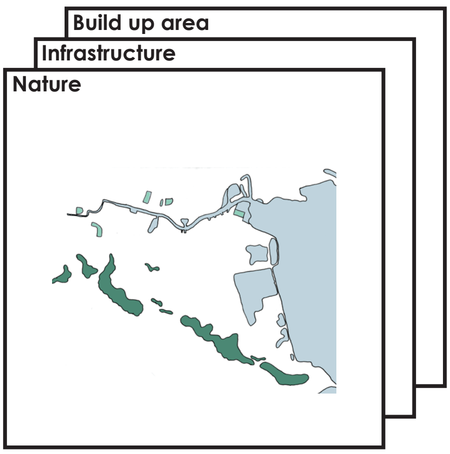

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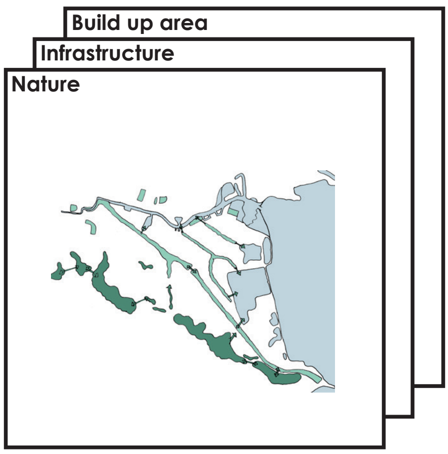
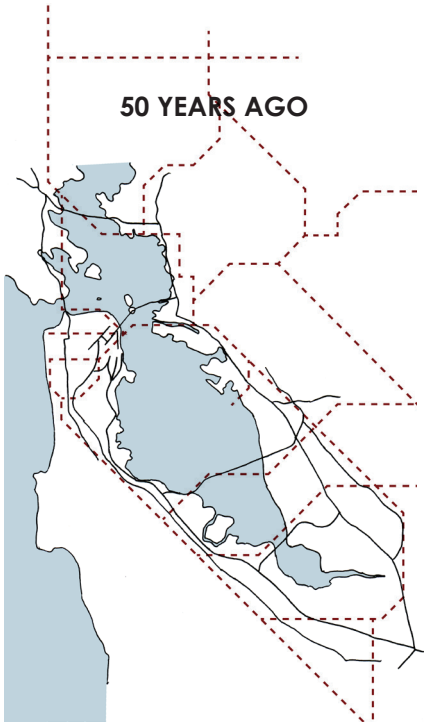


50 YEARS FROM NOW

INFRASTRUCTURE

50 YEARS AGO



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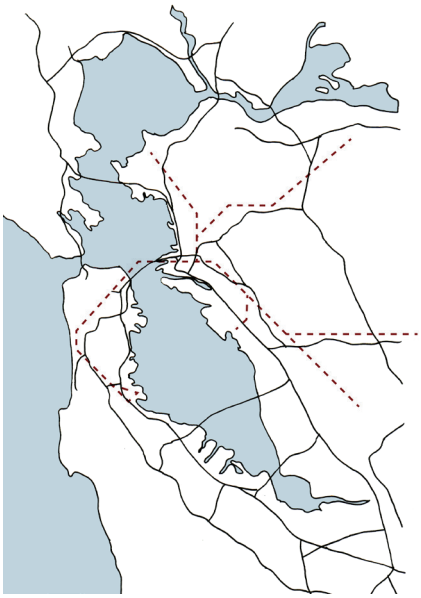

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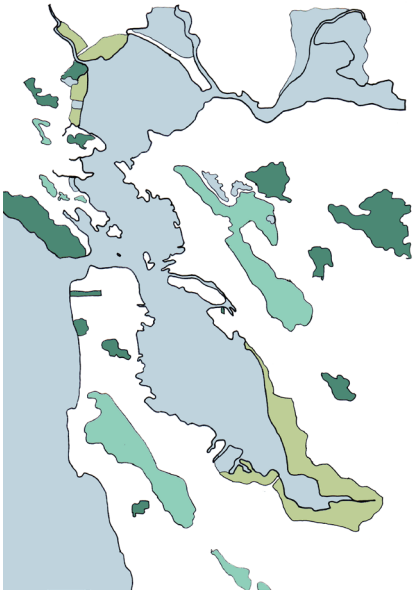


BUILD UP AREA

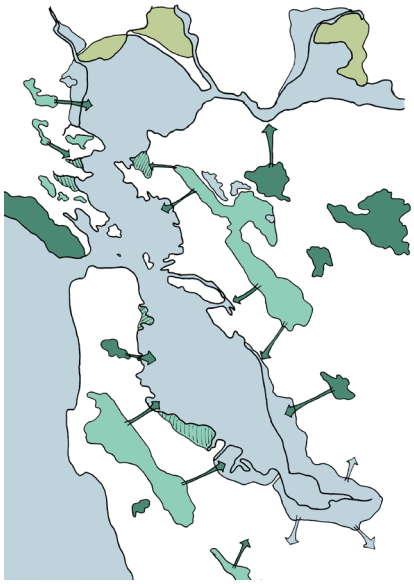
50 YEARS FROM NOW

METROPOLIS

50 years ago, car mobility was already far advanced in the United States, most of the road was already formed. Those roads are now the highway structure of the Bay Area, so they have changed from 2 lanes to 8. The main changes to the road structure is a secondary highway on the west side, these two high ways are the supply roads for silicon valley.

What has changed, is the public transport, but not as they had in mind in 1965. When the BART system started in the San Francisco Bay area, there were plans to go all around the bay, to connect north and south, east and west. The only strong connection that has been made, is between San Francisco and Oakland, the two major cities in the bay.

The focus will be on improving the public transport network, connecting the sides of the bay with each other. With less car mobility the highways in flood zones will be downgraded and only 1 ring will be used.

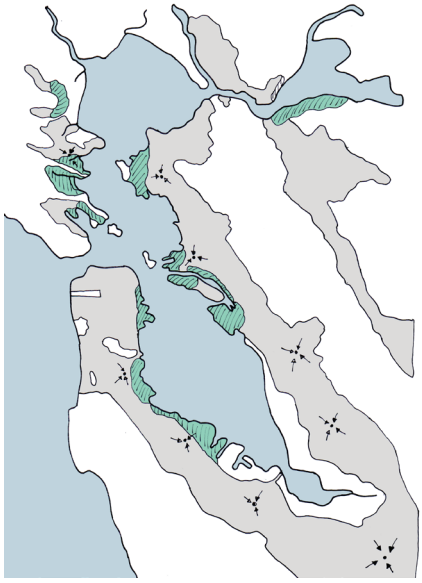


Tracing green was quite hard because they haven't been consistent on the historic maps, the colors have changed a lot, and different kinds of nature were highlighted in different areas.

What is clear, is the threat of urbanization, every neighborhood build means less nature in the bay area. In the more recent maps you find a lot more protected and restricted nature parks, they are trying to preserve the little real nature that is left.

Around the bay, you see a clear reduction in marshland during the last 50 years. A big part of the south bay has been turned into salt ponds for industrial purpose.

The green network of the bay will reach from marshlands to hilltops.



The development has made the clearest jump in the last 50 years. The rule seems to be, every inch that can be built will be built. The limit of the built-up area is nature. Where the mountains are too steep, the urbanization ends, and the same goes for the bay. In San Francisco, San Jose and Oakland there is no way, then up.

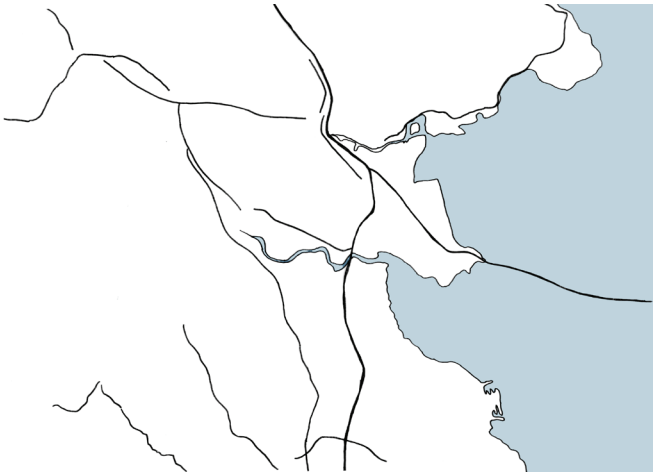
The lack of space in the south has pushed more people up north and they are slowly encountering the same restrictions as the rest of the bay.

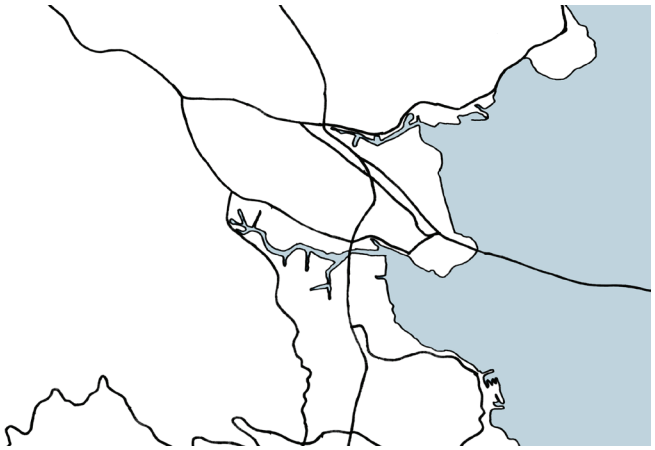
The former marshlands will not return but the build-up areas will improve their permeability through increasing infiltration capacity.

50 YEARS AGO

NOW

INFRASTRUCTURE





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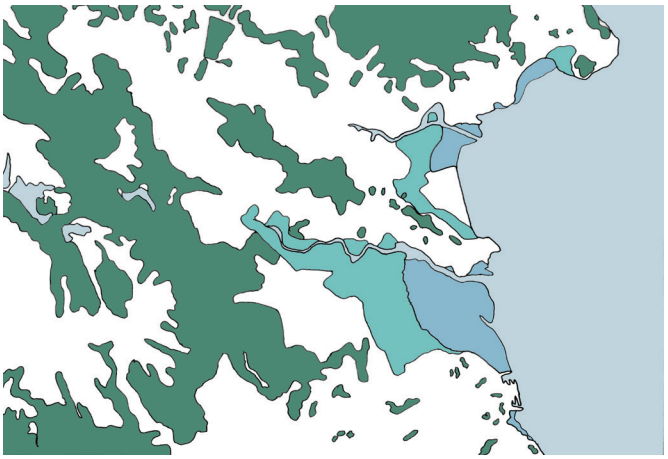
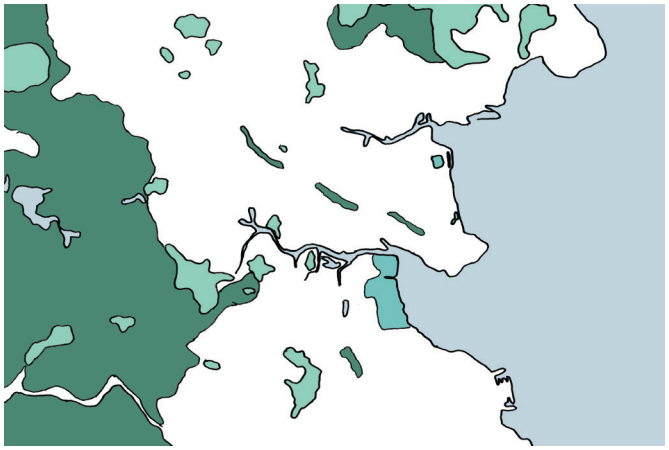
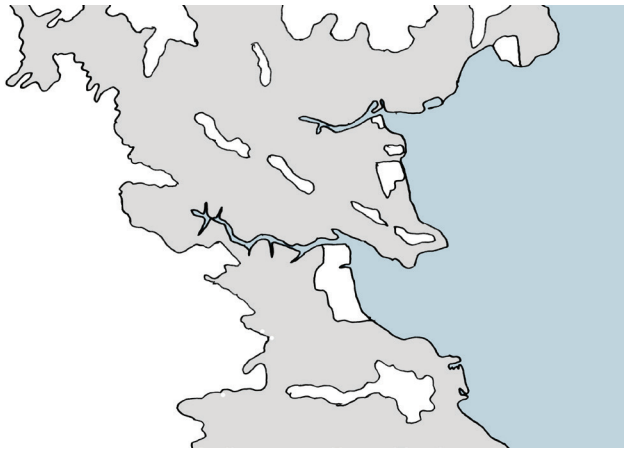
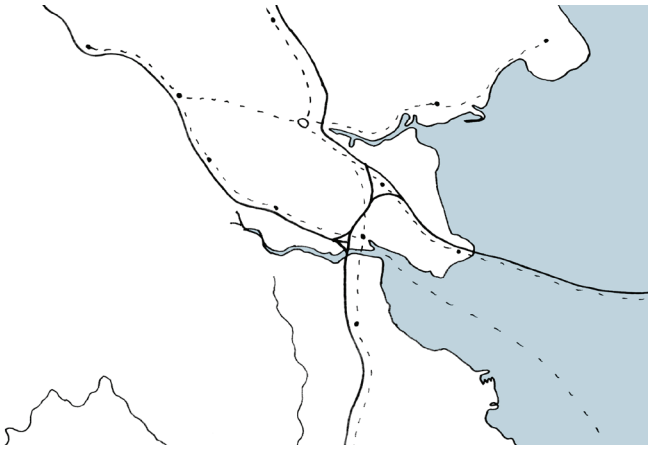




BUILD UP AREA





50 year ago San Rafael already had the same purpose of today, and city on the road towards the north. Roads to nearby towns ended in their city centers, but the road to Petaluma has always been there.

The road themselves have changed a lot, 50 years ago the roads might have been humble, today they are part of the emergency network of the bay. Huge, wide constructions, creating more barriers then connecting.

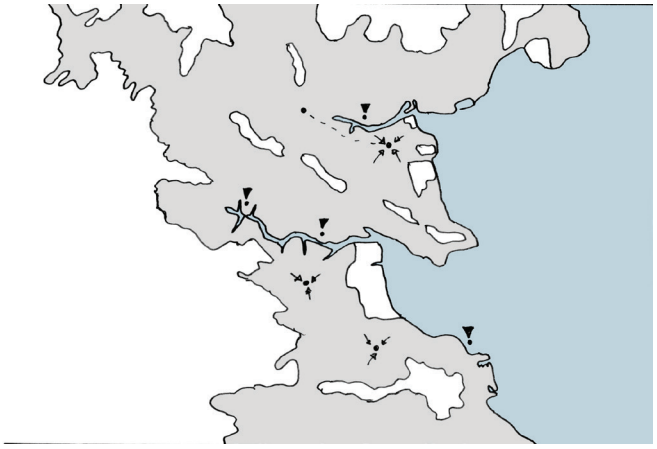
The main drive through roads will continue to exist, but all the extra shortcuts between the highways will disappear. They will be replaced by a functioning public transport network.

Just like the rest of the Bay area, the biggest
change in nature during the last 50 years, are the reclamations of the marshlands. The remaining marshlands are now protected.

A lot of green remains in the county, because of the terrain, the mountains to the west are simply to steep to develop further.

The amount of green within the build-up area is almost negligible, some protected park and sports fields, but no other open green to be found.

Where there are marshlands left, they will be connected to new or existing green zones.



With the marshlands able to develop upon, the urban area has made a move towards the water. The canals are completely surrounded and most of the coast as well.

The open spaces you find, are protected lands or mountain tops that are too steep. However, there is a big difference in the density, between the different urban areas.

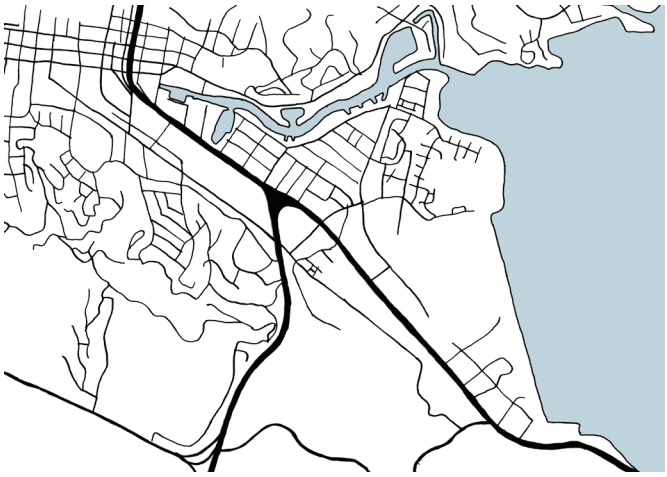
The hilltops almost seem green, with just a small house every now and then. The easier the land is to build upon, the denser the area.

Development will focus on strengthening the core of the city centers and discovering the waterfront as a quality.

50 YEARS AGO

NOW

INFRASTRUCTURE



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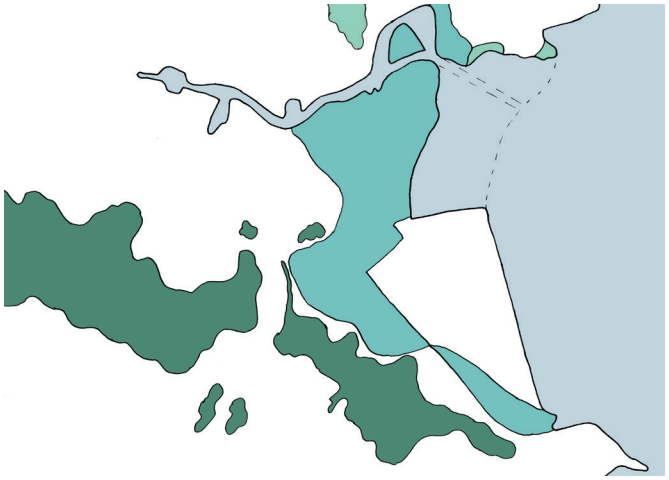
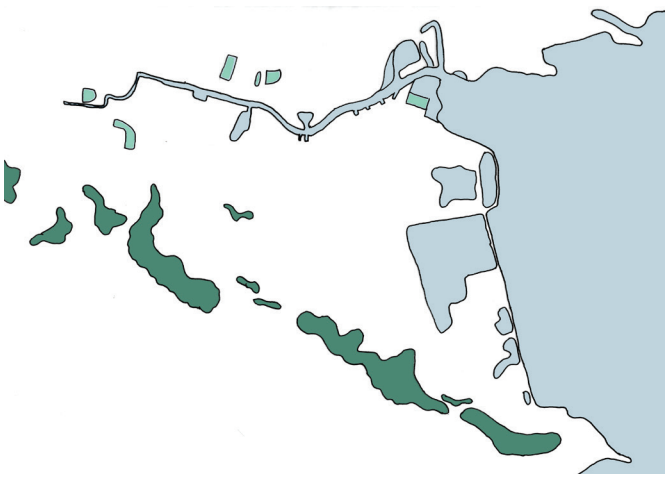
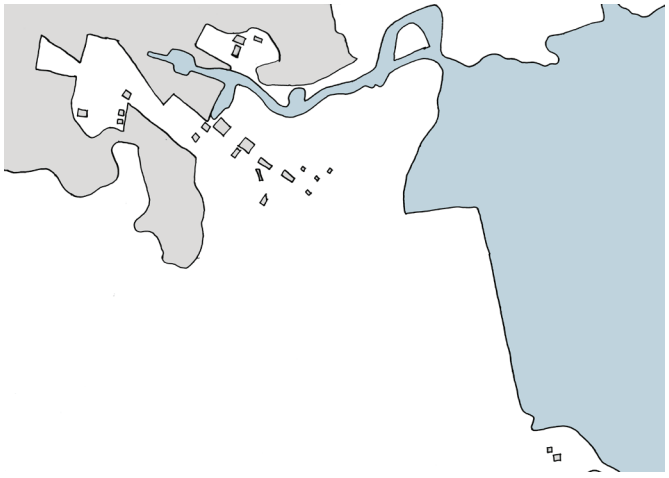




BUILD UP AREA



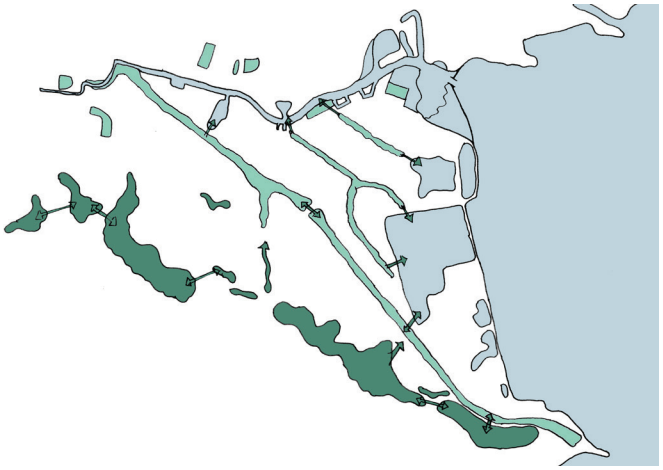
50 YEARS FROM NOW

LOCAL

50 years ago, the canal district wasn't even on the map yet. The San Francisco - Petaluma connection was already there, but much more moderate than today. Only the old harbor had a road structure.

Today the canal district is completely paved with roads, without a clear hierarchy. Every road is wider than it should be. The newest roads are a complete deviation of the road structure. The Canal district went from a grid to a suburban maze.

The highway will likely diminish, otherwise, it will still be raised and split to allow crossing underneath it. The Original grid structure will be strengthened.



The canal district was almost all marshland 50 years ago, most of the lands have been reclaimed and build upon. The remaining nature that is now protected is actually no marshlands from the origin.

Just like the whole urbanized area, besides the protected green at the coast, there are no green zones to find within the canal district. Within the urban structure, the only green you'll find are trees.

The new wadis will form an ecological network with the marshlands. Connections between rough nature and parks emphasized.

The first settlers of the canal district were there 50 years ago, the first industries, probably car related, rose next to the high way. As soon as the land of the marshland was reclaimed, the urban area spread over the land, until it became fully paved.

Most of the district is filled with industry, about 50% of those plots are reserved for parking cars.

The development will not continue in spreading but in densifying and raising. The focus will be on connecting the different neighborhoods and bridging the gaps in equality.

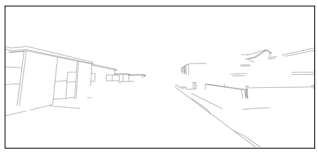
STREET VIEW ANALYSIS

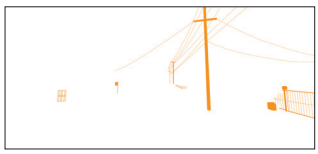
A3 San Rafael Street Analysis

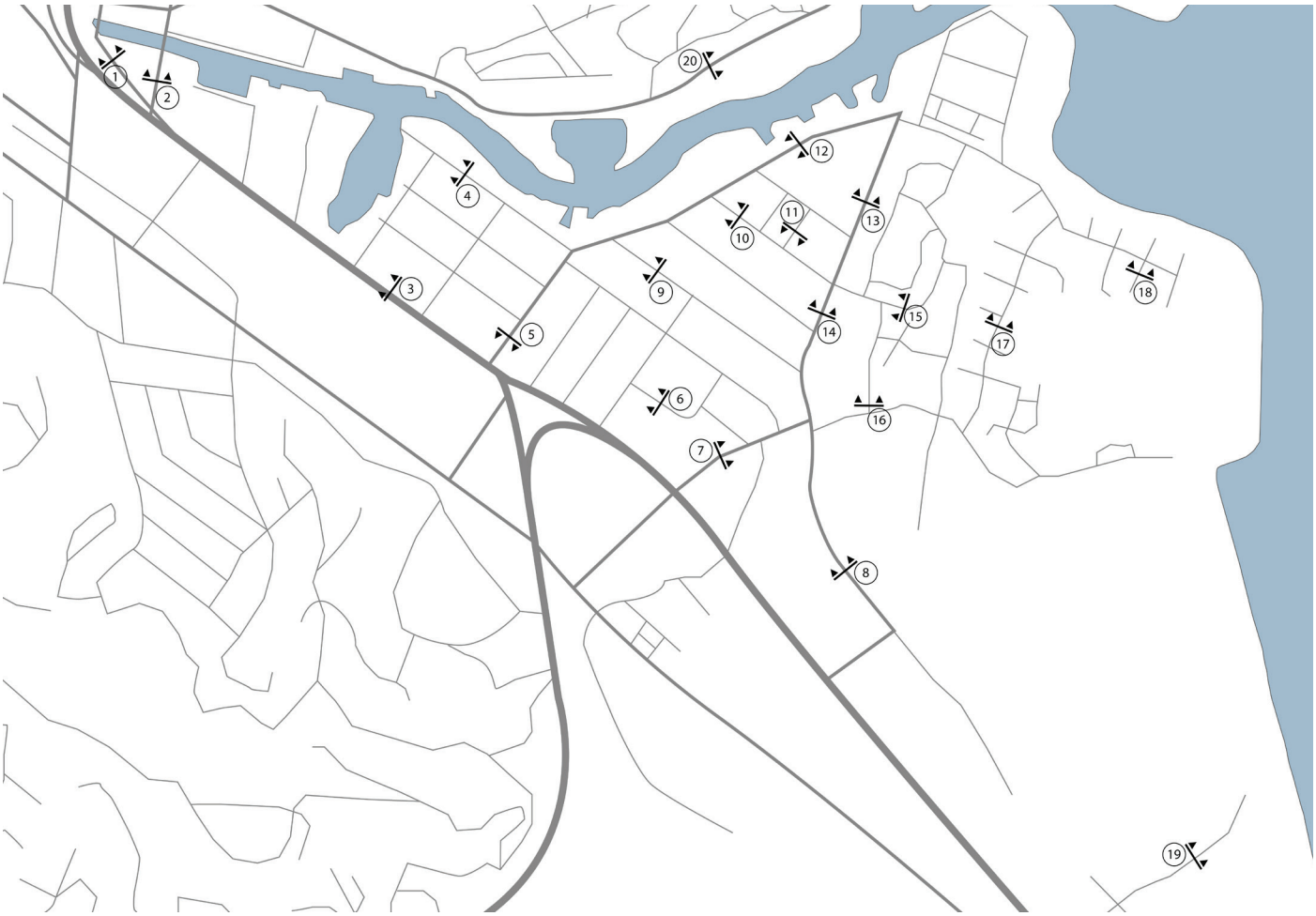
In an attempt to better understand the spatial problems, qualities and possibilities, 20 streets were chosen and analyzed with extraction methods. By Isolating the different layers of build up area, mobility, nature and street furniture it was easier to compare the different climates of the streets. This is the total overview of the different streets chosen.

The 20 different street view sections were picked to show the diversity in the district. Tracing paper the four different layers were isolated (buildings, mobility, furniture, and nature). Later they were made digital to make a comparison between the different neighborhoods in the district easier.

The main conclusion from the street view analysis is the visible relationship between building typology and crowded mobility. Dense neighborhoods have a high amount of car is in the public street, suppressing the open space. This eventually leads to less green and poor quality public space.







Street sections analysis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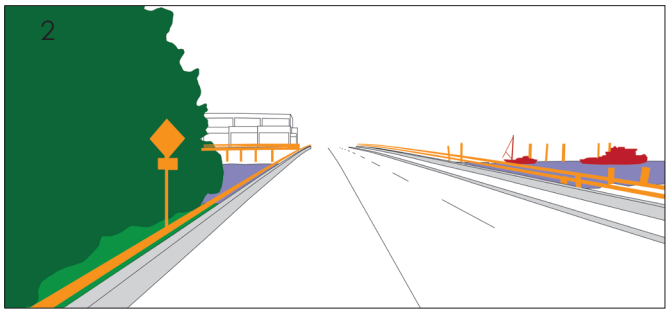
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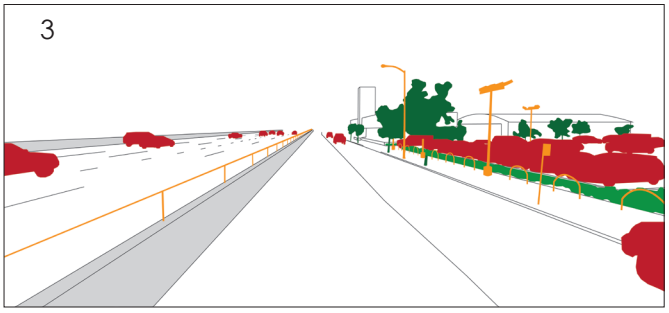
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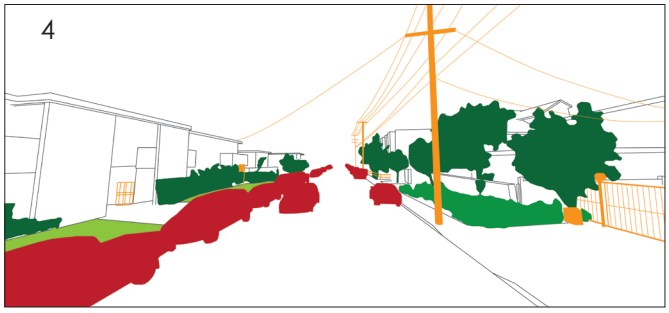
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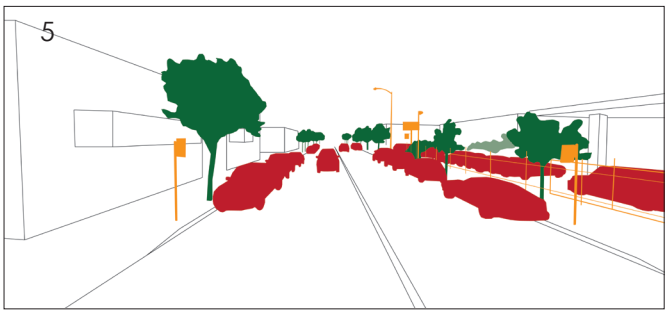
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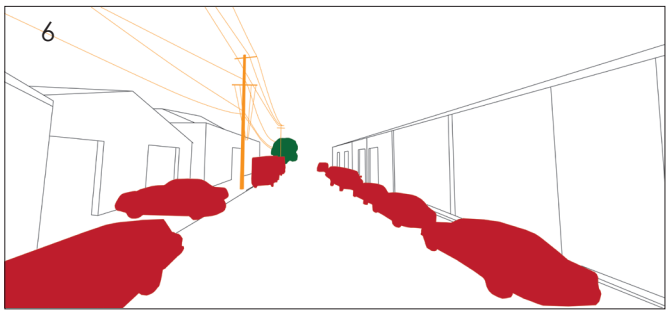
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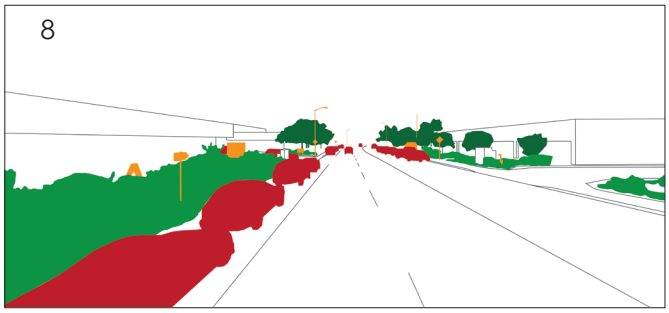
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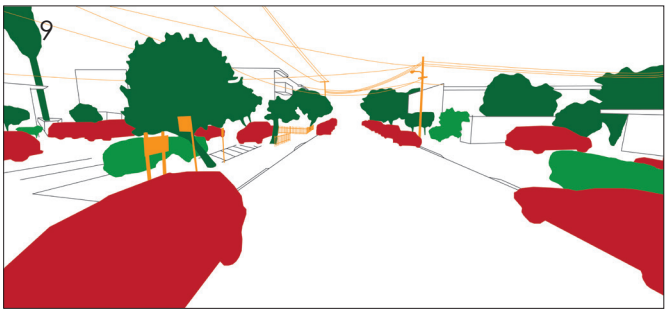
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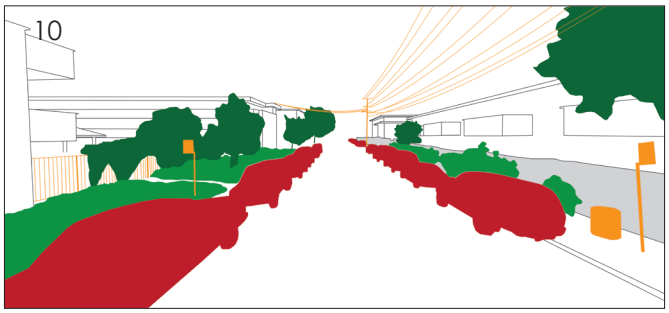
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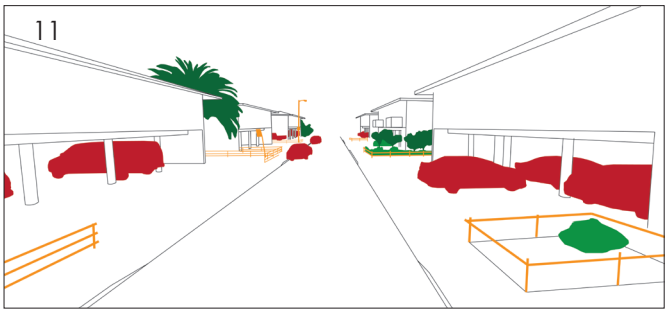
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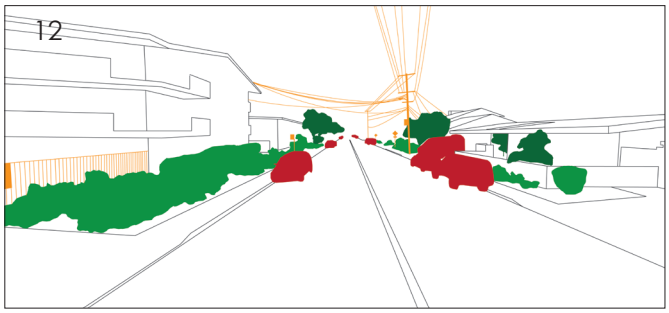
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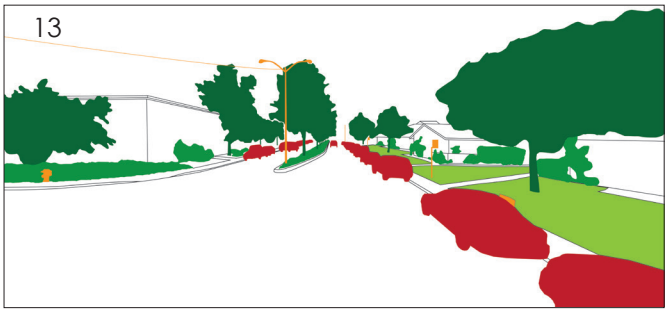
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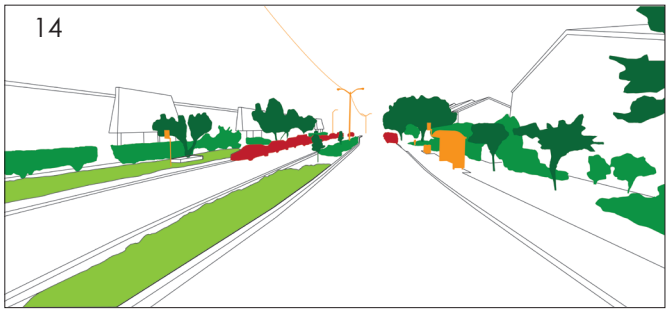
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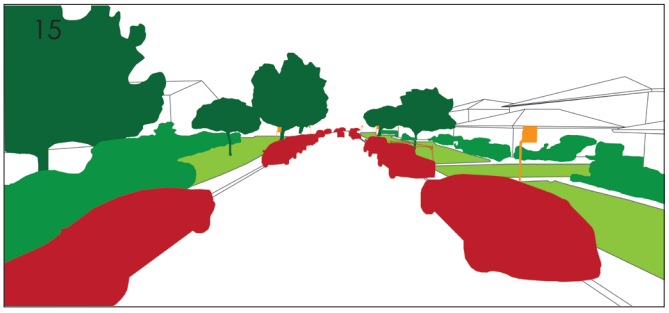
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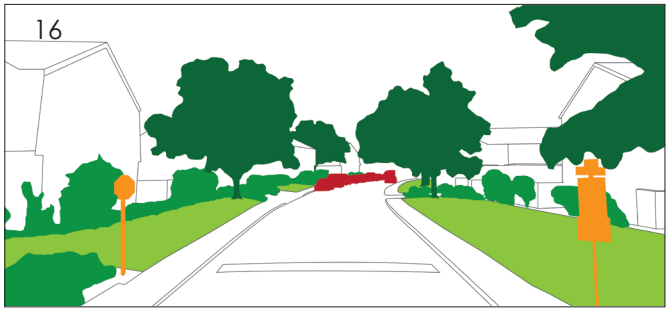
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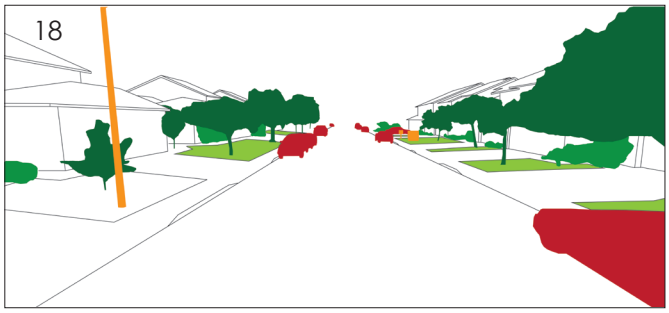
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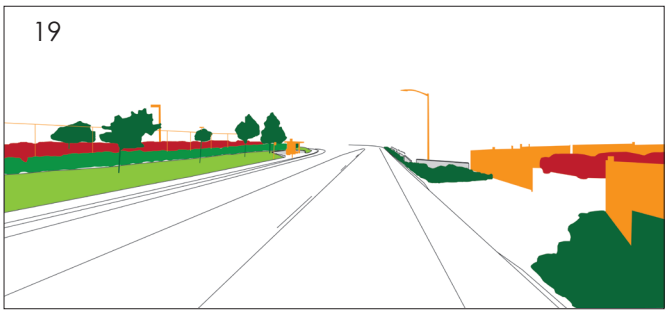
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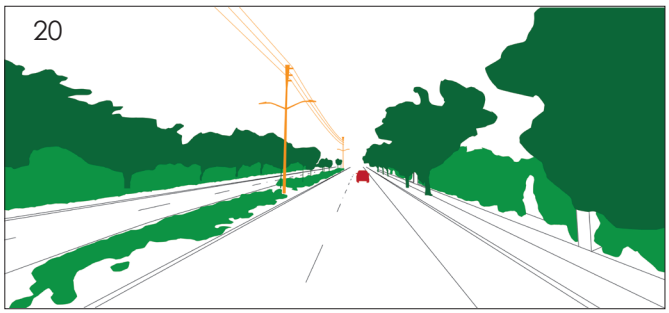
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WEATHER ANALYSIS

A4 Weather analysis

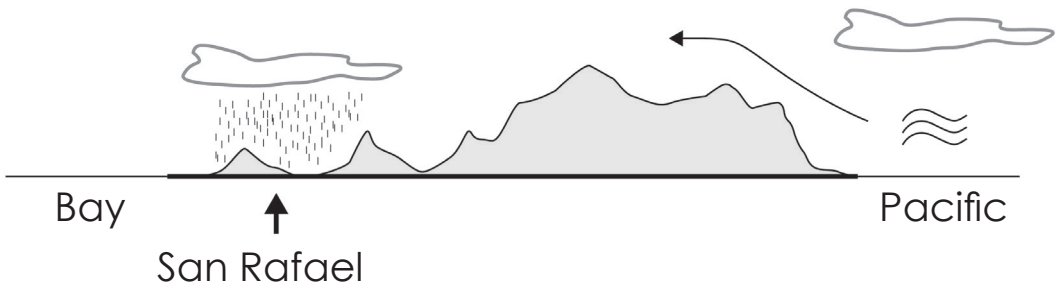
The San Rafael climate is quite unique, the geographical location is cause for more rain than any other city in the bay area experiences. On average just short of 900 mm of rain falls each year, all the surrounding areas have numbers 200-300 mm below that. That was a reason to take a closer look at the climate of San Rafael. Through a national weather databank, climate data since 1903 was gathered, however, the data for San Rafael only became viable after 1949, when a weather station was placed at the civic center. Over the years, for each month the total precipitation was measured and the maximal precipitation in 24 hours.

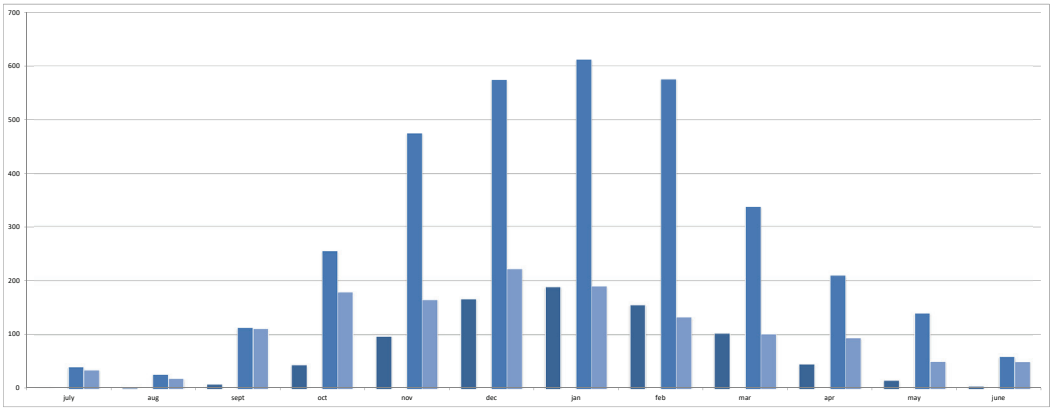
Annual precipitation

Rain is a bigger threat to San Rafael than any other city in the Bay Area. California as a whole has quite a dry climate, north is a little wetter but the south is completely dry. San Rafael has it's the only climate. Due to the unique location of mountains at sea, rainwater actually keeps gathering and only falls down on the other side, at San Rafael.

San Rafael annually receives 300 mm more than other cities in the central-north bay. They have two major watersheds, one covering the northern part and one covering the south, including the canal district. These watersheds both end up in the bay and can be considered completely separate.

Looking at the permeability of the watershed surface, all the unbuild and the rural area still has an infiltration capacity capable of handling a major rain event. But the city center, downtown San Rafael and the complete canal district, including the industrial zones are completely densified. These area's are not capable of handling rain showers on their own. Together with rainwater run-off from the higher part, these area completely relies on the sewer system and storage capacity of the San Rafael canal.



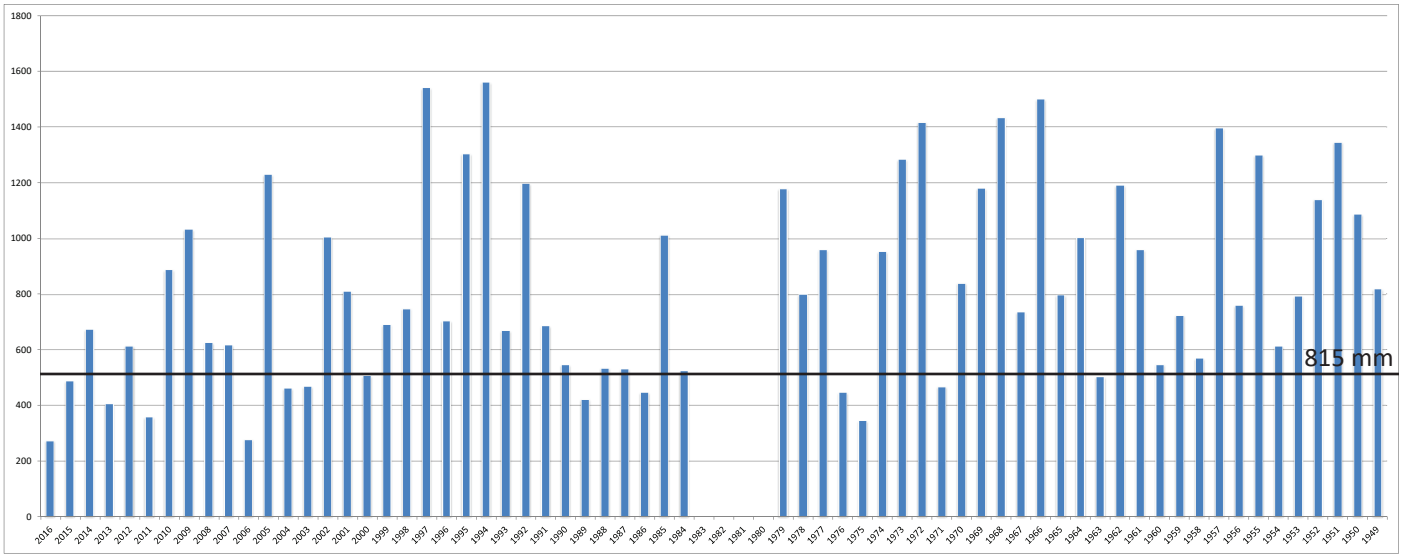


When looking at the annual numbers, some of the years were extremely wet and other extremely dry. But because of the raining season last from October to March, some years had the majority of the rain falling before the end of the year and others after. So instead, since July is the most stable month of the year, the data was rearranged to the raining seasons, from July to June the year after.

On average the data is quite stable, however, really wet and really dry years rotate frequently. In extreme events the month precipitation can be three times more than expected, the annual amount can fall in one month, sometimes 24h rain events drop more than the average monthly precipitation.

Rainwater events with more than 100 mm in 24h are not rare at all. The most extreme was 222 mm in 24 hours. 'San Rafael Flood 1995' instantly gets you search result on google. However, coping with 100 mm rainfalls is quite impressive already. The only question is if the rainfall events will get worse like climate change predicts. So far the collected data doesn't show a growing trend.

Over the years the weather has become less reliable. Years of drought, followed by one extremely wet year. The future of San Rafael might depend more on long-time storage of water then on handling heavy rainfall events.



Year with complete data
No data recorded
Year with incomplete data

Lowest precipitation
Low precipitation
High precipitation
Highest precipitation

Month with highest precipitation
Monthly precipitation record

Total rainfall

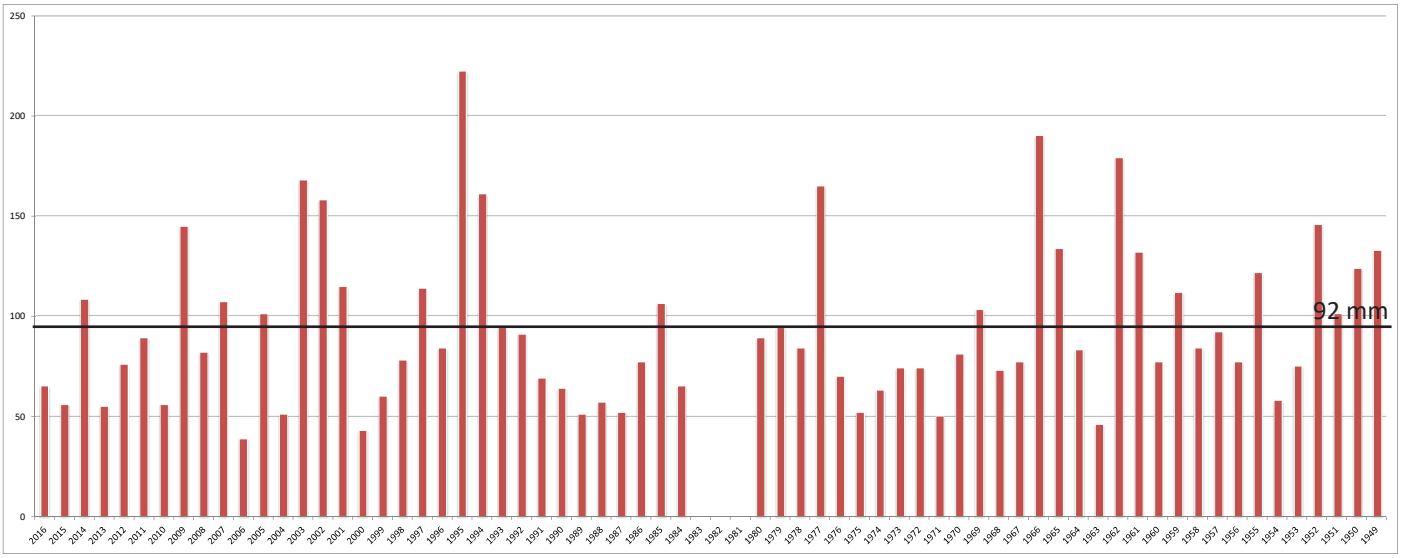
Mnth	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june		Total	
2016	0	0	0	163	111	NR								274	
2015	1	0	4	1	22	126	282	25	1	25	2	0		488	
2014	1	0	9	18	62	436	0	95	7	41	0	4		673	
2013	0	0	15	0	32	13	0	234	70	42	0	0		406	
2012	0	0	0	36	179	329	8	4	24	21	1	11		614	
2011	0	0	0	0	34	0	0	46	274	4	0	1		358	
2010	0	0	0	76	96	206	34	168	277	5	9	19		890	
2009	0	0	8	171	12	97	315	188	109	110	25	0		1035	
2008	0	0	0	30	94	94	14	301	46	14	31	0		626	
2007	0	0	1	60	19	90	361	81	3	2	0	0		617	
2006	0	0	0	20	0	0	8	194	5	41	10	0		278	634
2005	0	0	0	8	52	452	126	85	293	205	9	0		1230	
2004	0	NR	0	NR	0	NR	NR	128	183	53	85	13		462	
2003	0	0	0	0	NR	261	115	57	35	1	NR	NR		469	
2002	0	0	0	0	70	522	105	81	72	114	43	0		1007	
2001	0	0	3	16	223	358	101	33	54	9	15	0		812	
2000	0	0	3	86	32	17	136	188	37	5	0	3		507	
1999	0	0	2	0	NR	11	207	325	46	61	35	3		690	
1998	0	0	0	18	180	28	94	246	105	67	3	5		747	
1997	0	27	4	25	276	108	279	576	69	59	116	0		1539	
1996	0	0	0	20	26	331	281	5	19	6	9	6		704	874
1995	0	0	0	6	2	391	302	370	66	95	71	0		1304	
1994	0	0	0	13	297	134	612	24	339	80	39	20		1560	
1993	0	0	0	19	106	106	99	273	NR	27	38	0		669	
1992	0	0	0	98	5	282	471	222	53	21	30	17		1198	
1991	0	7	0	48	31	83	67	281	131	36	0	3		686	
1990	0	0	3	3	14	46	NR	119	327	24	2	8		546	
1989	0	NR	36	57	56	0	101	74	21	3	75	0		423	
1988	0	0	0	0	77	107	52	38	235	14	1	10		534	
1987	0	0	0	NR	38	247	162	14	0	54	10	7		531	
1986	0	0	24	0	2	45	98	163	104	9	2	0		447	
1985	0	0	0	NR	29	59	215	481	197	28	5	0		1014	919
1984	0	0	2	0	249	62	30	61	112	8	0	0		524	
1983	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0	1		NR	
1982	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		NR	
1981	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		NR	
1980	2	NR	0	3	5	125	NR	NR	NR	NR	NR	NR		NR	524
1979	0	0	1	91	131	250	259	312	43	82	8	3		1180	
1978	0	0	45	0	80	21	280	229	74	34	40	0		802	
1977	0	0	68	15	261	178	NR	214	154	70	2	0		961	
1976	0	26	16	13	75	68	84	60	74	8	23	0		447	
1975	6	1	0	121	15	18	9	37	90	50	0	0		346	
1974	40	0	0	39	20	100	66	376	253	57	2	0		954	
1973	0	0	5	79	475	167	191	53	247	63	3	2		1284	
1972	0	0	17	177	252	160	432	281	93	4	0	0		1416	
1971	0	0	6	0	92	171	51	51	15	76	0	6		467	
1970	0	0	0	57	247	364	58	4	72	30	10	0		842	
1969	0	0	2	120	30	362	504	90	61	3	2	7		1181	860
1968	0	8	0	83	130	358	419	330	43	62	1	0		1433	
1967	0	0	1	11	69	151	248	141	103	8	4	0		736	
1966	0	3	2	0	282	237	515	21	214	164	2	59		1500	
1965	1	20	0	0	195	147	265	140	10	16	5	1		800	
1964	0	1	0	81	148	312	227	52	67	118	0	0		1005	
1963	0	0	0	64	198	24	120	5	3	14	17	58		503	
1962	0	NR	0	255	22	167	295	112	174	156	10	0		1192	
1961	0	0	6	15	157	113	91	391	178	9	1	0		961	
1960	0	0	0	14	89	119	119	48	125	29	4	0		547	
1959	0	1	113	0	0	38	228	217	88	34	5	0		723	963
1958	1	0	1	2	6	63	255	212	18	12	0	0		569	
1957	0	0	41	199	22	NR	210	483	205	210	10	14		1395	
1956	0	0	4	91	1	4	164	190	123	41	140	0		759	
1955	0	0	1	3	120	575	336	249	NR	NR	16	0		1300	
1954	0	7	0	5	156	137	134	60	10	104	1	0		613	
1953	0	3	0	13	103	13	217	122	212	105	0	7		796	
1952	0	0	1	1	107	503	226	0	149	129	21	6		1141	
1951	0	0	0	48	146	407	441	99	120	43	13	27		1345	
1950	0	0	0	114	245	304	177	100	66	46	38	0		1088	
1949	1	3	1	2	75	106	314	204	51	50	13	1		822	
							24	131	252	0	9	0		417	873
1905	0	0	155	129	NR	NR								284	
1904	0	0	0	26	242	102	219	138	161	30	60	0		977	
							34	391	406	27	0	0		857	
	1	2	8	44	97	166	189	155	103	46	16	5	mm	815	mm

Montly Extremes													
	40	27	113	255	475	575	612	576	339	210	140	59	mm

Maximum in 24h

Mnth	july	aug	sept	oct	nov	dec	jan	feb	mar	apr	may	june		Total	
2016	0	0	0	57	65	NR								65	
2015	1	0	4	0	10	25	56	17	1	10	2	0		56	
2014	1	0	8	9	18	108	0	47	5	31	0	4		108	
2013	0	0	15	0	19	8	0	55	26	17	0	0		55	
2012	0	0	0	24	76	68	8	4	10	16	1	8		76	
2011	0	0	0	0	15	0	0	30	89	3	0	1		89	
2010	0	0	0	31	22	39	22	36	56	2	6	9		56	
2009	0	0	7	145	10	24	60	55	31	44	8	0		145	
2008	0	0	0	20	74	40	9	82	21	7	20	0		82	
2007	0	0	1	26	18	22	107	29	2	2	0	0		107	
2006	0	0	0	8	0	0	3	39	4	15	5	0		39	84
2005	0	0	0	6	20	101	31	57	66	78	5	0		101	
2004	0	NR	0	NR	0	NR	NR	37	51	18	32	6		51	
2003	0	0	0	0	NR	168	75	38	27	1	NR	NR		168	
2002	0	0	0	0	50	158	33	45	33	47	22	0		158	
2001	0	0	3	15	89	115	51	12	13	7	9	0		115	
2000	0	0	2	43	24	10	35	27	25	2	0	3		43	
1999	0	0	2	0	NR	11	54	60	13	27	18	2		60	
1998	0	0	1	18	43	13	15	78	33	27	3	5		78	
1997	0	14	3	13	49	31	44	114	31	23	35	0		114	
1996	0	0	0	15	34	65	84	2	13	6	9	6		84	93
1995	0	0	0	6	1	222	57	114	29	75	47	0		222	
1994	0	0	0	13	161	44	113	19	55	26	18	9		161	
1993	0	0	0	14	59	31	37	94	NR	15	14	0		94	
1992	0	0	0	63	3	59	91	50	14	19	11	15		91	
1991	0	7	0	32	30	35	27	69	42	30	0	2		69	
1990	0	0	2	3	6	25	NR	64	58	15	2	8		64	
1989	0	NR	21	33	51	0	37	37	7	3	51	0		51	
1988	0	0	0	0	24	36	18	20	57	4	1	10		57	
1987	0	0	0	NR	10	52	45	13	0	35	6	4		52	
1986	0	0	12	2	2	13	26	77	37	7	2	0		77	
1985	0	0	0	NR	14	51	54	106	70	10	3	0		106	93
1984	0	0	2	26	65	18	26	58	42	8	0	0		65	
1983	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0	0		NR	
1982	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		NR	
1981	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		NR	
1980	2	NR	0	3	4	89	NR	NR	NR	NR	NR	NR		89	86
1979	0	0	1	68	42	94	90	66	20	42	8	3		94	
1978	0	0	29	0	23	10	66	84	27	15	21	0		84	
1977	0	0	25	15	165	44	NR	50	30	21	1	0		165	
1976	0	13	12	12	27	59	70	26	40	5	11	0		70	
1975	6	1	0	52	10	12	8	10	48	22	0	0		52	
1974	35	0	0	38	18	36	43	63	63	18	2	0		63	
1973	0	0	4	38	74	44	39	16	47	39	2	2		74	
1972	0	0	10	56	67	44	74	54	23	4	0	0		74	
1971	0	0	6	1	41	50	25	19	10	27	0	6		50	
1970	0	0	0	25	63	81	20	3	41	17	8	0		81	
1969	0	0	2	87	22	98	103	30	34	1	2	6		103	81
1968	0	6	0	46	48	70	73	49	10	20	1	0		73	
1967	0	0	1	7	29	48	77	50	43	8	3	0		77	
1966	0	2	1	0	52	70	190	19	50	36	2	50		190	
1965	1	19	0	0	35	39	134	49	4	6	3	1		134	
1964	0	1	0	39	35	83	57	33	25	31	0	0		83	
1963	0	0	0	39	46	19	45	4	3	14	11	30		46	
1962	0	NR	0	179	11	51	145	35	57	36	6	0		179	
1961	0	0	6	8	51	51	56	132	74	6	1	0		132	
1960	0	0	0	9	25	77	37	19	36	24	3	0		77	
1959	0	1	112	0	0	36	43	64	22	22	5	0		112	109
1958	1	0	1	1	3	22	84	55	12	11	0	0		84	
1957	0	0	24	53	7	NR	69	77	32	92	8	13		92	
1956	0	0	2	77	1	4	43	43	32	33	51	0		77	
1955	0	0	1	2	61	122	50	103	NR	NR	9	0		122	
1954	0	3	0	5	58	46	34	26	6	43	1	0		58	
1953	0	3	0	9	53	9	75	44	70	56	0	4		75	
1952	0	0	1	0	52	146	50	0	101	94	9	5		146	
1951	0	0	0	22	36	101	100	47	39	23	11	17		101	
1950	0	0	0	37	82	124	49	29	37	45	20	0		124	
1949	1	2	1	2	69	36	75	133	33	21	7	1		133	
							14	30	60	0	8	0		60	102
1905	0	0	77	49	NR	NR								77	
1904	0	0	0	20	30	38	52	48	36	12	32	0		52	
							14	161	81	10	0	0		161	
	1	1	5	24	35	53	53	47	32	22	8	3	mm	92	
24h Extremes															
	35	19	112	179	165	222	190	133	101	94	51	50	mm		

Annual extreme 24h event



There is less fluctuation in the results of the 24h rainwater events, the 100 mm events are not rare and the 150 mm event usually create rainwater run-off problems. Basically every year a rainwater event between 100-150 mm is to be expected. And that is a value the city should defiantly be able to handle for the future.

Lowest precipitation
Low precipitation
High precipitation
Highest precipitation
Month with highest precipitation
Monthly precipitation record
No data recorded

SCENARIO'S FOR THE CANAL DISTRICT

A5 Development scenario's

Improving the mobility with San Rafael would be beneficial for the development of the Canal District. However, the whole San Francisco Bay area is looking for a location to develop, the demand for housing units is too high. Just connecting San Rafael with the east bay might have dire consequences. Those consequences might result in different scenarios. Although they might all prove to help against flood prevention, they might not be desired.

NEED FOR PUBLIC MOBILITY

The need for improved high-speed mobility is for the greater good for San Rafael. Currently, San Rafael is only a city for itself, there is barely any tourism going on inside the city.

Mobility in itself is not the issue, the whole city is one big concrete and asphalt surface. Completely designed to bring you from door to door by car. But the public transport is horrible. It's a trend you see in the whole bay area, like a downward spiral. It's bad, so no one uses it, so it doesn't improve. Resulting, that the people who actually need it, because they can't afford something else, struggle.

Making downtown San Rafael a connection Hub would bring San Francisco, Oakland, and Richmond within half an hour travel by public transport. There are not a lot of classic marina's in the south bay, San Rafael could fulfill that niche.

THE RISK

Creating a high-speed public connection to the east bay would create a further dispersion of silicon valley employees. If the interest of living in the area would be too high, it could put too much pressure on the existing residents.

NEED FOR GOVERNANCE POLICIES

Current systems for development can avoid regulations that require the building of social housing. For example, as a developer, you don't need to build social housing units if you build less then 20 units.

In order to keep the current residents of the canal district, to protect them. Strict regulations will have to be implemented to support the high demand for social housing.

Regulations will not only be needed for social housing development, in order to create an active waterfront, sufficient investments in the waterfront are required.

THE RISK

The American system is the way it is because the inhabitants don't want the government to constantly remind them of the rules. Real estate developers might stay away because they don't want to work will all the rules.

Institutional changes

- relying on thrust funds and housing authorities
- relying on the regional economy

Result

- lack of affordable housing

Economic changes

- continuous globalization & economic growth
- increase in property value and rental costs

Result

- growing gap between rich and poor

Demographic changes

- decrease in low income households
- decrease in median household size

Result

- loss of current hispanic population

Physical changes

- climate change effects
- post oil car mobility

Result

- permeability through suburbanization

Existing car mobility

Institutional changes

- adaptive pathways for future water management
- affordable housing policies for developers

Result

- increase in affordable housing options

Economic changes

- continuous globalization & economic growth
- stabilization of property value and rental costs

Result

- wealth increase for rich and poor

Demographic changes

- decrease in low income households
- decrease in median household size

Result

- maintaining a portion of the local population

Physical changes

- multi layered water management
- improving local connections

Result

- increasing public spatial quality

Maintaining existing governance policies

Revised governance policies

Institutional changes

- relying on thrust funds and housing authorities
- relying on the regional economy

Result

- growing demand of affordable housing

Economic changes

- continuous globalization & economic growth
- increase in influence from silicon valley
- increase in property value and rental costs

Result

- impossible rental prices, ownership gains

Demographic changes

- increased migration within the bay area
- attracting younger settlers

Result

- a changing population

Physical changes

- decreasing / alternative car usage
- increase in property development

Result

- densification around transport hubs

High speed public transport

Institutional changes

- adaptive pathways for future water management
- affordable housing policies for developers
- support for a local economy

Result

- sustainable future for vulnerable low income classes

Economic changes

- continuous globalization & economic growth
- increase in influence from silicon valley
- stabilization of property value and rental costs

Result

- wealth increase for rich and poor

Demographic changes

- support for low income households
- attracting younger settlers within the bay

Result

- a mixed population of old and new

Physical changes

- increase in property development
- decreasing / alternative car usage

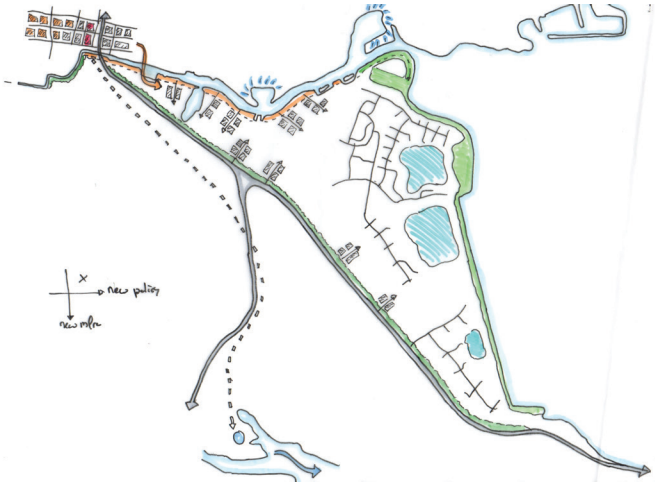
Result

- alternative use of public domain

Maintaining existing governance policies

Revised governance policies

Excisting car mobility

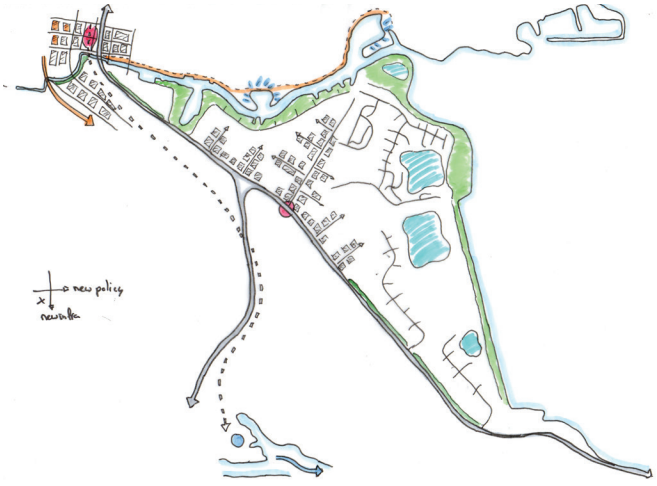


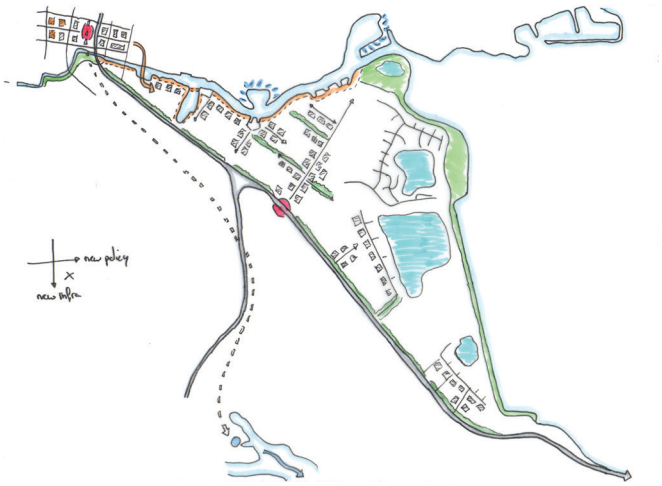
Excisting car mobility

Continuing in the current trend of suburbanization, eventually the current residents will leave due to the high real estate pressure. A 'room for the river' edge, together with a highly permeable suburban neighborhood, might provide enough water infiltration to prevent serious flood damage. But all the 'native' residents will be gone.

Policy changes to keep the current residents in the neighborhood will provide additional social housing units in the area, most likely through funds designed for that purpose. Without the increased mobility there might not be enough interest to attract other residents, creating a bigger concentration of social-economic vulnerable resident.

High speed public transport





High speed public transport

Maintaining existing governance policies

Revised governance policies

Creating a high speed transport connection will attract a new kind of residents towards San Rafael, without protecting the current residents through social housing requirements, new dense clusters of housing unites will emerge around the connection points. Additional room for water will likely be made around the canal.

The Improved connection to San Rafael will attract people from all different classes towards the canal district, while the current residents will be protected by new governance policies. This way real estate developers can profit from developments while also contributing towards the realization of social housing units.

REVIEW PAPER

Water management, a burden or social-economic opportunity

Water management linked to strategic spatial planning

AR3U022, Theory of Urbanism – Review paper

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January, 2017

Abstract – Unpredictable futures ask for long term visions, dynamic adaptive policy pathways and strategic spatial planning both work on this long term, but can they work together as one? Dynamic adaptive policy pathways address water management problems in a flexible way with multiple possible actions that are set in motion after a tipping point is reached. Strategic spatial planning is based on different tracks of actors and governance working simultaneously towards a long term vision, coming together within strategic projects that work as a catalyst of a larger area. An incentive for development in strategic spatial planning could be the benefits of flood protection; direct economic gains are created for residents in the form of property value and lower insurance, while long term flood prevention could save the urban system billions. Strategic project seem to fit within the adaptive pathway approach, possibly strengthening each other. Whether the projects could delay the tipping points or if they are the actions to be taken is reason for further investigation.

Key words - Urbanism, dynamic adaptive policy pathways, spatial strategic planning

Introduction

'Nowadays, decision makers face deep uncertainties about a myriad of external factors, such as climate change, population growth, new technologies, economic developments, and their impacts' (Haasnoot, et al., 2013, p. 485). There are a lot of undercities in our future, we can only use current trends as a guidance for what is to come but these trends are already a call for action. Climate change is incoming and will hit more people with problems we already have. One of those problems is flooding in delta areas, these same delta areas are growing explosively, both economically and in population numbers (UN habitat, 2008). Most of these developments are happening in underdeveloped countries (Nicholls, et al., 2007). As a result challenges in water management and spatial quality are faced simultaneously. Is there a combined solution to face these challenges, can water be the answer to solve both problems?

In this review paper current trends in water management and spatial planning approaches are investigated in search for common ground. First the known approaches relating to climate change are addressed. Then the dynamic adaptive policy pathways approach is summarized to understand current water management policies. Then, the same is done for strategic spatial planning, dealing with social-economic problems. The value and benefits of water and flood prevention is discussed with the help of the greater New Orleans water plan. And finally, possible links and solution between the different approaches are mentioned and a recommendation is made to continue on before implementing.

Climate change

At a symposium at the TU Delft, in December 2016, Henk Ovink, special envoy of international water affairs, warned his audience that we have only five years to save the world. He was referring to the aims of the 2015 Paris agreement. If those goals are to be met, we have to make drastic changes within the next five years

or they will fall beyond our reach. With the recent election of Donald Trump, America now has a president that said in an interview with Hugh Hewitt:

"I mean, Obama thinks it's the number one problem of the world today. And I think it's very low on the list. So I am not a believer, and I will, unless somebody can prove something to me, I believe there's weather. I believe there's change, and I believe it goes up and it goes down, and it goes up again. And it changes depending on years and centuries, but I am not a believer, and we have much bigger problems."

Donald Trump
(Lewis. In The Huffington post, 2016)

Chances are that America, one of the largest industries in the world, will no longer participate in the climate change agreements, signed in Paris. So we will have to start taking action ourselves and prepare for climate change to affect us. The best case scenario, which we'll likely miss, is already predicting a sea level rise of 0.4-0.6 meters (Abraham, 2013). With open water connections to the sea, many delta area's will have to deal with this rising water level.

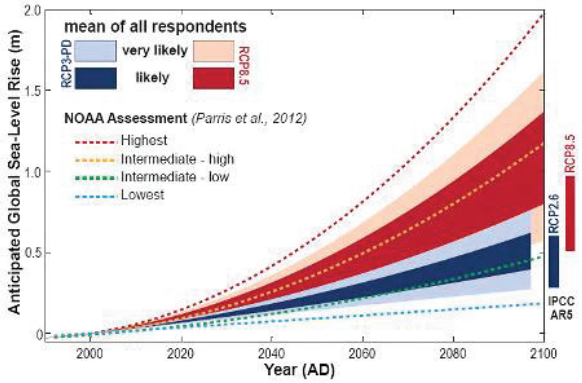

Figure 1 – *The anticipated global sea-level rise till 2100, 0.4-0.6 meters are considered most likely, but possible scenarios up to a rise of 1.5 meter. (Abraham. In The Guardian, 2013)*

When it comes to dealing with uncertain but estimated threats, there are four types of sustainable approaches: resistance, resilience, static robustness or dynamic robustness (Walker, et al., 2013). Resistance is about being able to handle everything, preparing for the worst case scenario and prevent anything from happening. Resilience is about being able to recover to the original form after an incident quickly. And robustness is about reducing the vulnerability, if something happens the influence is minimal. The difference between static and dynamic robustness is the time of implementation. Dynamic robustness allows for change over time, it's about adapting to changing conditions. In recent years resilience against possible threats was the parent trend but slowly adaptation is becoming more relevant.

Water management

When it comes to water management, the Dutch have gained a considerable amount of knowledge dealing with water since the beginning of their first settlements. At first there was a protection against flood then there was guidance of the water to their benefits. Now the Dutch are living with water in a harmonistic relationship, it has become a part of their environment, life, economy and history and climate change is becoming a threat to all of that. At the same time, the gained knowledge from the Dutch has become an export product to the rest of the world. Simultaneously, Dutch companies and universities are developing strategies to tackle the problems in delta areas, in the Netherlands and all over the world. One of the reasons the Dutch excel in water management strategies is their multi-layered governance, according to a study between the governance approaches in three major delta regions, the 'steering capacity is crucial in addressing climate-related risks as it allows for coordinating spatial planning and flood management activities which typically tend to be uncoordinated' (Francesch-Huidobro, et al., 2016).

One of these bigger, steering, governance programs is the Dutch Delta Programme. Within this program room for adaptation to changing scenarios is reserved (Delta Programme, 2017). This Adaptive Delta Managements inspired the Dutch office Deltares to further develop a policy decision making strategy they call the 'Dynamic Adaptive Policy Pathways approach' (Haasnoot, et al., 2013). This approach is a combination of two underlying approaches, adaptation pathways and adaptive policymaking. The adaptation pathways approach is based on tipping points rather than fixed time periods, it's a system based on continuously monitoring of the system. When a certain threat level is reached a decision will be made with which policy action to continue. This allows for different developments in time.

Different pathways can be chosen, pathways that are more suitable for the current time period or pathways that will beneficial in the long term. Every tipping point allows for a new opportunity for a pathway change and therefor more flexibility.

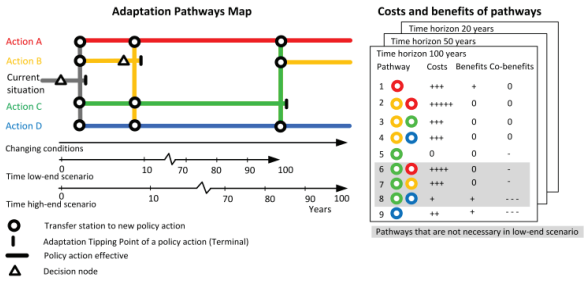

Figure 2 *– An illustration of the adaptation pathway approach, multiple actions that can lead to the needed protection, executed the moment a tipping point is reached. (Haasnoot et al., 2013)*

Adaptive policymaking is directly linked to designing dynamic robust plans and rooted in Assumption-Based planning (Haasnoot et al., 2013). A wide variety of uncertainties is left open and dealt with by creating a robust solution, it's a system continuously preparing for the worst and making sure you deal with it ahead of time. The combination of both in the dynamic adaptive policy pathways is supposed to deliver an approach that 'describes a sequence of promising actions with a monitoring system that provides contingency actions to keep the plan on the track of the preferred pathway' (Haasnoot et al., 2013, p. 489).

Figure 3 *– The dynamic adaptive policy pathways approach, a continuous loop of measuring and reassessment to steer the development into a favorable scenario. (Haasnoot et al., 2013)*

The main reason this approach is interesting in future developments is the flexibility of handling the future problems. The approach starts by analyzing the current problems and vulnerabilities but the actions do not apply until the tipping points are reached. When dealing with climate change and the future development most strategies implement different future scenarios. By creating a fast amount of different actions that can be taken in time room created to develop these actions according to the scenario's expected. It's even possible to steer the actions in the most desirable scenario.

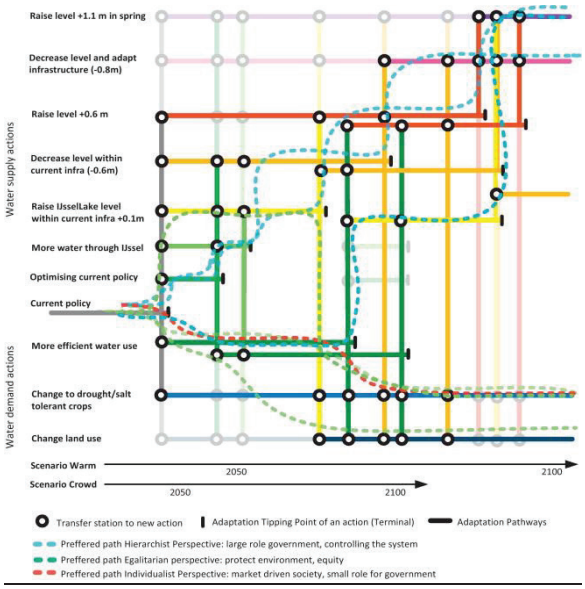

Figure 4 *– A mix of possible actions and desired scenarios. While the actions are activated when the tipping points are reached, the dynamic policy allows for more steering and control. (Haasnoot et al., 2013)*

The water management approach of Dynamic Adaptive Policy pathways allows for more flexibility and steering option in the long term, qualities that are very important when it comes to flood protection in delta areas (Francesch-Huidobro, et al., 2016). However, this approach is solely based on water protection and doesn't take social-economic developments in consideration.

Strategic planning

When it comes to improving the quality of life, we usually speak of spatial planning. Place making through promoting, managing and regulating. Spatial planning in Europe emerged in the twentieth century, when public health concerns rose and many countries started regulating properties and housing laws. At first this resulted in new types of development like garden cities and utopias but transformed into

management and regulation of urban expansion. When new towns started emerging outside the existing urban fabric with the implementation of cars, the role of the cities became a topic and strategic planning arose between the 50s and 80s, to hold or give meaning to areas that lost or needed it (Healey, 1997).

'Strategic planning starts form the position that societies are not prisoners of their past and therefore carry responsibility for their future'

(Oosterlynk, et al., 2011, p. 1)

In Strategic spatial project: catalyst for change, the role of strategic spatial planning is analyzed with the help of different projects in Europe. At the same time a four-track approach was designed to operationalize strategic spatial planning.

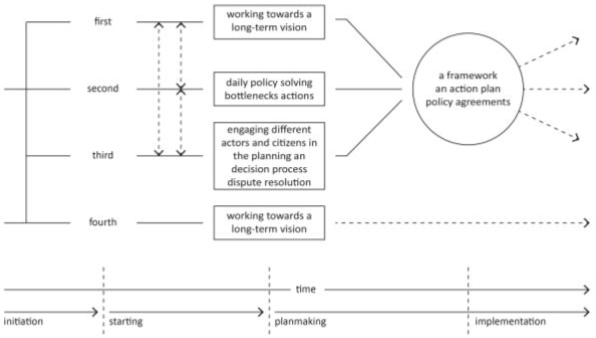

Figure 5 *– The four track approach for strategic spatial planning. Spatial development guided along four interacting track. (Oosterlynck et al., 2011)*

The tracks work alongside each other but in different speeds and are aimed at different levels of governance. The first track is meant for the larger governance organs, the municipalities, counties or national government. It's about creating a long time term vision that accounts for alternative futures but with and structural social-spatial transformation in mind. This track can be considered as the plan making track. The second track is more short term, it aims on addressing the problems of today, it still works towards the desired future but the focus lays on the here and now. Where the first track doesn't depend on the current governance, the second track does, it's all about the decision making. The third track is where the different actors meet, that play a meaningful role in spatial quality and spatial development. This is considered the implementation track. The fourth track is not about any level of governance but aimed at involving non-conventional actors. It is about empowering socially disadvantaged groups, by giving them the option to participate in the strategic planning process. This track is about social innovation.

The first and fourth track are both working towards a long term vision, but are from the perspective of the highest form of governance to the single individual. It's about asking both questions, what can the city do for me? And what can I do for the city? The link between the different tracks can be found within strategic project. Moving away from conventional large-scale urban development projects, which are often used to generate growth or to strengthen the competitive position. The strategic projects focus on small scales where the different actors belonging to the different tracks meet.

There are three factors that are contributing to the successful effect of strategic project. First, even though the projects themselves can be on a small scale, they serve as a catalyst and impact on a larger scale. The implementation of strategic projects creates mobilization of new actors which can start a chain reaction of more developments to follow. Second, strategic projects bring together different actors from different levels of government. They allow for diverse actors from different positions in the economy and society to come together and participate in the development. Especially for the actors involved in the fourth track, strategic projects can strengthen their position in the urban society. And third, because of the scale strategic projects are more feasible, they are easier to implement and take less time to realize. Because of the small scale, the opportunities will first benefit the local society and market developments before it will influence the larger scale. Eventual the goal of the strategic projects will always be the long term vision set in the first track, the strategic projects solely serve to bring different policy sectors together in a shared, spatial vision.

Water as a value strategy

Both on the area of water management and spatial planning, similar problems occur, namely, the unpredictable nature of the future. One is the result of climate change, which we know is coming but not in which degree, the other is dependent on social-economic development. We do know that currently 40 million people (0,6% of the global population) are living in areas that are at risk of coastal flooding, with a predicted increase to 150 million people at risk, in 2070. And most of them are living in underdeveloped countries with low investments in spatial quality (Nicholls et all., 2007).

In the near future more investments in flood risk protection will have to be done in these delta areas. However, infrastructural projects like delta interventions require a lot of investments and are usually considered as a big burden. But smart investments and development with water could also be an asset, because there is an economic value to be found in water. Properties directly facing the water are considerably worth more and considered as a stable investment. At the same time, larger waterbodies like rivers and lakes create a water related economy from maritime and recreational purposes.

After the devastating hurricane Katrina, the city of New Orleans tried to change their relationship with water. With the help of many international companies and agencies the greater water plan was created, in this document a vision for the future of New Orleans was presented. A part of this greater water plan focused on the estimated economic value of the plan, which was mainly based around water. One of the conclusions they made, was an estimated increase of property value of over 41.500 properties that lie within 200 meters of a proposed intervention area, the predicted value of these properties was a gain of $183 Million over 50 years (GNO Urban Water Plan, 2013).

The increase in property value is not the only benefit from an extensive plan to deal with water, in New Orleans a total economic benefit of $22,3 billion is estimated. A large part of this (51%) is gained from implementing the water plan and the jobs that are created by that, but other than that the protection against flood has such a big impact in the long term that the benefits of the actions taken outweigh the costs. In 50 years' time a loss of $10.2 billion is estimated from damages of flood events and subsidence. Smaller benefits are the lower insurance premiums to be paid by property owners due to the decreased flood risk.

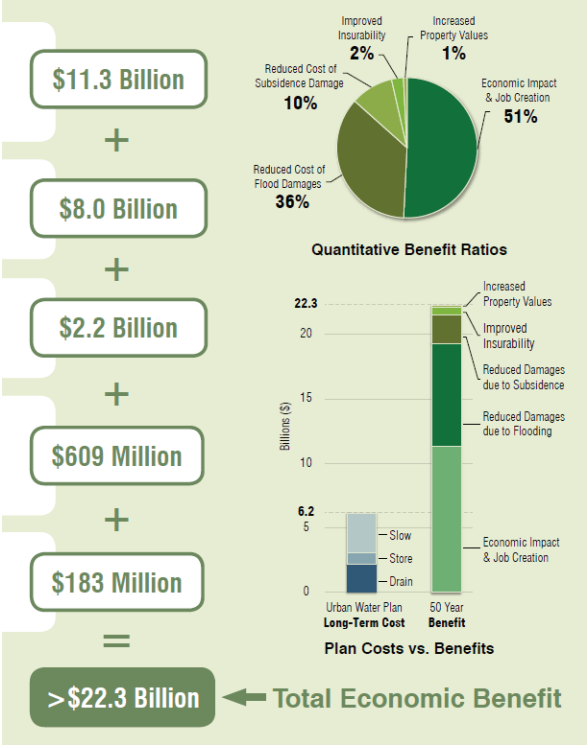

Figure 6 *– An overview of the quantitative benefits from the estimated economic value of the greater New Orleans urban water plan. (GNO Urban Water Plan, 2013)*

So when looking at the economic value of water in the existing urban fabric, adding water does have a positive economic effect but it's small compared to the cost that have to be made. When arguing about implementation it is better to focus on the long term effect and the decreased risk of flooding.

Conclusions

Climate change and the global population growth bring a lot of uncertainty to the future, the keyword of tackling these problems seems to be adaptation. Both in water management and in social-economic development the approach seems to be focused on a long-term vision in which a range of options are possible solutions to handle problems on the go. In water management they take actions when a tipping point is reach and the

vision needs readjusting, in strategic planning the projects can be considered as the tipping points themselves. When it comes to economic value, this focus on the long-term seems to fit right in; the benefits of preventing damages in the future outweigh the direct costs to be made.

Using strategic projects to either extent the time to the next tipping point or as an intervening action in the water management approach could be a way to simultaneously invest in flood protection and social-economic change. Designing catalytic projects around a water management solution could improve the social-economic growth right now, with a lager impact on a bigger scale in the future. While the water management implementation might not be necessary right now, it does delay the time between next actions to be taken.

Recommendations

An interesting next step would be to integrate the four track system approach of strategic spatial planning into the dynamic adaptive policy pathway approach, to find out if the strategic project would be implemented as actions after the tipping points or if they would serve better as loose projects within the pathways to extent the tipping points.

A problem that could emerge when working with both approaches is the fact that the dynamic policy pathway approach was mainly created for coastal and fluvial flooding. It is really designed as a water management tool. In many urban fabrics, the rising problem is pluvial flooding in combination with the increase in surface density. Before implementation in a design project, an analysis should be made to see if it's possible to measure or create measures for these tipping points.

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