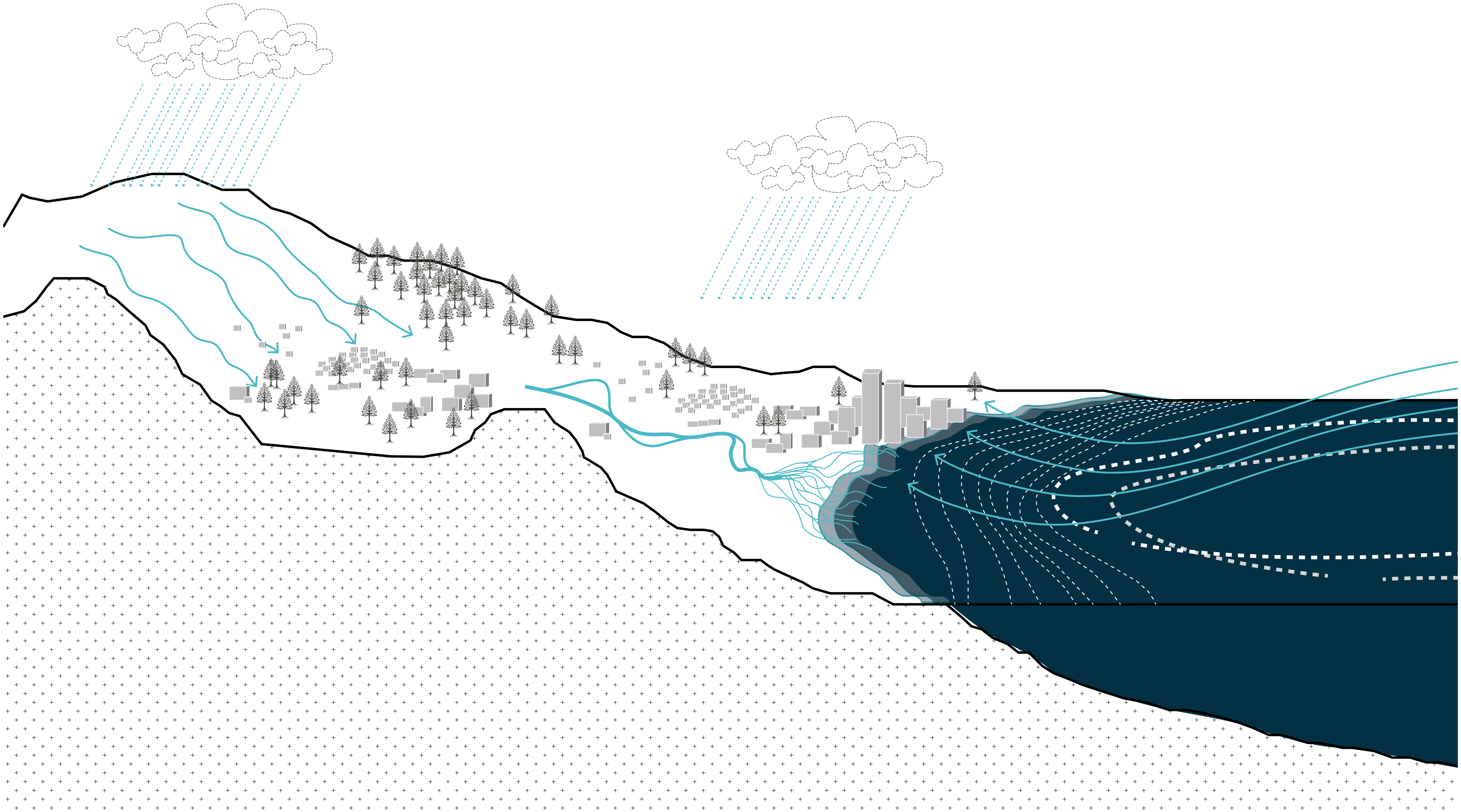

MULTIPLIED GROUND

A NEW LENS FOR SAN FRANCISCO'S NORTHEAST EDGE

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Fig.0: San Francisco Bay's encroaching waters. Rising Reality, http://projects.sfchronicle.com/2016/sea-level-rise/part1/

1. BACKGROUND

1.1 Climate Change

Climate change, which is suggested to be man-made and catastrophic, occurs in the shape of synthesis of nature and society. With the publication of the Fourth Assessment Report of the International Panel on Climate Change (IPCC), the significant effects of climate change are currently occurring and visible: melting polar ice caps, rising temperature, accelerating sea level, more intense heat waves and extreme weather events. Climate change affects all cities with a combination of extreme events and chronic conditions for which they are not physically or socially prepared. For example, Hurricane Sandy was an extreme event, and its effects on New York were acute and devastating for people in the path of its storm surge. While, the rising level of water is a chronic condition and its effects may be less dramatic, but they will be more pervasive.

Residents in cities across the globe are coming to learn the chronic effects of climate change. It afflicts cities not only with catastrophes, but with daily operational challenges. Increased temperature, more variable precipitation, and higher winds are becoming a fact of urban life. And all this against a backdrop of constantly rising sea levels as rising temperatures increase the rate of polar ice melt. As sea level rises, coastal cities will find more of their population closer to sea level, or even below it. Rotterdam is an example of a city familiar with the dangers of too much water and too little elevation. The projected rise in sea levels will not only affect the infrastructure of a city, but also the physical and mental health effects of its residents. Extreme weather and flooding can also lead to a variety of adverse health effects. For example, floods can contaminate freshwater supplies, damage or destroy sewage pipes, wipe out crops, heighten the risk of water-borne diseases, and create breeding grounds for disease-carrying insects such as mosquitoes.

1.2 Coastal Cities

Climate change, treated as a natural catastrophe, is a global issue that influences worldwide and poses a series of interrelated challenges to various human settlements. Its impacts are expected to be particularly severe in cities, which are the center of discussion addressing this phenomenon. Cities have become early responders to climate change challenges and opportunities due to two simple facts: first, urban areas have large and growing populations that are vulnerable for many reasons to climate variability and change; and second, cities depend on extensive infrastructure systems and the resources that support them. However, many cities are not capable of adapting to the climate change and its long-term impacts.

Sea level rise may pose an even greater challenge for coastal cities. Average sea levels have risen about 1.2 inches per decade in the city since 1900, or about 1.1 feet overall. This is almost twice the average global rate of 0.5 to 0.7 inches per decade. This trend is expected to accelerate in the coming decades as greenhouse gas emissions generated by human activity continue to trap more of the sun's heat, warming and expanding the oceans and melting land-based glaciers and ice caps, among other contributions.

1.3 Waterfront

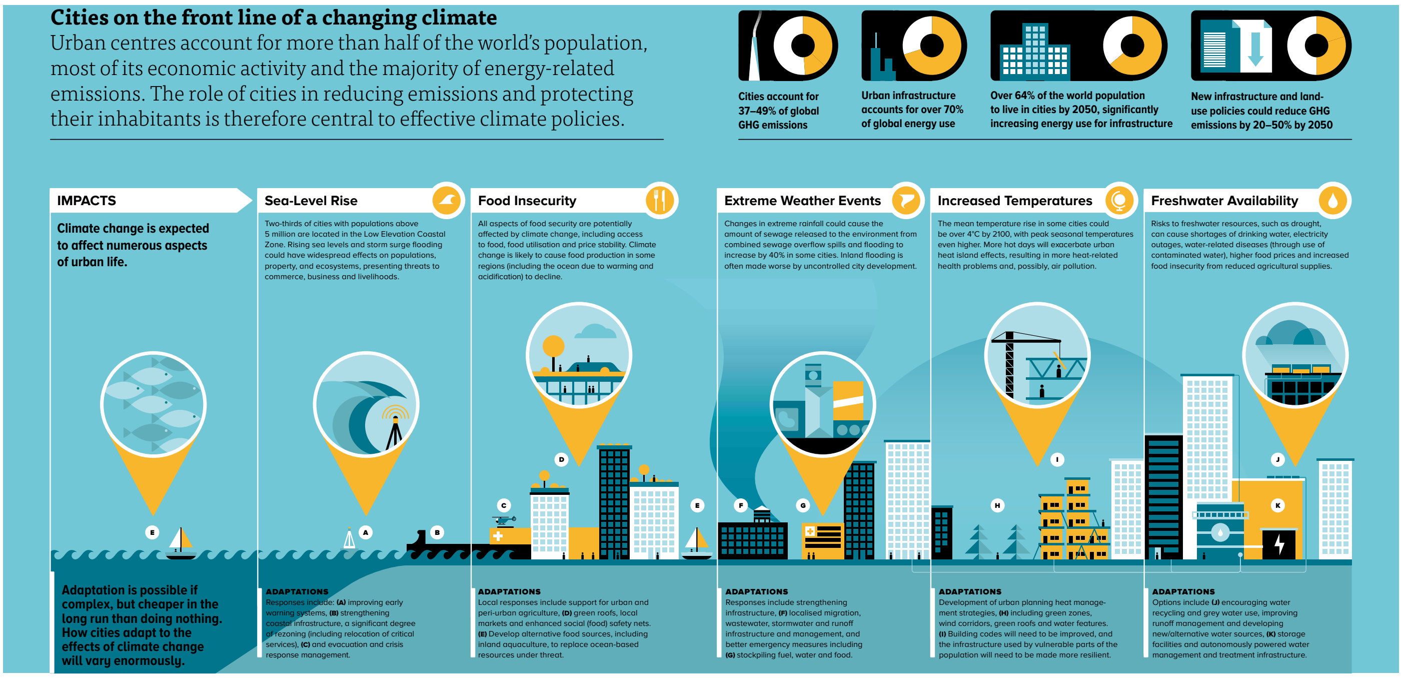
For a dense metropolis, today as much as centuries ago, the waterfront is where a city opens up beyond the topography of daily life. Basically, the waterfront has to serve as front yard and service alley, cultural stage and civic space, playground and profit center. In short, it is the paradigmatic site for the future public life. The scale of waterfronts is more than local, and it demands metropolitan-scale activities – highways, ferries or recreation centers – serving far more than the immediate local population. However, the waterfront, in between the land and the water, are even more vulnerable to the coastal flooding, the rising seas and more frequent storms. How can citizens rebuild its waterfront in a way that recognizes these two fundamental functions: the first, to accommodate a working waterfront, both for emergencies and the everyday; and the second, to serve as the iconic front yard of the city?

1.4 The Site

Of all American cities on the water, San Francisco has an incomparable natural advantage in the beauty of its harbor and the most terrible disadvantage in its vulnerability to earthquakes and flooding. Located at the north end of the San Francisco Peninsula, it includes significant stretches of the Pacific Ocean and San Francisco Bay within its boundaries. In this case, the rising sea levels have the potential to interact with storm surges and high tides to present a serious flood threat to coastal area, where houses the majority of populations and properties. Thus the challenge to San Francisco is more profound: to accommodate the bay's impending expansion as it rises because of our warming planet; and to accomplish that in a way that won't put our human and environmental resources at risk.

The focus of this project is San Francisco's urban waterfront, an area nearly entirely under the jurisdiction of the Port of San Francisco. It is roughly a seven-mile stretch of San Francisco on its bay side, running from Fisherman's Wharf on the north to India Basin on the south. The Embarcadero, comprised of piers, buildings, container terminals, roads, pathways, open spaces and other physical elements, located at the northeast edge of the port. It was constructed on reclaimed land along a three mile long engineered seawall, from which piers extend into the San Francisco Bay. The Embarcadero is a vitally important regional resource that can support port and related maritime facilities, public access, open space, recreational sites, and water-oriented commercial recreation. Recently, it has been named one of America's at-risk historic treasures –not because of development threats, but the looming dangers posed by earthquakes and sea level rise. This calls for a resilient and integrated approach to maintain its value and to preserve its historic resources.

Fig.1: Climate Change Effects on Cities. https://www.desmogblog.com/2014/09/05/what-does-climate-adaptation-actually-look-check-out-awesome-new-infographic-series-cambridge



2. PROBLEM FIELD

2.1 Sea-level-rise as Threat

The shoreline of the San Francisco Bay comprises approximately one third of the total California coastline. The wonder and beauty of the Bayshore and Pacific Coast waterfronts are major contributory factors to making this a vibrant and extraordinary city and region in which to live.

Rising Bay and coastal water levels are already affecting San Francisco with periodic coastal flooding of low-lying shorelines, increased shoreline erosion, and salt water impacts to San Francisco's wastewater treatment systems. When rain falls during higher-than-normal tides, tide levels can also slow the drainage of rainfall run-off into San Francisco Bay, increasing the potential for urban stormwater flooding.

Flooding is a process that has literally made waterfronts. It is an issue both timeless (seasonal and epochal flood trends have given geological shape to waterfronts) and immediate (recurrent flooding affects use and short-term development). Flooding is a natural phenomenon within the hydrologic cycle of a region, and is a necessary occurrence through which nutrients and fine-grain sediments are returned to soil systems. Natural flood events of varying scales can be predicted—or at least expected—at certain temporal junctures: rainy-season high water, for example, and ten-year and 100-year floods.

Flooding leaves its mark at the waterfront on both built and natural systems. It can cause erosion of river and estuarial edges because of flood pulses. On sites where the water's edge has long had structures such as levees and seawalls, the effects of floods can be seen in the layers of sedimentary deposits and refuse that collect and build in the floodway channel.

There have been significant advances in the scientific understanding of the risk of accelerating sea level rise (NRC 2012). Present sea level rise projections suggest that global sea level in the 21st century will be much higher due to both the expansion of the oceans by warming and, increasingly, by the melting of land-based glaciers and ice sheets. These projections are summarized in the recent National Research Council report on West coast sea level rise (NRC 2012) which provides estimates of regional sea level rise for San Francisco. By 2050, the mid-range projection for sea level rise is 11 inches with an upper projection of 24 inches and by 2100, the mid-range projection is 36 inches with an upper projection of 66 inches (Fig. 2).

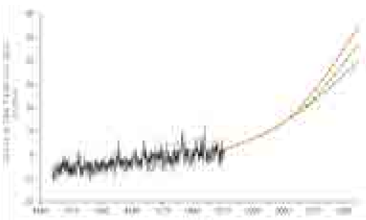


Fig.2: Historic measured and future projected sea level rise. Historical (black jagged line) from Presidio tide gauge. Dotted lines indicate OPC 2013 sea level rise projections. Source: ESA PWA.

It is not sea level rise that is increasing the risk of coastal flooding in the San Francisco Bay Area. Rather, it is the increasing frequency of extreme water levels that will cause more extensive flooding in the near future (Fig. 3). Water levels that exceed predicted tides occur due to ocean conditions such as El Niño as well as due to precipitation, wind, and low pressure during storms (e.g., "Pineapple Express" storms). As shown in Figure 3, a structure inundated with a 100-year recurrence interval flood in the year 2000 will be inundated by a 20-year recurrence interval flood by 2033 and a 2-year recurrence interval flood by 2060. Exposure to more frequent extreme water levels will have an impact on infrastructure much earlier than mean sea level; that is, operations will be affected by more frequent flooding long before the site is permanently inundated by sea level rise.

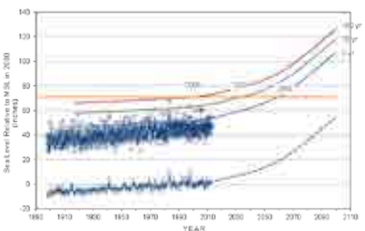
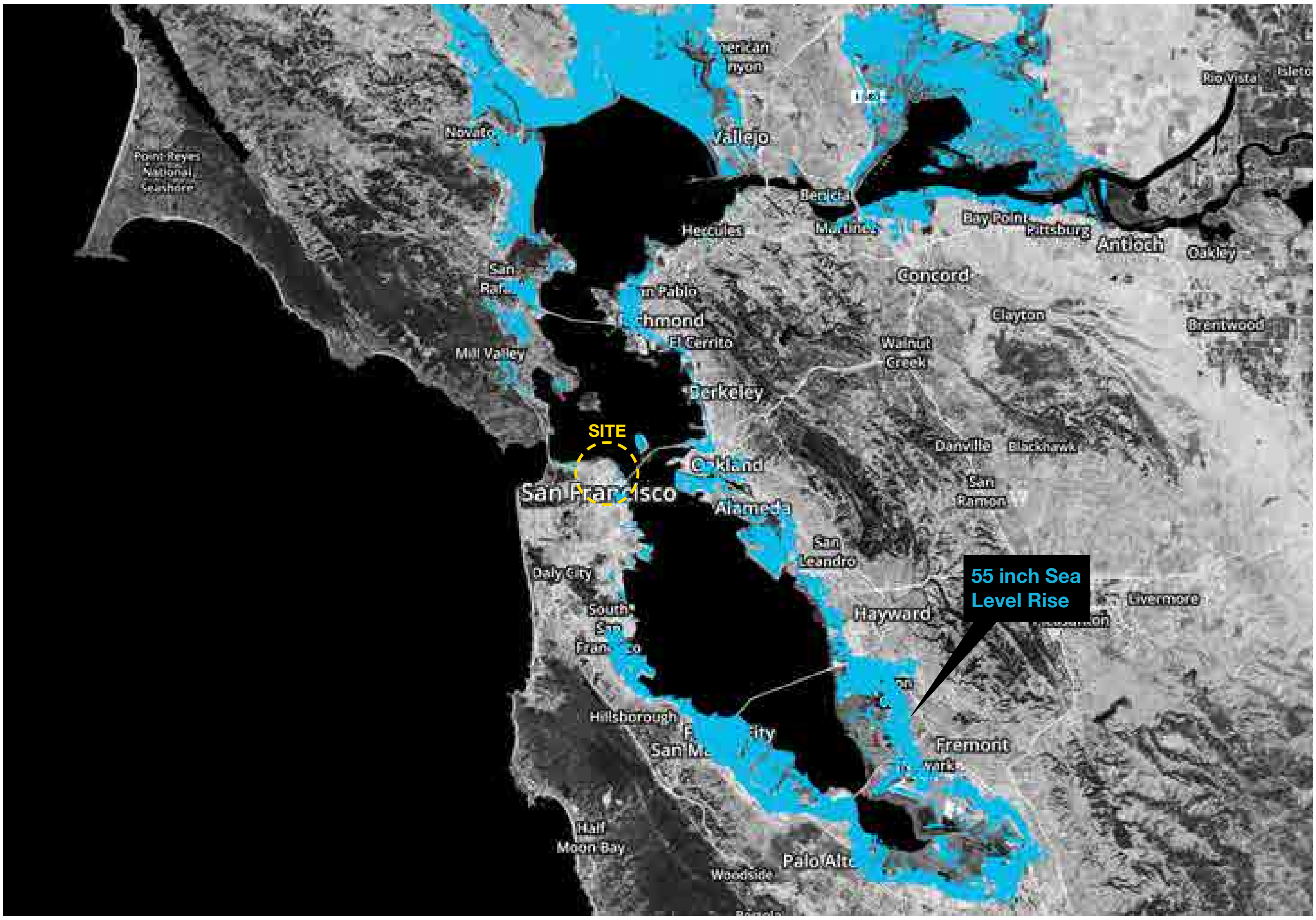


Fig.3: 100-year flood events caused by extreme water levels become two-year flood events by 2060 with sea level rise. Historical (blue jagged line) and annual extreme water levels (blue crosses) from Presidio tide gauge. Infrastructure impacted by flooding at a given elevation is represented by the orange line. Source: Developed from Kriebel (2011).

San Francisco waters experience daily tides, King Tides, and temporary "extreme" tides. The average daily high tide is 12 inches lower than the average yearly high tide or King Tide. Extreme tides are periodic elevations of coastal waters, caused by storms, El Niño, or other factors, and can be from 12 inches (1-year extreme tide) to 42 inches (100-year extreme tide) above average daily high tide, or higher. As coastal waters rise, the frequency and extent of temporary flooding will increase.

The map(Fig. 4) depicts possible future inundation that could occur if nothing is done to adapt or prepare for sea level rise over the next century. Over the coming decades, SLR-related impacts will increase in frequency and extent, and additional areas will begin to experience periodic coastal and/or urban flooding. Where shorelines are built on Bayfill, subsidence may further intensify flooding risks, and higher groundwater levels may increase liquefaction and seismic risks during earthquakes. San Francisco's Embarcadero will be completely inundated as the projects suggested. This means that thousands of historic resources along its shorelines and its economy, residential, infrastructure will be at significant risk. In the face of accelerating sea level rise associated with storm surge, how will the waterfront survive and move forward?

Fig.4: San Francisco Bay Area Inundated Zone. Drawed by Author.



2.2 Earthquake as Risk

At the turn of the 20th century, the construction of the Great Seawall along San Francisco's northern edge transformed the shallow Bay tidelands into an urban maritime waterfront that has supported the Bay Area's growth for over 100 years. The formation of Embarcadero area attributes to this seawall, which allows to extend the footprint of the city to the water's edge. By reclaiming the tidal marsh as land, San Francisco was able to build out over deeper bay waters, constructing port facilities for large ships in the past. For now, the seawall has provided protection against floods. The Embarcadero becomes one of the city's most bustling areas, where historic streetcars glide down the street, sharing the waterside boulevard with tourists, joggers and foodies sampling the various eateries.

But city officials and engineers now said that the popular Embarcadero area, a three-mile stretch from Fisherman's Wharf to AT&T Park, faces a different kind of seismic threat.

San Francisco is no stranger to risk or disasters. Evidence of the devastating 1906 earthquake and fire remains in photographs (Fig. 5), and looms large in its cultural memory; the more recent 1989 Loma Prieta earthquake is still vivid for many. Robust hazard mitigation plans and the City's efforts to build earthquake resilience remind us of the importance of learning from the past when building our future. Seismic activity has not yet returned to late 1800's levels, but as stresses continue to build, scientists expect more frequent and stronger earthquakes in the future. The U.S. Geological Survey and partners estimate that there is a 72% likelihood of one or more major earthquakes (magnitude 6.7 or greater) within the next 30 years (Fig. 6). San Francisco's location between two major faults, San Andreas and Hayward, make its seawall especially vulnerable.

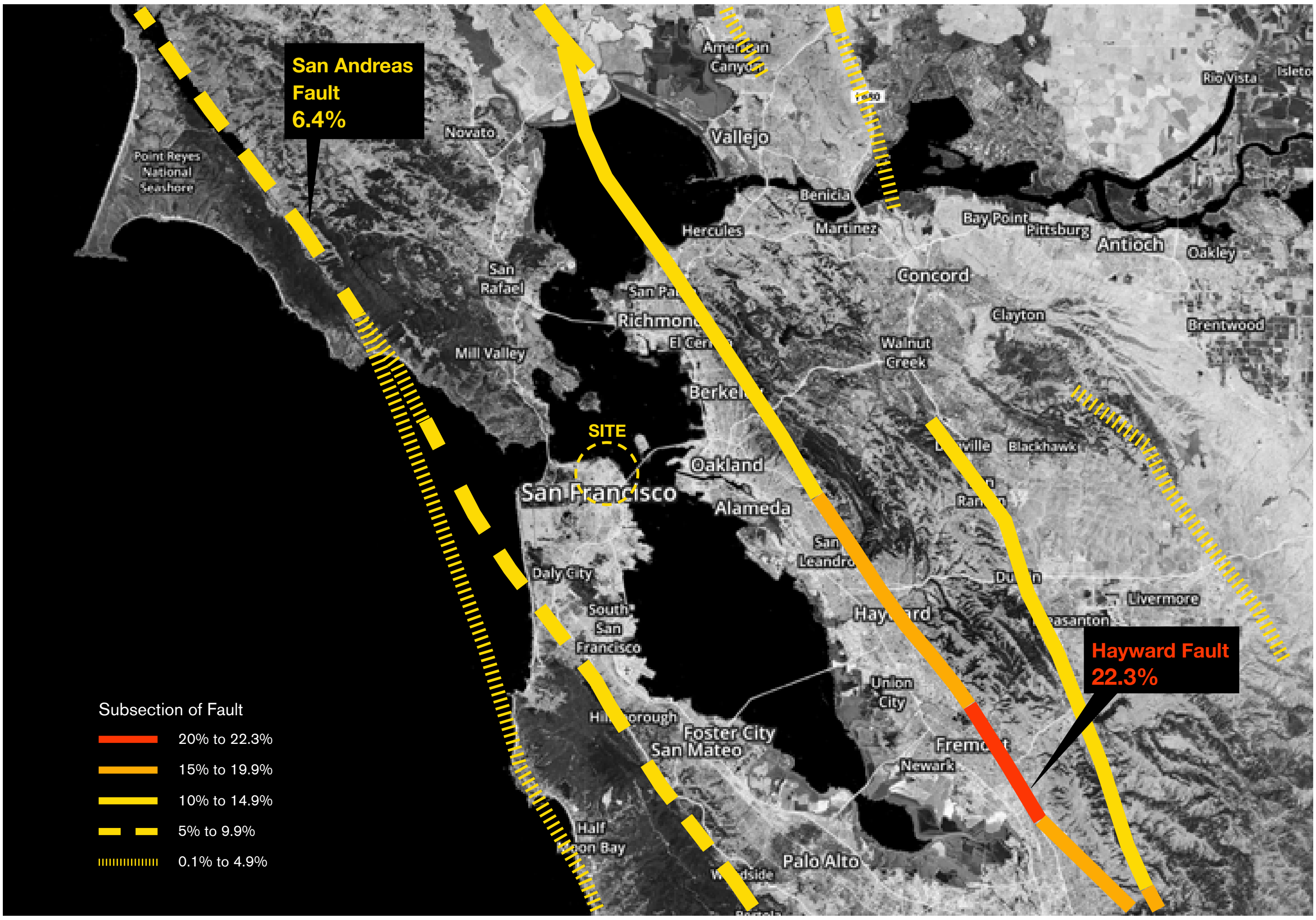
The seawall was formed by carving a trench in the mud and filling it with a pyramid-shaped dike of rocks that was topped with a wall. Land was created behind the wall using fill, which acts like a liquid when shaken. The liquefied fill could increase pressure on the seawall during a major earthquake. Making matters worse, below the wall is a weak mud. That means the seawall — while not expected to completely fail — could suddenly move toward the bay during an earthquake, damaging the wharves, piers, buildings and roadway above it.

Another problem is that some of the historic wharves — decks that extend the shoreline beyond the seawall — are supported by brittle concrete columns that could collapse during shaking. That poses a risk to the buildings on top of the wharves and the finger-like piers attached to them. In the meantime, the existing seawall isn't nearly tall enough to cope with long-term projections related to climate change. If it simply is raised in height, the historic piers would be cut off from the Embarcadero and the inland city. Those interrelated threats make it quite difficult to strengthen and improve the seawall.

The Embarcadero has never been more vibrant and inspirational, yet the Great Seawall upon which it all rests is strained. Without a complete repair, the physical foundation supporting so much of the city's diverse economy, recreation, future affordability, and identity is at risk of being washed away. San Francisco must identify and implement funding strategies to build a resilient foundation for the waterfront that can withstand both immediate seismic risks and long-term rising water levels.

Fig.5: San Francisco 1906 Earthquake.
https://en.wikipedia.org/wiki/File:1906_Earthquake.jpg

Fig.6: San Francisco Bay Area Sesmic Risk. Drawed by Author.



2. PROBLEM FIELD

2.3 Infrastructure as Barrier

As one of the largest ports in the world, the northeast side of San Francisco witnessed the prosperity of the city during industrial age. Meanwhile, the island has also suffered from the heavy industrial infrastructure which blocked the waterfront from the city (Fig.7).

2.3.1 1850, BUSTLING PORT TOWN

Although San Francisco Bay was discovered by the Spaniards in 1775, it was not until the 1849 gold rush that the region had its first wave of population growth. The focus of the growth was in the area adjacent to the Bay where deep and protected waters provided a natural harbor (Fig.8).

During these early days, the waterfront was a lively part of town, busy with sailors and those hoping to earn their fortunes in the gold fields. City dwellers would stroll along the waterfront and enjoy the marvelous view of the Port and the Bay. The nearby hillsides were the sites of the earliest settlements and later became fashionable neighborhoods. Through World War II, the waterfront retained its image of a thriving port and center of the City's economic vitality. The Ferry Building, located at the foot of Market Street, became a landmark structure symbolic of the City's ties with the Bay Area and the World. The western half of San Francisco's waterfront, was developed for military and recreational use and in recent years has become part of the magnificent Golden Gate National Recreational Area.

Fig.8: San Francisco From Above. http://www.foundsf.org/index.php?title=Early_Development_Around_Mission_Bay,_1850-1857

2.3.2 1890, STATE BELT RAILROAD

With the passage of time, however, the Embarcadero Waterfront became increasingly separated from the rest of the city and began to decline in activity. In 1890, the harbor commission built the State Belt Railroad, designed to improve the flow of goods and materials up and down the waterfront by serving the earliest orderly constructed piers and wharves, and linking them with the outlying commercial warehouses and railroads (Fig.9). While, the nature of activity on and around the Embarcadero changed over the course of the 20th Century. With the completion of the Bay Bridge in 1930's, traditional cargo shipping was declined and moved to Oakland. Warehouses and wholesale markets were replaced by office and housing towers. In order to accommodate growing auto traffic, the Embarcadero Freeway was built, effectively cutting the city off from a large swath of its waterfront.

Fig.9: The State Belt Railroad. https://www.nps.gov/goga/learn/historyculture/state-belt-railroad.htm

2.3.3 1957, ELEVATED FREEWAY

The construction of Embarcadero Freeway began in 1953, and was originally intended to directly connect the Golden Gate Bridge to the Bay Bridge (Fig.10). But as the plans unfolded, public opposition grew. Over 30,000 people signed petitions at meetings organized in the Sunset, Telegraph and Russian Hills, Potrero, Polk Gulch and other threatened areas. In 1959 The Supervisors voted to cancel 75% of planned freeway routes through the city. But it still created a concrete wall along the waterfront from Folsom Street to Broadway. For 30 years, much of these waterfronts was separated from downtown.

Fig.10: the Embarcadero Freeway. Gary Fong, The Chronicle, http://projects.sfchronicle.com/2016/sea-level-rise/part2/

However, the 1989 Loma Prieta earthquake(magnitude 6.9) severely damaged the Embarcadero Freeway, as well as the piers and many of the structures near the Seawall, thus providing the opportunity to rethink the relationship between the city and its waterfront and to implement policies that had been in place since 1977 as part of the Northeastern Waterfront Plan. Furthermore, the city had for years maintained as official policy that the Embarcadero Freeway should be removed.

Fig.11: Embarcadero Boulevard. http://futurecapetown.com/2012/05/cape-town-without-the-foreshore-freeways/#.WUqSvxOGNZo

After the earthquake, San Francisco started the waterfront's revitalization and transformation, from a dangerous of work into a place of leisure and entertainment.

transformation, from a dangerous of work into a place of leisure and entertainment. It replaced the damaged freeway with a spectacular boulevard — the Embarcadero Boulevard, which is comprised of Muni Metro, Caltrain and bicycle lanes.

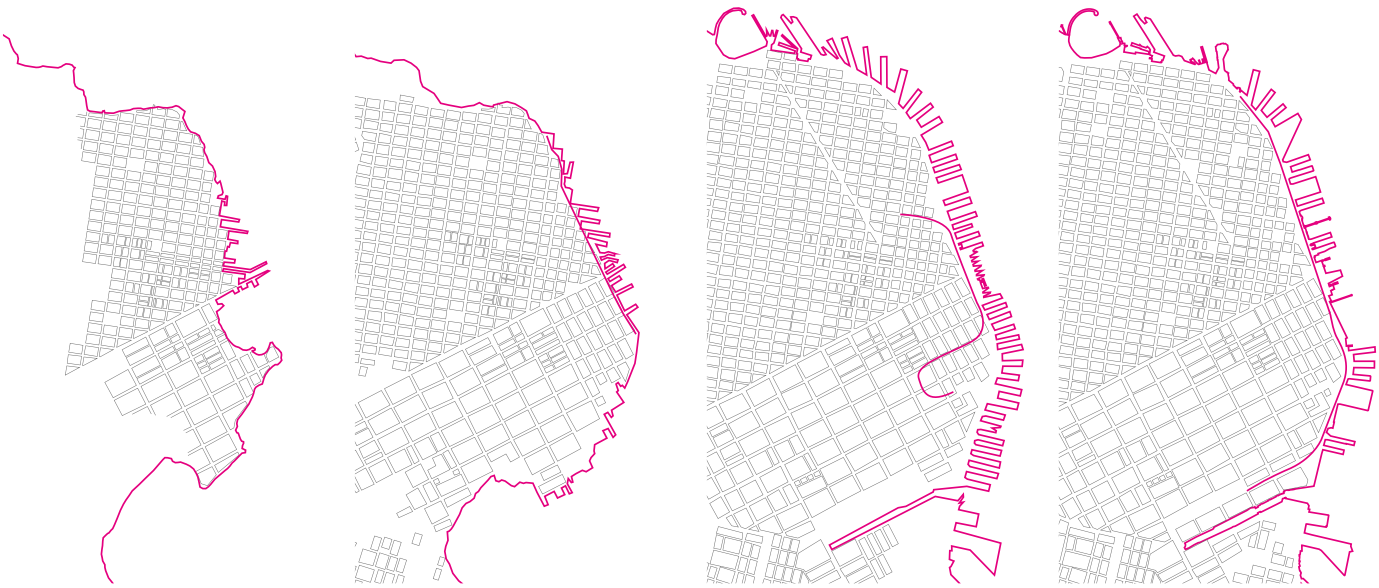
2.3.4 2000, BOULEVARD

Planning for the new roadway was undertaken in a multiagency effort coordinated by the city's Chief Administrator's Office under the rubric of the Waterfront Transportation Projects Office (WTPO). As described by the WTPO, the city had been "presented with an unprecedented opportunity to realize its vision for a tree-lined boulevard with rail, bicycle, pedestrian, and public art amenities along the northeastern waterfront and [to] create a civic plaza that acknowledges the importance of the Ferry Building, the terminus of Market Street, and the city's historic relationship to the waterfront."

All the components were completed by the early 2000s (Fig.11): a new alignment for the Embarcadero boulevard that incorporates bicycle lanes and an exclusive right-of-way for an extension of the F streetcar line from the Ferry Building to Fisherman's Wharf (service started in 2000); a water-side pedestrian promenade that runs from Fisherman's Wharf to China Basin Channel (Herb Caen Way); an extension of MUNI's light-rail system south of Townsend Street along an exclusive right-of-way in the center of the Embarcadero, completed in 1997; an underground MUNI switching yard that was originally to be placed under the elevated freeway; several open-space improvements; and lots of Canary Island palm trees (without dates, so no messy cleanup).

Now the boulevard with critical infrastructure is located along downtown San Francisco, where the majority of workers commute in from outside the city. In order to support this job density, approximately 1.1 million people enter the city each weekday. Of these, 440,000 arrive by boat at the Ferry Building and Muni registers over half a million daily boardings on routes that terminate downtown. These transportation systems and facilities support the city's economy, commuting and tourism performance. Due to the large amount of car traffic, the city has a negative connection with its waterfront. In other words, the grids had seldom touched the waterfront because of the city's reliance on heavy transportation.

Fig.7 Historic Evolution of Embarcadero. Drawed by Author.



1850, Bustling Port Town
Originally, this area served as a beachhead for men seeking their fortunes in the goldfields and as early center of commerce that grew to support the Gold Rush. The Gold Rush has dramatically transformed San Francisco into a bustling port town, exploding with new people and construction.

1890, State Belt Railroad
In 1890, the harbor commission built the State Belt Railroad, which is designed to improve the flow of goods and materials up and down the waterfront by serving the earliest orderly constructed piers and wharves, and linking them with the outlying commercial warehouses and railroads.

1957, Elevated Freeway
Construction of the Freeway began in 1953, and was originally intended to directly connect the Golden Gate Bridge to the Bay Bridge. But it creates a concrete wall along the waterfront from Folsom Street to Broadway. For 30 years, much of these waterfronts was separated from downtown.

2001, Embarcadero Boulevard
Following the 1989 Loma Prieta earthquake, the Embarcadero Freeway was permanently closed to traffic and made its removal. A new project proposed to replace it with an elegant waterfront road and paths gained traction politically, which also facilitated a greatly enhanced ferry service.

3. Research Question

Cities' waterfronts face risks from coastal hazards today. With sea level rise and greater frequency of the most intense coastal storms, these risks will increase. According to the projections for sea level rise, the lowest-lying areas of the city will gradually become more vulnerable to regular flooding from daily and monthly high tides. Unreinforced shorelines and weakened shoreline structures will become more vulnerable to erosion. Sea-level-rise means that coastal storms will create higher storm surges that will flood larger areas, and changes in storm activity will lead to a greater number of the most intense hurricanes. In this case, people need to explore a range of coastal management and protection options that are suited to urban areas with large existing populations in flood zones, limited space, and shorelines that have been altered and often hardened in a variety of ways.

Besides that, the waterfront calls for an open mind. In major cities that were once or are still world ports, from Rotterdam to Shanghai to San Francisco, the call is especially intense. Still flowing with the give-and-take of goods, people, and cultures, today's most successful waterfronts offer the experiences and articulate the values of an open society, in which ideas are exchanged freely, transparent transactions are valued, and people are free to come and go. However, cities' heavy reliance on shipping industry, which blocked the waterfront from the city, made it impossible for people to enjoy its waterfront in the early times. Nowadays, cities are planning to transform its waterfront from an exotic and dangerous place of work into a place of leisure, distinguished by beautiful public spaces and entertainment facilities that attract visitors from around the world.

Considering these two aspects, the main research question is formulated in a very general way, in which it can be applied to other metropolitan areas with same issues.

HOW CAN SPATIAL INTERVENTIONS HELP THE URBAN WATERFRONT TO EFFECTIVELY ACCOMMODATE WITH INCREASING FLOODING RISKS AND TO POSITIVELY ORGANIZE THE RELATIONSHIPS BETWEEN CITY AND WATERFRONT?

The main research question can be divided into two parts: one is related to flooding issues and another is related to urban relationships. Therefore, the following subquestions are categorized into these two aspects as well:

- FLOODING ISSUES:

1) What coastal management and protection strategies are suited to urban areas with large populations and limited space?

2) What resilient measures can be taken to accommodate with different ranges of sea level rise?

3) How to implement potential strategies for adaptation effectively across various physical and time scales?

- URBAN RELATIONSHIPS:

1) What component of the site can be used for public use in such limited space and dense urban fabric?

2) Where to strongly connect the city with its waterfront physically and programmatically?

3) How to create a multi-functional waterfront system that integrated with cultural resource and natural resource?

The objective of this graduation project can be divided into two aspects: one is general goal while the other one is more specific.

The general one is directed to find potential strategies to cope with flooding risks in dense urban waterfront. The nature of the increasing risk from coastal hazards will vary from site to site, requiring a geographic analysis to understand which strategies are applicable where. Based on this knowledge, the goal is to create a toolbox of interventions, directed to increase the capacity of existing urban fabric to accommodate with floods across various physical and time scales. This toolbox should be transferable to any urban environment with the same issues. This means that the intention of the toolbox is not only to present information on a wide range of potential strategies, but also to help narrow the list of strategies to consider for a given situation.

The specific goal based on the desire to re-unit the city with its waterfront in many locations. In this case, the aim is to propose a new northeastern waterfront that is well organized as a holistic system integrated with culture, protection and landscape, meanwhile it is also strongly connected to the city interior physically and programmatically. In this case, the concept is to formulate a network of open space, integrated with transportation improvements to enhance public access and enjoyment. Along this network, there are a diverse array of maritime, commercial, entertainment, civic, open space and recreation activities for people. Besides that, a multi-functional flood protection structure is built not only to moderate the force of storm surge, but also to provide additional value.

Fig.12: 'The BIG U' by BIG. http://www.rebuildbydesign.org/our-work/all-proposals/winning-projects/big-u

5. METHODOLOGY

1.1 Climate Change

This graduation project, can be characterized as 'Research driven Design', within which the research and the final design proposal are of equal importance.

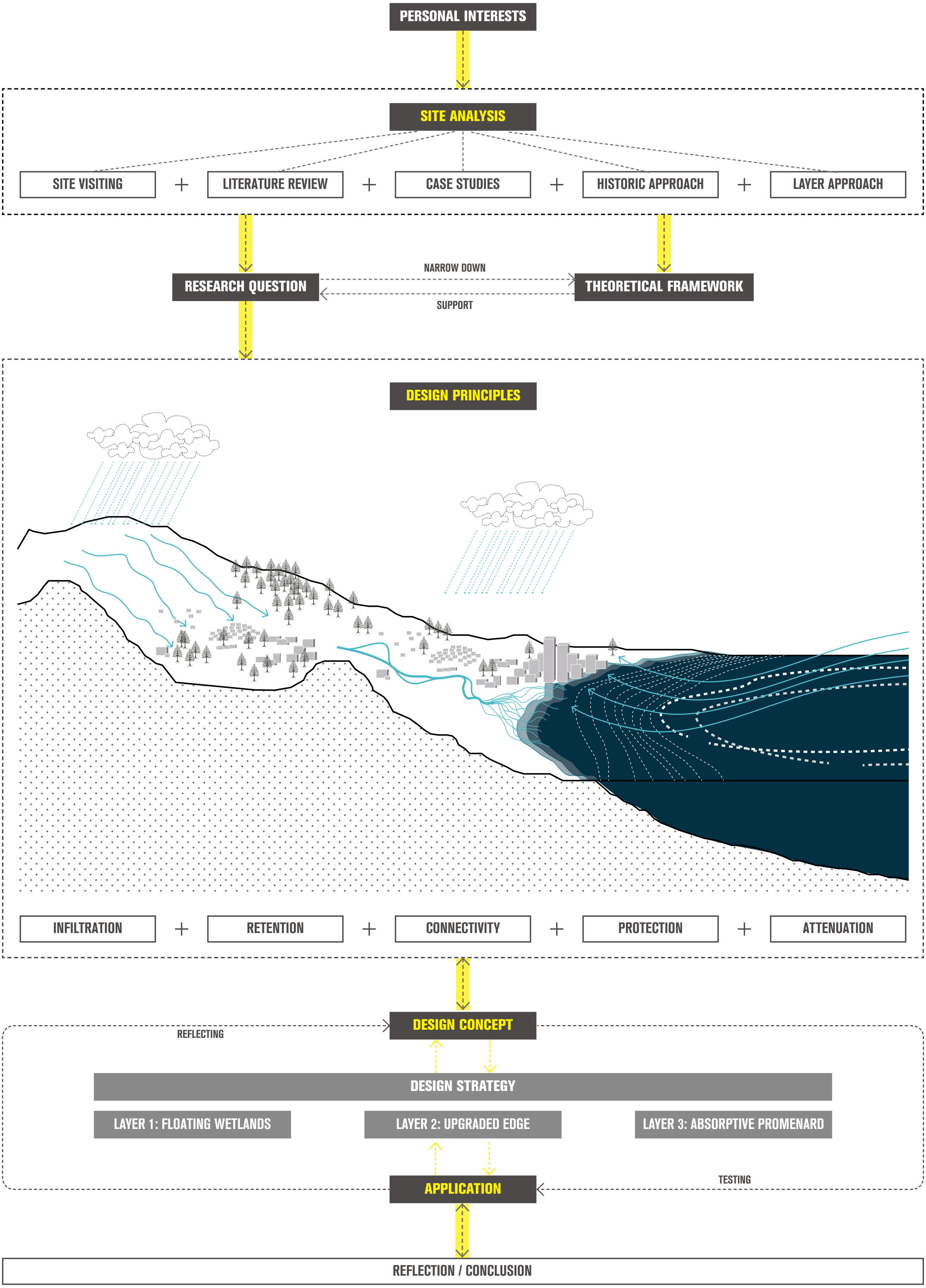
As the diagram illustrated, the process of this graduation project can be divided into four different stages: Personal Interests, Theoretical and Analytical Framework, Design Proposals and finally Application Part.

First part consists my personal interests and the search of the relationship between the theme of the graduation lab and the subject. The personal fascination narrows down the research scale and leads direction to my own interesting and inspired topics. In the first part, this project will start with the literature review and general site analysis to identify the study area and design context, focusing on the impacts of sea level rise and the future potential of the design area.

Second stage "Theoretical and Analytical Framework" are the fundamental part of my graduation project. It is deliberately made in order to achieve the main research question: HOW CAN SPATIAL INTERVENTIONS HELP THE URBAN WATERFRONT TO EFFECTIVELY ACCOMMODATE WITH INCREASING FLOODING RISKS AND TO POSITIVELY ORGANIZE THE RELATIONSHIPS BETWEEN CITY AND WATERFRONT? To answer the main research question, the theoretical framework is mainly focused on three topics - Resilience, Waterfront Development, and Adaptive Strategies. The first step to get the answer is to understand the meaning of the Resilience concept and the development of waterfront in urban environment. This is done through literature studies and publication reviews, and articles from various disciplines. Then, case studies around the world show me that there are numerous adaptation measures and strategies to cope with flooding risks. According to existing theories and researches, those measures are divided into four categories based on different geographies. In the next part they will be evaluated in six aspects according to their ability to adapt to flooding and the potential co-benefits and disadvantages.

In the design part, design proposals will be integrated with case studies to get further design strategies. The third section is the conclusion of the Analytical part, and a reflection on the investigations that were made in the previous section. The last step, which is also important, tries to reflect and test the design in the context and within the field of resilience studies.

Fig.13: Methodology Framework. Drawed by Author.



6. THEORETICAL FRAMEWORK

The structure of theoretical framework for this graduation project is composed of three topics - Resilience, Waterfront Development, and Adaptive Strategies - according to the literature review and case study. The aim of the theoretical framework is to understand of the problem field through existing theories and body knowledge. All this will help to answer for the main research question and subquestions.

6.1 The definition of Resilience

Climate change is a global issue that influences worldwide, while the impacts are expected to be particularly severe in cities, in where lives the majority of world populations. In this case, the notion of resilience and resilience thinking is rapidly gaining ground in the field of urban design and planning.

Although the concept of resilience is a recent addition to planners' discursive repertoire, it is by no means a new concept (Davoudi, 2012). Resilience has a long history of use in ecology, social sciences, engineering, and psychology, so there are many different definitions of resilience. A Canadian theoretical ecologist, Crawford Stanley Holling's seminal article, published in 1973, is often cited as the origin of modern resilience theory. In his article, he explains that resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist. In this definition resilience is the property of the system and persistence or probability of extinction is the result (Holling, 1973).

Since Holling's definition, the concept of resilience has evolved and been applied to a wide variety of fields and focus areas, including anthropology (Vayda and McCay, 1975), engineering (Godschalk, 2003), environmental sciences and social science (Brown et al., 2012), business management and accounting (Wamsler et al., 2013), agricultural and biological sciences (Wagner and Breil, 2013). A review of these resilience literature reveals that a divide exists between single-state equilibrium, multiple-state equilibrium and dynamic non-equilibrium (Davoudi et al., 2012; Folke, 2006; Holling, 1996), which are often identified as engineering resilience, ecological resilience and socio-ecological resilience.

6.1.1 Engineering Resilience

Holling defined engineering resilience as the capacity of a system to return to a previous equilibrium state after a disturbance (Holling, 1996), which could be either a natural disaster, such as flooding or earthquakes, or a social mutation, such as banking crises or revolutions (Davoudi, 2012). This single-state equilibrium is also prevalent in the fields of disaster management, economics and psychology (Pendall et al., 2010). In this perspective, the resilience focus on efficiency, constancy and predictability – all contributes at the core of engineers' desires for fail-safe design (Holling, 1996). Due to the emphasis on stability near an equilibrium steady state, the resistance to disturbance and the speed to return to the equilibrium are used to measure the resilience and property. This means that the faster the system return to previous state, the more resilient it is.

6.1.2 Ecological Resilience

Ecological resilience assumes that the system has different equilibrium steady states, and in the face of a disturbance, may be transformed by flipping a system into another regime of behavior – that is, to another stability domain (Holling, 1973). In this case, the measurement of resilience is the magnitude of disruption that can be absorbed before the system changes its structure by changing the variables and processes that control behavior (Holling, 1996). Therefore, resilience is defined not just according to the return time, but also how much disturbance it can take and remain within critical thresholds. Ecological resilience concentrates on persistence, change and unpredictability – all

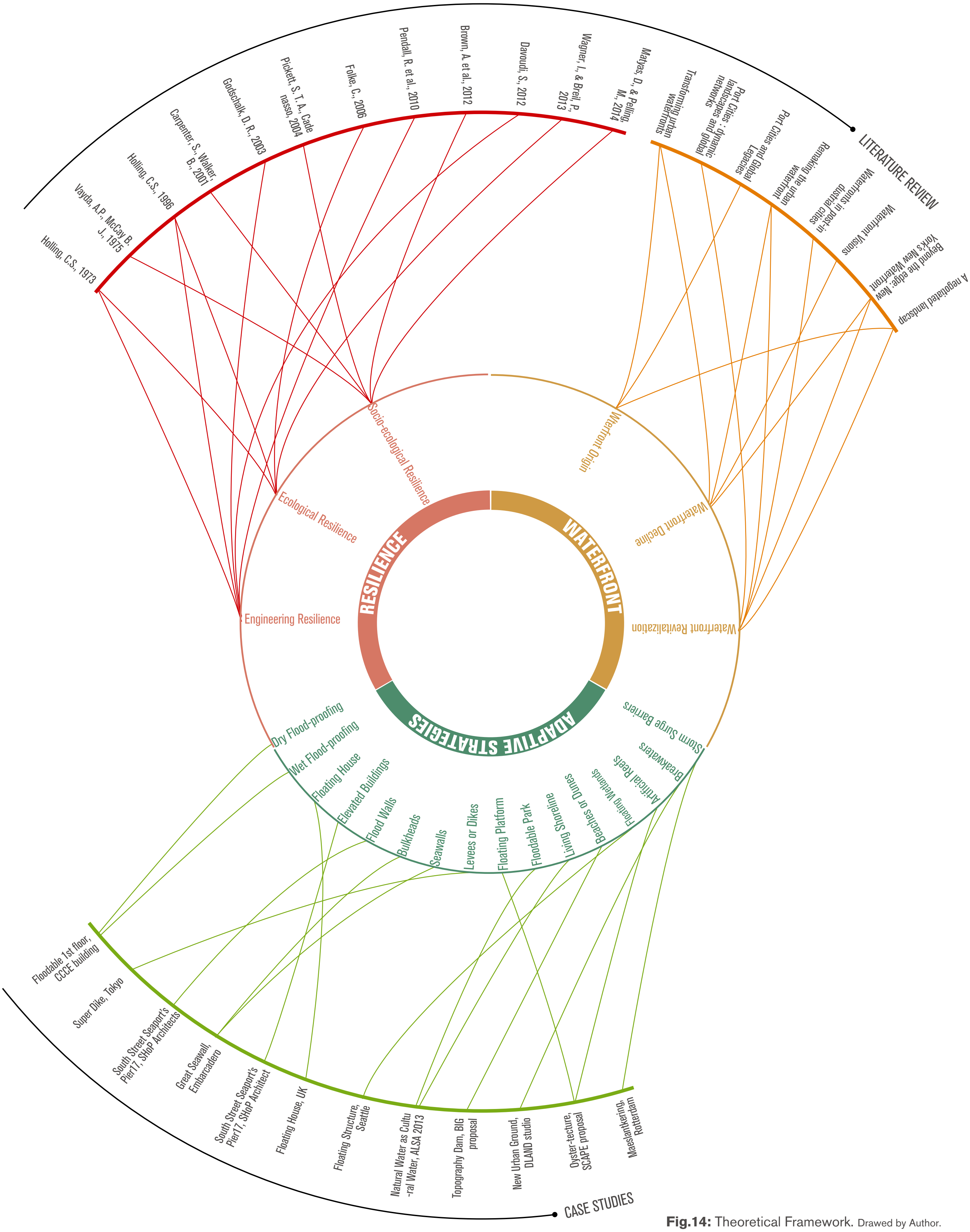


Fig.14: Theoretical Framework. Drawed by Author.

attributes embraced and celebrated by biologists with an evolutionary perspective and by those who search for safe-fail designs. The main difference between engineering resilience and ecological resilience is that ecological resilience rejects the single stable equilibrium, and instead acknowledges the existence of multiple-state equilibrium, and not necessarily remains the same.

6.1.3 Socio-ecological Resilience

In recent years, social-ecological resilience, however, challenges the concept of equilibrium and advocates that systems undergo constant change and have no stable state (Pickett, Cadenasso, & Grove, 2004). Indeed, urban areas are complex, and they present a combination of ecological, social and technical systems. Rather than seeing the cities as orderly and reasonably predictable, some scientists think urban areas as dynamic, uncertain and unpredictable. So they consider that cities are constantly changing and may not return to a prior state. In this perspective, resilience is not treated as a return to normality, but rather as the ability of complex socio-ecological systems to change, adapt and crucially, transform in response to stresses (Carpenter et al., 2001). This development has moved theory away from the idea of resilience as "bouncing back" (Matyas & Pelling, 2014), and conceptualizes resilience as operating in a state of non-equilibrium or multi-equilibrium. What's more, resilience reflects a system's capacity to maintain key functions, but not necessarily to return to a prior state.

In spite of the abundant research on resilience, there is still no single, widely accepted definition for it. However, there is a consensus understanding that in face of change, resilience refers to the ability of a system to maintain particular aspects under stress, to recover from a disturbance, and to function in a desirable state.

6.2 Waterfront Development

To see a city - or a waterfront - often requires a historical approach.

Water, the primary human resource, was the reason for the original location, providing means of transport, defense, leisure and recreation. Many people are fascinated by ports - or at least the sites of what were once working waterfronts. The waterfront was a lively part of town, busy with sailors and filled with the earliest settlements during early days. Old waterfronts have an especially alluring quality. They are often in cities' older sections and their bits and pieces, from piers to historic ships, are easily recognized, making them a visible part of local history. The popularity of waterfront development owes much to the fact that virtually every city has a downtown waterfront that offers a mix of scales and uses close to the center, offering an urban quality while at the same time providing new development opportunity.

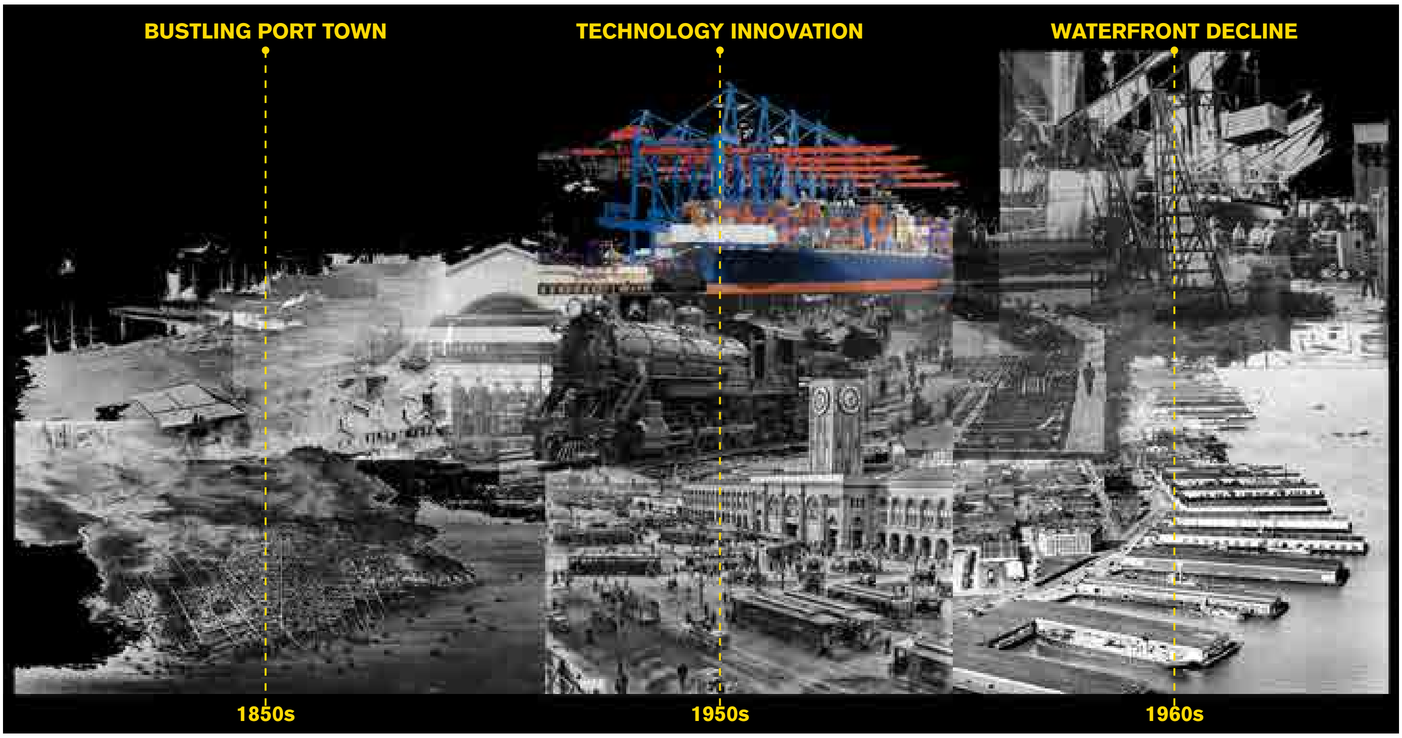
The decline of waterfronts is generally due to the influence of technology development. In particular, changes in transportation technology and other large-system factors such as economic restructuring have been of major importance. During the last half century, the most significant and probably most apparent force behind the loss or relocation of cargo operations was the advent of new transportation technology. For many ports, the result has been abandonment and disuse, turning what was once a vibrant connection between city and water into a deserted no-man's land. Most ports that floundered, including San Francisco's, started to do so in the late 1950s and early 1960s, when containerization revolutionized the shipping industry. Site and situation played a major role in whether ports could adopt the new technology and remain competitive. Even if a port authority or other entity could absorb the tremendous capitalization costs to develop the specialized facilities needed to handle and move containers, they often simply did not have the space available. And, because container ships require deep channels, ports found themselves having to pay for dredging - an expensive project and today a very sensitive environmental issue. A host of related problems arises from trying to convert old port facilities to new ones, the most salient being that urban infrastructure adjacent to old ports usually cannot absorb the additional activity, particularly truck and rail traffic, associated with containerization. New technology and its requirements quite quickly rendered the older port morphology of finger piers and storage sheds obsolete.

Starting at the beginning of the 1960s, and coming into full force by the early 1980s, cities around the world have made efforts to reuse the land at the water's edge. By the late 1970s, waterfront revitalization in the United States had become such a common urban issue that federal and national agencies began to produce guides and reports to address the trend. Revitalization appears in many forms and at many scales, including upgraded shipping and maritime-related facilities, new industrial growth that is not necessarily water-related, mixed-use commercial projects, new recreation opportunities, and residential development. Growing wealth, growing populations and increased leisure time enabled a new generation of leisure-oriented developments, often using the historical associations as a form of brand image. Over the course of the last fifty years, much of the waterfront has been transformed from an exotic and often dangerous place of work into a place of leisure, distinguished by beautiful public spaces and entertainment facilities that attract visitors from around the world.

Now in the 21st century, threatened by climate change, waterfront development is facing new challenges and opportunities.

BOOKS:
1. Transforming urban waterfronts : fixity and flow
2. Port Cities : dynamic landscapes and global networks
3. Port Cities and Global Legacies
4. Remaking the urban waterfront
5. Waterfronts in post-industrial cities
6. Waterfront Visions : transformations in North Amsterdam
7. Beyond the edge: New York's New Waterfront
8. A negotiated landscape : the transformation of San Francisco's waterfront since 1950

Fig.15: Waterfront Transformation. Drawed by Author.



6. THEORETICAL FRAMEWORK

6.3 Adaptive Strategies

While it is impossible to ever fully eliminate risks from flooding, there are many tools available to manage and adapt to those risks. Case studies around the world show us that there are numerous adaptation measures and strategies. The nature of the risk from coastal hazards will vary from neighborhood to neighborhood, requiring a geographic analysis to understand which strategies are applicable where.

Thus, I classify four types of potential strategies to accommodate with rising sea levels according to different geographic situations: individual buildings, shoreline structure, offshore structure and in-water structure. Based on four geographic features, potential strategies can also classify into four parts: for individual buildings, it has Dry Flood-proofing Structures, Wet Flood-proofing Structures, Floating House and Elevated Buildings; along the shoreline, it has flood walls, Bulkheads, Seawalls, and Multi-functional Levees or Dikes; in offshore area, it has Floating Platform, Floodable Park, Living Shoreline and Beaches or Dunes; in-water area, it includes Floating Wetlands, Artificial Reefs, Breakwaters and Storm Surge Barriers.

Some measures will reduce the frequency of inundation, such as storm surge barriers, sea walls and levees; these are called structural flood risk management measures. Meanwhile, other measures can reduce the consequences of flooding, such as flood-proofing assets and buildings.

Each strategy carries with its costs and benefits. A careful exploration and analysis must evaluate adaptation alternatives and options to identify a strategy to make best use of limited resources in achieving goals and objectives. In this case, I chose to assess a qualitative value by rating its performance (from -5 to 5) to show the negative or neutral or positive effect on six aspects: cost, life span, sea-level-rise effectiveness, storm surge protection, natural ecology and installation time.

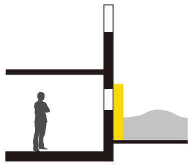
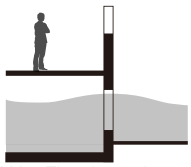
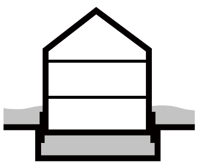
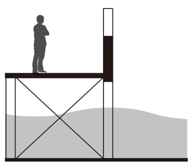
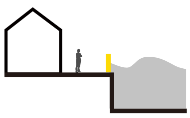
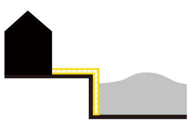
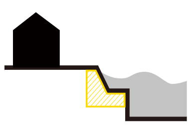
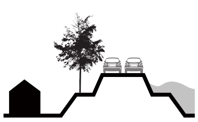
For example, storm surge barriers around the world play an important and sometimes indispensable role in flood protection. In the Netherlands and London, they shorten the line of defense (miles of coastline to be protected) considerably, which reduces construction and maintenance costs. Storm surge barriers are flexible in that they allow for navigation and, if properly constructed, can be adapted to future conditions. However, storm surge barriers today are expensive, they can affect local sediment transport and other ecological processes, and they bear the additional risk of a closure failure.

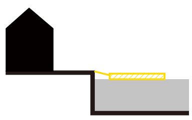
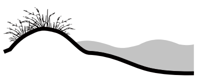
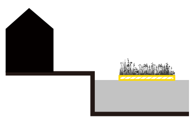
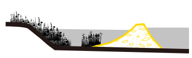
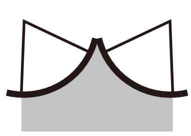
As a result, the case study helps me to identify the multiple adaptive strategies and recognize its advantages and disadvantages by comparison. It is an effective method to answer the first sub research question: “What coastal management and protection strategies are suited to urban areas with large populations and limited space?”

CASES:
1. Floodable 1st floor, CCCE building
2. Floating House, UK
3. South Street Seaport’s Pier17, SHoP Architects
4. Dam-Wall combination, New Orleans
5. Great Seawall, Embarcadero
6. Super Dike, Tokyo, Japan
7. Floating Structure, Seattle
8. Natural Water as Cultural Water, ALSA 2013 Students Awards
9. Topography Dam, BIG proposal in Rebuild by Design competition
10. New Urban Ground, DLAND studio proposal in Rebuild by Design competition
11. Oyster-tecture, SCAPE proposal in Rebuild by Design competition
12. Maeslantkering, Rotterdam, Netherlands

+ Positive Effect
– Negative Effect
0 Neutral Effect
± ±1
± ±0.5

Fig.16: Adaptive Strategies and its Evaluations. Drawed by Author.

Strategies \ Evaluations	Cost	Life Span	SLR Effec-tive-ness	Storm Surge Protec-tion	Natural Ecol-ogy	Instal-lation Time
 Dry Floodproofing	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Wet Floodproofing	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Floating House	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Elevated Building	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Floodwalls	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Bulkheads	+ + + + +	+ + + + +	+ + + + +	+ + + + +	– – – – –	+ + + + +
 Seawalls	+ + + + +	+ + + + +	+ + + + +	+ + + + +	– – – – –	+ + + + +
 Levees or Dikes	+ + + + +	+ + + + +	+ + + + +	+ + + + +	– – – – –	+ + + + +

Strategies \ Evaluations	Cost	Life Span	SLR Effec-tive-ness	Storm Surge Protec-tion	Natural Ecol-ogy	Instal-lation Time
 Floating Platform	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Floodable Park	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
 Living Shoreline	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
 Beaches or Dunes	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
 Floating Wetlands	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
 Artificial Reefs	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
 Breakwaters	+ + + + +	+ + + + +	+ + + + +	+ + + + +	0	+ + + + +
 Storm Surge Barrier	+ + + + +	+ + + + +	+ + + + +	+ + + + +	– – – – –	+ + + + +

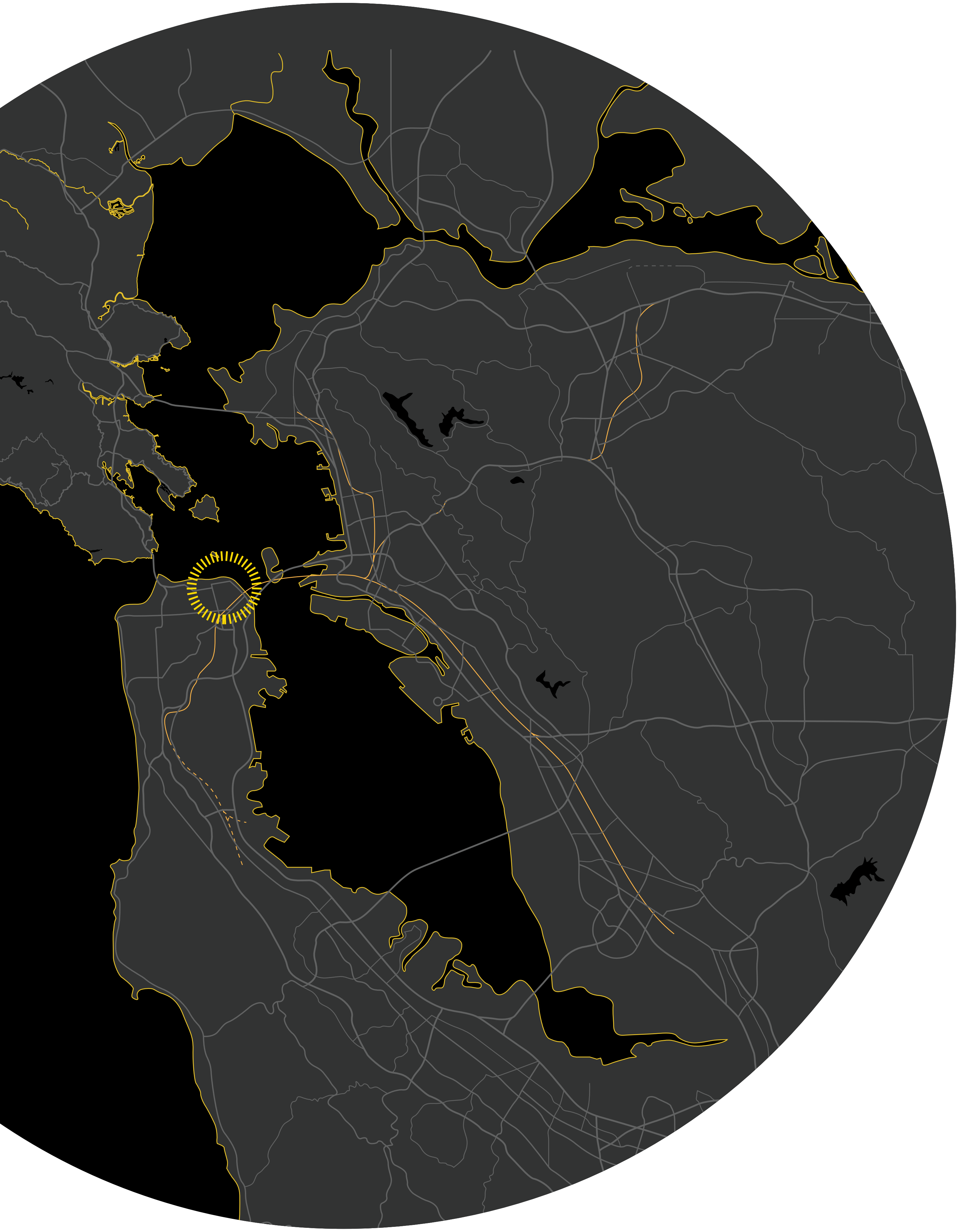
PART II ANALYTIC FRAMEWORK 021

Fig.17: San Francisco Bay's encroaching waters. Rising Reality, http://projects.sfchronicle.com/2016/sea-level-rise/part1/

1. MACRO-SCALE: SAN FRANCISCO BAY AREA

This part of the Graduation Project is to understand the site at multi-scales. It consists of three different scales. The first one defines the general orientation within the San Francisco Bay Area context; the second part discloses the spatial vision and structural plan for Embarcadero waterfront; and the third stage investigates the preliminary strategy for the project site based on the results of current in-depth analysis.

Fig.18: San Francisco Bay Area. Drawed by Author.



1. MACRO-SCALE: SAN FRANCISCO BAY AREA

1.1 Port in San Francisco Bay Area

Ports require a flat, expansive waterfront location on navigable, deep water channels with excellent ground transportation access and services. Such sites around San Francisco Bay are limited, and are a regional economic resource that should be protected and reserved for port priority uses, such as marine terminals and directly related ancillary activities, ship repair, supporting ground transportation facilities, and directly related marine service facilities.

However, the ship is getting larger and larger. Sufficiently deep, wide, and well maintained navigation channels are essential to the operation of Bay Area ports. Ocean-going vessels require shipping lanes of adequate depth and width to safely access marine terminals. In addition, channels, basins and berths can require deepening to accommodate newer, larger ships that are calling on Bay ports. This need is particularly true in the container shipping business, where larger ships with deeper drafts are standard.

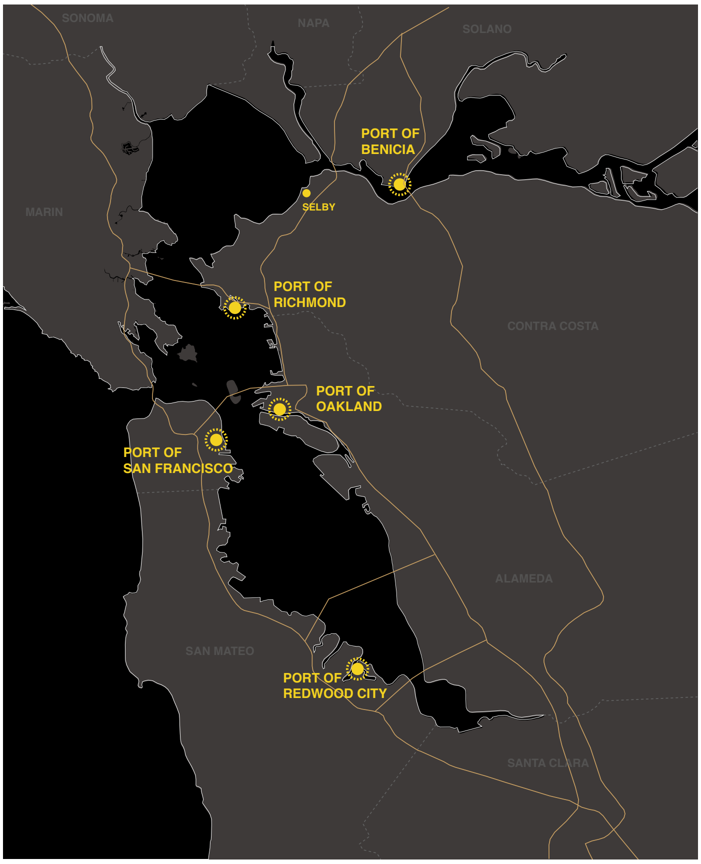


Fig.19: San Francisco Bay Area's Ports System. Drawed by Author.

Fig.20: San Francisco Bay's Major Dredging Areas. Drawed by Author.

1.2 Ecosystem in San Francisco Bay Area

Climate change is altering the natural world at an accelerating pace, particularly in low-lying coastal areas like san Francisco Bay. Today, management of the bay's shores must account for a future of rising sea levels and more extreme weather events while continuing to address the challenges posed by the demands of a growing urban population.

Climate-change science has advanced greatly since the 1999 Baylands Ecosystem Habitat Goals were developed, spurring the need for a technical synthesis of climate-change projections and updated recommendations. The findings of this science Update indicate clearly that restoring a vibrant and functioning baylands ecosystem will make our future shorelines more resilient to these stresses. Baylands restoration is not a luxury but an urgent necessity as ecological change accelerates. Restoration managers have begun to reverse over a century of habitat loss in the baylands, recommitting tens of thousands of acres to the natural world through a comprehensive and adaptive restoration approach that enhances wildlife habitat, recreational opportunities, water quality, and flood protection.

Fig.21: HISTORICAL BAYLANDS,1850. Drawed by Author.

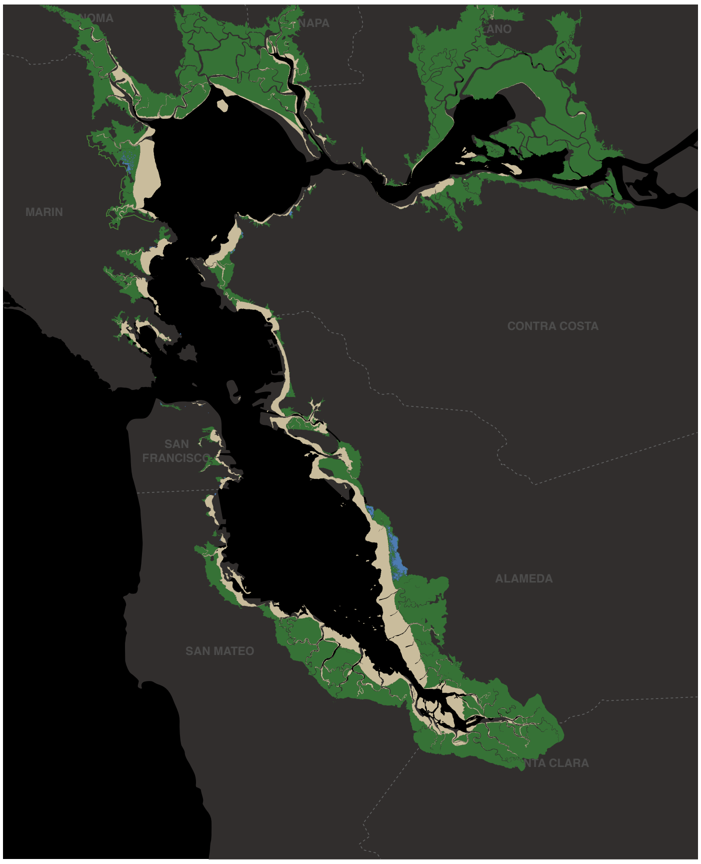
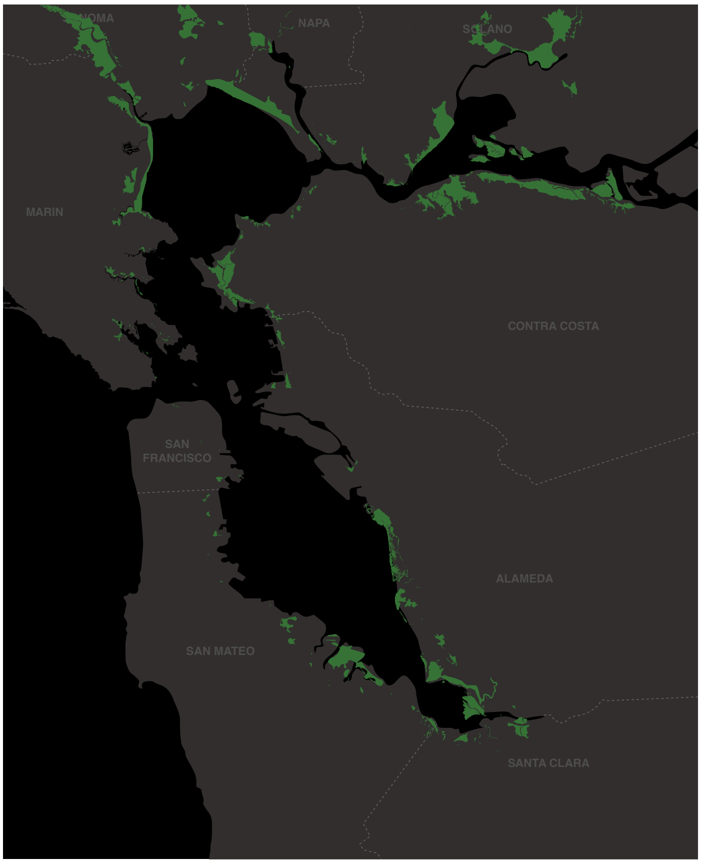


Fig.22: MODERN BAYLANDS, 2016. Drawed by Author.



1. MACRO-SCALE: SAN FRANCISCO BAY AREA

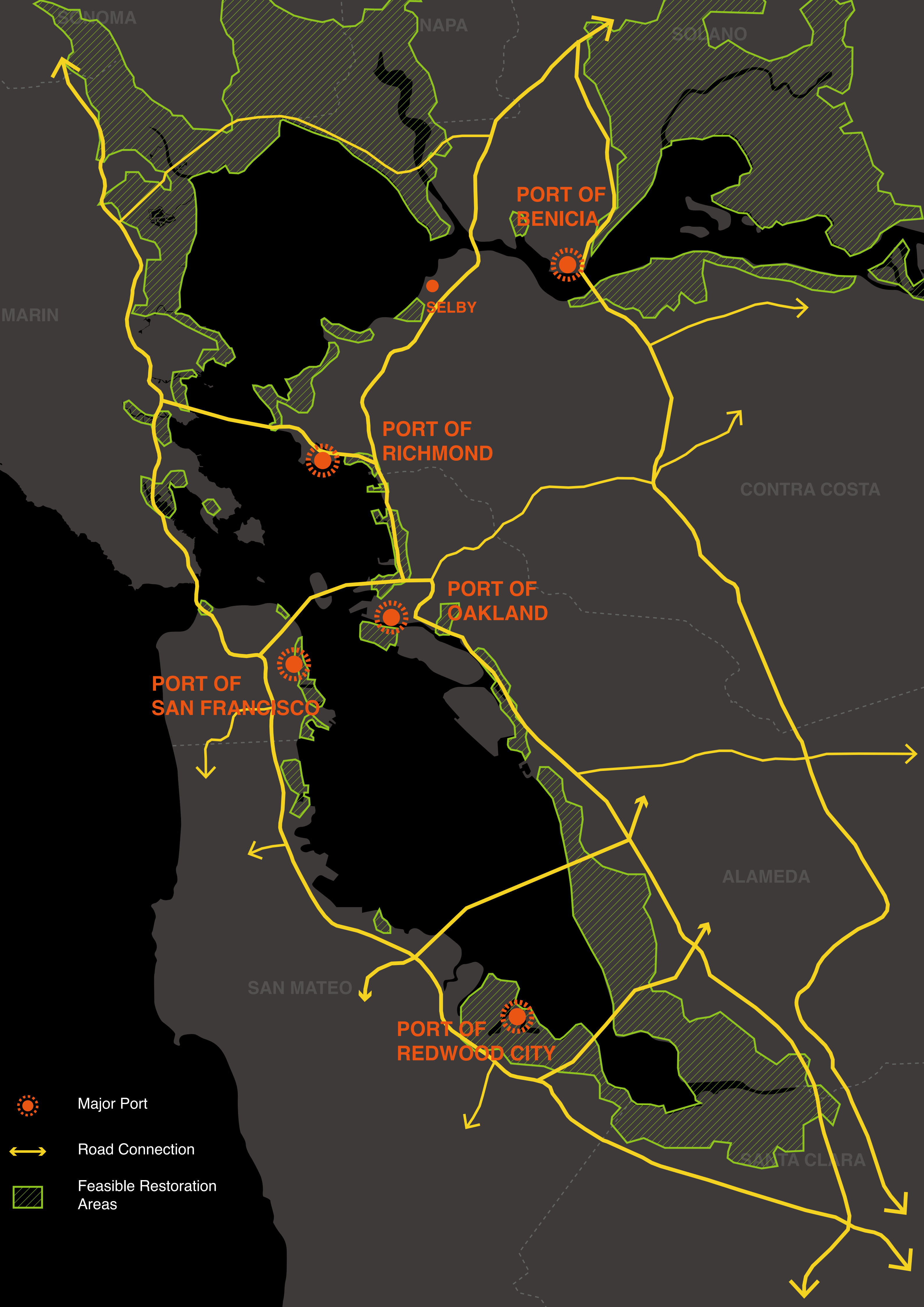
1.3 Conclusions & Potentials

To build a healthy shoreline, we need to construct and maintain more sea walls and levees in places where wetlands are not naturally sustainable, and to encourage the rapid restoration and enhancement of the natural infrastructure that cost-effectively protects people and property while also supporting native plants and animals.

1. Improve and integrate surface transportation facilities to ensure a continuation of San Francisco Bay port system as a major world port and contributor to the economic development.

2. Encourage the restoration and enhancement of Baylands to maintain a healthy shoreline.

Fig.23: Potentials in San Francisco Bay Area. Drawed by Author.


SONOMA
NAPA
SOLANO
MARIN
PORT OF BENICIA
SELBY
PORT OF RICHMOND
CONTRA COSTA
PORT OF OAKLAND
PORT OF SAN FRANCISCO
ALAMEDA
SAN MATEO
PORT OF REDWOOD CITY
SANTA CLARA
Major Port
Road Connection
Feasible Restoration Areas

2. MESO-SCALE: PORT OF SAN FRANCISCO

This part of the Graduation Project is to understand the site at multi-scales. It consists of three different scales. The first one defines the general orientation within the San Francisco Bay Area context; the second part discloses the spatial vision and structural plan for Embarcadero waterfront; and the third stage investigates the preliminary strategy for the project site based on the results of current in-depth analysis.

Fig.24: Port of San Francisco. Drawed by Author.


PORT OF SAN FRANCISCO

2. MESO-SCALE: PORT OF SAN FRANCISCO

2.1 Geology

Along the shoreline, the major geology type is landfill. The artificial fills are those most vulnerable to storm surges and shaking in an earthquake. Because they are comprised of landfill as opposed to natural hard rock or other solid surfaces. The soil here is less stable and more prone to liquefying. If the soil liquefies, the structures above or around are prone to more extreme and erratic movements in times of stress, such as an earthquake or storm surge. Thus, the edge requires different stabilization solutions based on its existing condition.

Stabilizing existing areas is harder and much more expensive. Access is more difficult and

Fig.25: Risk Zone. Drawed by Author.

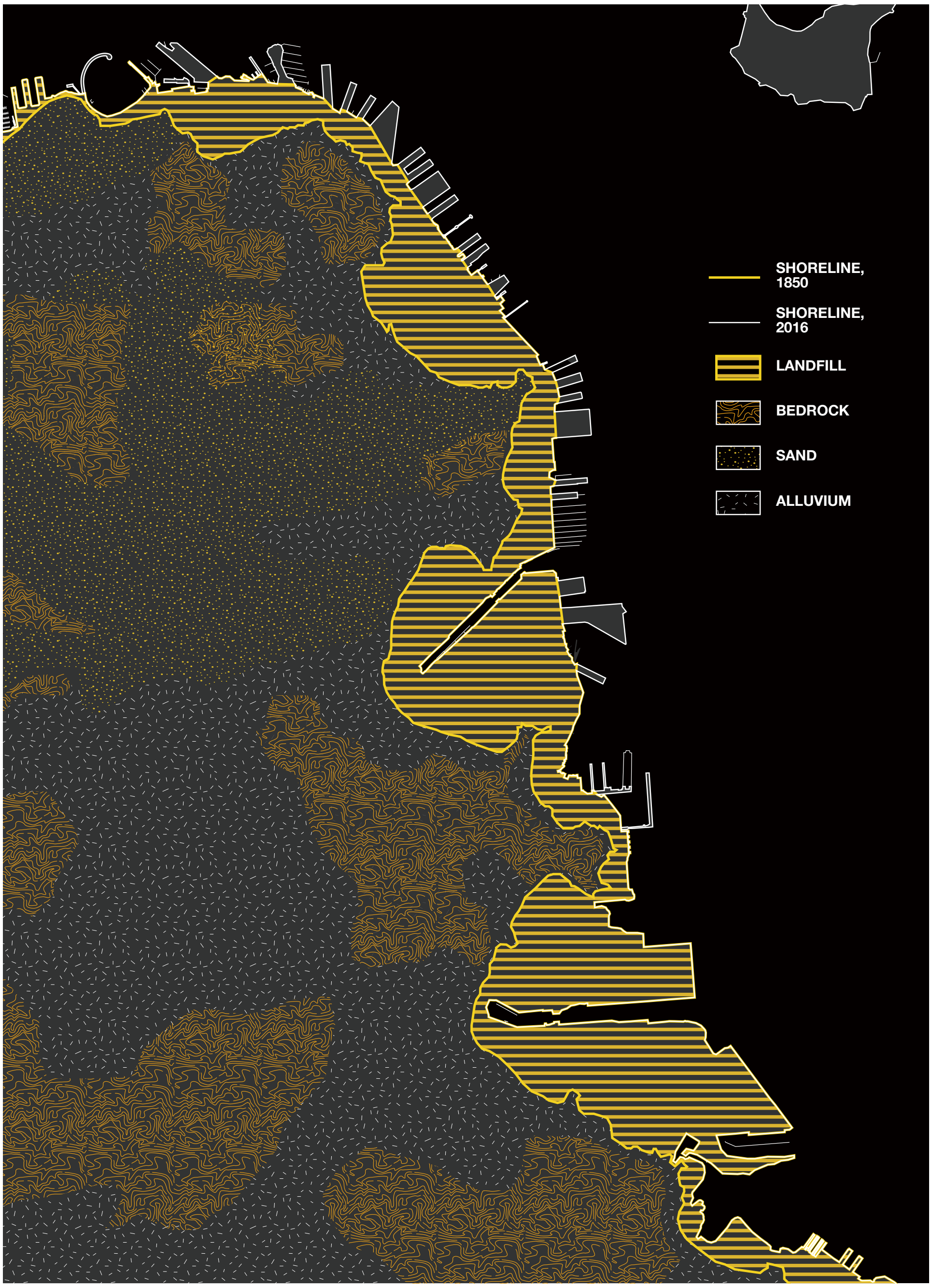
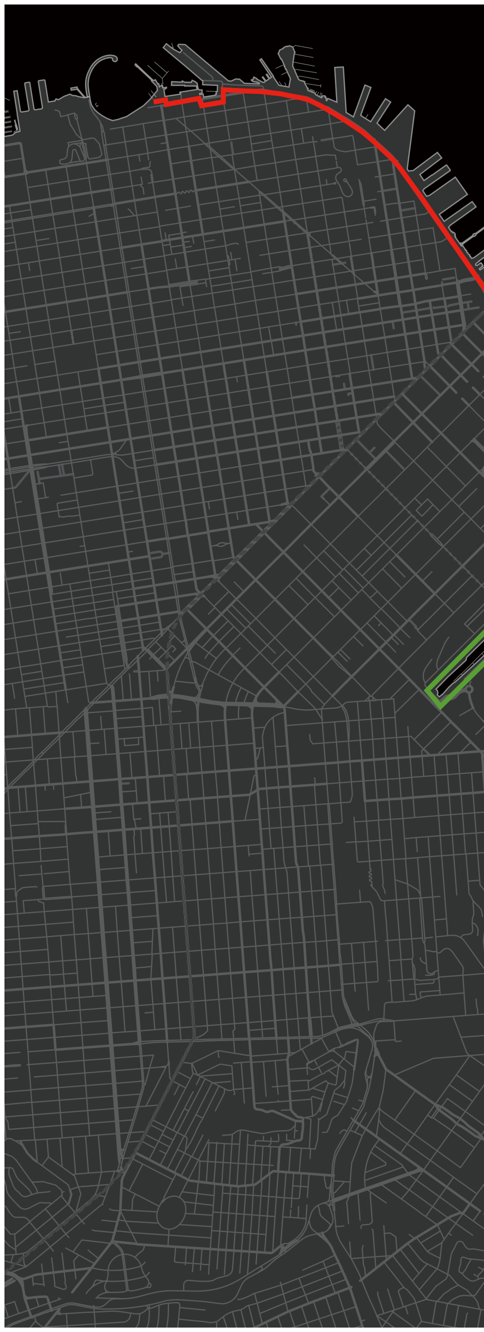


Fig.26: Existing Shoreline Condition. Drawed by Author.

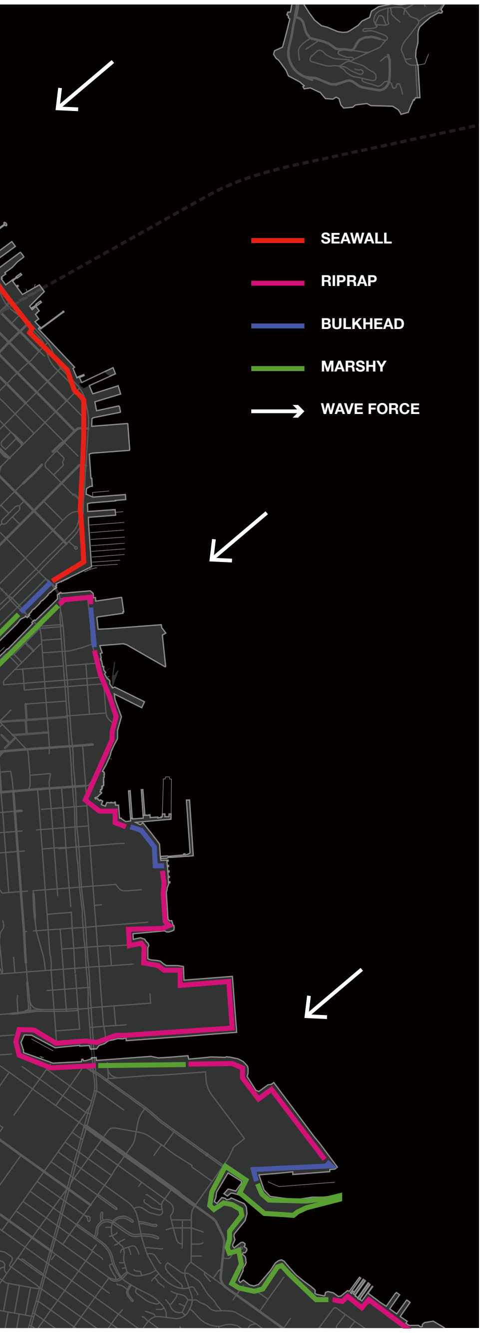


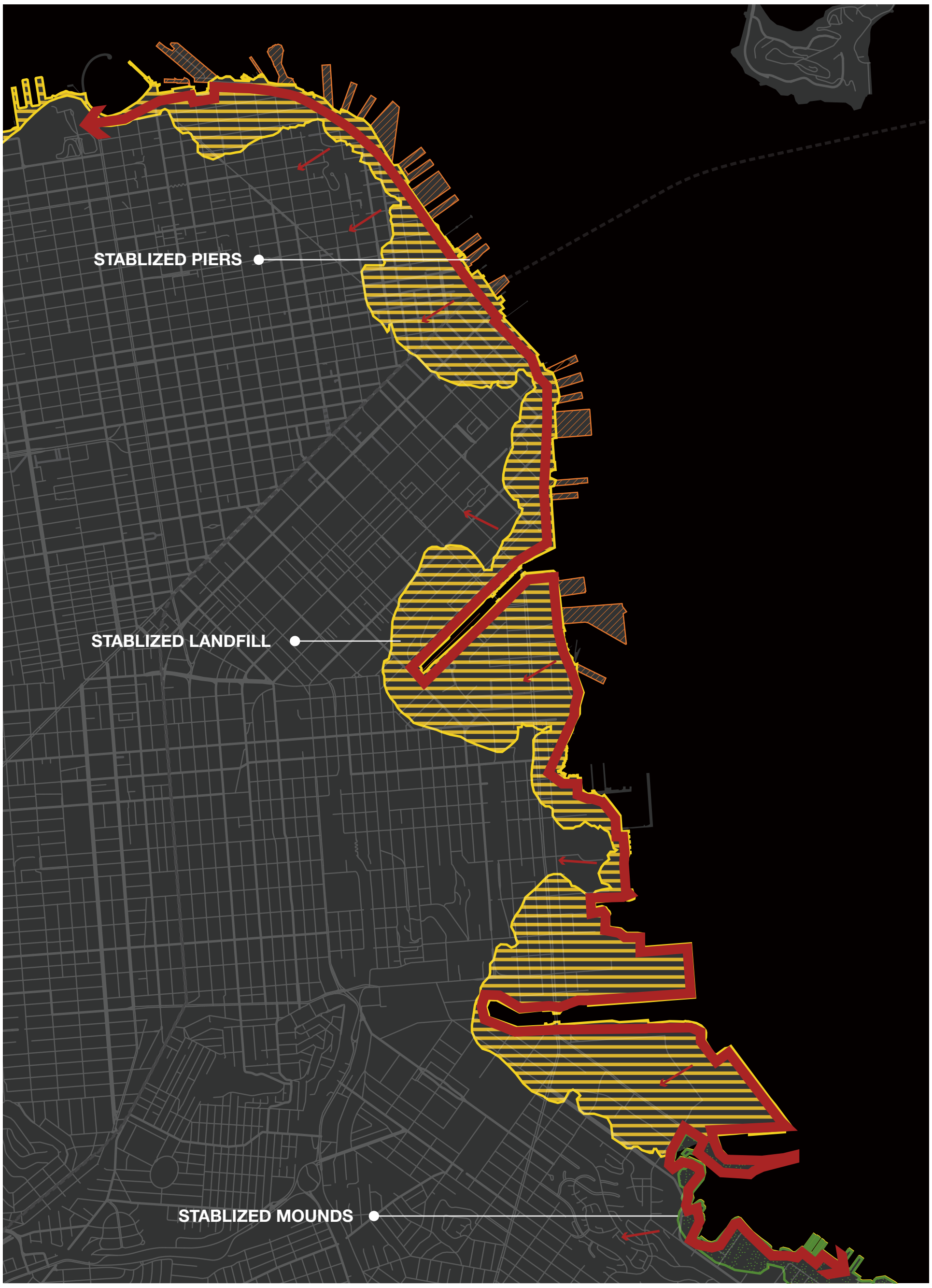
tens to be dealing more with edges and existing conditions - but there are a variety of techniques from vertical drains to vacuum consolidation to cement slurry injection.

Except for soil stabilization, stabilizing the infrastructure along the edge is necessary as well. The road along the shoreline will be subject to tidal flooding in the near future. In fact, portions of the paving are already failing due to saturation in the road base. Filling over the current level and employ compaction techniques is urgent to stabilize it.

The shoreline can be developed to stabilize the land fill.

Fig.27: Stabilization. Drawed by Author.





2. MESO-SCALE: PORT OF SAN FRANCISCO

2.2 Economy

Waterfronts are always considered as the economic center of costal cities, and it provide us with great space for fishery farming. Except for the fishery production, some other activities like tourism, energy industry and shipbuilding industry are also boosting local economy.

The Northern part of the Port is home to many of San Francisco's leading tourist attractions, including the Ferry Building, AT&T Park, the Exploratorium, Alcatraz Landing, James R. Herman Cruise Terminal, Fisherman's Wharf, and Hyde Street Pier, which draw more than 24 million visitors annually to the Port's northern waterfront.

Fig.28: Land Use. Drawed by Author.

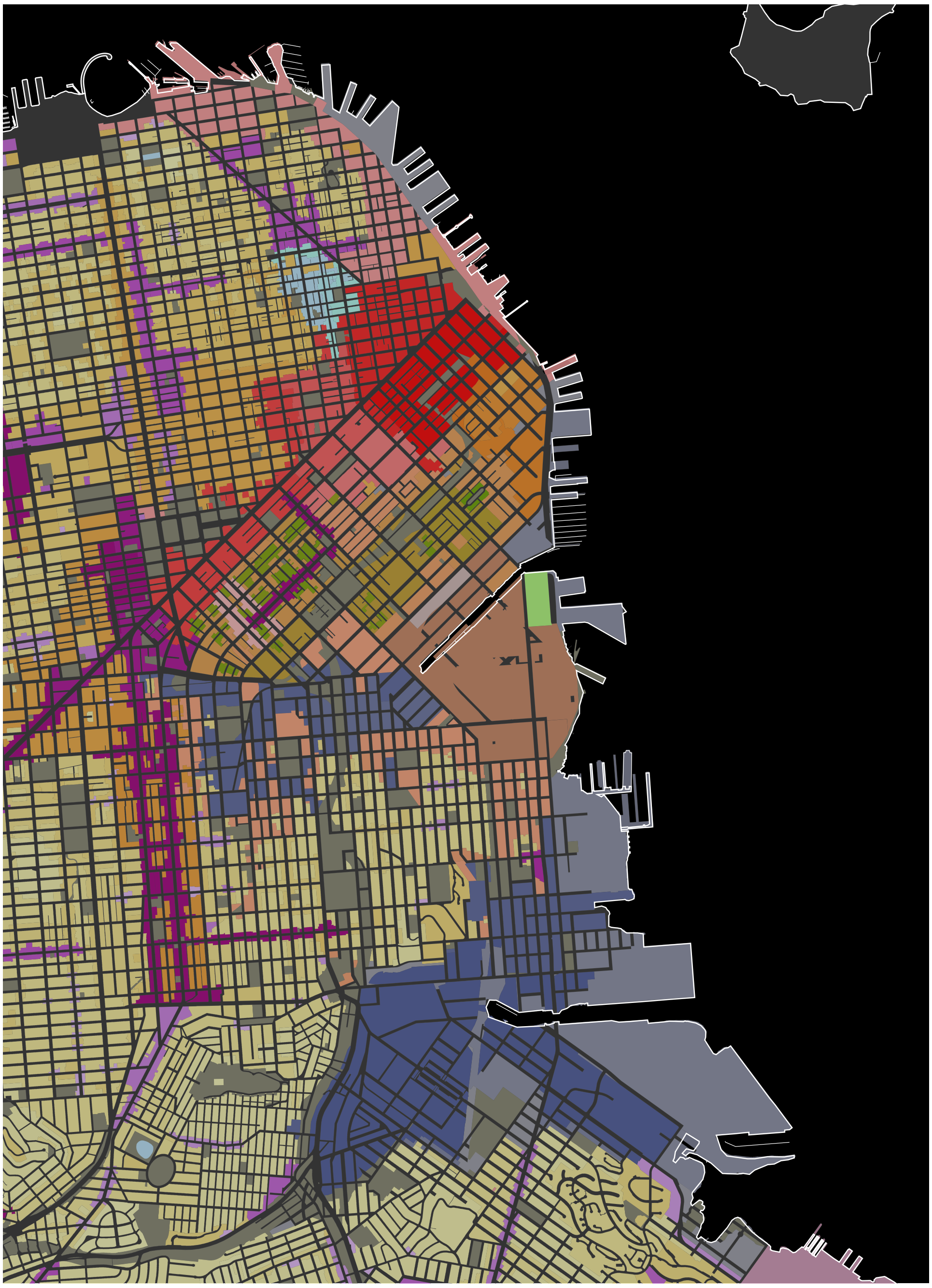
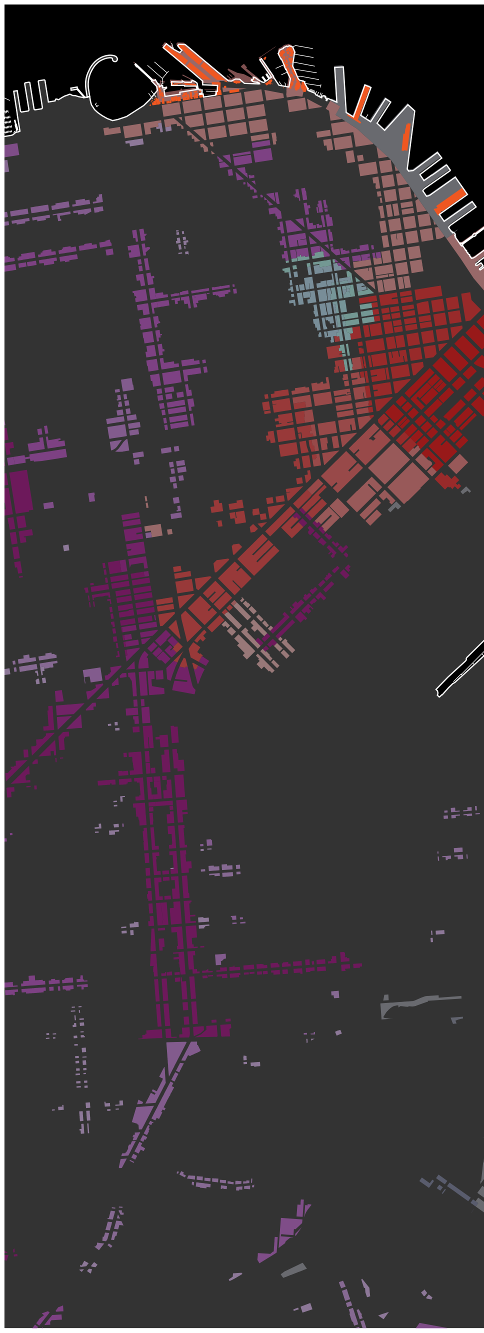


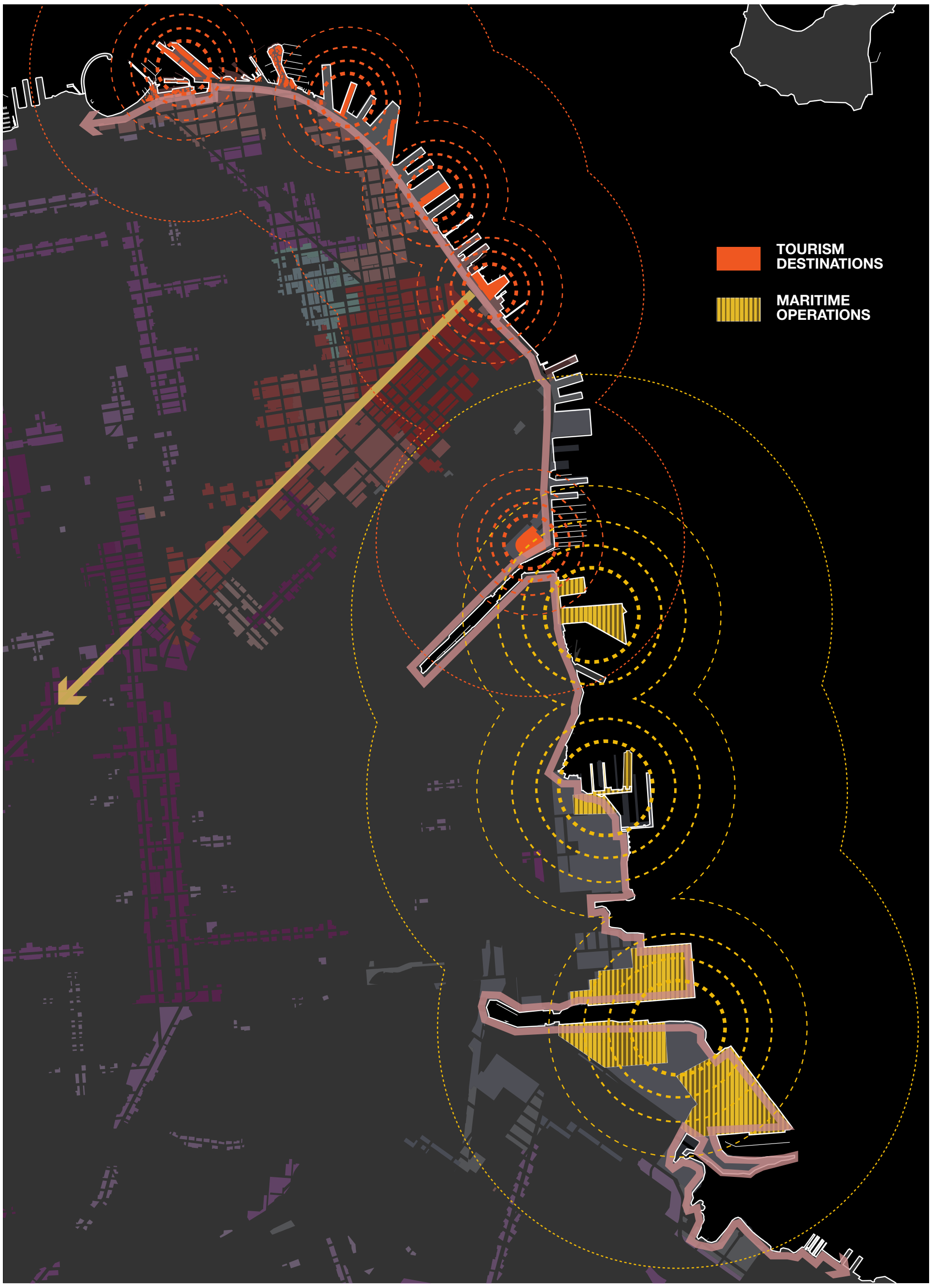
Fig.29: Initiatives. Drawed by Author.



Today, shipping and ship repair are located primarily south of China Basin and cruise ships, ferries, recreational boating and commercial maritime operations remain on the northern waterfront. The Mission Bay project had just been approved and work to transform this industrial area was in its nascent stages, starting with light rail service to Caltrain. San Francisco Drydock operated ship repair facilities at Pier 70. Pier 80 was a containerized cargo terminal struggling to compete with the Port of Oakland. Much of the southern waterfront area from Piers 90-96 and the adjacent Backlands was unimproved.

The shoreline can act as economic engines.

Fig.30: Economic Engines. Drawed by Author.



2. MESO-SCALE: PORT OF SAN FRANCISCO

2.3 Green Network

Shoreline is also an important recreation center. As the transition part of river and ocean, waterfront tends to attract people for its special terrain. In many coastal cities, millions of people visit shorelines every year for boating, swimming, watching birds or other wildlife. Those activities not only accelerate the city renewal, but also promotes the development of transportation.

Along the shoreline, there are a series of communities and neighborhoods, including Northeast, Downtown, South of Market and South Bayshore, which occupy the most dense areas in San Francisco. The waterfront area, not only interacts with the water in

Fig.31: Existing Open Space. Drawed by Author.

Fig.32: Potential Greenway Connection. Drawed by Auth

Bay area, but also closely associates with the local residents.

People's need for public activities and healthy environment is increasing. And water is a very natural landscape element, which has great potential to be combined with recreational functions. Thus, it is possible for us to extend urban life on the water and create more recreations for people.

The shoreline can offer recreational space to enjoy the bay, and can also unify the green space and connect to the landscape network as a whole.

hor.

Fig.33: Proposed Green Network. Drawed by Author.

2. MESO-SCALE: PORT OF SAN FRANCISCO

2.3.1 Lombard Street

Lombard Street, with two parking lane on the two side of the road, is quite steep.

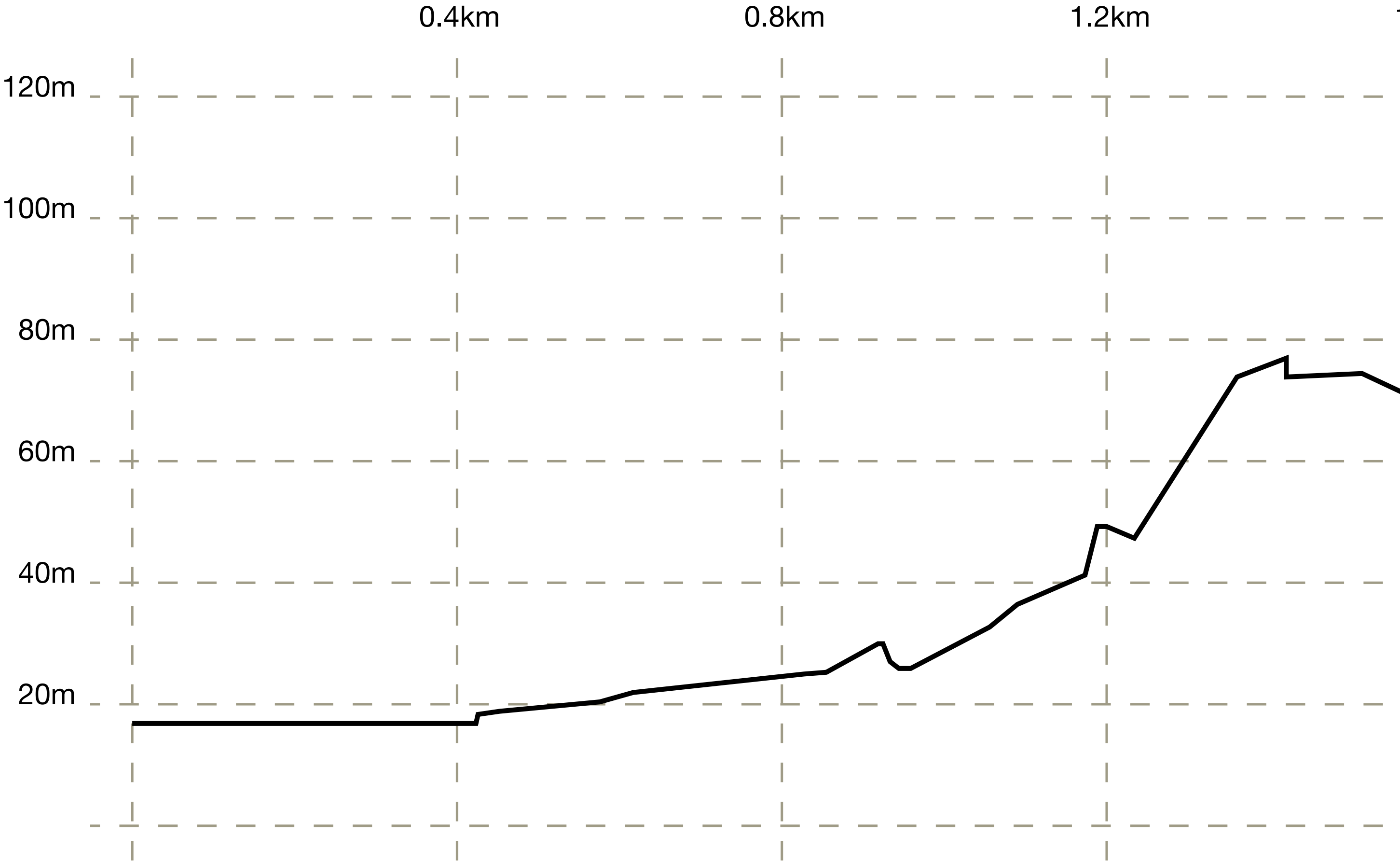
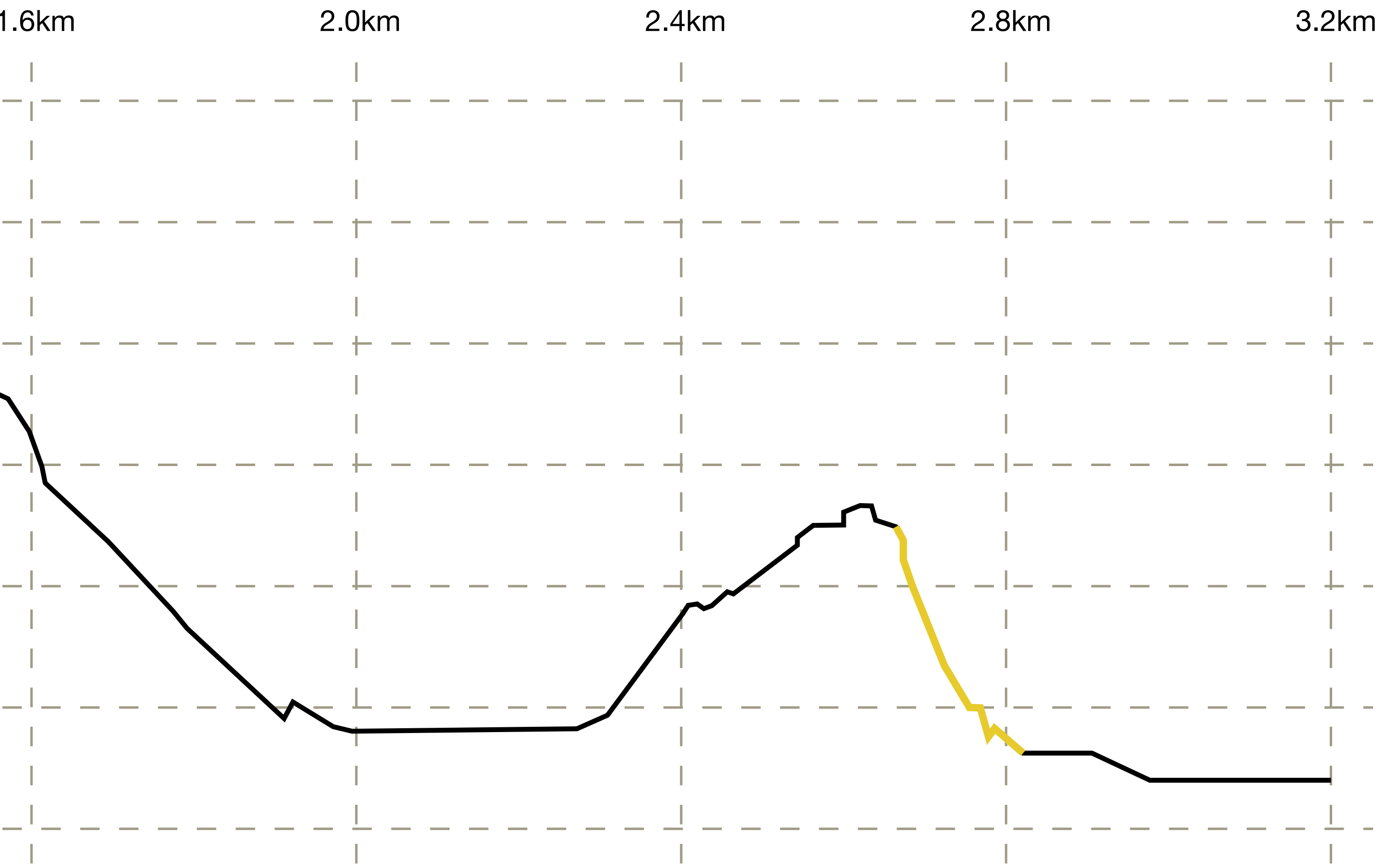


Fig.34: Typical Street Section - Lombard Street. Drawed by Author.



2. MESO-SCALE: PORT OF SAN FRANCISCO

2.3.2 Washington Street2.3.3 Folsom Street

Washington Street has a hilly streetscape with parking lanes on the two side of the road.

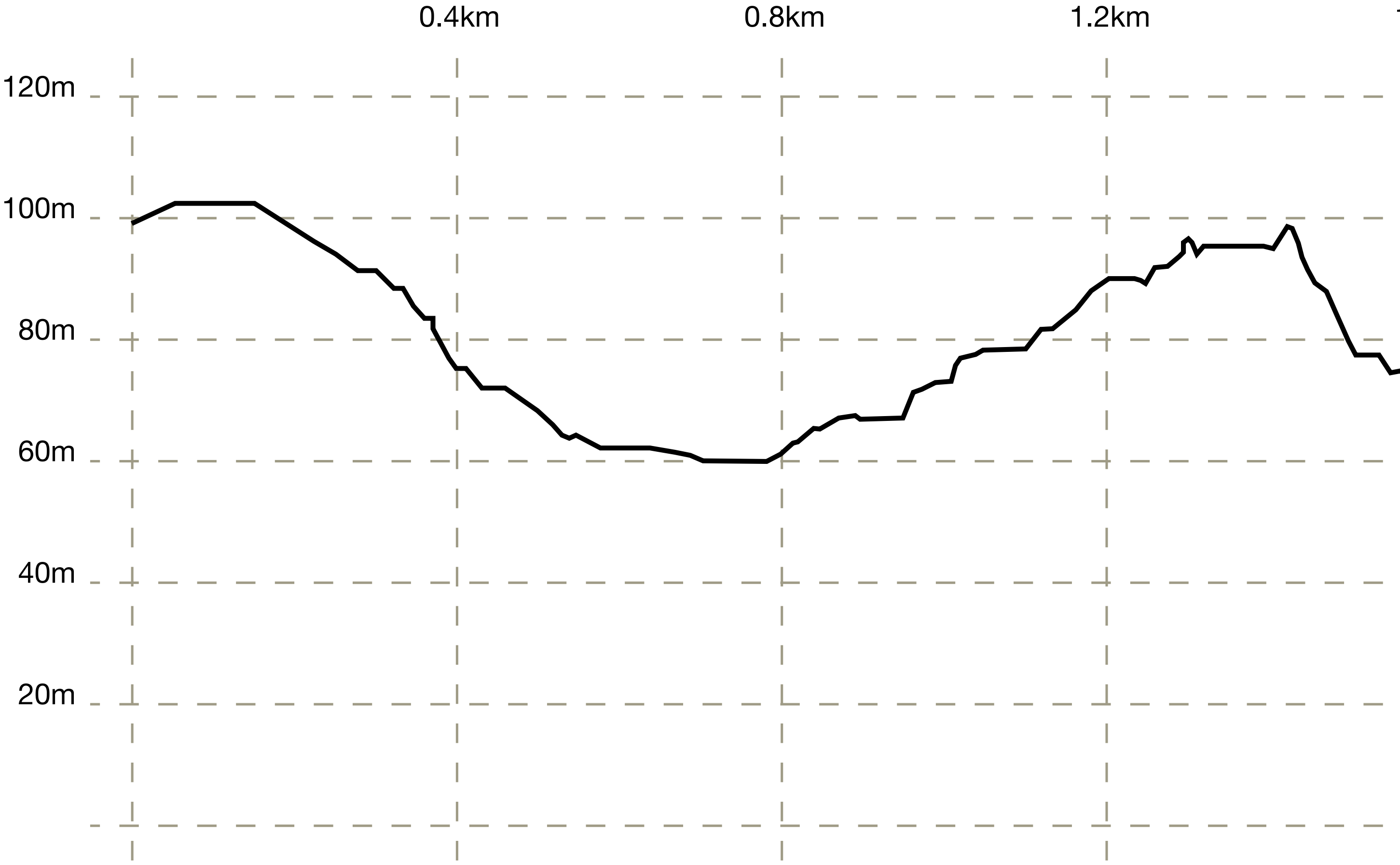
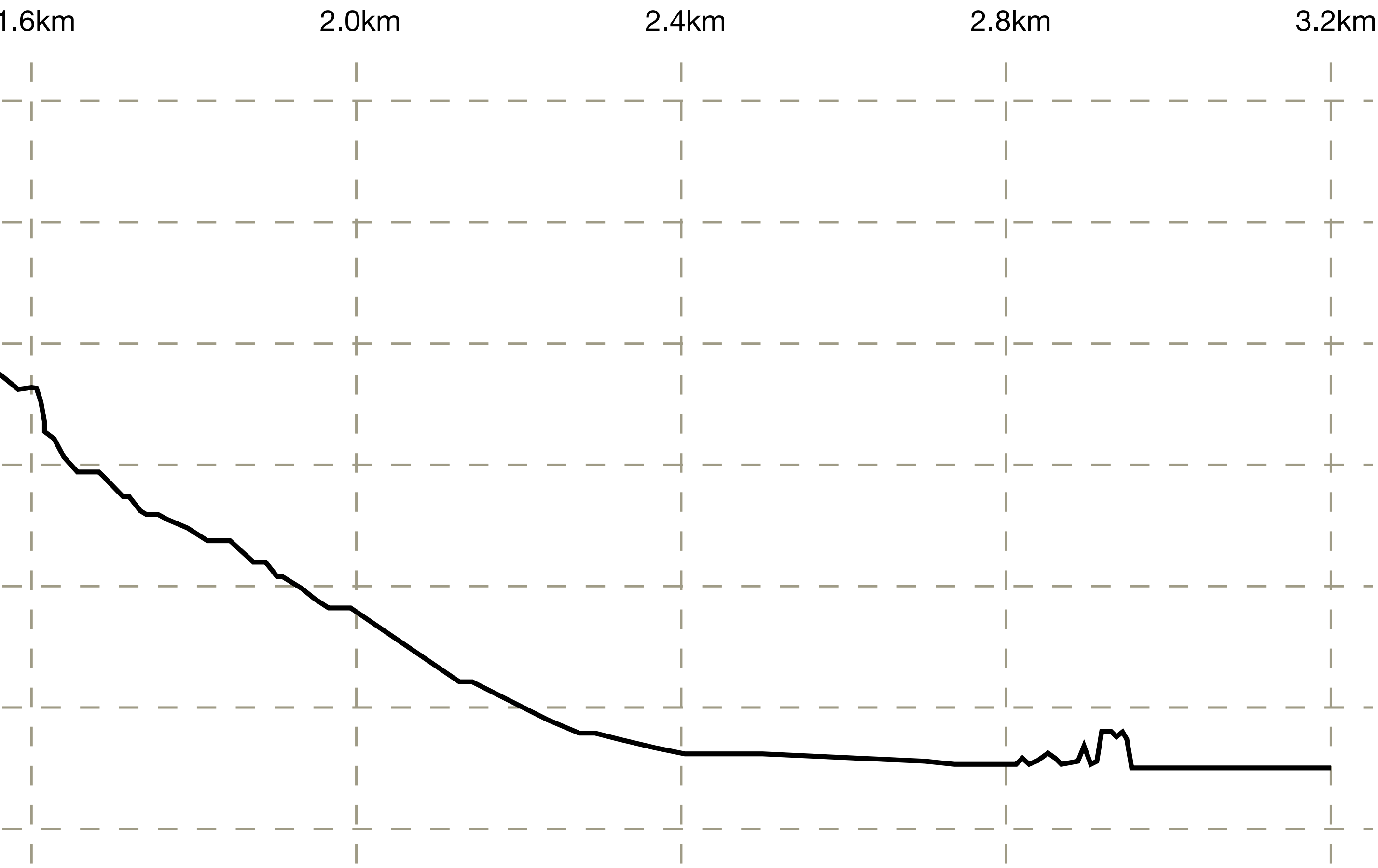
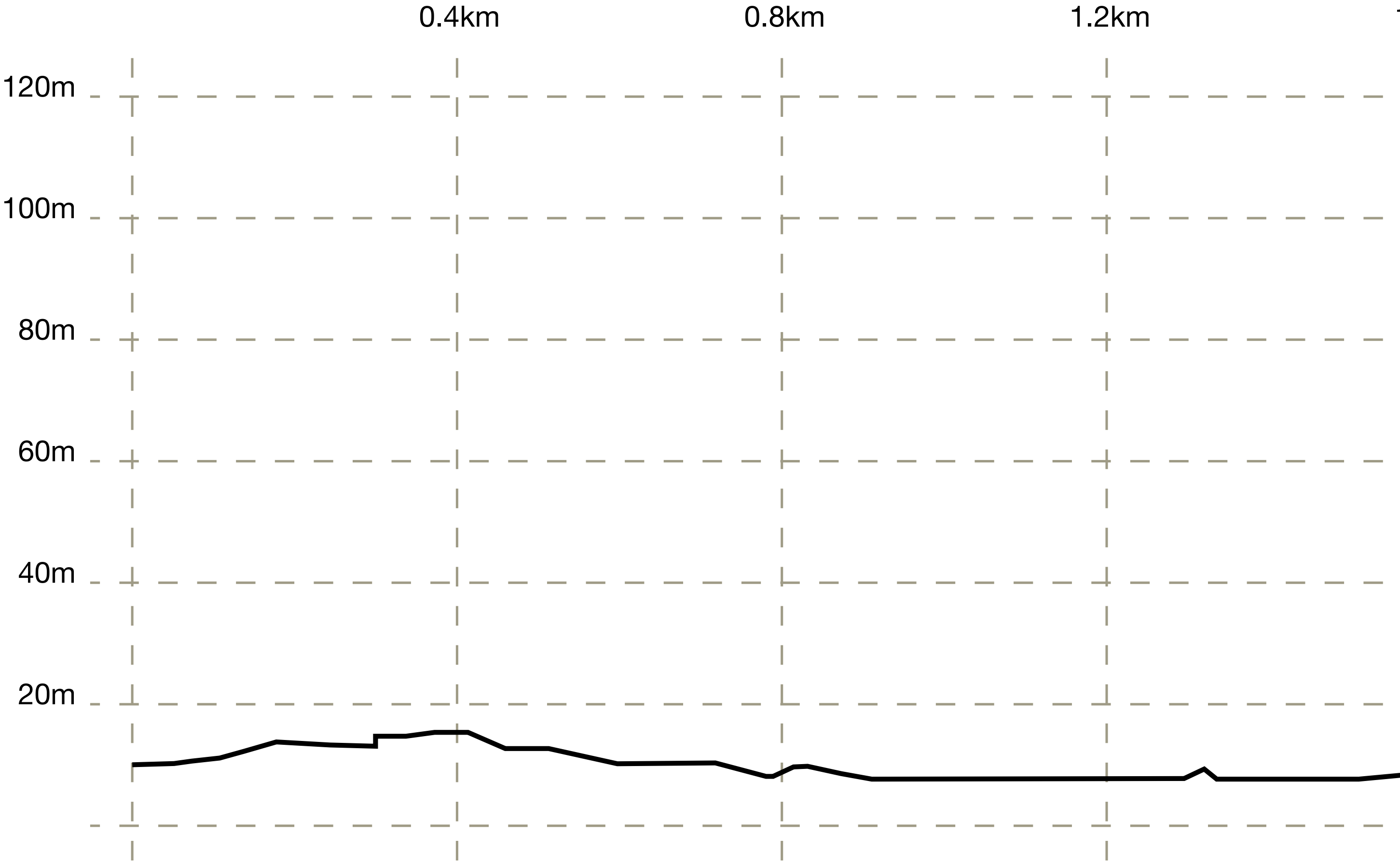


Fig.35: Typical Street Section - Washington Street. Drawed by Author.



2.3.3 Folsom Street

Folsom Street is wide and busy, including an unsafe bicycle lane.



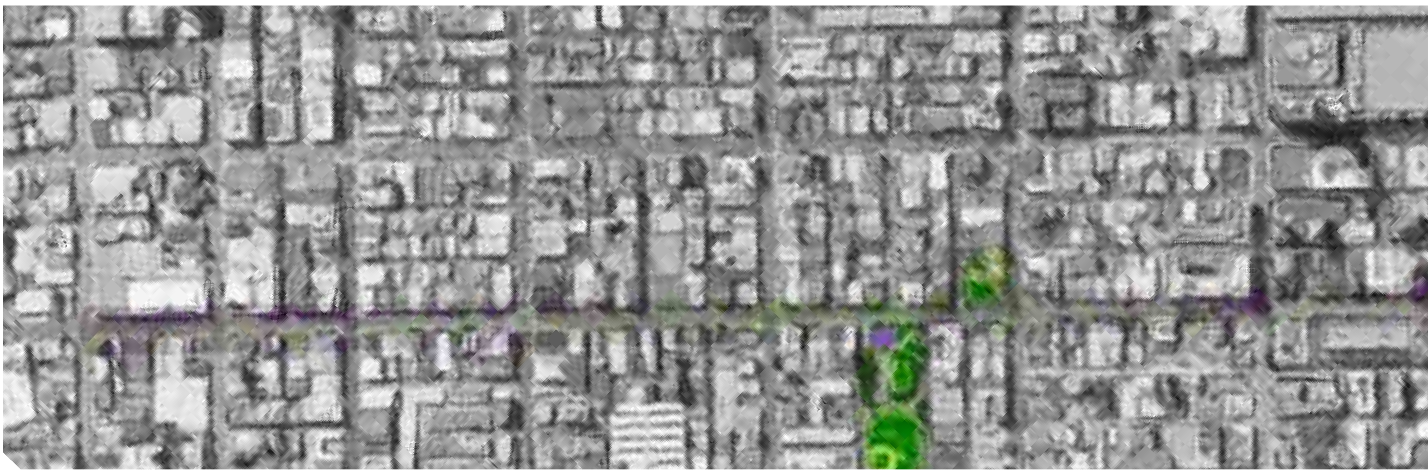
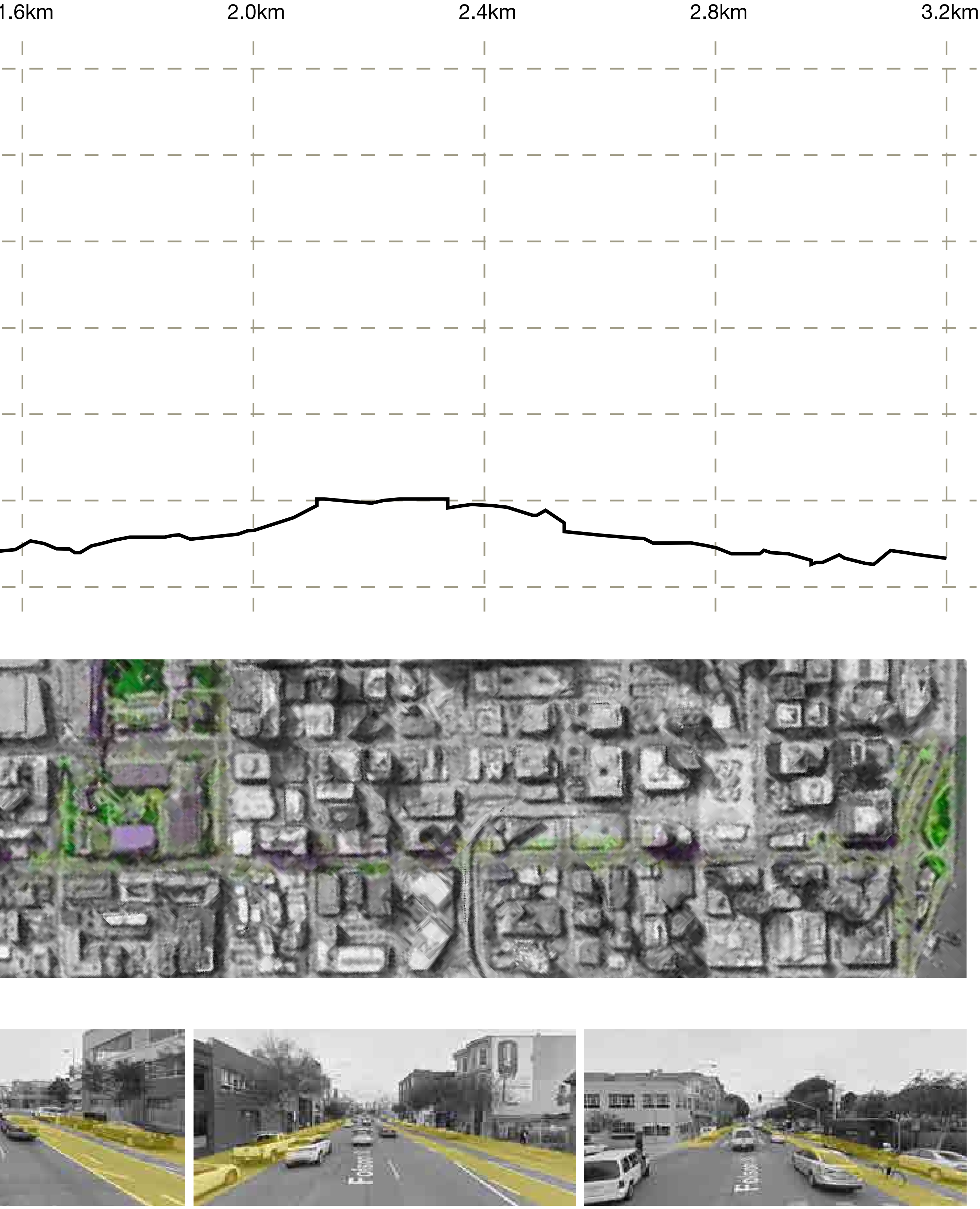


Fig.36: Typical Street Section - Folsom Street. Drawed by Author.



2.4 Infrastructure

Much of the critical infrastructure such as seawalls, tunnels for combined sewage and storm flows, roads, railways, and wastewater treatment plants are all built at the edge of the city. San Francisco, already a dense urban environment, decided that separation was too costly and disruptive to the residents.

According to the existing sewage infrastructure system and the historic wetlands, we need to adjust our policies and our methods to encourage rapid restoration and enhancement of natural infrastructure to protect people and property while also supporting natural processes, and protecting habitat for native plants and animals.

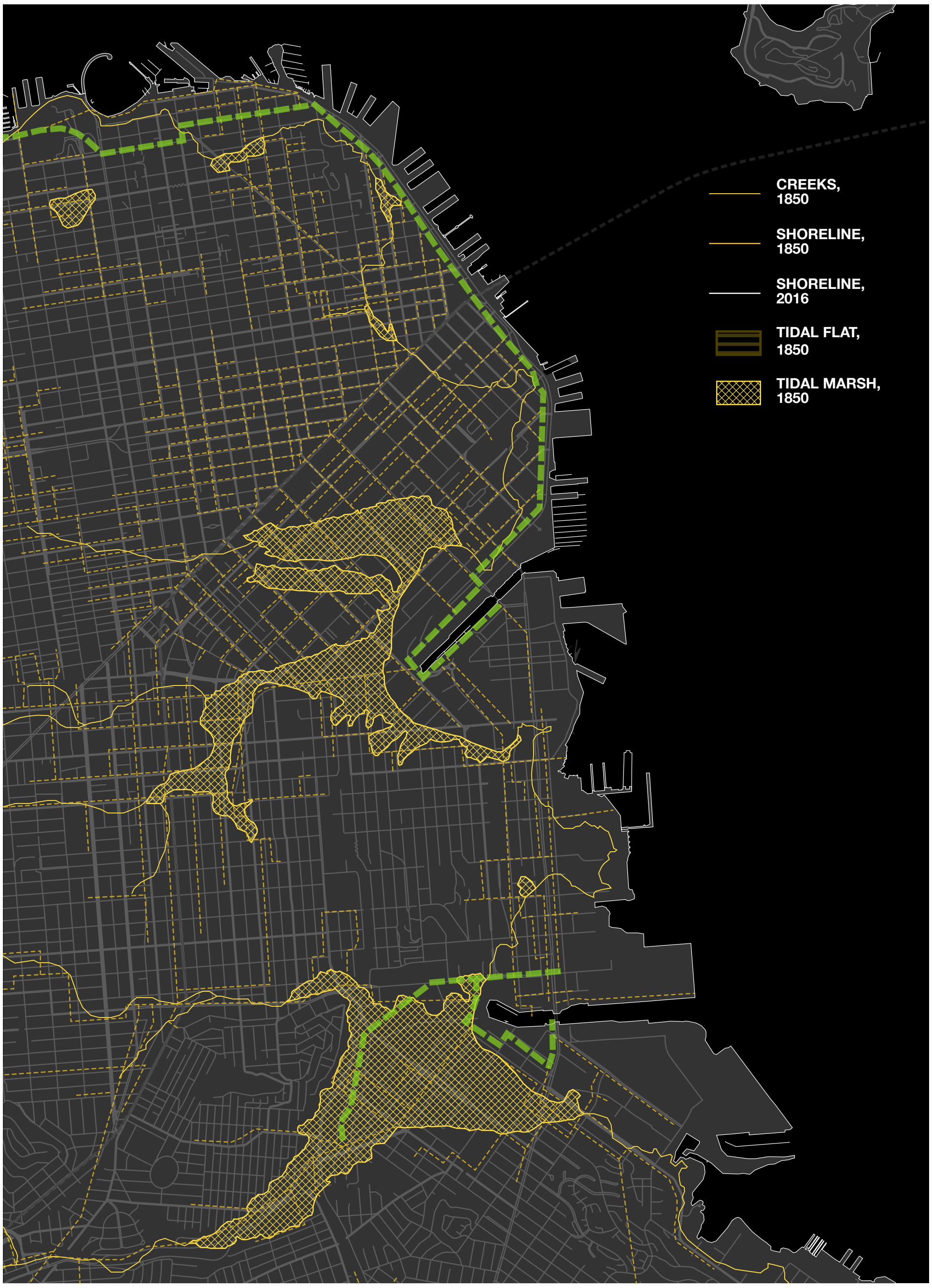
Fig.37: Existing Sewage Infrastructure. Drawed by Author.

Fig.38: Historic Wetlands. Drawed by Author.

At areas of high urban density (northern part), waters flow through hard and soft-bottom channels, from sidewalk swales to plaza basins. The alternating conditions of saturation and desiccation at these urban spaces fosters a dynamic range of recreational and commercial activities. At the littoral zone of southern part, the character of the landscape is quite different. Biotic succession and daily tide dynamics are evident in the expansive salt marshes, while kelp cultivation groins extending into Bay become armatures for sediment accumulation and spontaneous vegetation. Public access throughout this zone, via boardwalks that convey wastewater for treatment, allows for immersive cultural experiences.

A variety of landscape-based solutionscan be employed throughout the site.

Fig.39: Proposed Solutions. Drawed by Author.



2. MESO-SCALE: PORT OF SAN FRANCISCO

2.5 Conclusions

"America's oceans and coasts are priceless assets. Indispensable to life itself, they also contribute significantly to our prosperity and overall quality of life. Too often, however, we take these gifts for granted, understanding their value and ignoring our impact on them." (An Ocean Blueprint for the 21st Century: Final Report of the U.S. Commission on Ocean Policy, Recognizing Ocean Assets and Challenges, page 1.)

In this scale, I explored my interests in relation to the Port of San Francisco, a shoreline which contains numerous potentials and possibilities.

From technical aspect, much of the waterfront is made up of artificial landfill, which is quite vulnerable to flooding and liquefaction. So the shoreline can be developed to stabilize the land fill. From social aspects, as economic center, tourism center and transport center, the shoreline can stimulate huge economic development. While from the ecological aspects, the shoreline, a linear space, can unify the open space and interact with the inner landscape system. Because much of the critical infrastructure lies along the shoreline, it is possible to treat waters throughout the site in order to protect public health and ensure environmental quality.

Fig.40: The shoreline can be developed to stablize the land fill. Drawed by Author.

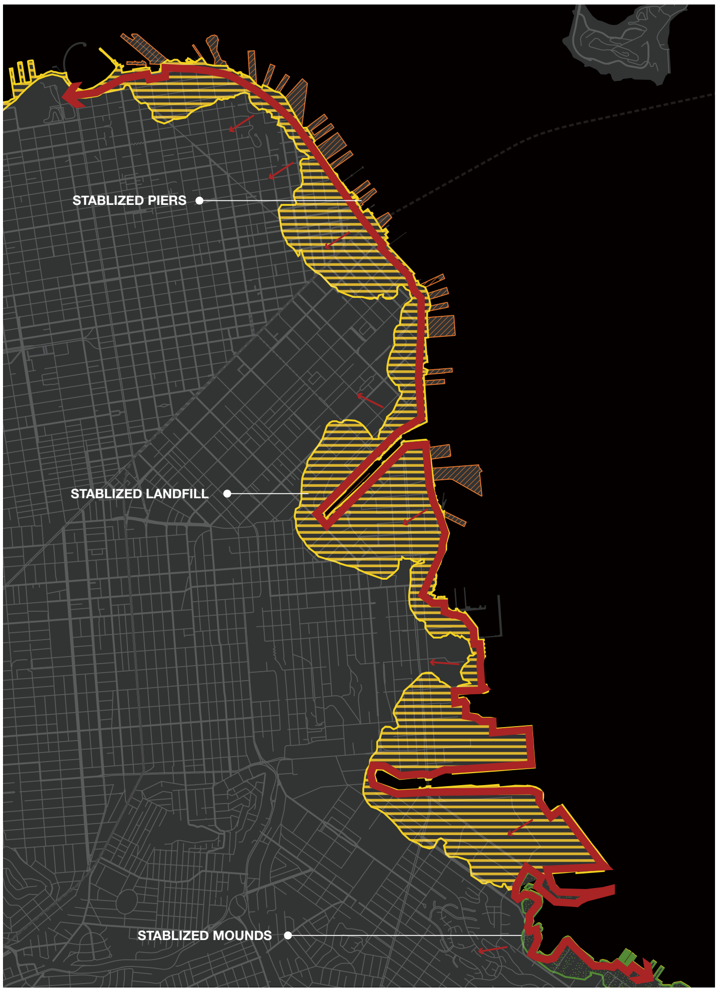


Fig.41: The shoreline can act as economic engine. Drawed by Author.

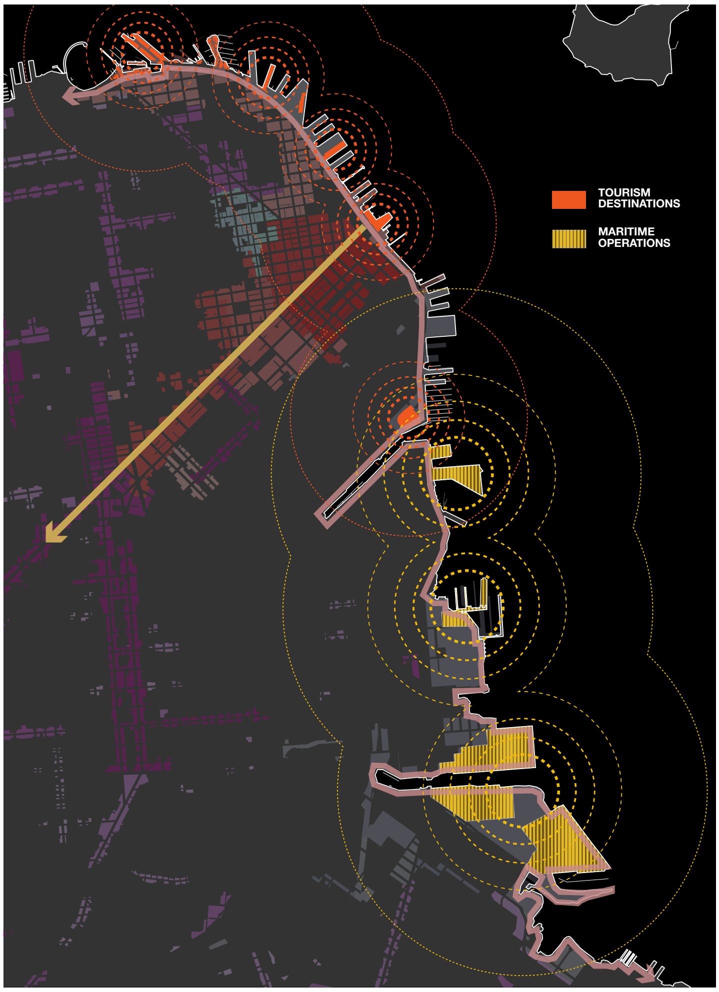


Fig.42: The shoreline can unify the open space and connect to the landscape network. Drawed by Author.

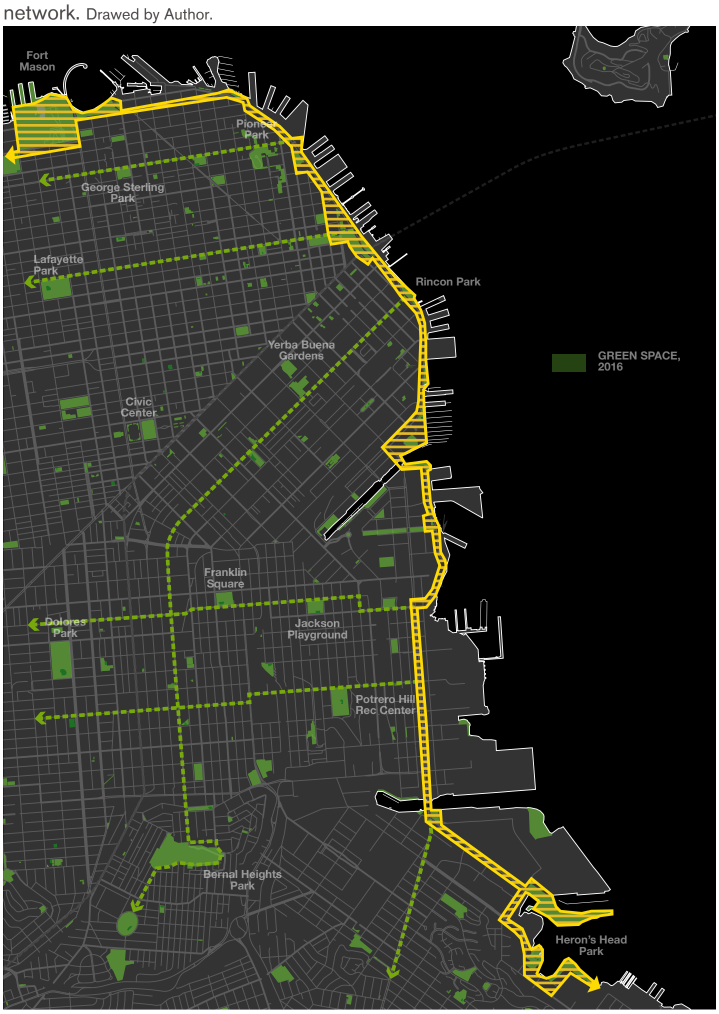
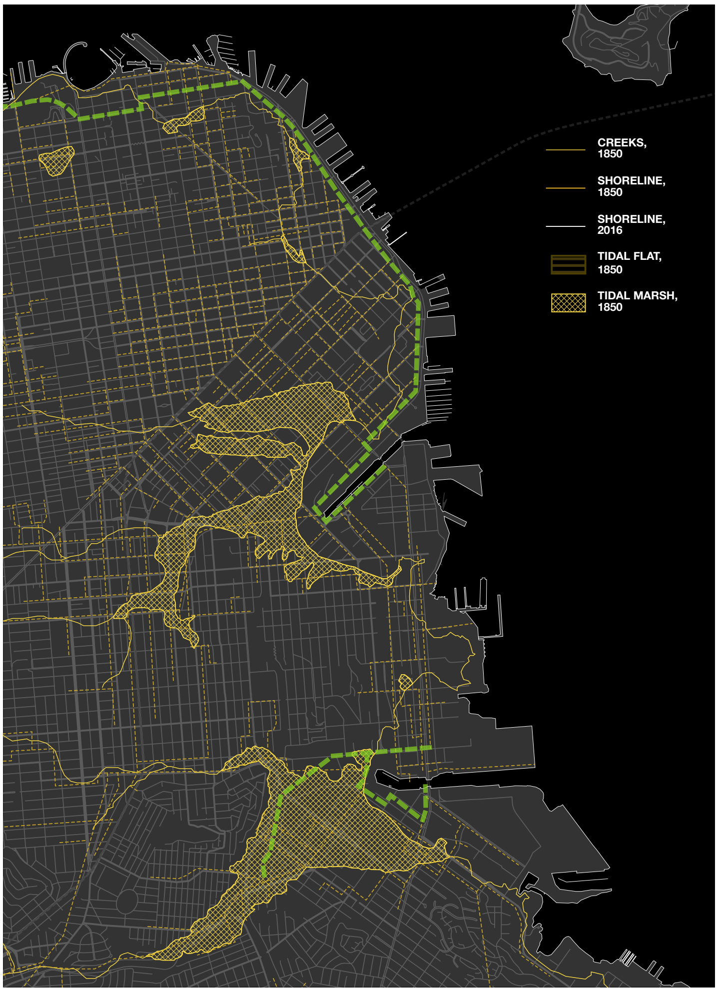


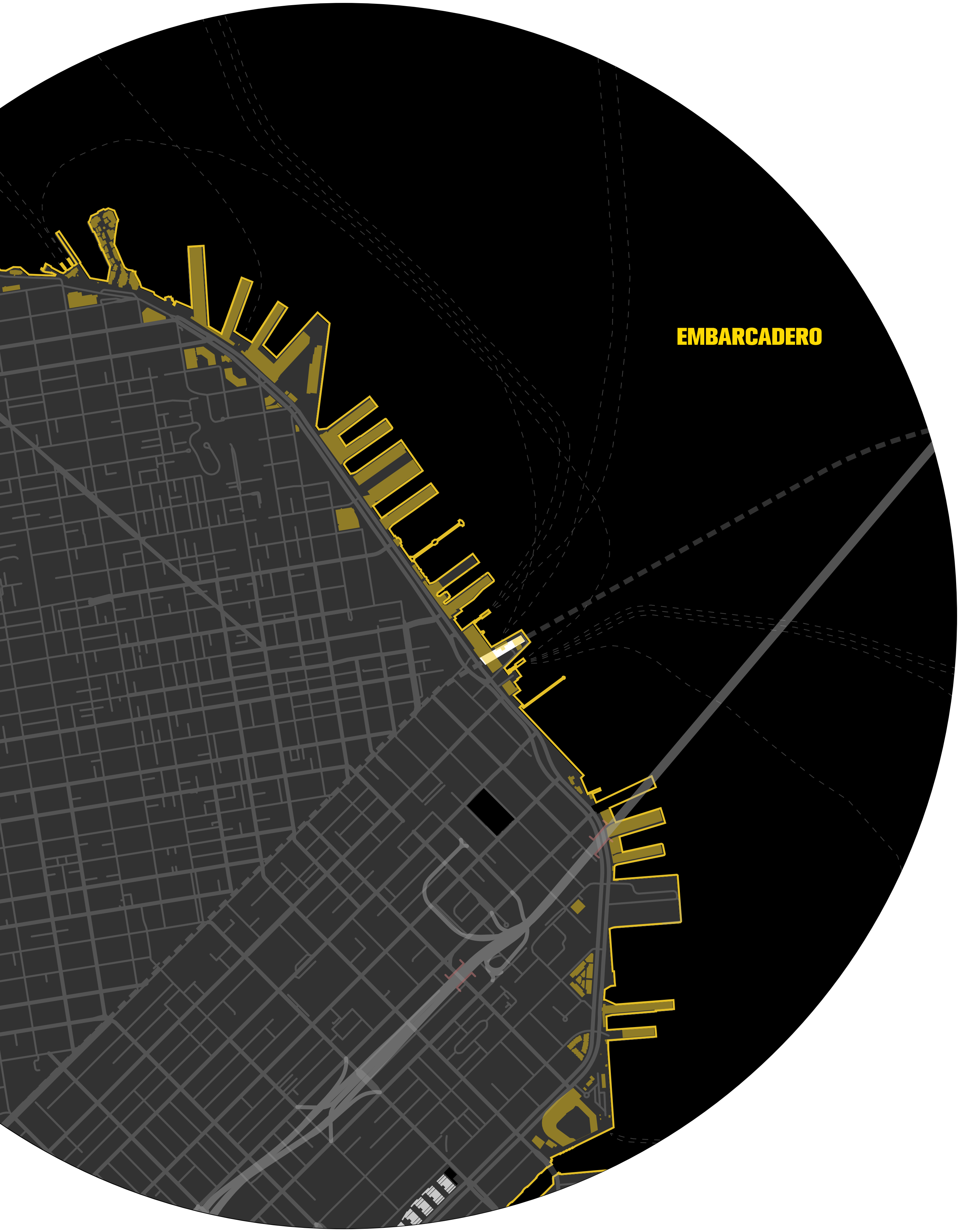
Fig.43: The shoreline can protect public health and the environment. Drawed by Author.



3. MICRO-SCALE: EMBARCADERO

This part of the Graduation Project is to understand the site at multi-scales. It consists of three different scales. The first one defines the general orientation within the San Francisco Bay Area context; the second part discloses the spatial vision and structural plan for Embarcadero waterfront; and the third stage investigates the preliminary strategy for the project site based on the results of current in-depth analysis.

Fig.44: Embarcadero. Drawed by Author.


EMBARCADERO

3. MICRO-SCALE: EMBARCADERO

3.1 Historic Evolution

Many people are fascinated by ports - or at least the sites of what were once working waterfronts. Old waterfronts have an especially alluring quality. They are often in cities' older sections and their bits and pieces, from piers to historic ships, are easily recognized, making them a visible part of local history.

Over the course of the last fifty years, much of San Francisco's waterfront has been transformed from an exotic and often dangerous place of work into a place of leisure, distinguished by beautiful public spaces and entertainment facilities that attract visitors from around the world. The decline of waterfronts is generally due to the influence of technology development. In particular, changes in transportation technology and other large-system factors such as economic restructuring have been of major importance. During the last half century, the most significant and probably most apparent force behind the loss or relocation of cargo operations was the advent of new transportation

Fig.45: Embarcadero's Historic Evolution. Drawed by Author, Images credit Rising Reality.

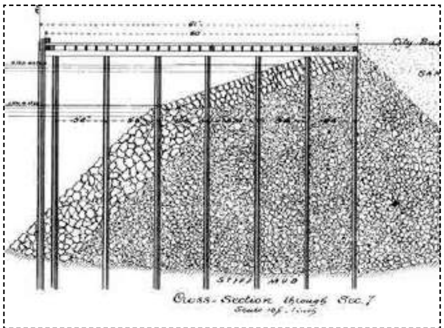
WATERFRONT FLOURISH

WATERFRO

State takes control of the Port of San Francisco, in part to allow for the orderly construction of wharves and piers as the shoreline is expanded into shallow portions of the bay.

1863

State approves "harbor lines" for San Francisco that roughly match today's Embarcadero. Construction of a seawall to turn it into reality begins two years later.



1878

The last sections of the seawall beneath the Embarcadero is completed, including upgrades to some of the earliest sections near Fisherman's Wharf.

1915

The Bay Bridge opens
six months later by the

1

technology. For many ports, the result has been abandonment and disuse, turning what was once a vibrant connection between city and water into a deserted no-man's land. Most ports that floundered, including San Francisco's, started to do so in the late 1950s and early 1960s, when containerization revolutionized the shipping industry.

Starting at the beginning of the 1960s, and coming into full force by the early 1980s, cities around the world have made efforts to reuse the land at the water's edge. By the late 1970s, waterfront revitalization in the United States had become such a common urban issue that federal and national agencies began to produce guides and reports to address the trend.

ONT DECLINE

WATERFRONT REVITALIZATION

in November, followed Golden Gate Bridge.

1936

The 1989 Loma Prieta earthquake knocks chunks of concrete from the Embarcadero Freeway. The structure is razed in 1991.

1989

Embarcadero Freeway opens, creating a concrete wall along the waterfront from Folsom Street to Broadway.

1959

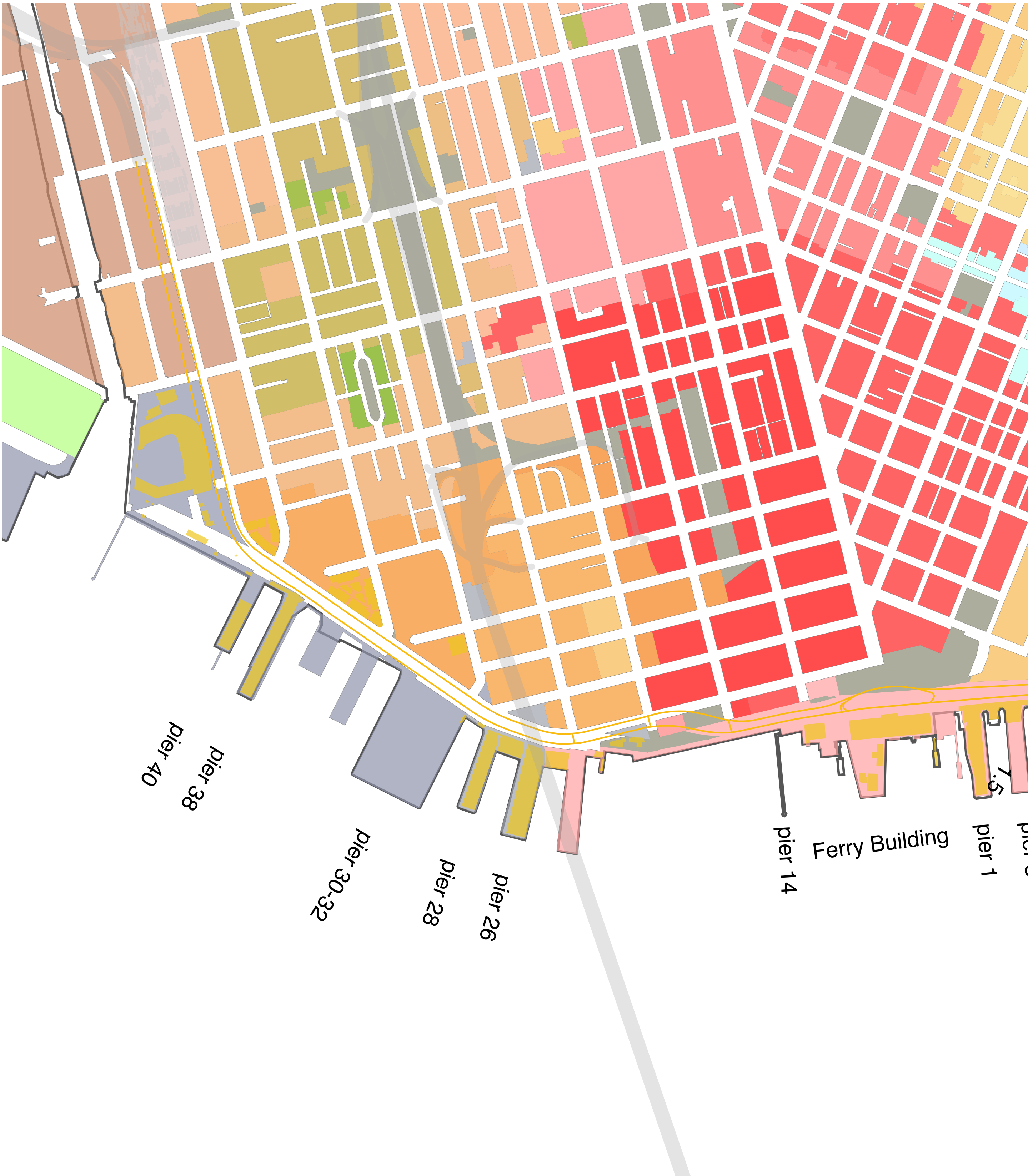
The seawall is in danger of severe damage in a major earthquake and sea level rise.

2016

3. MICRO-SCALE: EMBARCADERO

3.2 Current Land Use

Embarcadero is mix-used. This integrated mix of land uses makes Embarcadero quite vibrant and appealing. In the blocks closest to the waterfront, this diversity is evident: sheds on piers are given to public institutions; other lands along the edge are occupied by residential, commercial and business.



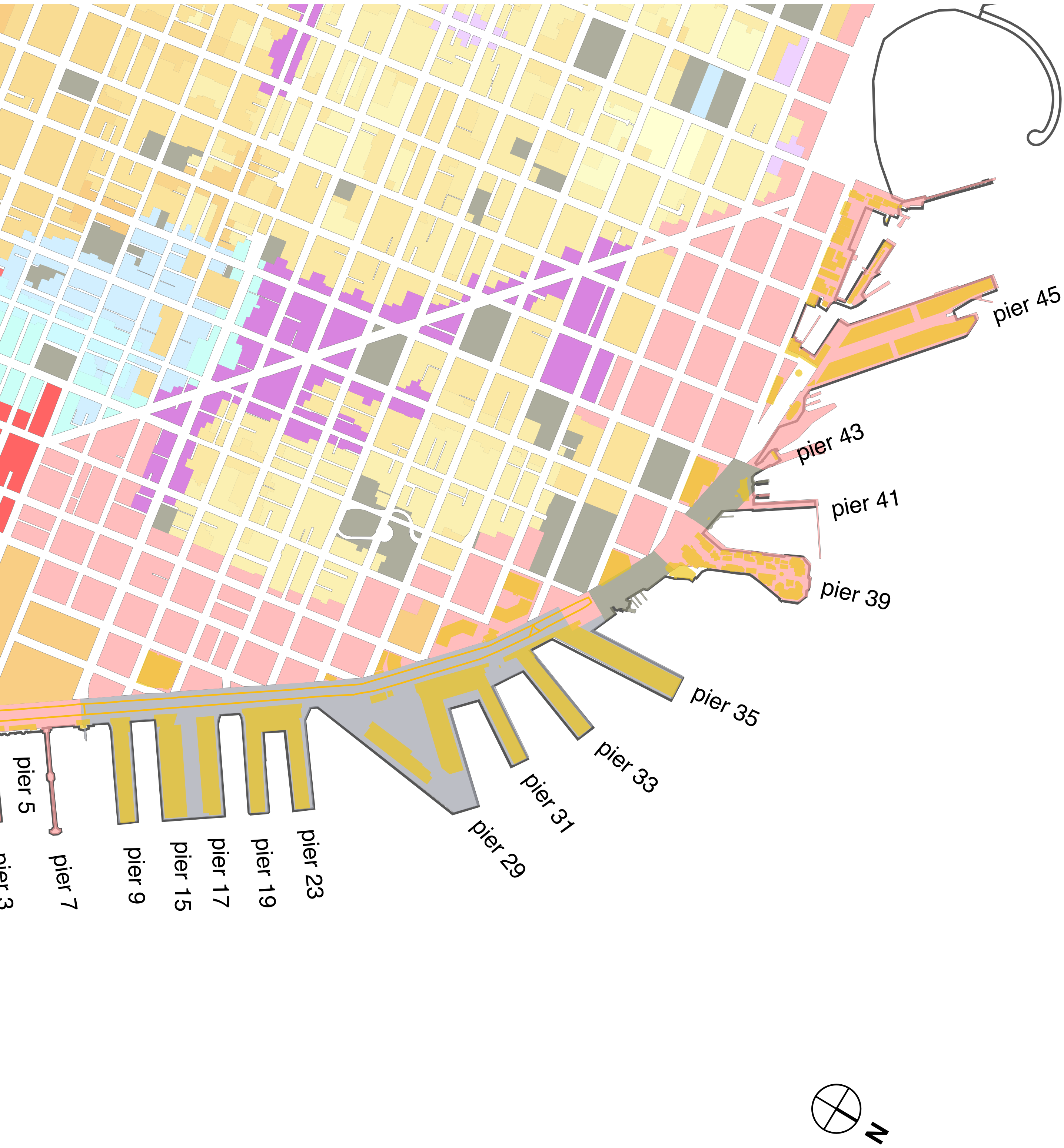


Fig.46: Embarcadero's Current Land Use. Drawed by Author.

3. MICRO-SCALE: EMBARCADERO

3.3 Current Infrastructure System

Embarcadero has negative relation with its waterfront. Although Embarcadero is crisscrossed by several transportation patterns, it is mainly served by a car-driving road with large traffic volumes. Its heavy reliance on car traffic and lack of pedestrian friendly space made the shoreline and waterfront obsolete.

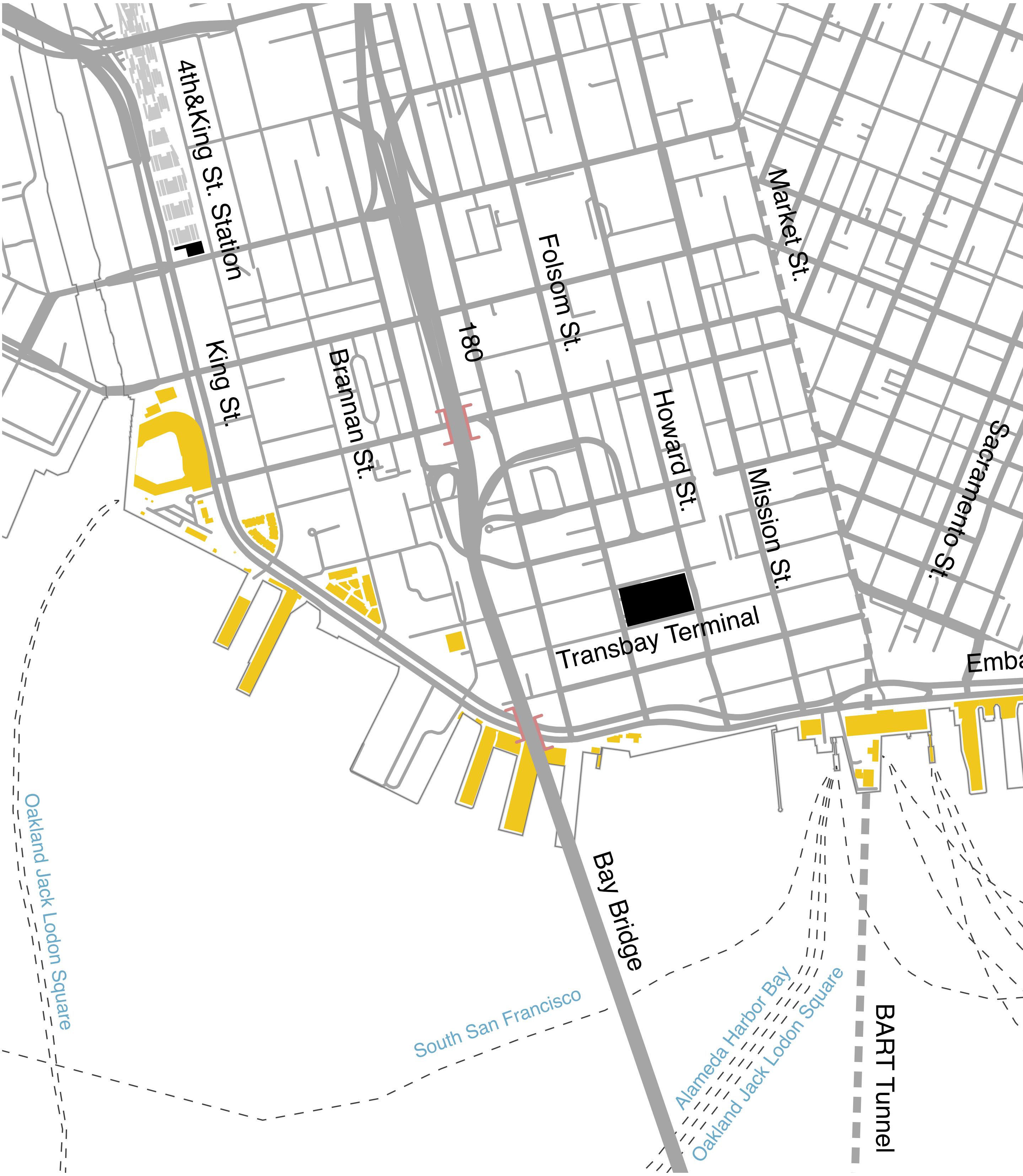


Fig.47: Embarcadero's Current Infrastructure System. Drawed by Author.

3.4 Current Open Space

Embarcadero has little desirable open space. Open space along the Embarcadero area is composed by parking lots, parks, plazas and small green space. There is little variety among the types of open spaces available - flat squares and parks make up the majority of assets, with many ballfields and courts available only to paying members of leagues.

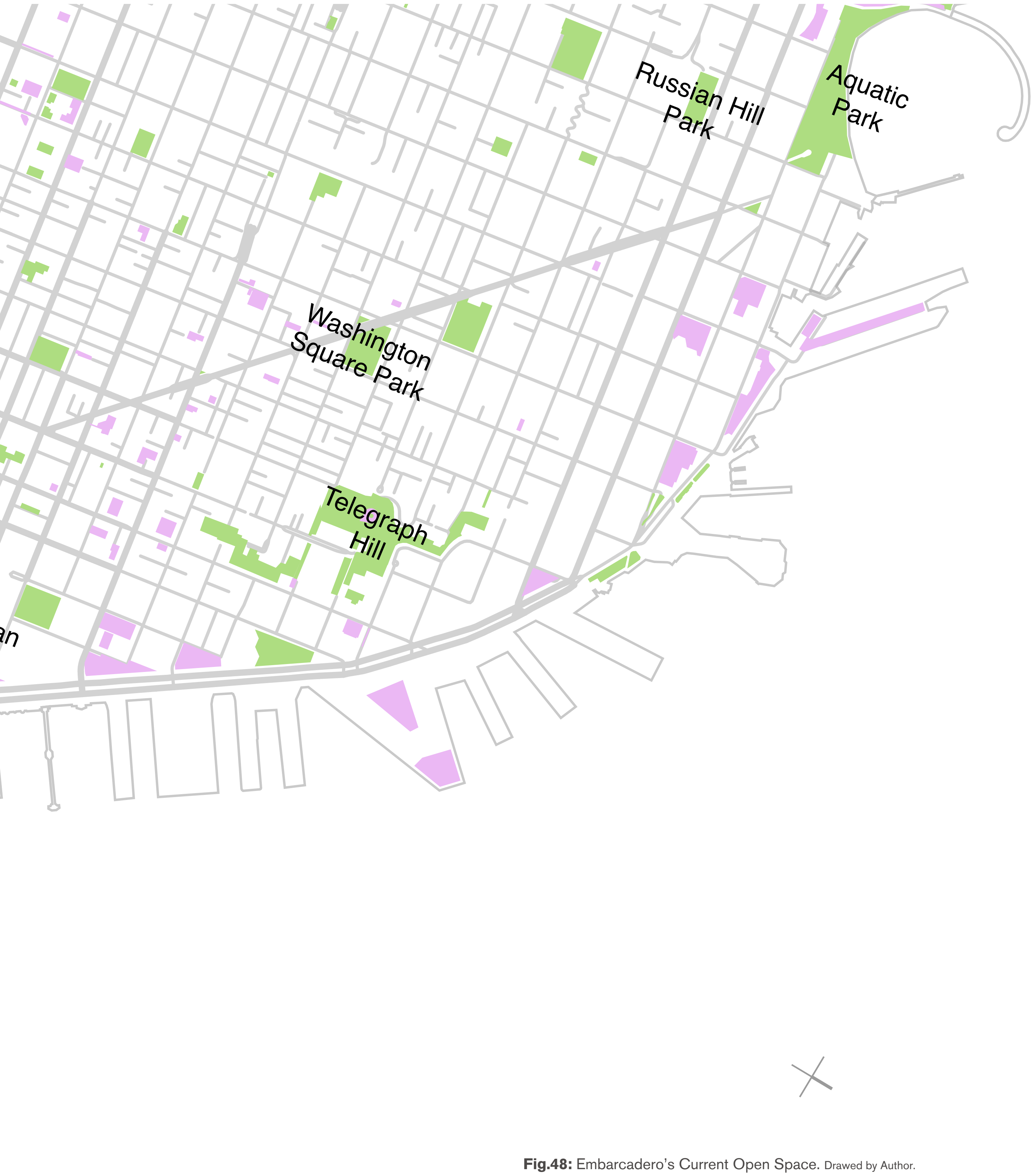


Fig.48: Embarcadero's Current Open Space. Drawed by Author.

3.5 Current Elevation

Embarcadero is relatively low-lying. San Francisco is a spectacular city thanks to its diverse topologies. There are several hilly streets in the city, while Embarcadero is flat and just lied at the foot of Telegraph Hill. As a result, the end of all the grid system meet at the city's edge - waterfront and finger piers.

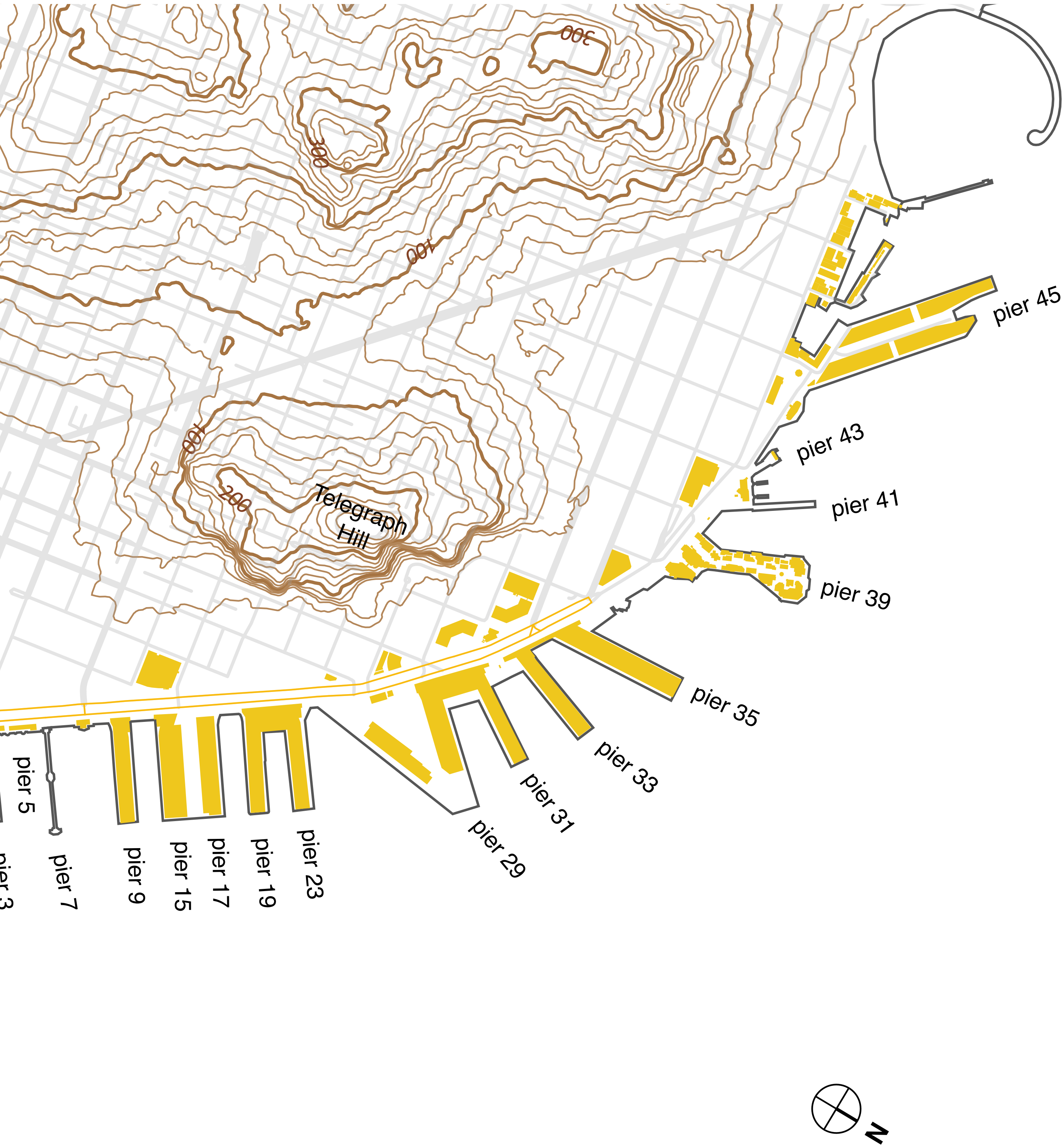


Fig.49: Embarcadero's Current Elevation. Drawed by Author.

3.6 Current View Corridors

Embarcadero has splendid street view corridors. San Francisco is a city with diverse urban patterns, including water, hills, piers and streets. The splendid street view corridors are well known all over the world. Some of the view corridors lead to Bay area and others are oriented to bulkhead buildings.

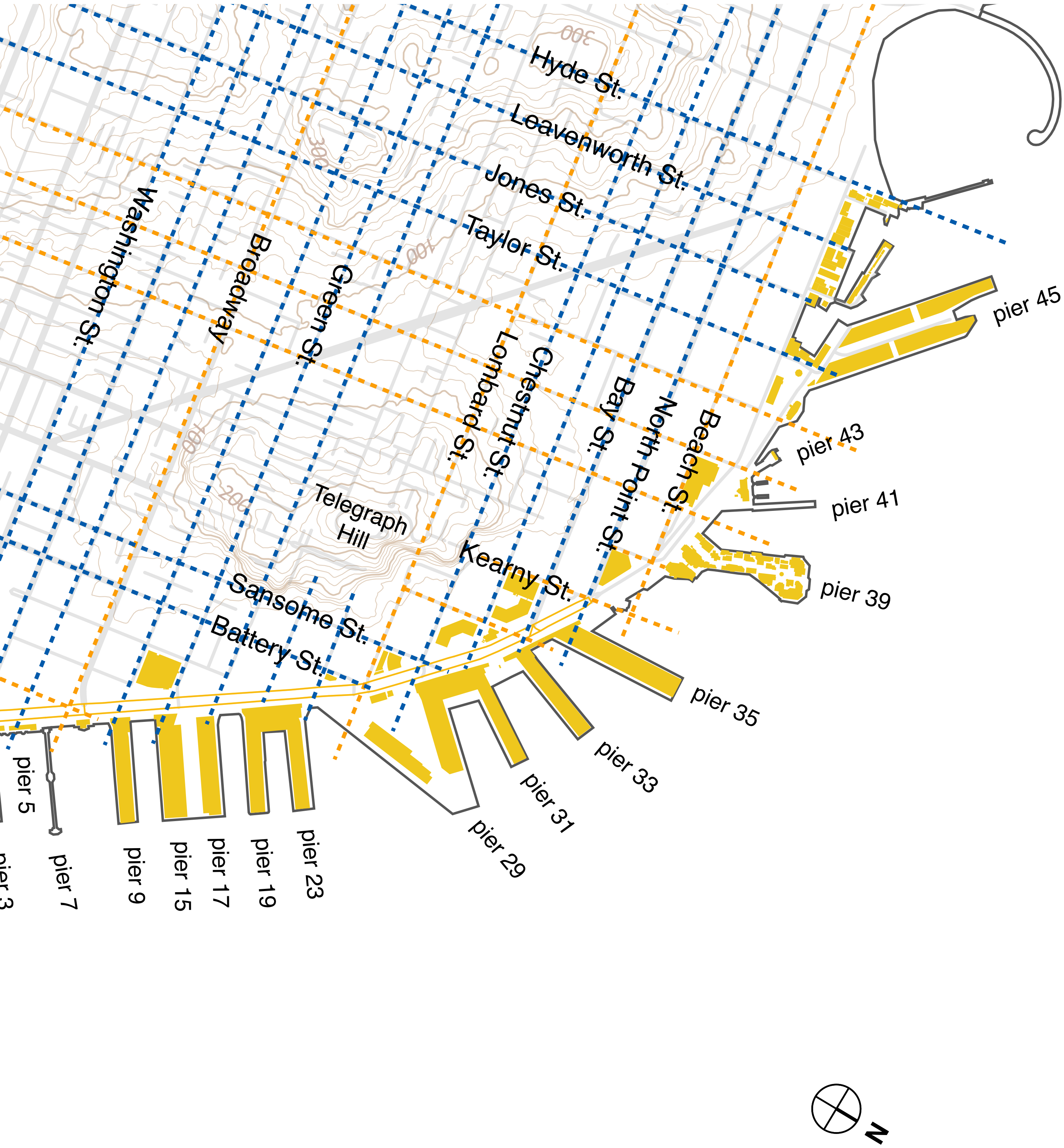
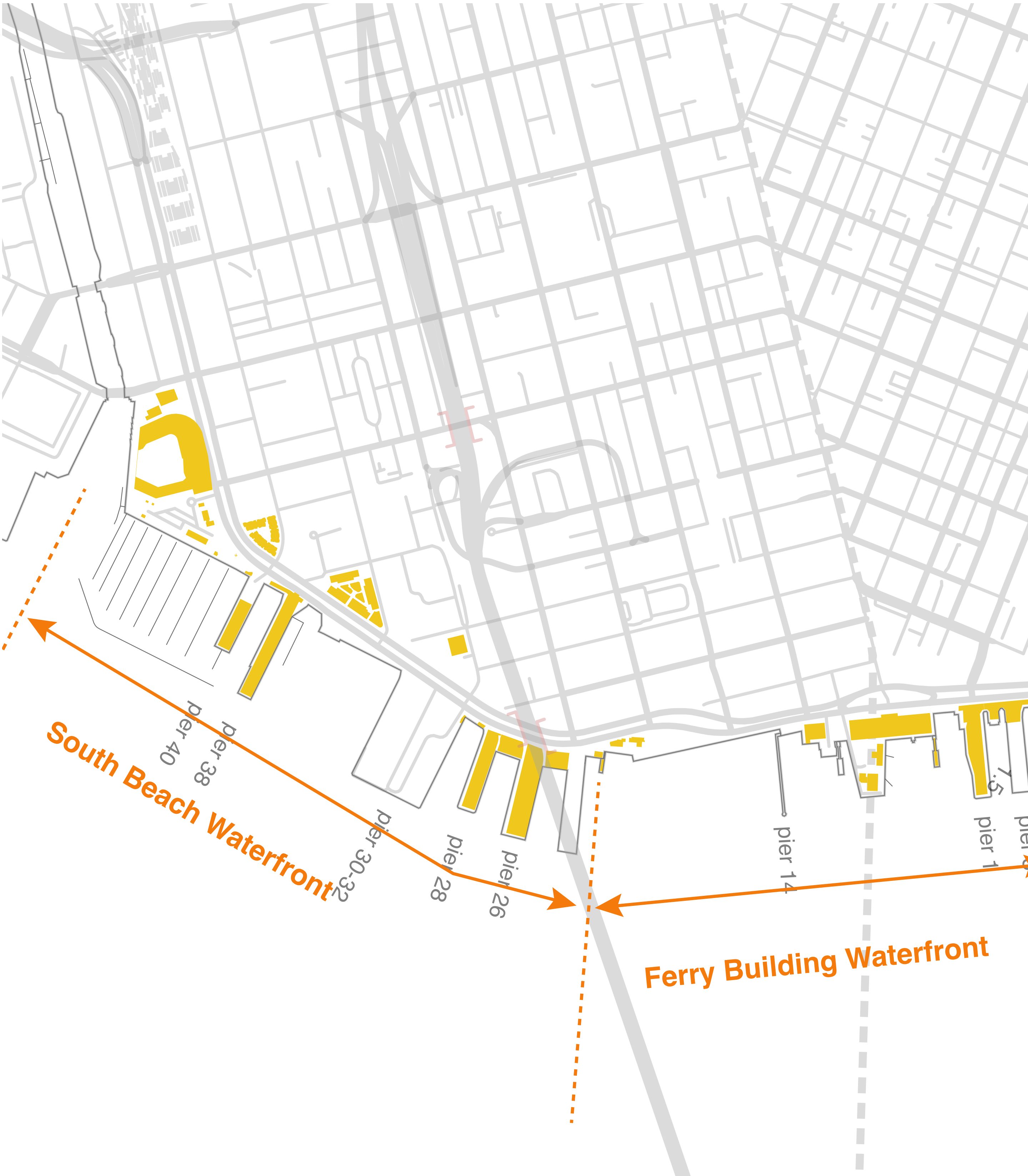


Fig.50: Embarcadero's Current View Corridors. Drawed by Author.

3.7 Current Character Zone

Embarcadero is diverse. To provide specific direction for the different facets of the Port, the Waterfront Plan establishes four geographic subareas, each with a tailored set of subarea objectives that reflect adjacent neighborhoods and districts, balanced with broader City and regional needs.



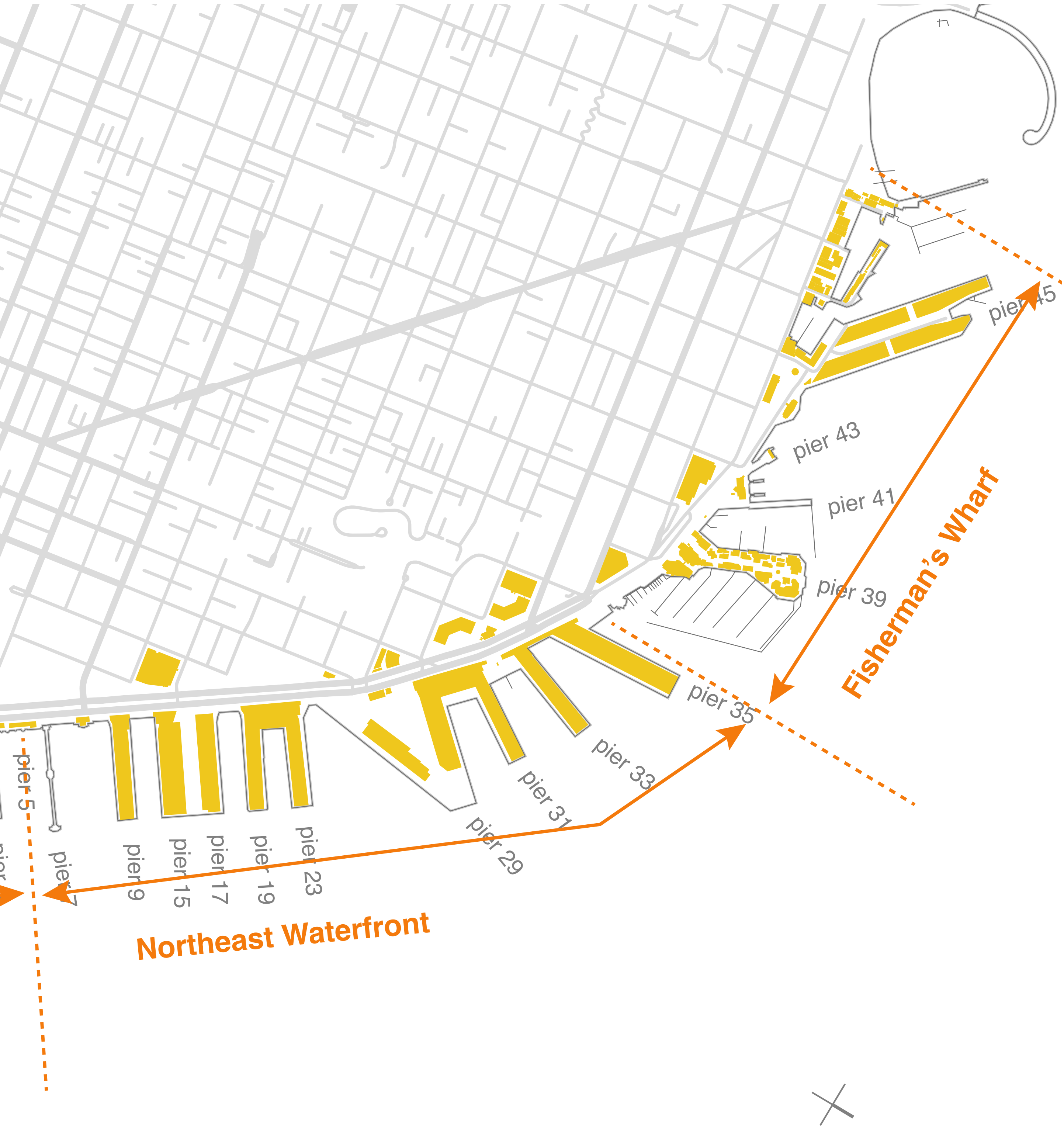


Fig.51: Embarcadero's Current Character Zone. Drawed by Author.

3. MICRO-SCALE: EMBARCADERO

3.7.1 Fisherman's Wharf

The Fisherman's Wharf Waterfront subarea extends from the swimming club docks at the east end of Aquatic Park to the east side of Pier 39. In the past 17 years, the Port has reinstated Fisherman's Wharf as a major fishing industry center on the west coast, based at Pier 45 and the Hyde Street Fishing Harbor. The objectives for this area place priority on the restoration and expansion of the fishing industry, including commercial and sport fishing, and fish handling and distribution. It is also necessary to attract new revenue-generating activities to help subsidize the fishing industry, which has suffered economic decline in recent years.

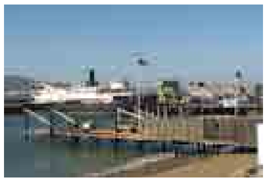
Fig.52: Fisherman's Wharf. Drawed by Author. Image credit Google.

Pier 39 Concourse

Pier 43 Ferry Arch

Wild Wave Sportfishing

Fisherman's Wharf



Hyde Street Fishing Harbor

3.7.2 Northeast Waterfront

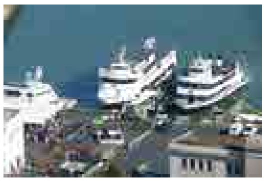
The historic sheds and bulkhead buildings located between Pier 35 to Pier 9 are the richest segment of the Embarcadero Historic District. Port's efforts are now focused on ways to provide public-friendly uses in some of these valuable structures. For example, Pier 29 once was vacated by the America's Cup festivities. The goal is to maximize opportunities for retaining maritime operations in this area. Another important objective is to activate this area with an array of day and nighttime uses which will appeal to San Franciscans and visitors alike. The key point is to enjoy the valuable culture and enhance visual and physical access into the bay.

Fig.53: Northeast Waterfront.
Drawed by Author. Image credit Google.

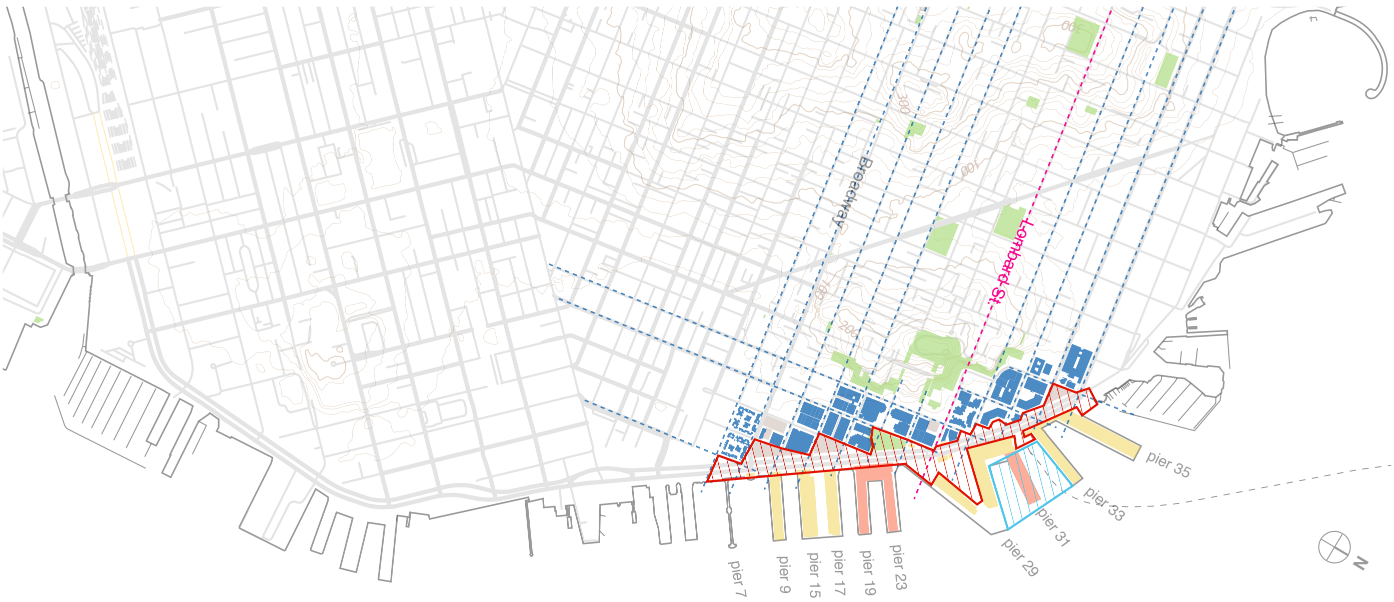

Pier 7 A long, skinny pier


The Exploratorium


Cruise Ship Terminal


Alcatraz Landing

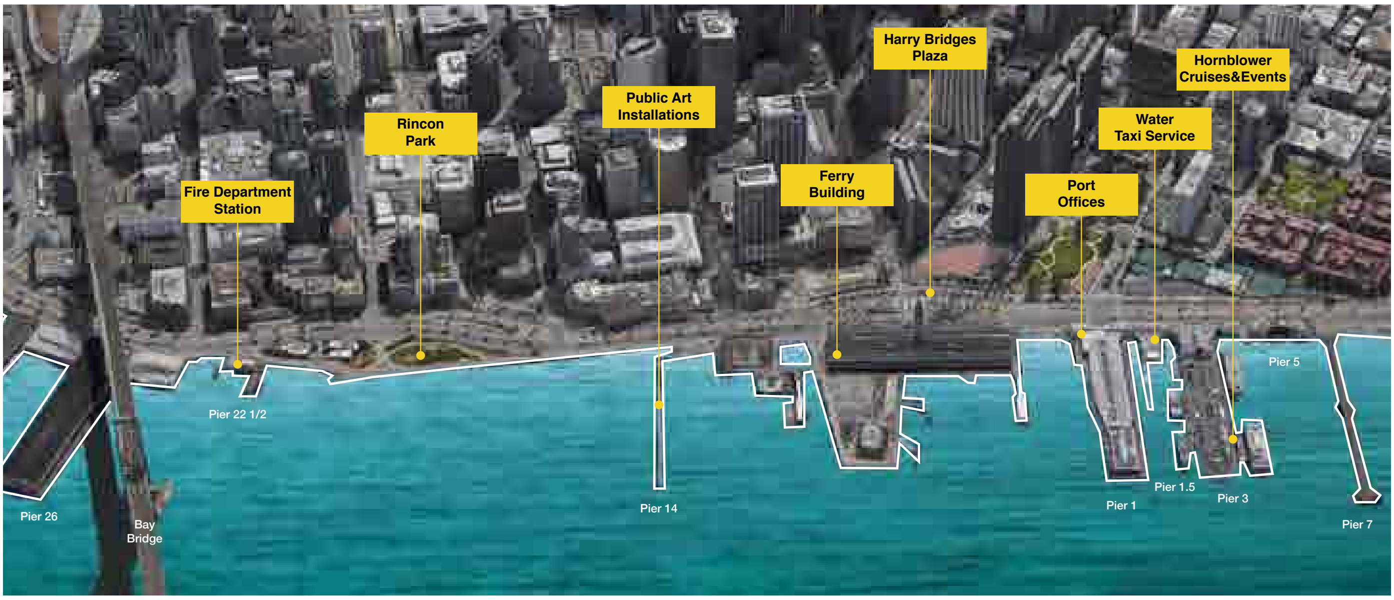

Pier 35 Bulkhead Building



3.7.3 Ferry Building Waterfront

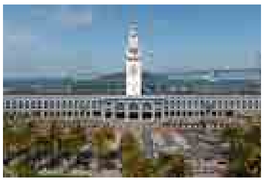
This area is a key transition zone in San Francisco. The Ferry Building has become San Francisco's new living room, where San Franciscans, commuters and visitors from around the world are all welcome. These projects, together with the expansion of ferry landings at the Downtown Ferry Terminal and the creation of Pier 14 public access pier and Rincon Park, have created a homecoming of sorts. A central objective for this area is the preservation and restoration of historic structures, which promote waterborne commute and recreational travel and enjoyment, and the restoration of the area as a major intermodal transit center for the City.

Fig.54: Ferry Building Waterfront.
Drawed by Author. Image credit Google.



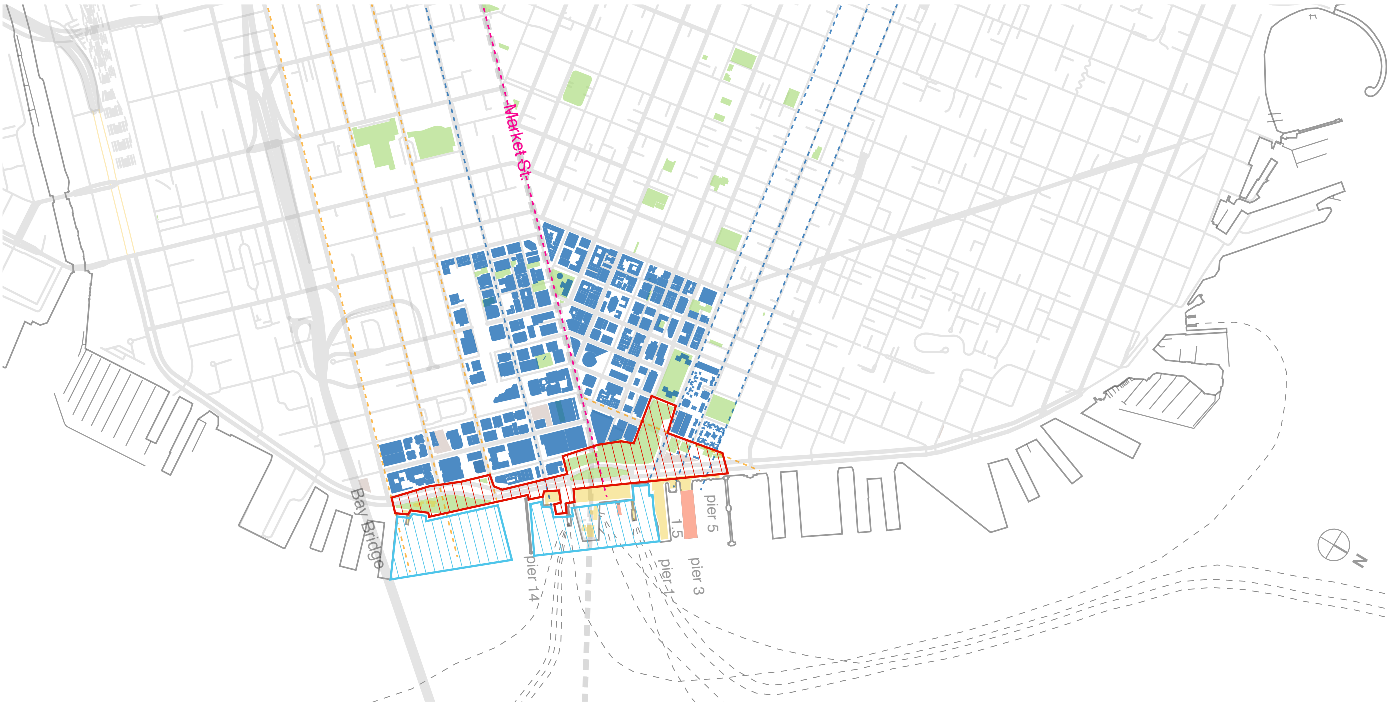

Rincon Park


Public Art Installation


Ferry Building


Harry Bridges Plaza

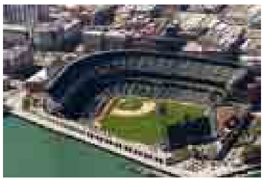

Pier 1 Bulkhead Building

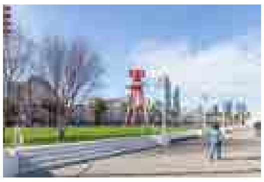


3.7.4 South Beach Waterfront

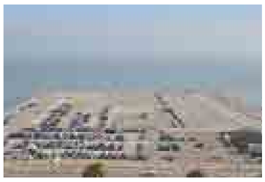
Although many of the piers in this area are in deteriorated condition and cannot support the array of industrial maritime activities that once dominated the area, there are still some scattered industrial maritime-related businesses that should be continued and consolidated in an efficient manner. The maritime-orientation of this area is now characterized by recreational boating and water use facilities at South Beach Harbor. New developments will offer opportunities to expand such commercial and recreational maritime activities, and mix them with other public-oriented activities such as nighttime entertainment, commercial recreation, family amusements, and residential uses.

Fig.55: South Beach Waterfront.
Drawed by Author. Image credit Google.


AT&T Park


South Beach Park

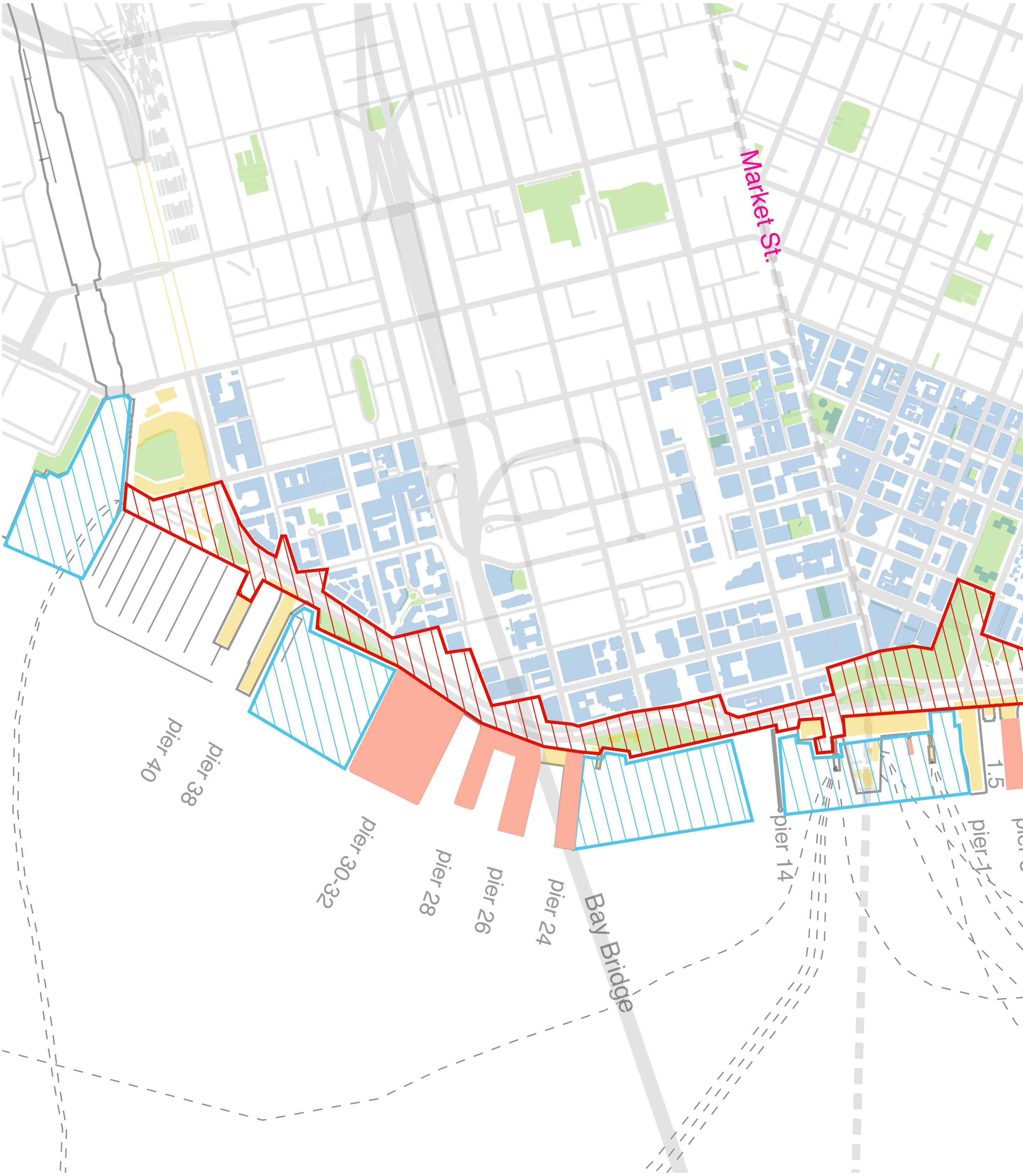

South Beach Harbor


Pier 30 Parking


Pier 28 Bulkhead Building

3.8 Spatial Framework

The waterfront is divided into four subareas and area-wide objectives are described to land uses within a subarea. Acceptable uses are defined by individual site location, and site-specific development standards are provided to further guide improvements to existing facilities and the development of new maritime, open space, and commercial or other uses. Combined with all four sub areas, this strategic map depicts the concept



is to formulate a network of parks, plazas, walkways and open spaces, integrated with transportation improvements to enhance public access and enjoyment. The construction of this Pedestrian Friendly Promenade with a tailored set of subarea programs will reflect adjacent neighborhoods and bay area, balanced with broader City and regional needs. Along this network, there are a diverse array of maritime, commercial, entertainment, civic, open space and recreation activities for San Franciscans and visitors. This means that it aims to respect waterfront's historic character, while also create new opportunities.

Fig.56: Embarcadero's Potential Land Use. Drawed by Author.

PART III DESIGN PROPOSAL 069

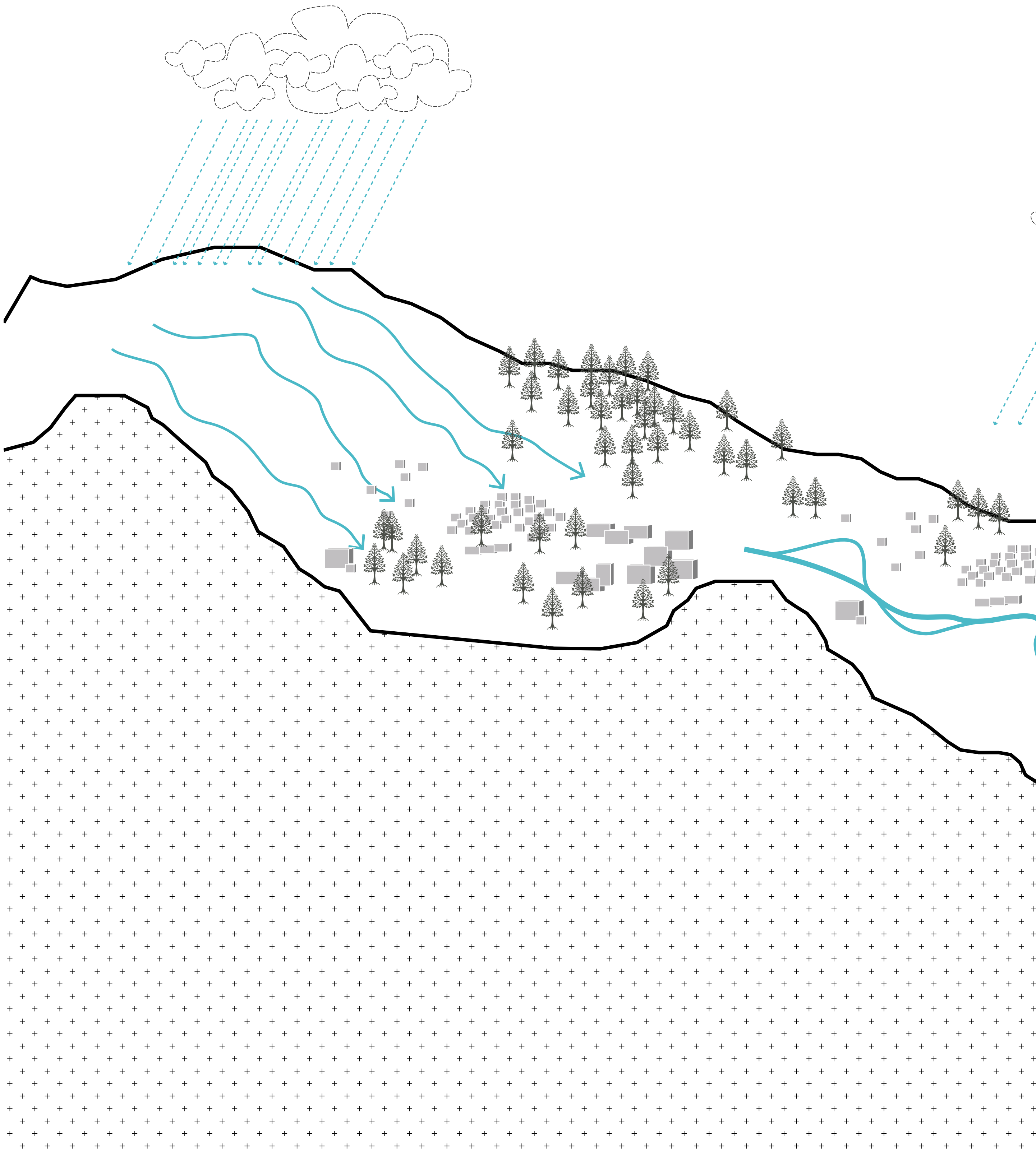
Fig.57: San Francisco Bay's encroaching waters. Rising Reality, http://projects.sfchronicle.com/2016/sea-level-rise/part1/

1. DESIGN PRINCIPLES

1.1 Vulnerability

As part of what creates the image of a city, urban designers also note the importance of a waterfront's location at an edge, in Kevin Lynchian term. An edge at once joins and separates two different areas of activity, two different aspects of the physical landscape, in this case, land and water.

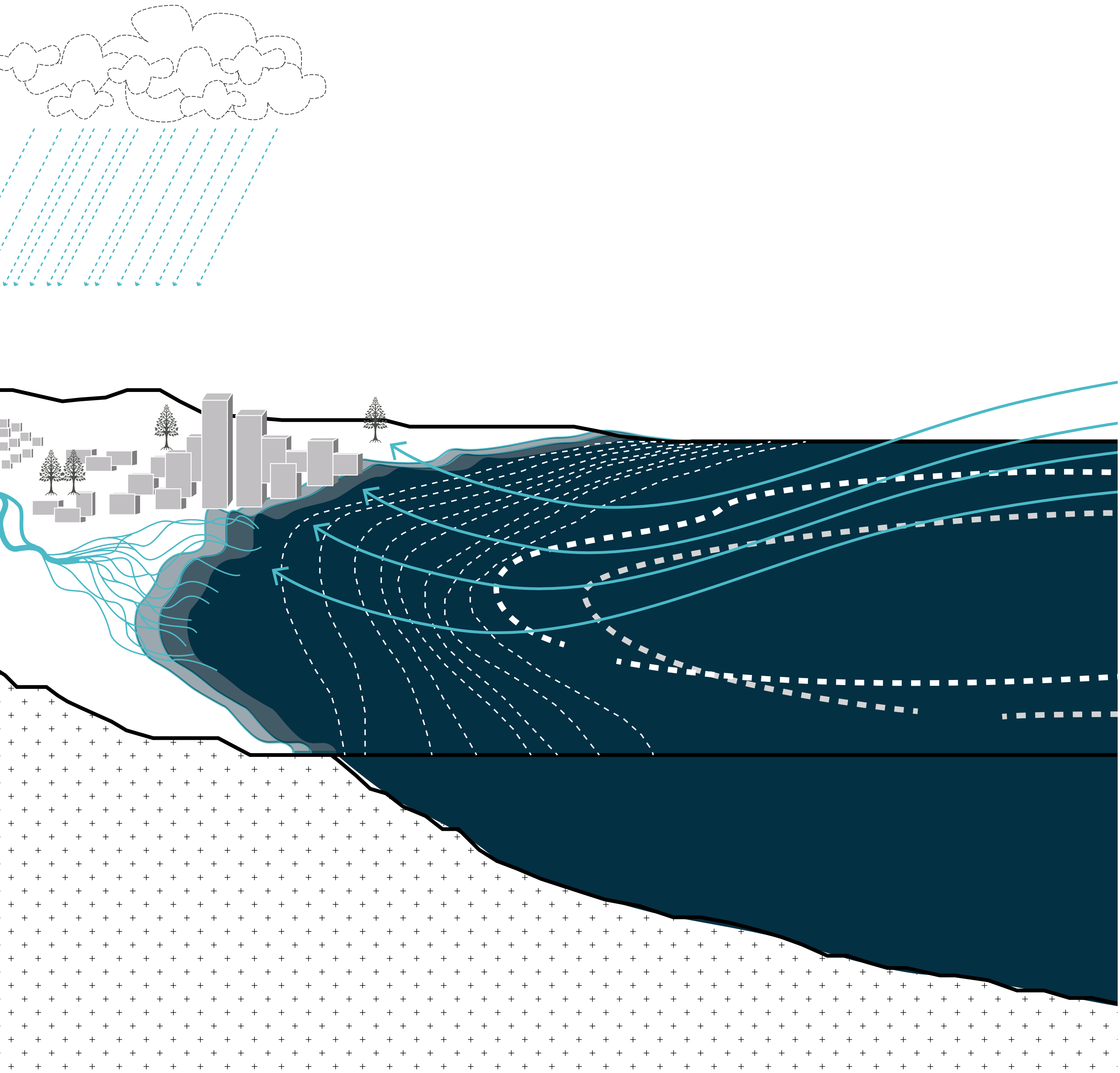
Upland areas perceive precipitation only within its area, while low-lying areas expect



precipitation within its scope, plus the excess more which have not been absorbed upstream.

Only the waterfront area is exposed to precipitation and river floods, and has to cope with the excess water from upland streams. The Embarcadero, in-between the land and the water, is the most vulnerable area during flooding. It is exposed to precipitation, present day flooding from the Bay, urban stormwater runoff and future sea level rise.

Fig.58: Geographic Scheme in Embarcadero. Drawed by Author.

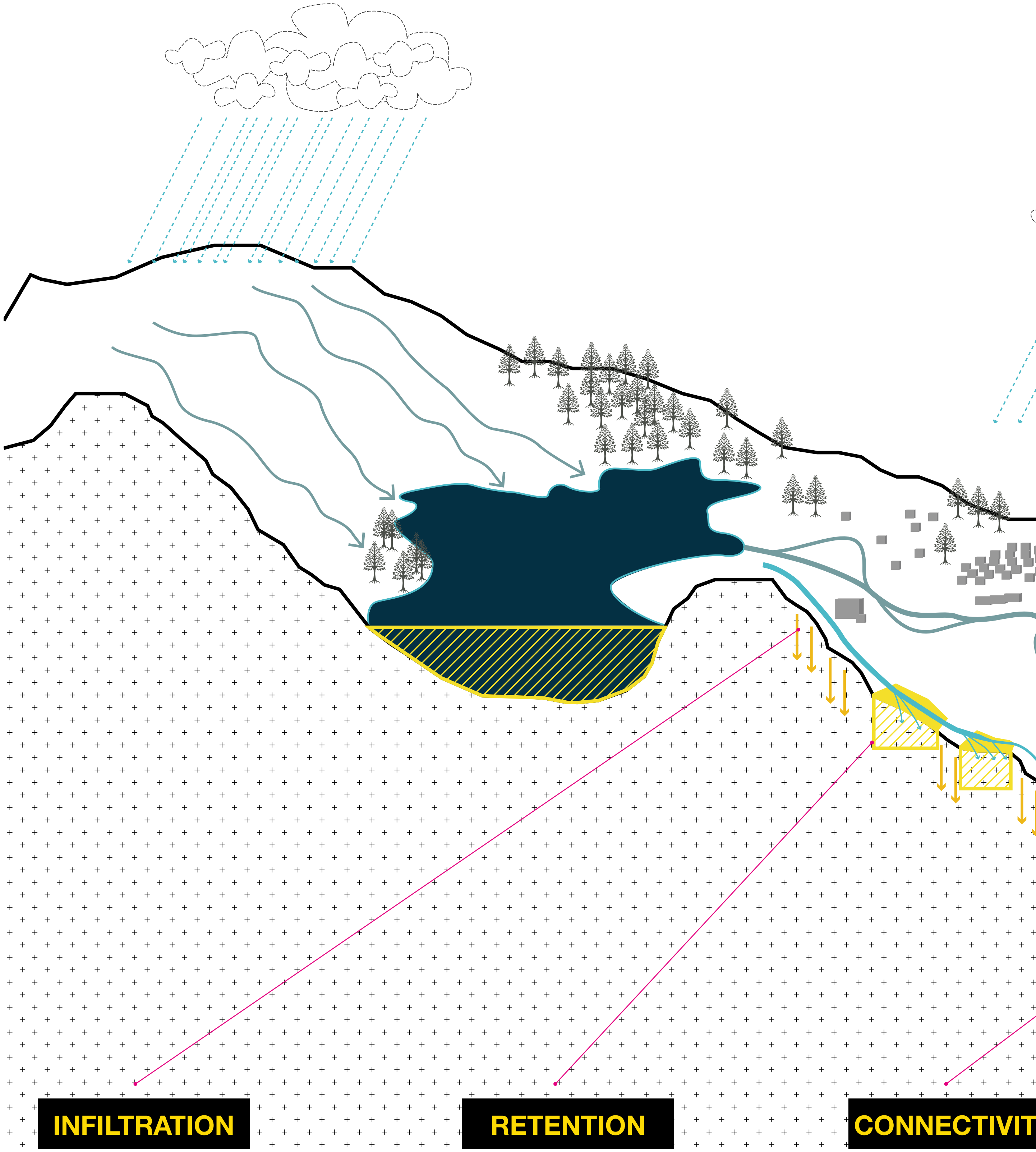


1. DESIGN PRINCIPLES

1.2 Strategy

While it is impossible to ever fully eliminate risks from flooding, there are many strategies available to manage and reduce those risks.

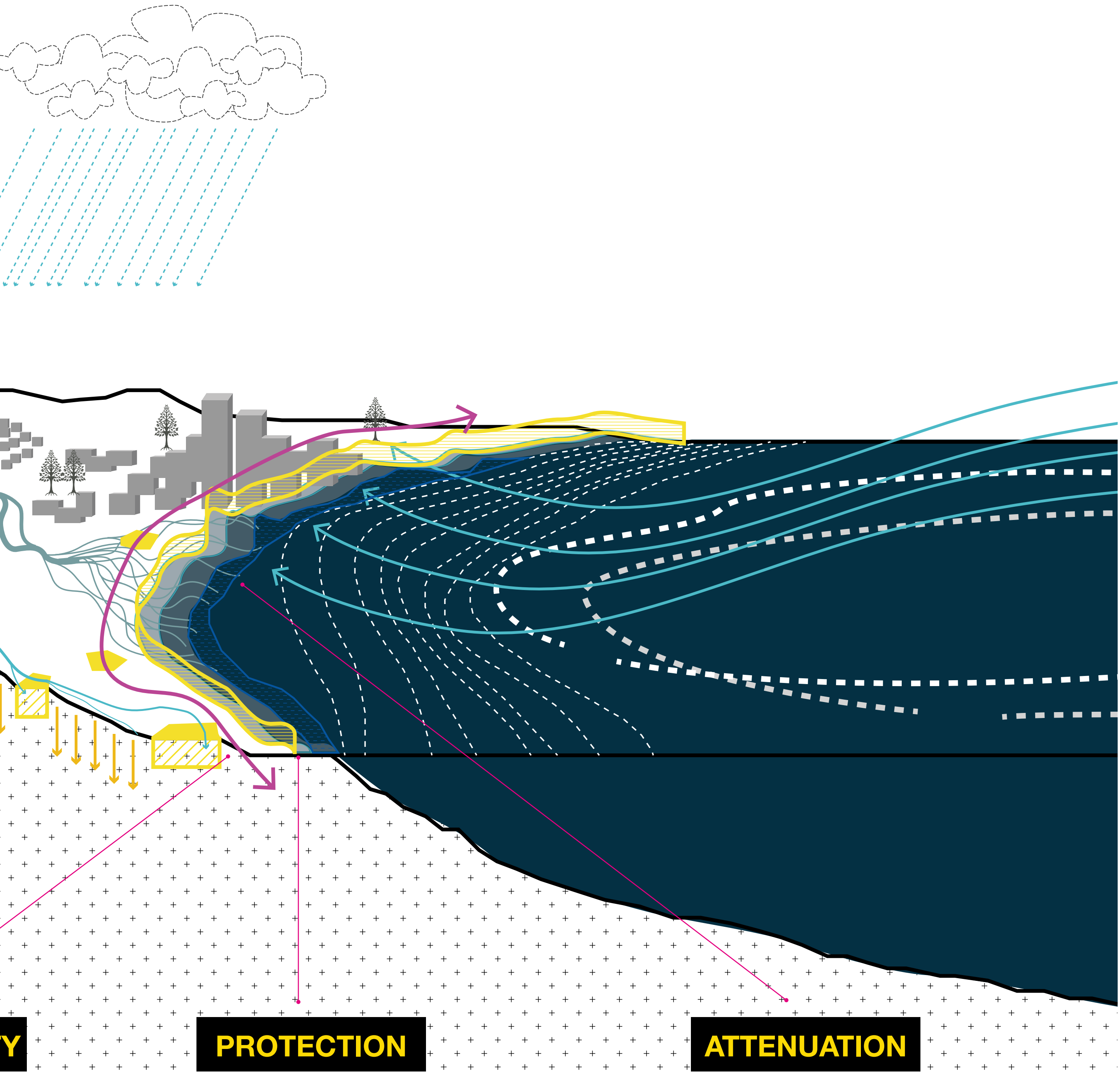
Daily flooding from the Bay together with the city runoff from upland area and precipitation in rainy days, threaten the Embarcadero area. In this case, I establish five design principles based on different geographic conditions, to not only moderate the force



of storm surge, but also to ameliorate the impact of upland rainwater runoff.

As a result, the collaborative solutions, through enhancing the adaptive ability of the spaces on the upland areas and offshore areas will reduce pressure on the urban waterfront area. This approach will allow different combinations of proposals for various geographic conditions, and provide a more flexible, economical, efficient and environmentally sustainable design.

Fig.59: Strategies to reduce flooding risks. Drawed by Author.



1. DESIGN PRINCIPLES

1.3 Case Study

Through case studies and existing body knowledge, there are numerous potential strategies to manage and adapt to flooding risks.

INFILTRATION

Treat as much stormwater as possible on site and reduce stormwater flowing into sewer system.

BIOSWALES / CONSTRUCTED WETLANDS / RAIN GARDENS / PERMEABLE PAVEMENT

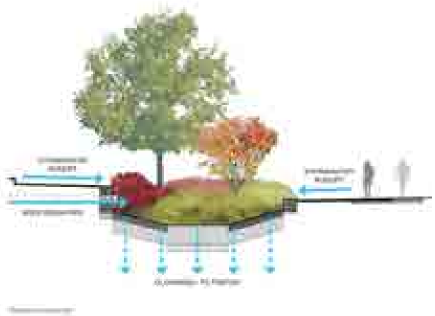


Fig.60: http://www.lwa-architects.com/sustainable-design/

Soft canyon can partly infiltrate the rainwater, but it moves surplus water towards downstream areas. It is called soft canyon because it is not limited by street form but consists of spaces inside the blocks and streets network. This method allows to create bigger and more integrated spatial system, reacting on water volumes in the same way and at the same time performing in accordance with its urban surroundings.

RETENTION

Public space is an important resource to be actively considered for the utilisation as stormwater retention area.

CONSTRUCTED WETLANDS/ POROUS PAVEMENT / PLAZA / PARKS

Fig.61: Copenhagen Strategic Flood Masterplan, http://www.landezine.com/

Retention areas serve as a storage zone for the rainwater running from the surrounding streets or the city runoff from upstream area. It is used mainly during heavy rains and cooling the overall area in dry periods. Designed as network of public space, this storage system has also public function and can contribute to overall quality of urban environment, apart from its main function of water storage.

CONNE

An integrated netw
space and transpo
acting with adjace
grams.

PEDESTRAIN-FI
ENADRDE

Fig.62: http://www.arch
a-walk-on-the-high-line-v

Retention areas
age zone for the
from the surround
city runoff from u
used mainly durin
cooling the overal
ods. Designed as
space, this storag
public function an
overall quality of u
apart from its mair
storage.

CTIVITY

vork of active open
rtation lines, inter-
ent roads and pro-

RIENDLY PROM-

daily.com/550810/take-
with-iwan-baan

serve as a stor-
rainwater running
ling streets or the
pstream area. It is
g heavy rains and
l area in dry peri-
network of public
e system has also
d can contribute to
rban environment,
n function of water

PROTECTION

A system of multi-purpose flood protection structures, consist of infrastructural and recreational componemts.

INFRASTRUCTURAL&RECREATIONAL COMPONENTS

Fig.63: New BIG-Designed Neighborhood, http://www.archdaily.com

Historically most infrastructure, has been built for one purpose only—to hold back floodwaters. In densely built urban areas, multi-purpose flood protection can provide additional value by integrating flood protection with other urban functions, like transport, waste water management, housing, recreation, nature and tourism. Multi-purpose flood protection infrastructure can improve the urban ecosystem and enhance living conditions for local communities.

ATTENUATION

A natural edge, composed of wetlands and marsh, is an ecological habitat, buffer, and indispensable resource.

WETLANDS / SALT WATER MARSH

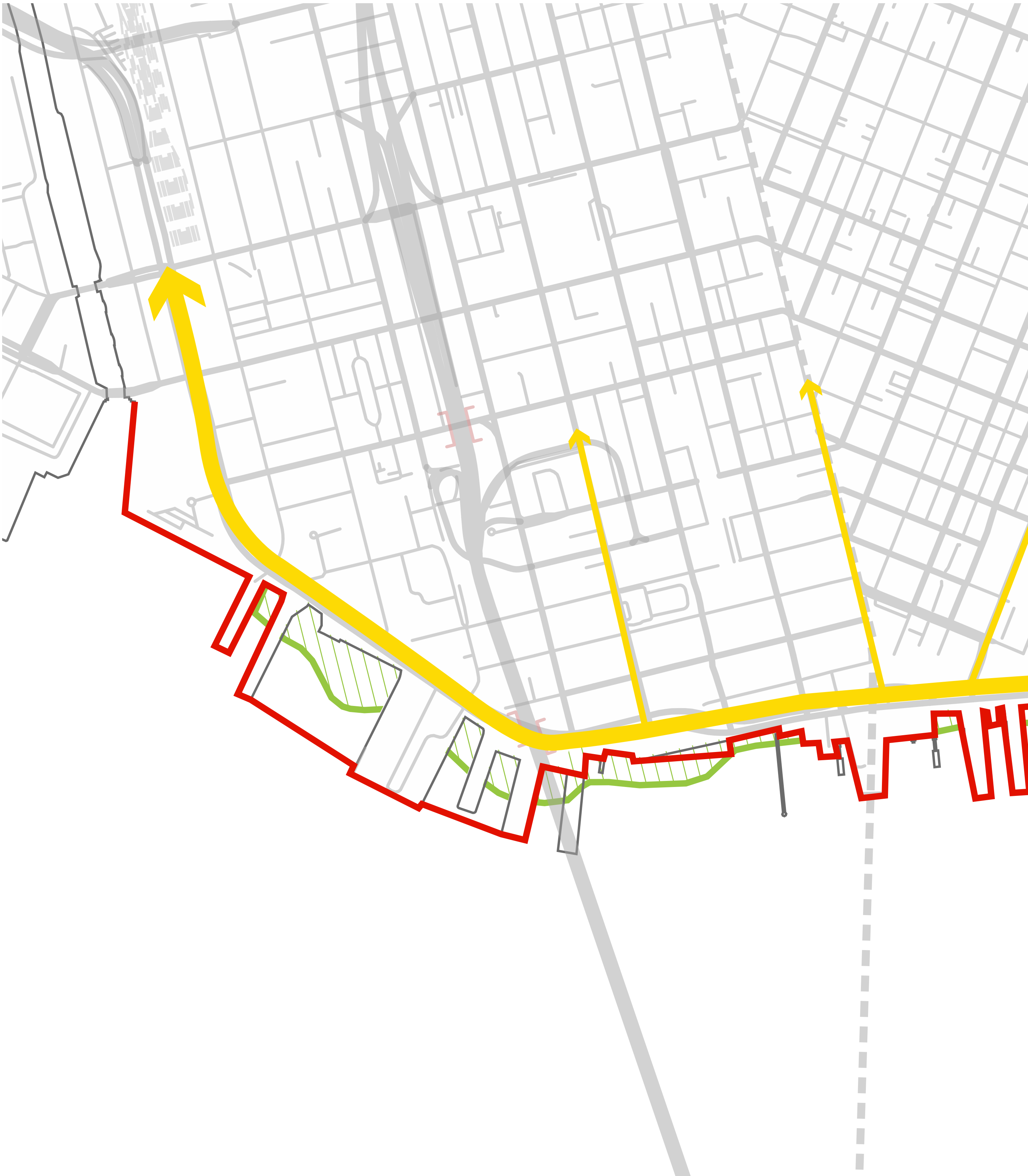
Fig.64: http://www.archdaily.com/53736/rising-currents-at-moma

Historically most infrastructure, has been built for one purpose only—to hold back floodwaters. In densely built urban areas, multi-purpose flood protection can provide additional value by integrating flood protection with other urban functions, like transport, waste water management, housing, recreation, nature and tourism. Multi-purpose flood protection infrastructure can improve the urban ecosystem and enhance living conditions for local communities.

2. DESIGN CONCEPT

2.1 Multiplied Ground

The design concept is to transform the traditionally productive grounds (maritime industry) into an integrated network of attractive open spaces by multiplying three infrastructural and programmatic layers - a layer of the floating wetlands in the offshore area to attenuate wave force; a layer of multi-functional flood protection structure along the edge to resist storm surge; and a network of open space, integrated with transportation



improvements, to enhance public access and enjoyment. This approach responds to the idea of developing a linear project in a city that goes beyond a single function, and that attempts to combine a series of linked actions that endow the city with a cosmopolitan nature. It also envisions a new legacy of publicly-supported infrastructure and projects, which explore the value of infrastructure not only as an engineering endeavor but as a robust design opportunity to strengthen communities and revitalize cities.

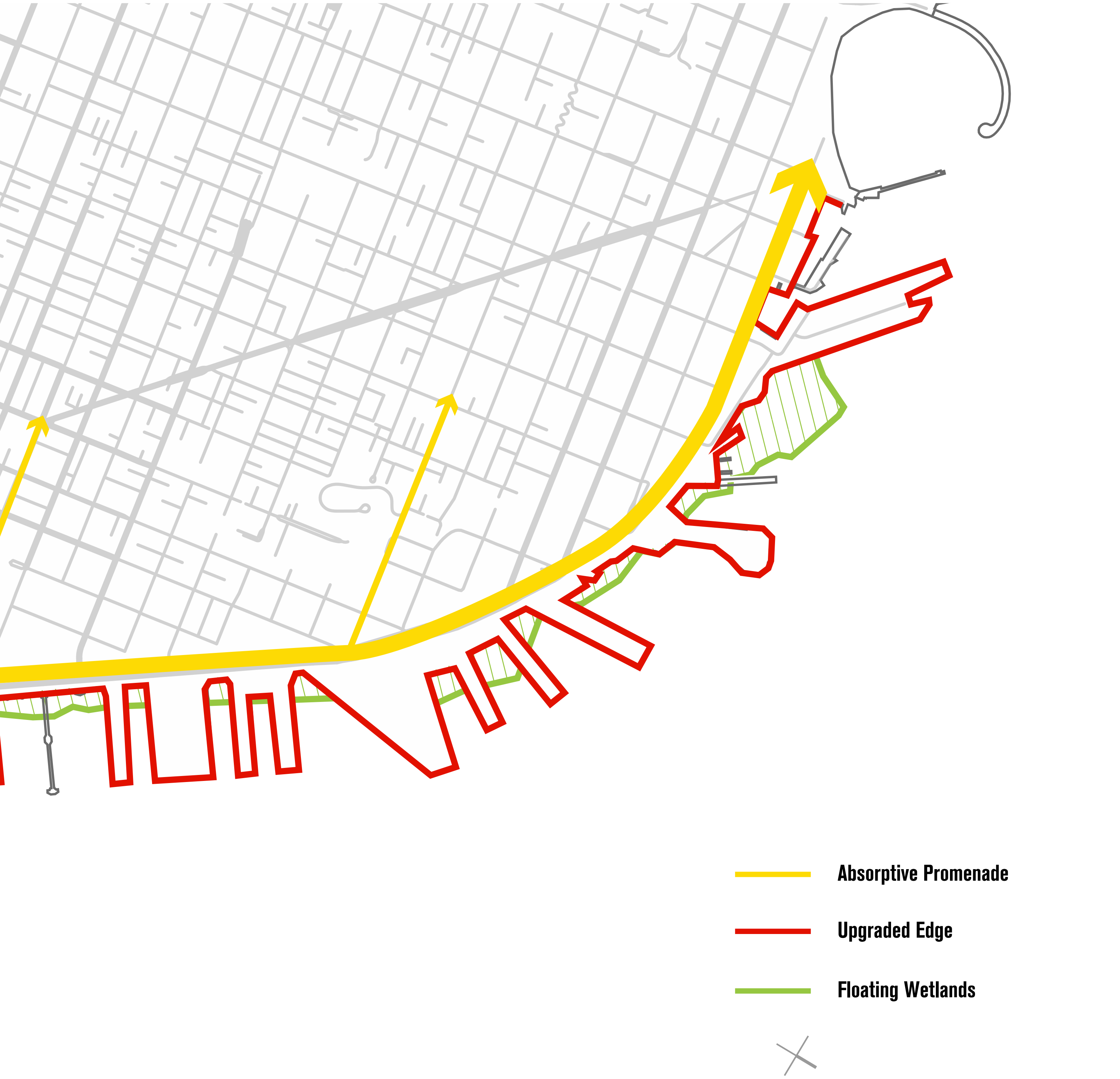


Fig.65: Design Concept. Drawed by Author.

2.2 Floating Wetlands

Because of the mono-gradient water bed in Embarcadero, there are less natural habitats for flora and fauna. However, the water is quite shallow in some part of the Embarcadero, and the finger piers can somehow catch the sediment when the water moves. So these shallow areas has potential to develop ecological habitats, which can improve the local environment.

There are three basic elements needed for any variety of pre-made or custom system: a base, anchor, and the plant material. The base should be made of a material that is proven to be non-toxic to sea life and able to withstand being submerged in salt water for the life of the project. It must, of course, also be buoyant.

Depending on the intensity of wave action for a given site, the anchor type may vary. A helical (screw-like) anchor works well for higher wave areas. Stainless steel cords and attachment hardware are recommended for salt water.

A floating wetland can either be anchored to the floor of the water body or tethered to an existing stationary object such as a pier, pile, or on-shore object. Enough slack must be provided in the attachment to allow for tidal variation. The use of salt marsh plants allows for occasional inundation of islands without damage to the plants.

Fig.66: Floating Wetlands. Drawed by Author.

PART III DESIGN PROPOSAL

2. DESIGN CONCEPT

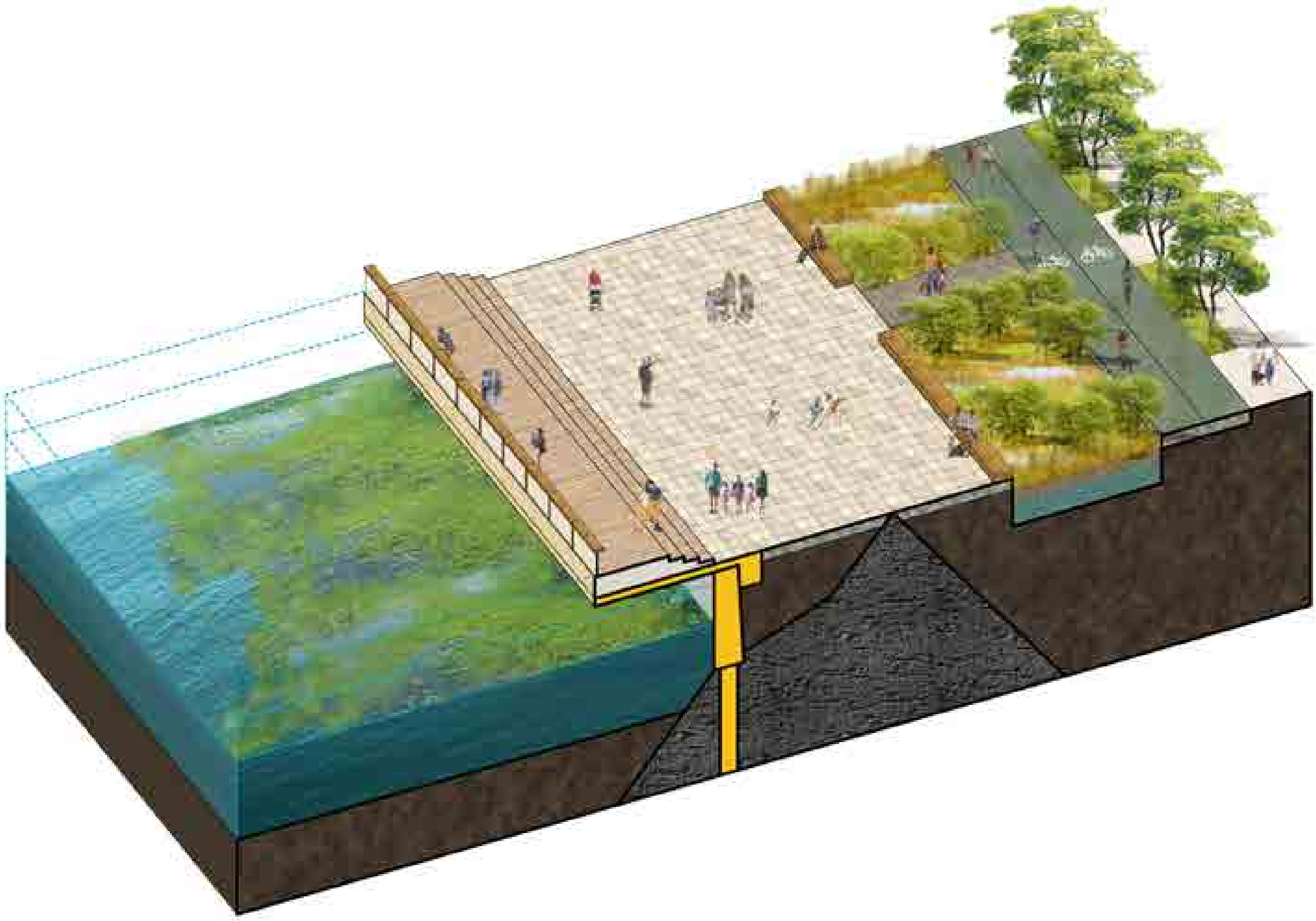
2.3 Upgraded Edge

According to the existing vertical data and the projection of sea-level-rise by 2100, a 0.8-meter-height flood protection structure is required along the edge. So I proposed six topologies of multi-purpose flood protection structures in site to balance the safety and livability.

2.3.1 Elevated Platform

The elevated platform together with the constructed wetlands, not only creates new possibilities for recreational activities, but also resist flooding by bay.

Fig.67: Elevated Platform. Drawed by Author.



2.3.2 Broadways

Broadways help to extend urban life into bay area. Piles can attenuate wave action and lead to a sustainable ecological environment.

Fig.68: Broadways. Drawed by Author.

2. DESIGN CONCEPT

2.3 Upgraded Edge

According to the existing vertical data and the projection of sea-level-rise by 2100, a 0.8-meter-height flood protection structure is required along the edge. So I proposed six topologies of multi-purpose flood protection structures in site to balance the safety and livability.

2.3.3 Extended Pier

Extended piers make it possible for people to get close to the bay and enjoy its splendid view. By introducing commercials, some underutilized piers can further stimulate tourism.

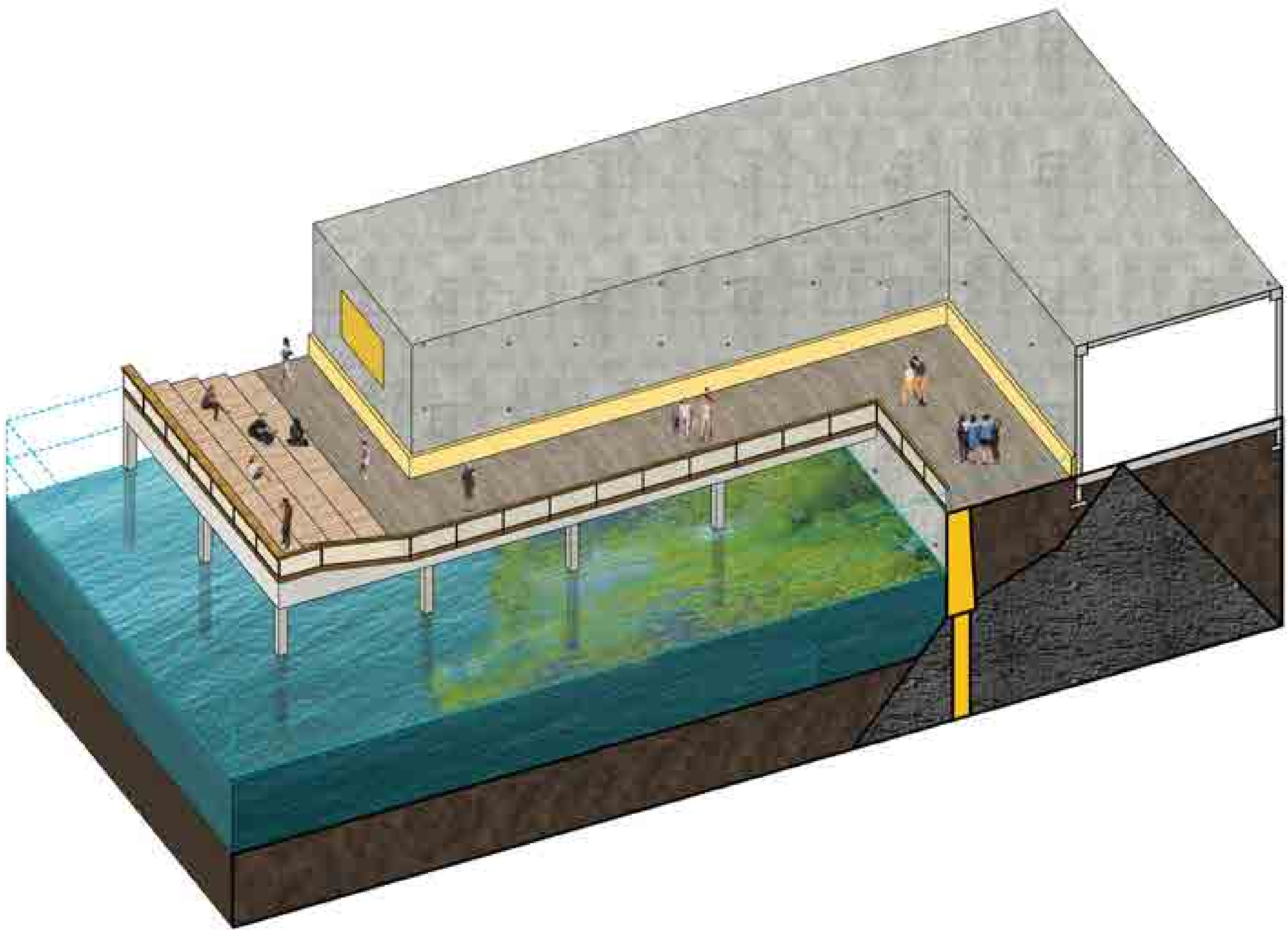
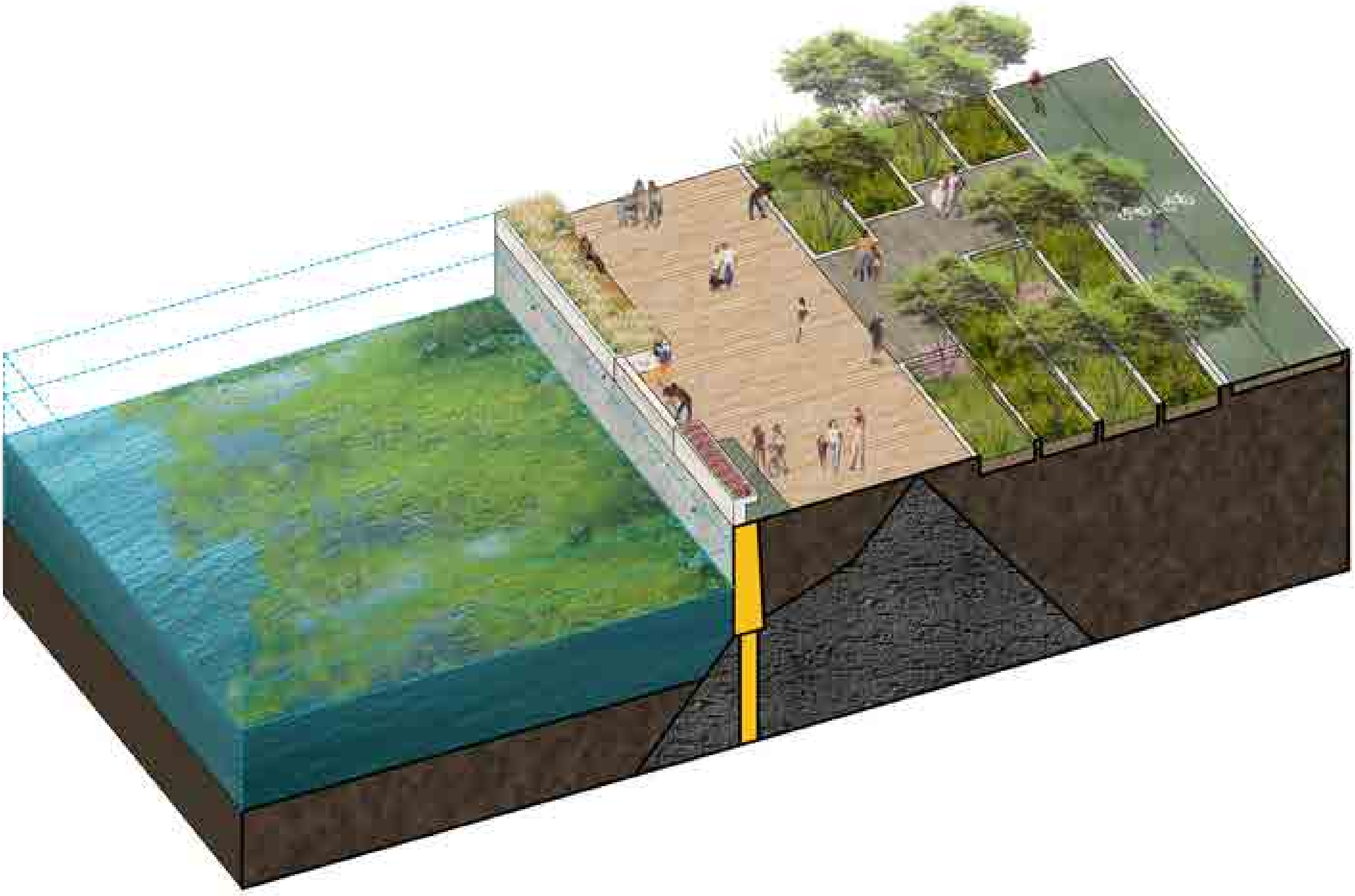


Fig.69: Extended Pier. Drawed by Author.

2.3.4 Self-rising Wall

Self-rising wall is invisible in the normal condition. It will be lift automatically when there is a storm surge or other extreme events.

Fig.70: Self-rising Wall. Drawed by Author.



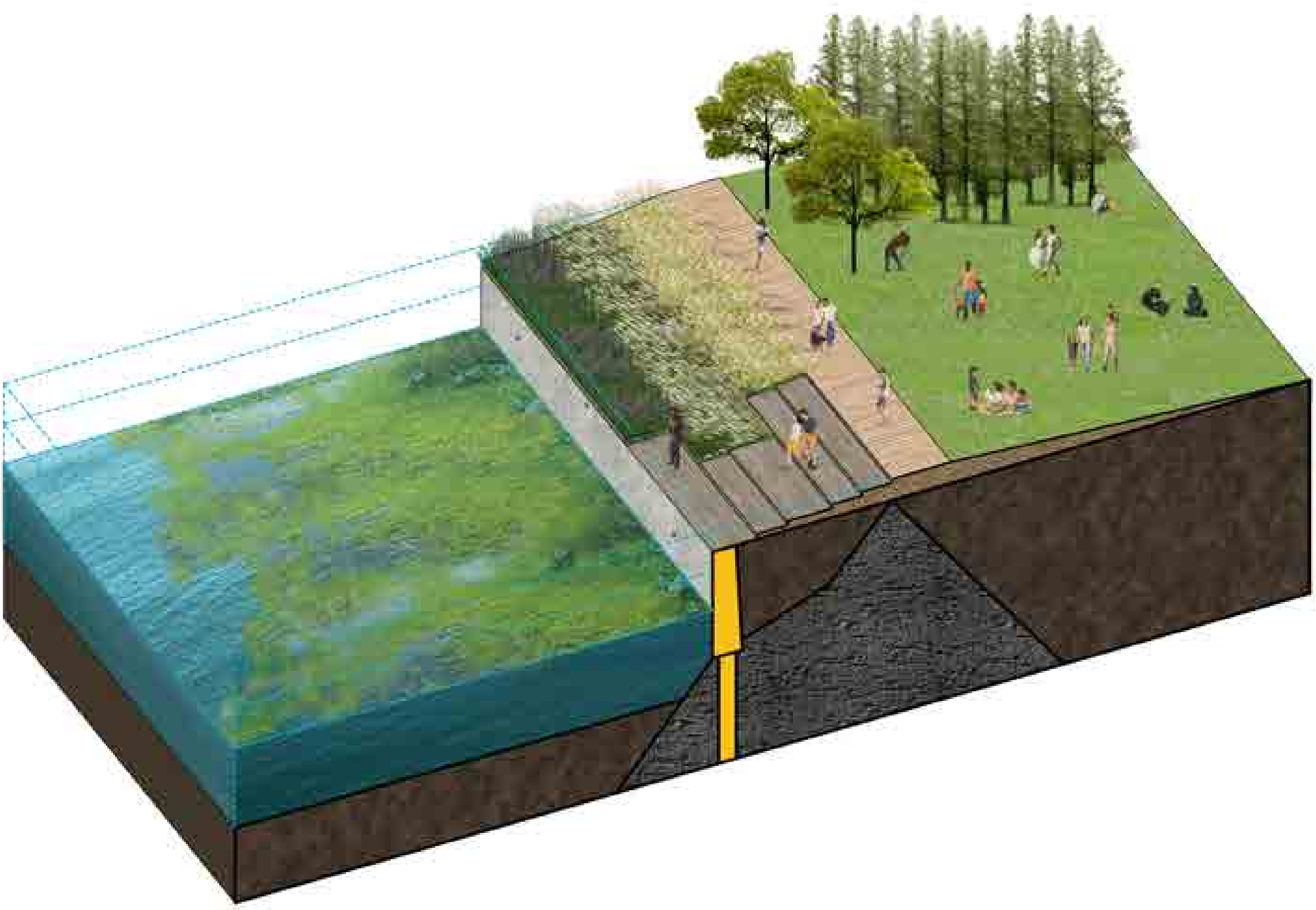
2.3 Upgraded Edge

According to the existing vertical data and the projection of sea-level-rise by 2100, a 0.8-meter-height flood protection structure is required along the edge. So I proposed six topologies of multi-purpose flood protection structures in site to balance the safety and livability.

2.3.5 Planted Slope

Planted slope can be applied in the natural areas, in where the slope can create new topographies. Thus it can provide recreational opportunities, ecological benefits and flood protection as well.

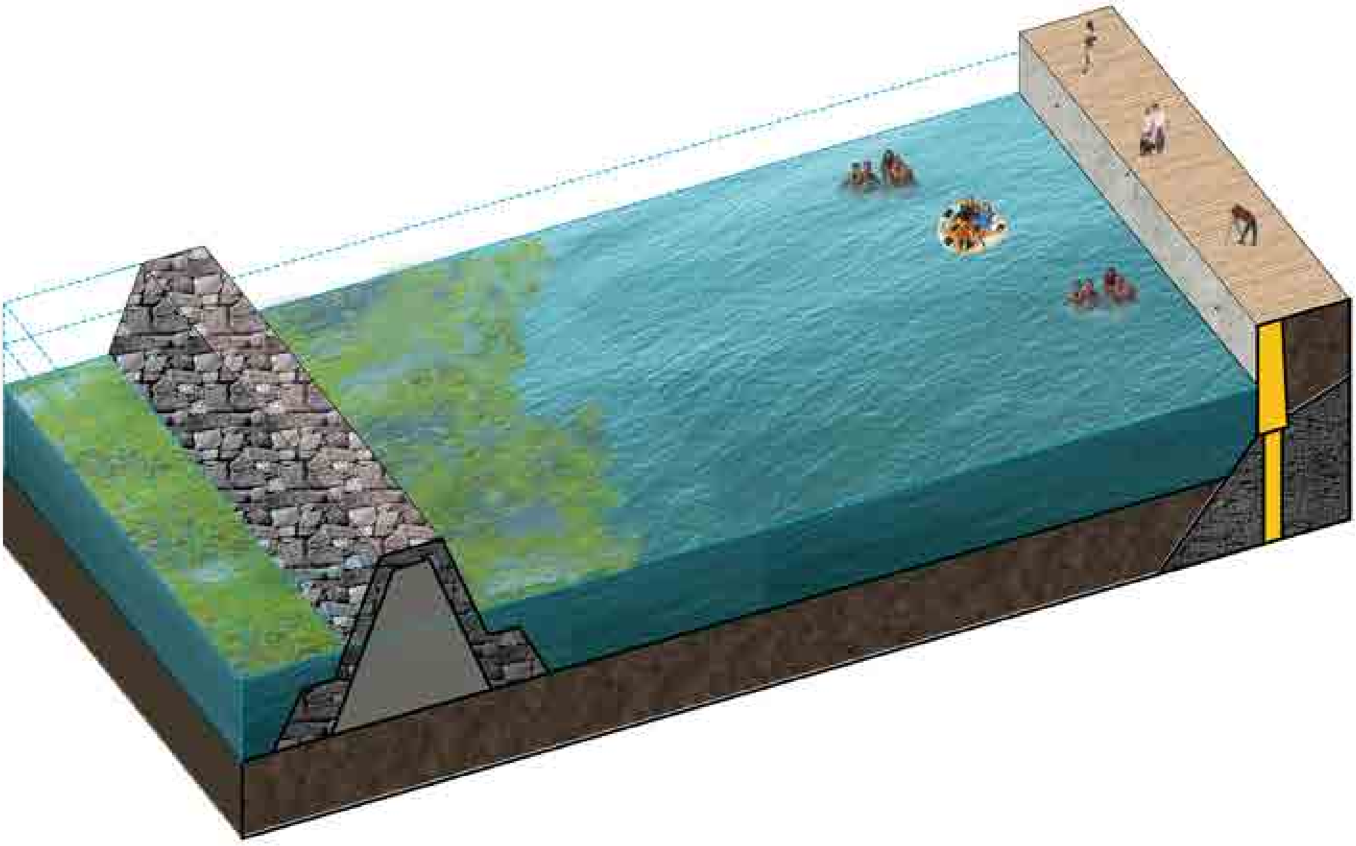
Fig.71: Planted Slope. Drawed by Author.



2.3.6 Outlying Seawall

A new seawall, parallel to the existing shoreline, is built outboard of the piers that prevents high water from inundating Embarcadero. Also it can be used for new recreation and habitat development.

Fig.72: Outlying Seawall. Drawed by Author.



2. DESIGN CONCEPT

2.4 Absorptive Promenade

The idea is to transform the car dominated roads into a pedestrian-friendly promenade, which explore the value of infrastructure not only as an engineering endeavor but as a robust design opportunity to strengthen communities and revitalize cities.

The use of permeable pavement, constructed wetlands, bioswales and rain gardens in the new promenade help for the conveyance and treatment of residual aquaculture waters, stormwater, and grey water.

This absorptive promenade ringing the waterfront can organize not only the edge but also the urban relationships inland and across the water. The construction of it with a tailored set of subarea programs will reflect adjacent neighborhoods and bay area, balanced with broader City and regional needs.

Along this network, there will be a diverse array of maritime, commercial, entertainment, civic, open space and recreation activities for San Franciscans and visitors. The promenade aims to respect the waterfront's historic character, while also create new opportunities.

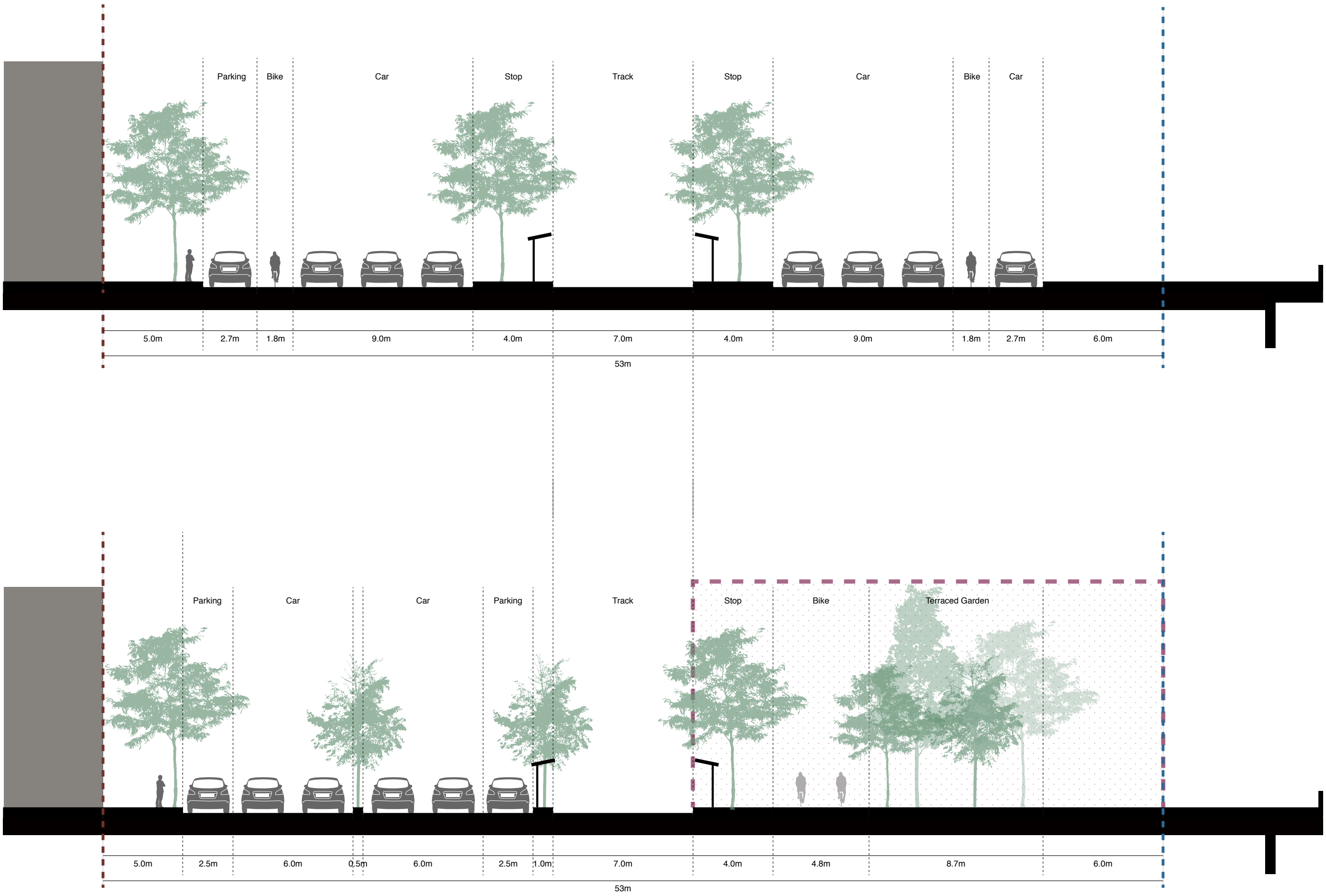


Fig.73: Transformation into an absorptive promenade. Drawed by Author.

Fig.74: Section of adjacent road. Drawed by Author.

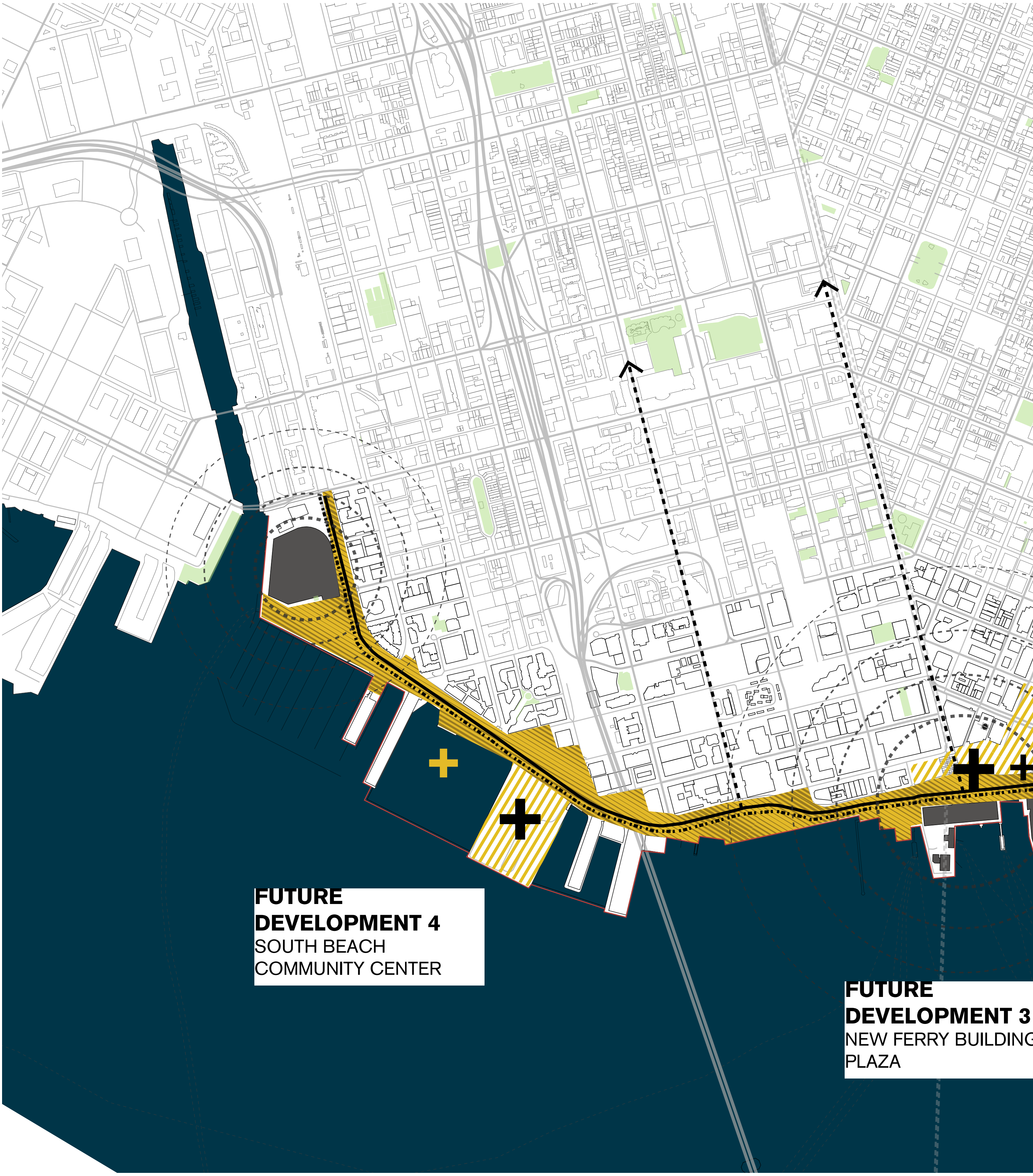
Fig.75: San Francisco Bay's encroaching waters. Rising Reality, http://projects.sfchronicle.com/2016/sea-level-rise/part1/

1. MASTER PLAN

PART IV APPLICATIONS

Fig.76: Site Plan. Drawed by Author.

Fig.77: Strategic Map. Drawed by Author.




Core Development
Tram Line
Pedestrain Line
Green Connection
Protection Line
Economic Engine
Multiplied Ground
Potential Space
Green Area
Tourism Destination
FUTURE DEVELOPMENT 1
FISHERMAN'S WHARF PARK
FUTURE DEVELOPMENT 2
HISTORIC PIER WALK
N

3. SPECIFIC DESIGN

3.1 Fisherman's Wharf Park

+ Restore and expand the fishing industry.

+ Enhance the colorful ambiance and mix of activities which draw visitors from around the world.

+ Provide new activities to attract more San Franciscans.

+ Improve public access and circulation.

Fig.78: Fisherman's Wharf Park. Drawed by Author.


BAY ST
CHESTNUT ST
JONES ST

Fig.79: Fisherman's Wharf Park. Drawed by Author.

Fig.80: Entrance of the Fisherman's Wharf Park. Drawed by Author.

3.2 Historic Pier Walk

+ Continue cargo operations for as long as feasible.

+ Provide new activities to draw San Franciscans to the water's edge.

+ Protect historic resources as the area evolves.

+ Highlight gateways to Fisherman's Wharf, North Beach and Chinatown.

+ Maximize people's access into Bay area.

Fig.81: Historic Pier Walk. Drawed by Author.

Fig.82: Terraced Garden in front of the Piers. Drawed by Author.

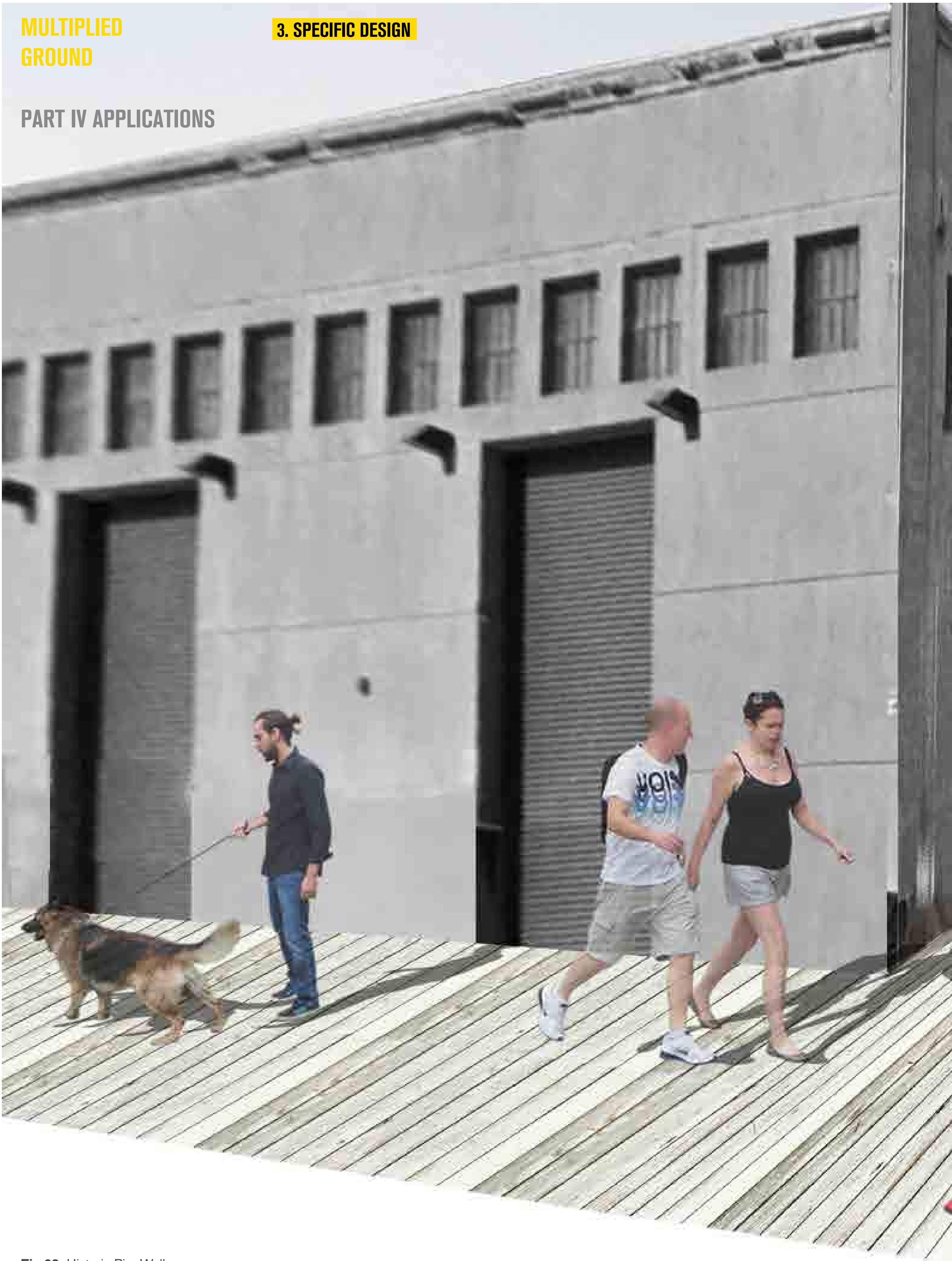


Fig.83: Historic Pier Walk. Drawed by Author.

3.3 Ferry Building Plaza

+ Restore the Ferry Building as the centerpiece of the waterfront.

+ Reintegrate with Downtown and the Market Street corridor.

+ Expand and connect transportation on water and land.

+ Re-establish the area's civic importance.

Fig.84: Ferry Building Plaza. Drawed by Author.

Fig.85: Ferry Building Plaza. Drawed by Author.

3.4 Community Center

+ Provide new activities to attract San Franciscans.

+ Respect the needs of new residents.

+ Connect public access between South Beach and China Basin and provide new parks.

+ Expand recreational boating south of China Basin.

Fig.86: Community Center. Drawed by Author.


BRYANT ST
BRANNAN ST
KING ST
Park
China B

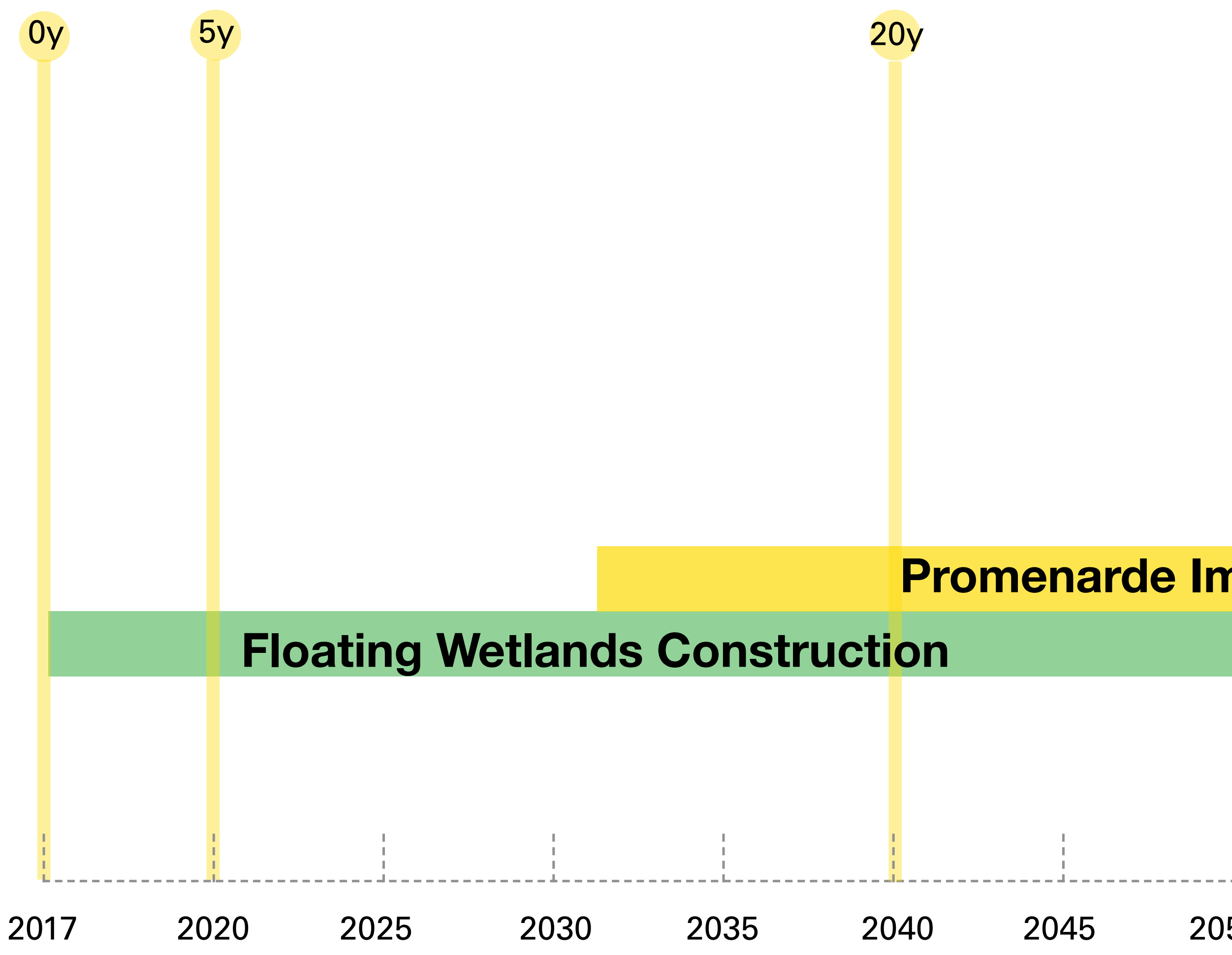
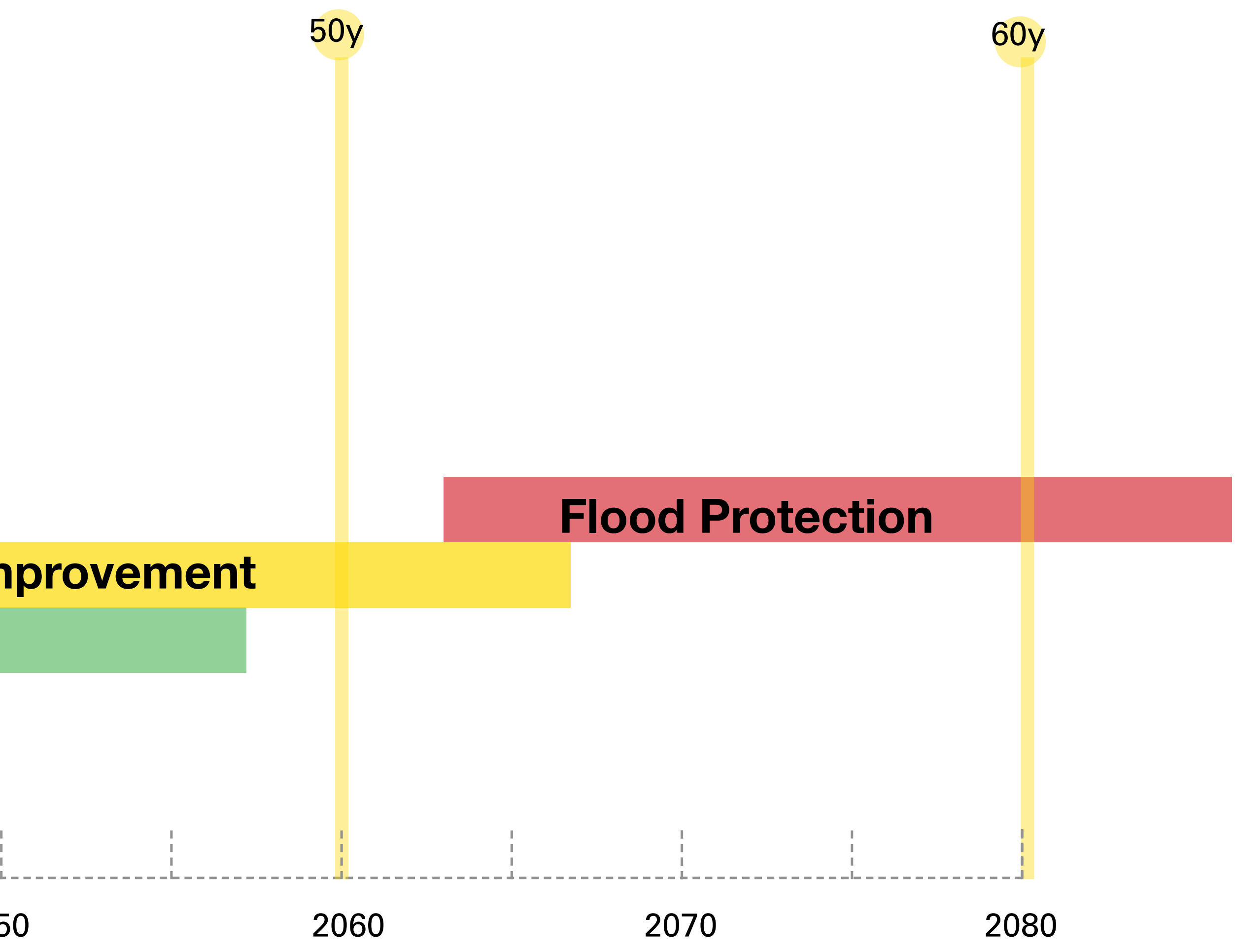
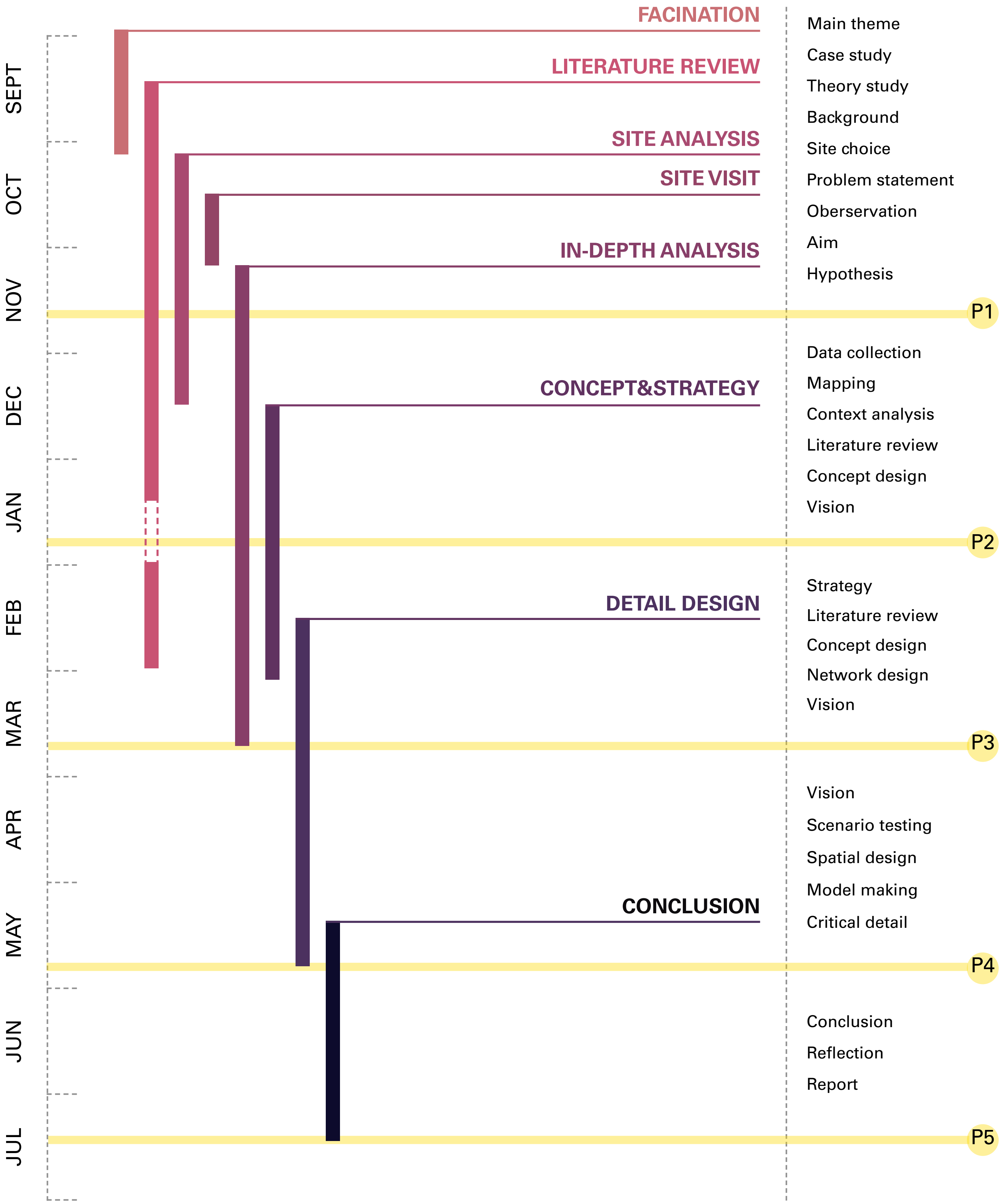


Fig.87: Phase Design. Drawed by Author.



50y
60y
Flood Protection
nprovement
50
2060
2070
2080

5. TIME FRAMEWORK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Background
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Concept design
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P2
Strategy
Literature review
Concept design
Network design
Vision
P3
Vision
Scenario testing
Spatial design
Model making
Critical detail
P4
Conclusion
Reflection
Report
P5

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