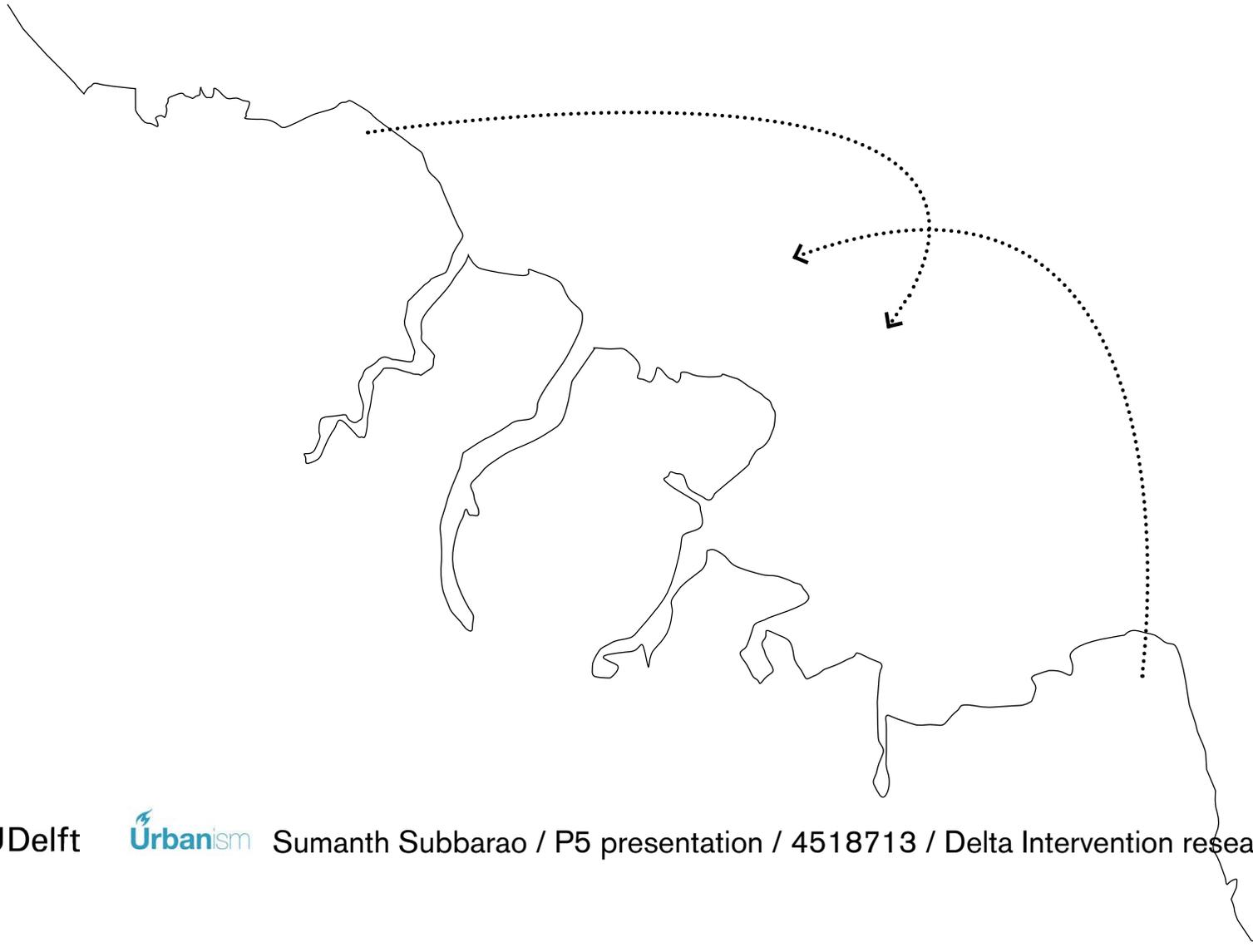# Variable Vulnerability

A comparative understanding of different socio - economic systems.
San Francisco bay region

D-i   **TU**Delft   **Urban**ism   Sumanth Subbarao / P5 presentation / 4518713 / Delta Intervention research group / June 2017

'Variable' -   not consistant or having a fixed pattern

'Vulnerability' -   The quality or state of being exposed to possible hazard

Vulnerability is the degree to which a system is susceptible(or sensitive) to, and unable to cope with, adverse effects of climate change...   (IPCC 2007)
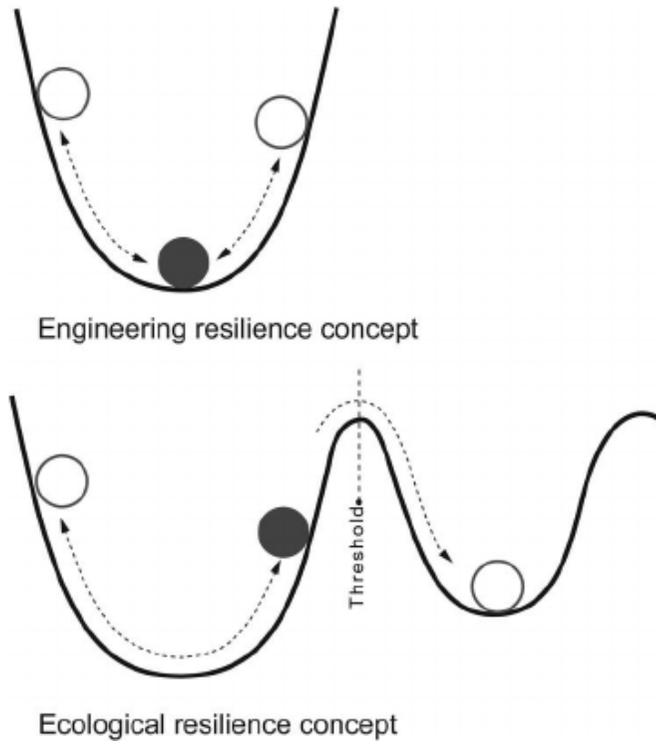
'the vulnerability of any system (at any scale) is a function of the exposure and sensitivity of that system to hazardous conditions and the ability of the system to cope or recover from the effects of those conditions (Smit & Wandel (2006)
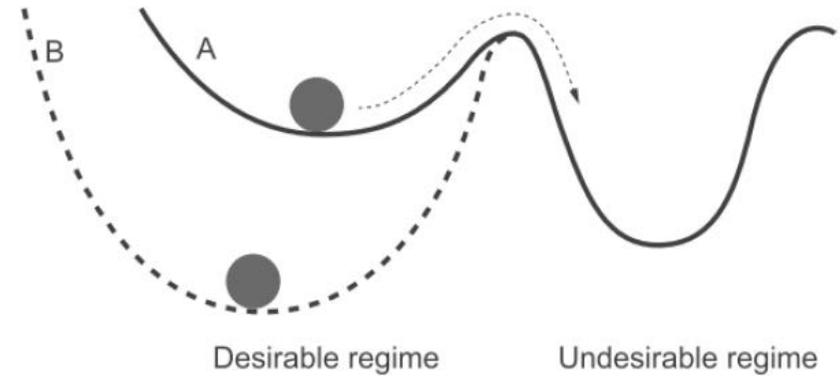
moma.org/wp/inside_out/wp-content/uploads/2010/04/nyc-june-08-218.sm_.jpg

Exposure +sensitivity + response

Engineering resilience concept

Ecological resilience concept

B

A

Desirable regime   Undesirable regime

Urban resilience

The basin of attraction depends on the tolerable range of the socio- economic state.
In case A the range is lower compared to case B. (Liao, 2012).
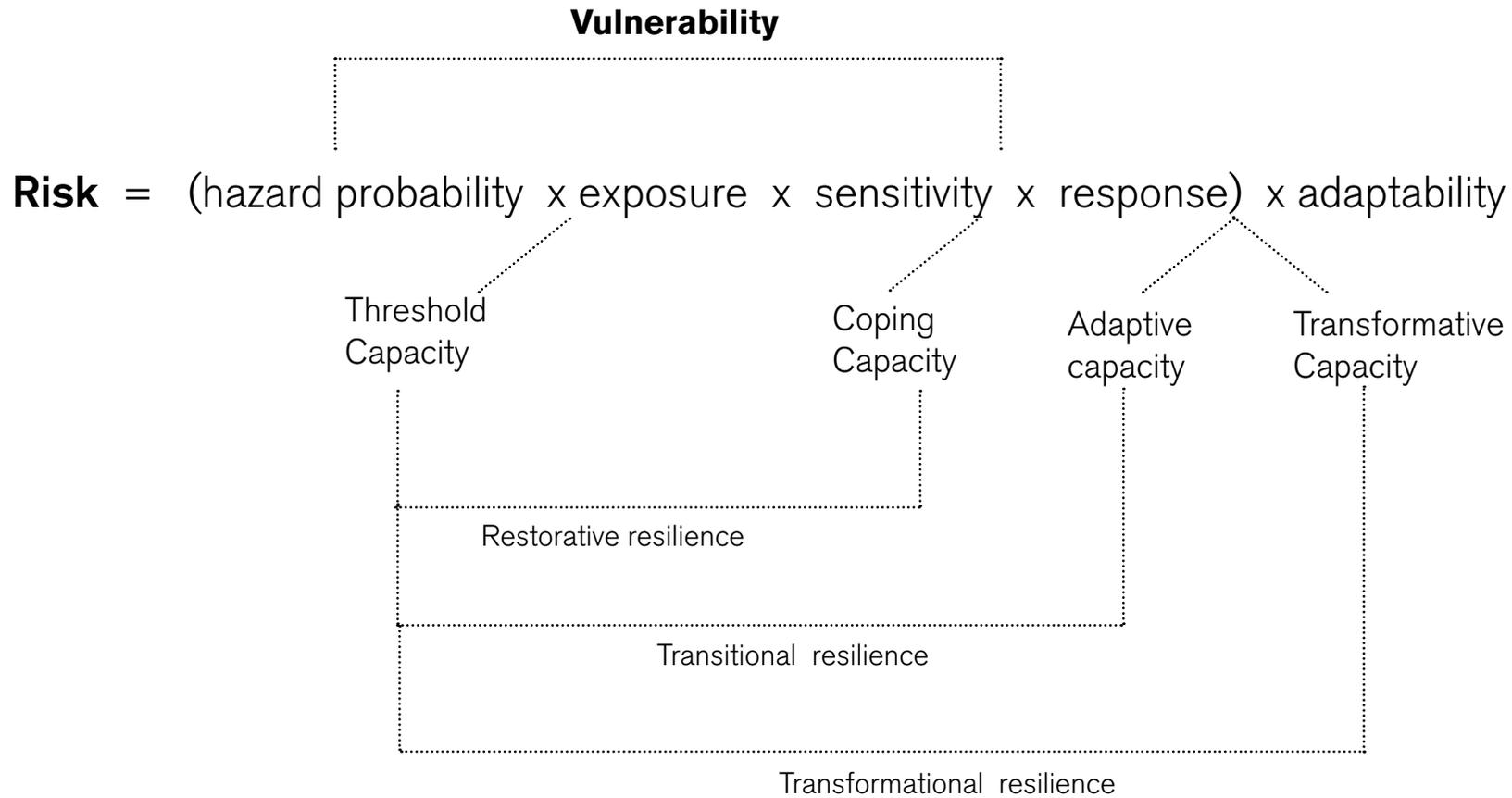
Urban resilience = dynamic of socio - ecological interaction

Threshold, or Tipping Point

New System State

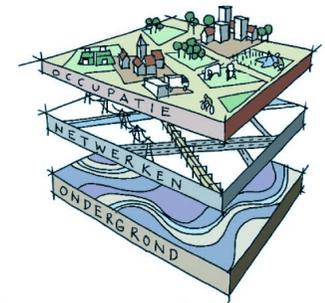Resilience

The System
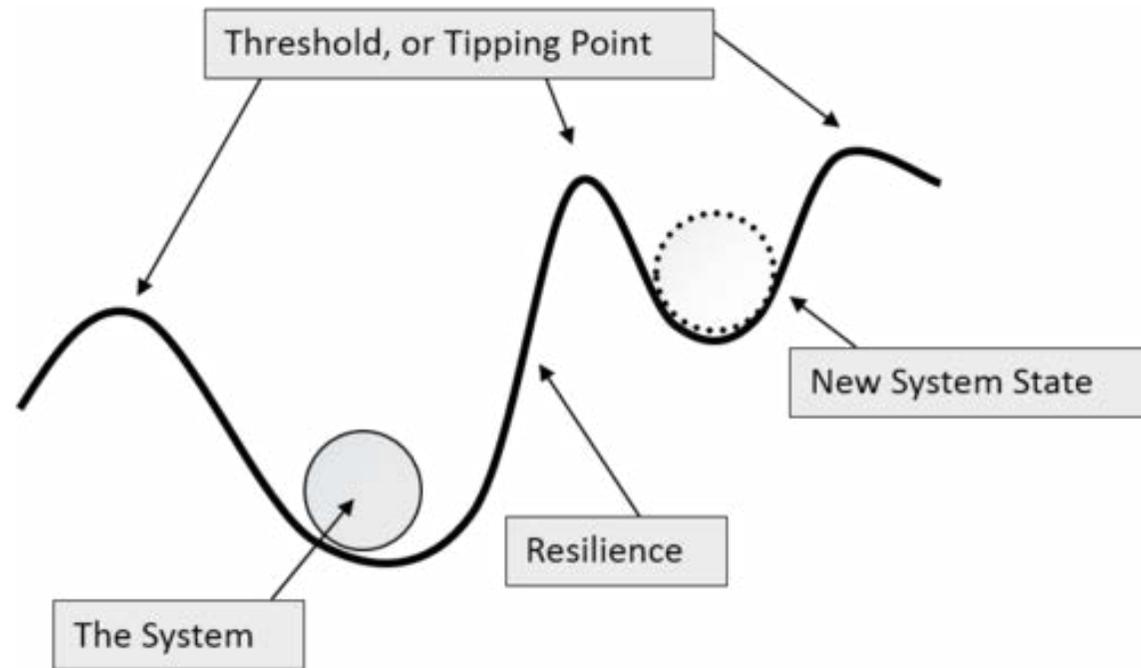
conservationofchange.org/resilience/

High adaptive capacity = reduce exposure through higher threshold

Risk equation

Vulnerability

$$\text{Risk} = (\text{hazard probability} \times \text{exposure} \times \text{sensitivity} \times \text{response}) \times \text{adaptability}$$

Threshold Capacity

Coping Capacity

Adaptive capacity

Transformative Capacity

Restorative resilience

Transitional resilience

Transformational resilience

De Graaf, (2009) who distinguishes four capacities that define vulnerability.

Understanding Risk in Urban Environment

Population density   Income Inequality   Infrastructure Assets

Exploitation

Human - nature
equiibrium state

Human - nature
existance

INCREASE IN RISK

URBAN DEVELOPMENT

ECONOMY

SOCIAL SYSTEM

INFRASTRUCTURE

SUB STRATUM ECOSYSTEM
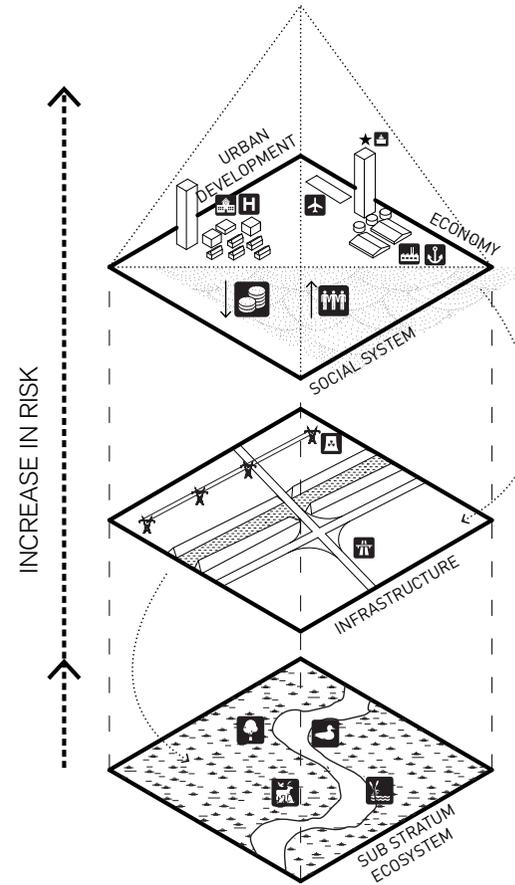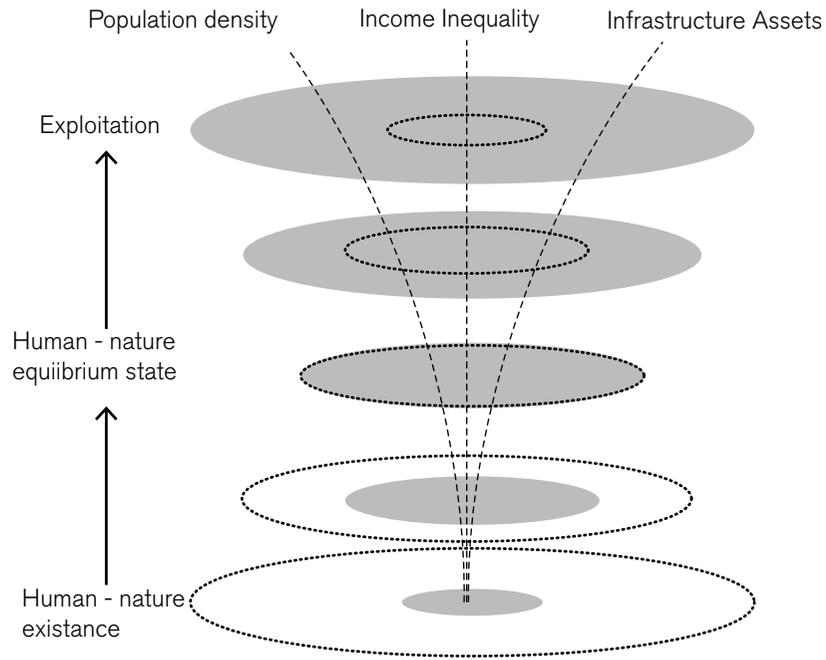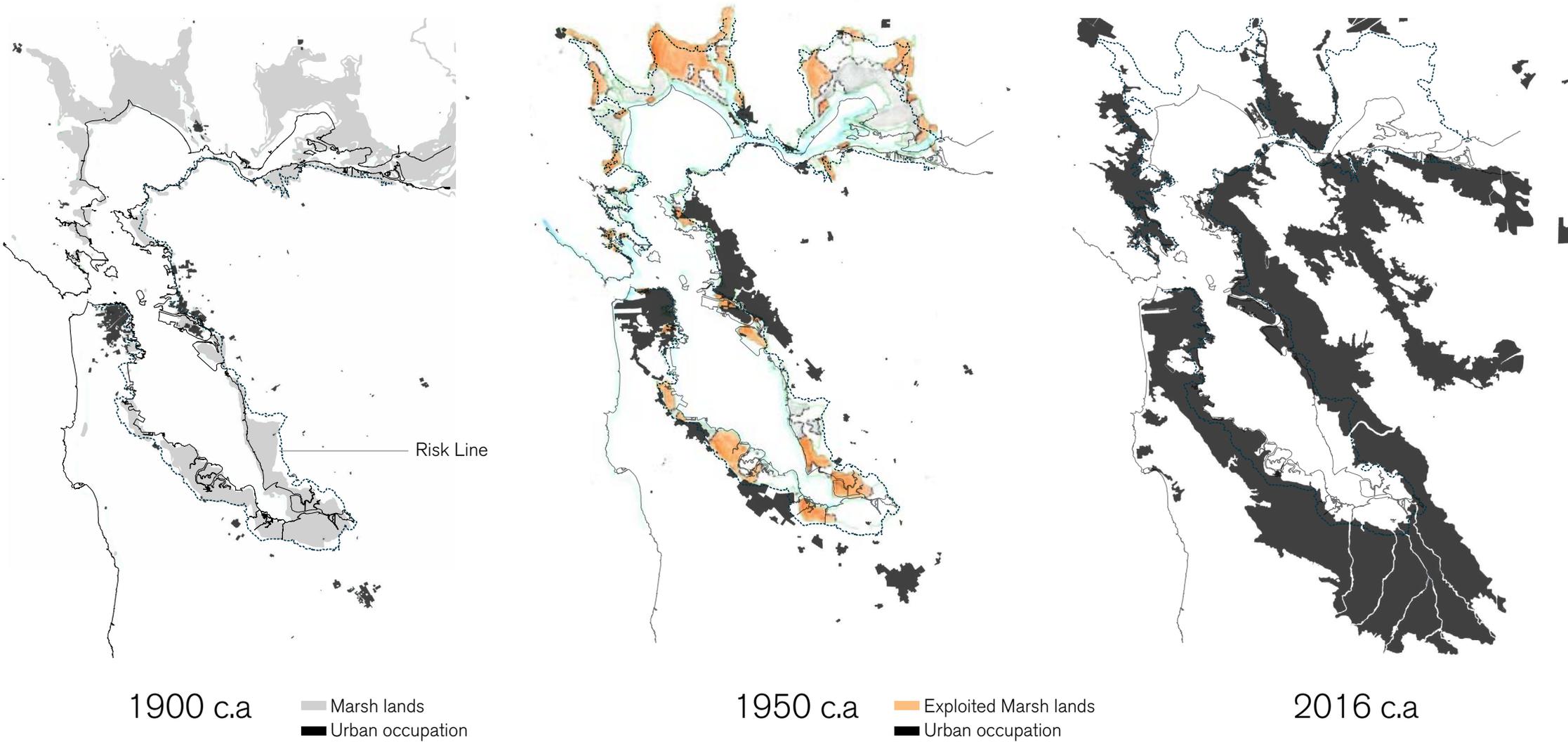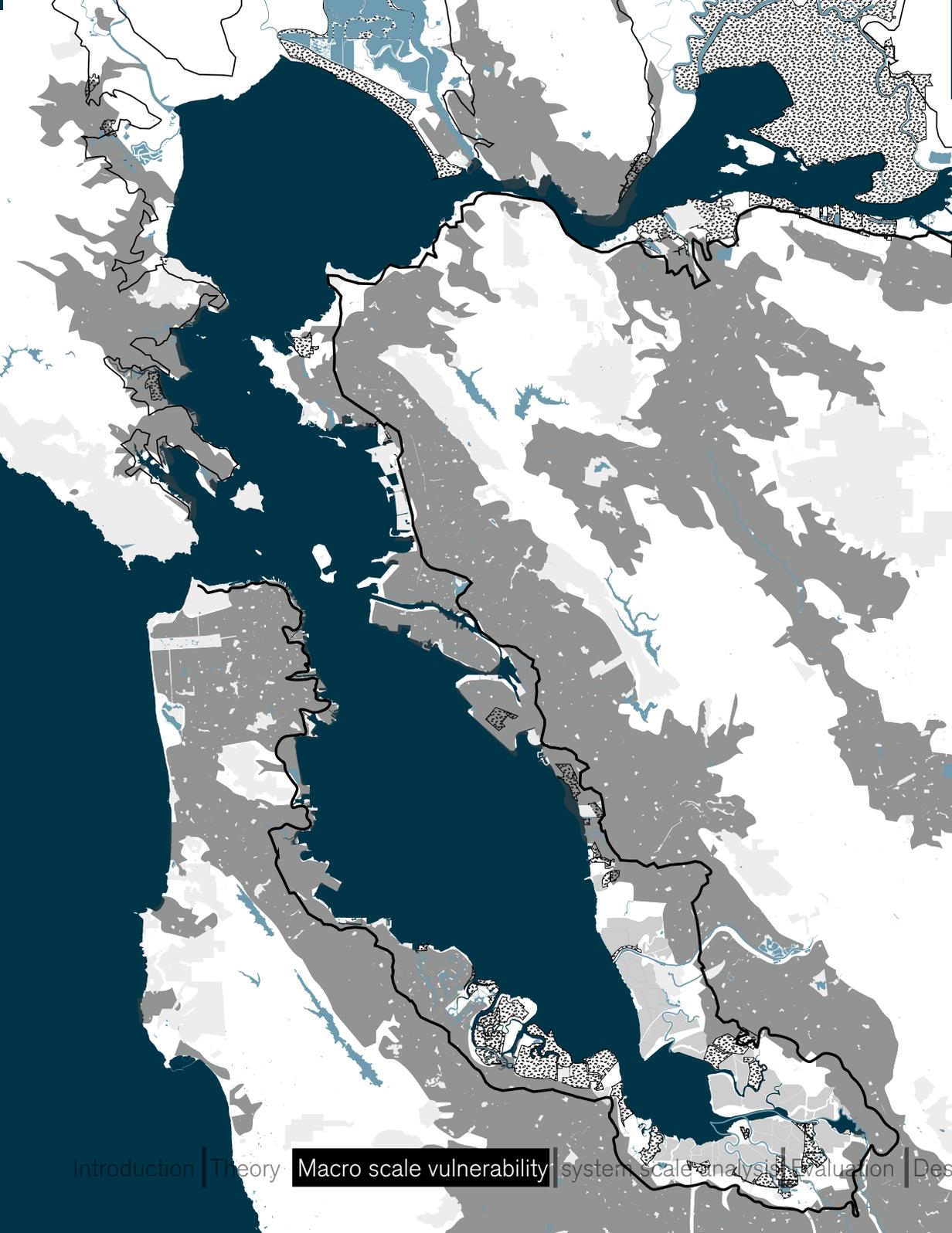
The layers approach
(Sijmonds, Feddes, & al., 2002)
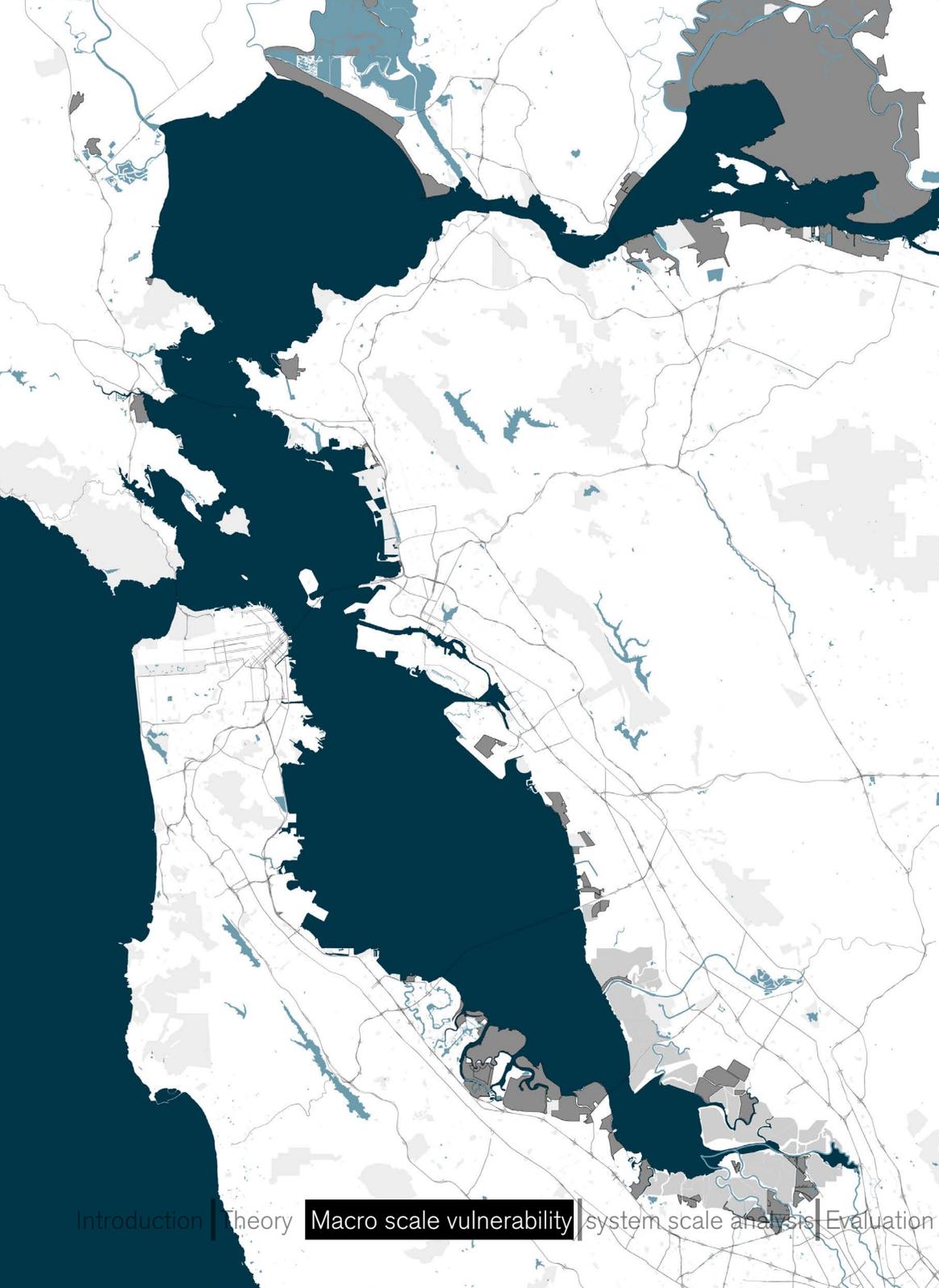
Understanding Risk in the context of San Francisco Bay area

Historic growth

Risk Line

1900 c.a   ■ Marsh lands
            ■ Urban occupation

1950 c.a   ■ Exploited Marsh lands
            ■ Urban occupation

2016 c.a

Occupation

lh5.googleusercontent.com/-awUrFNhUsmI/UaDPNiAP6GE/AAAAAAAAd6k/W6EsNbfwZAo/s640/BirdSEyeViewOfSanFrancisco.jpg

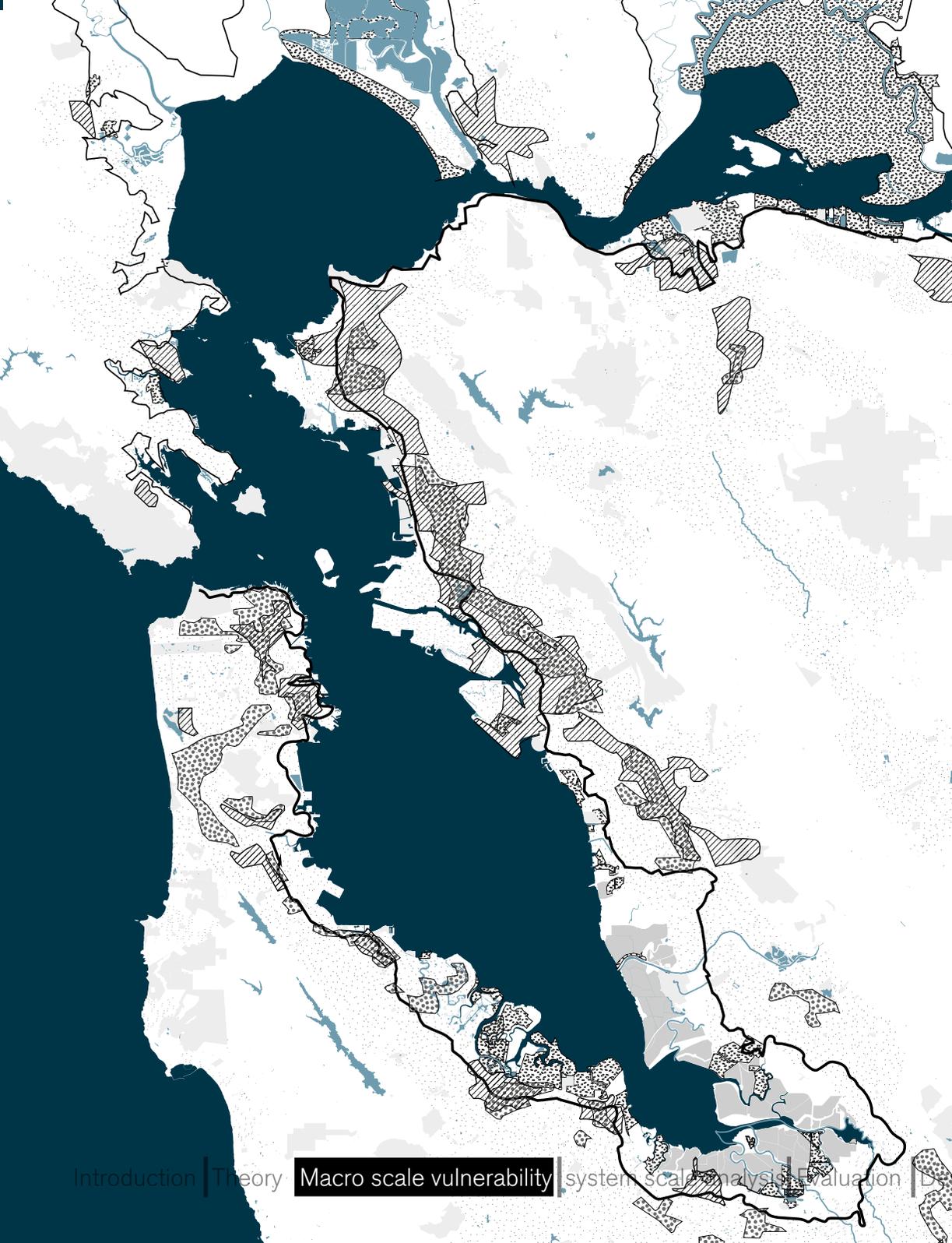joehaws.com/wp-content/uploads/2016/03/foster-city-1.jpg

archinect.net/images/1200x/im/imbqcd4rt025tbqt.jpg

c1.staticflickr.com/7/6016/5926838189_8cfb2f853b_b.jpg

Current urban occupation

Restoration of marsh lands

Low income and high population density

peninsulapress.com/wp-content/uploads/2015/12/Image-3.jpg
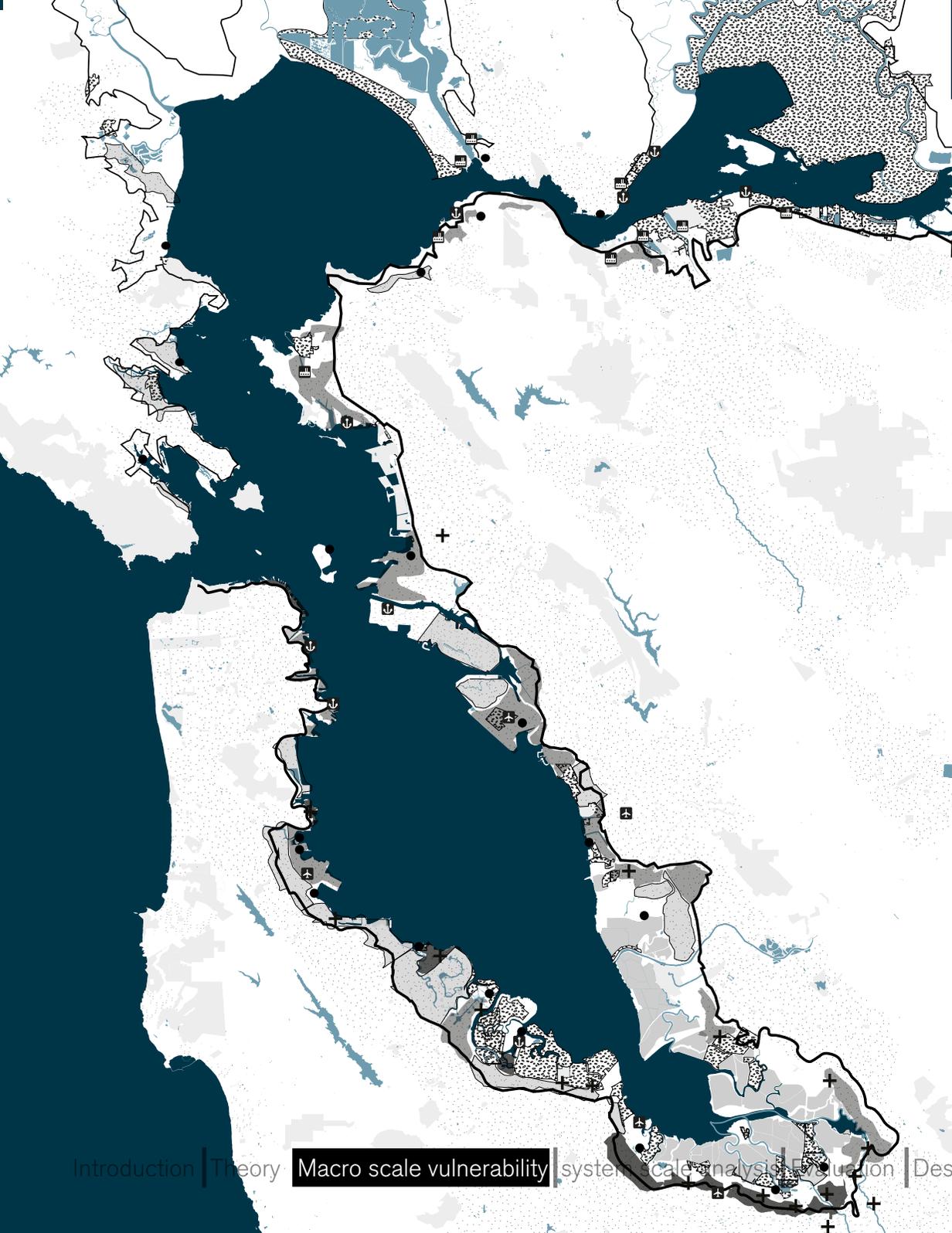

hdnux.com/photos/25/04/50/5524006/5/1024x1024.jpg

urbandisplacement.org/sites/default/files/tenants_together.jpg

(C) Sunny Wu 2011

Areas of high population density
Areas of Low income

Urban assets

facebook   1 Hacker Way

upload.wikimedia.org/wikipedia/commons/a/ae/Facebook_Headquarters_Entrance_Sign_Men-lo_Park.jpg

http://c8.alamy.com/comp/D7PRDT/google-headquarters-in-mountain-view-california-D7PRDT.jpg

limoserviceairport.biz/wp-content/uploads/2014/05/slide2-683x240.jpg

http://clui.org/sites/default/files/ludb/ca/4993/21_san_jose_treatment.jpg

	Residential land use at risk of inundation
	Industrial land use at risk
	Commercial land use at risk
●	Critical infrastructure at risk
+	Important economic drivers of region (silicon valley)
✈	Airports
⚓	Ports
🏭	Port related industries
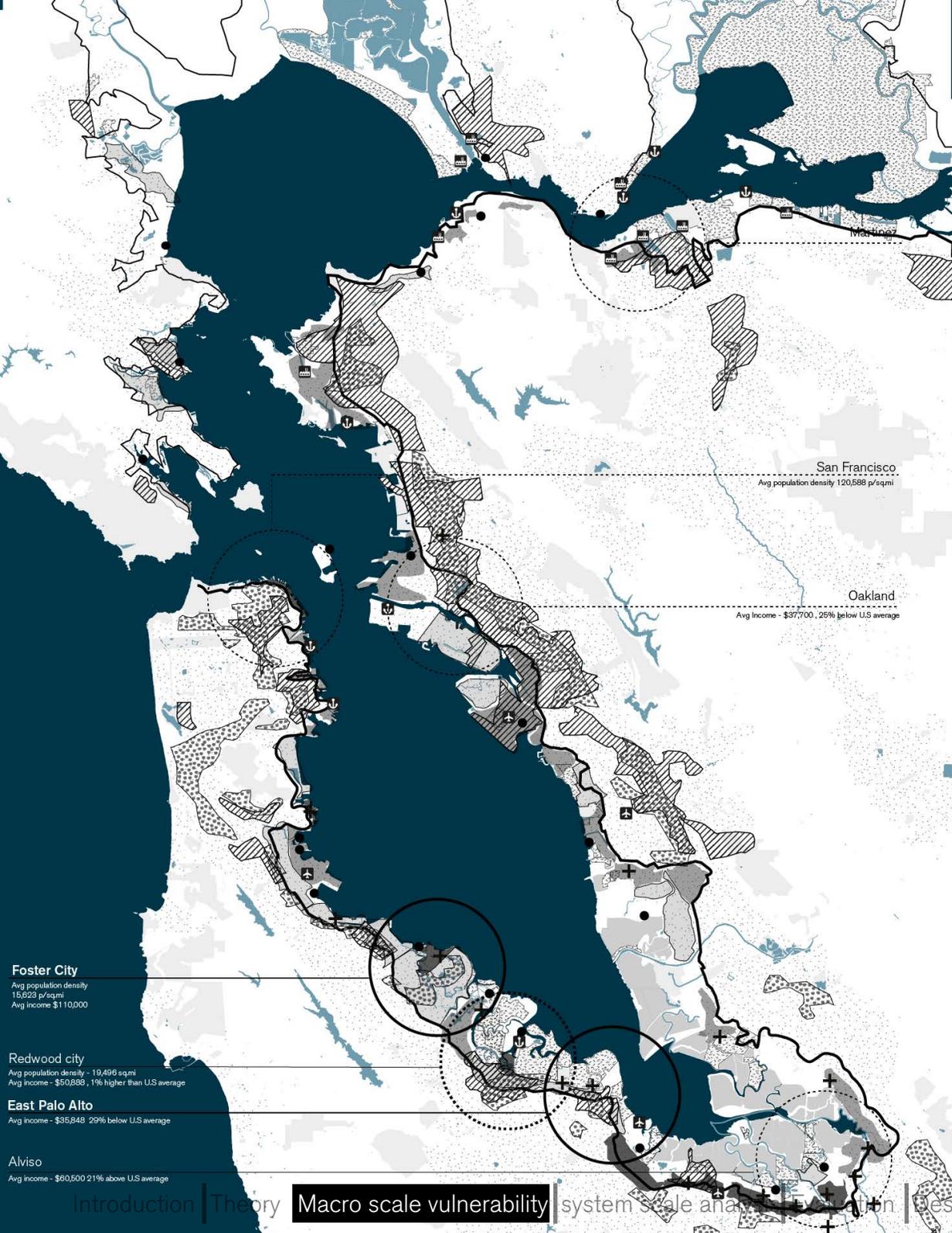
Variable vulnerability

Martinez
Economic value

San Francisco
High population density, dense built structure

Oakland
Low - income communities

Alviso
Land elevation

East Palo Alto
Low -income communities , population density

Redwood City
population density

Foster City
population density ,economic value

San Francisco
Avg population density 120,588 p/sq.mi

Oakland
Avg Income - $37,700 , 25% below U.S average

Foster City
Avg population density
15,623 p/sq.mi
Avg income $110,000

Redwood city
Avg population density - 19,496 sq.mi
Avg income - $50,888 , 1% higher than U.S average

East Palo Alto
Avg income - $35,848 29% below U.S average

Alviso
Avg income - $60,500 21% above U.S average

Pattern - typology

Average density :
120,588 persons / sq.mi

SAN FRANCISCO

Average density :
15,623 persons / sq.mi

Average density :
19,496 persons / sq.mi

Average income :
$50,888, 1% above US
average

FOSTER CITY

REDWOOD CITY

Average income :
$35,848 , 29% below US
average

Average income :
$24,414, 50% below US
average

EAST PALO ALTO

Average income :
$37,700 , 25% below US
average

Average density :
27,268 persons / sq.mi

MARTINEZ

OAKLAND

Average income :
$60,500, 21% above US
average

ALVISO

Institutional capacity

> **"What we choose to protect and how we pay for it may have a disproportionate impact on low - income neighbourhoods and communities of colour"**

HEBERGER, M. 2012. The impacts of sea level rise on the San Francisco Bay, California Energy Commission.

Flood risk magement physical structure

Levee structures - hard edge conditions

San Francisco bay has a centralised mechanism of managing floods. Shoreline protection structures elminates natural tidal processes and ecological exchange.
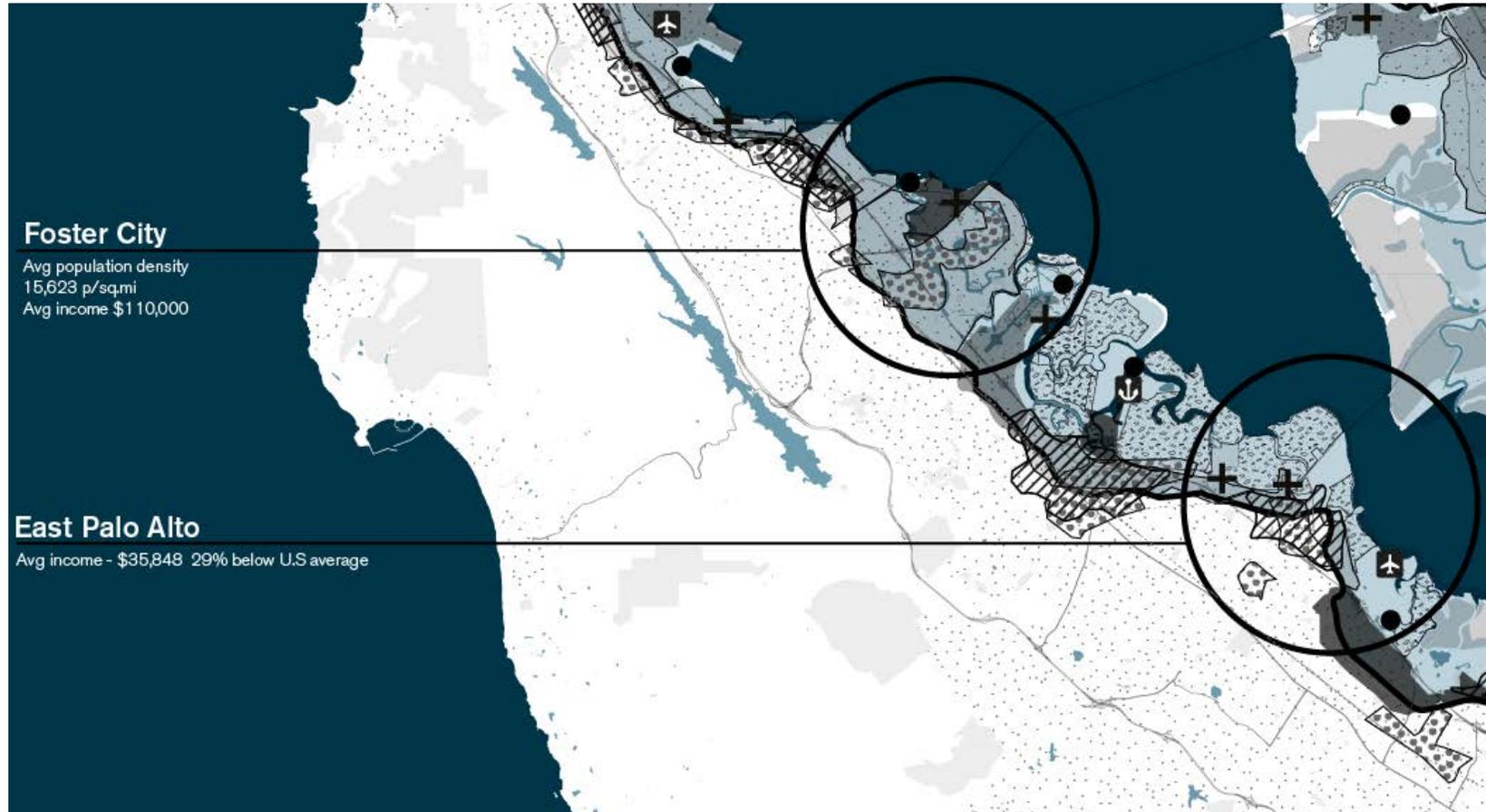
Problem statement

Risk

Flood risk modulation

Re- inventing to face climate change
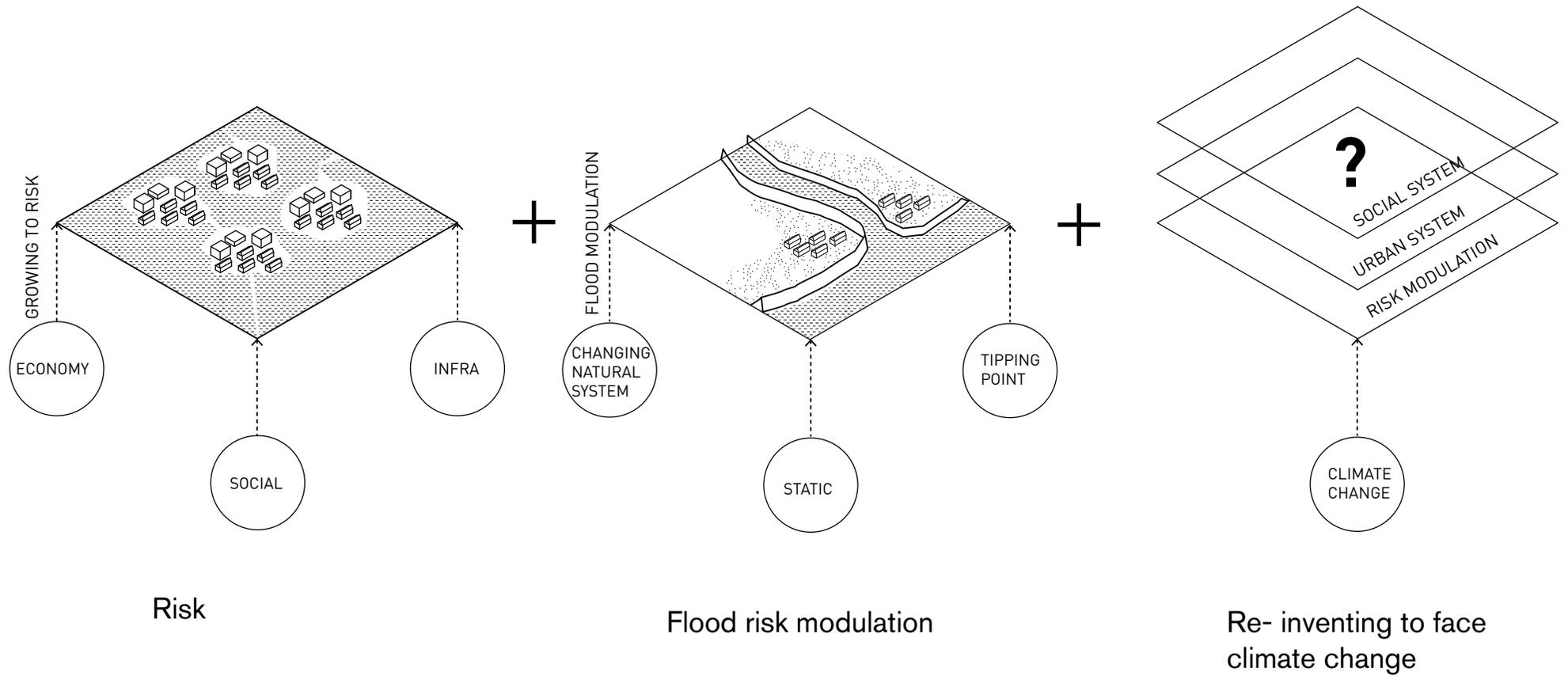
Research question

How to integrate flood risk modulation into a specific existing socio- economic development to enhance urban resilience towards climate uncertainties

Comparitive study into two different system

Foster City
Avg population density
15,623 p/sq.mi
Avg income $110,000

East Palo Alto
Avg income - $35,848 29% below U.S average

Methedology for research

3 **step analysis -** *defining the methedology*

2 **Visions** **-** *specific to the socio economic context*

1 **design objective -** *increase capacities to build resilience*
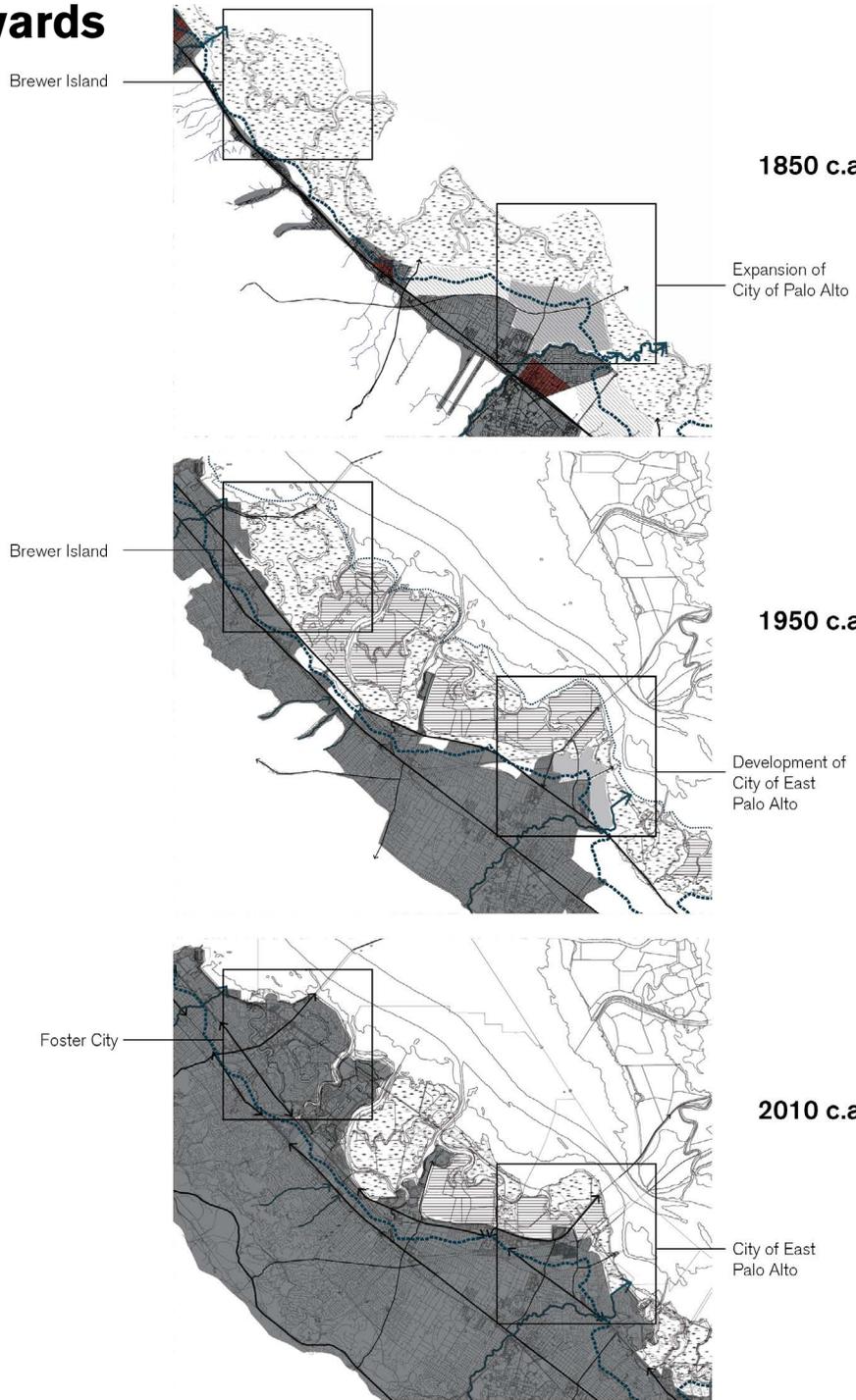
spatial structure and relation with bay

East Palo Alto
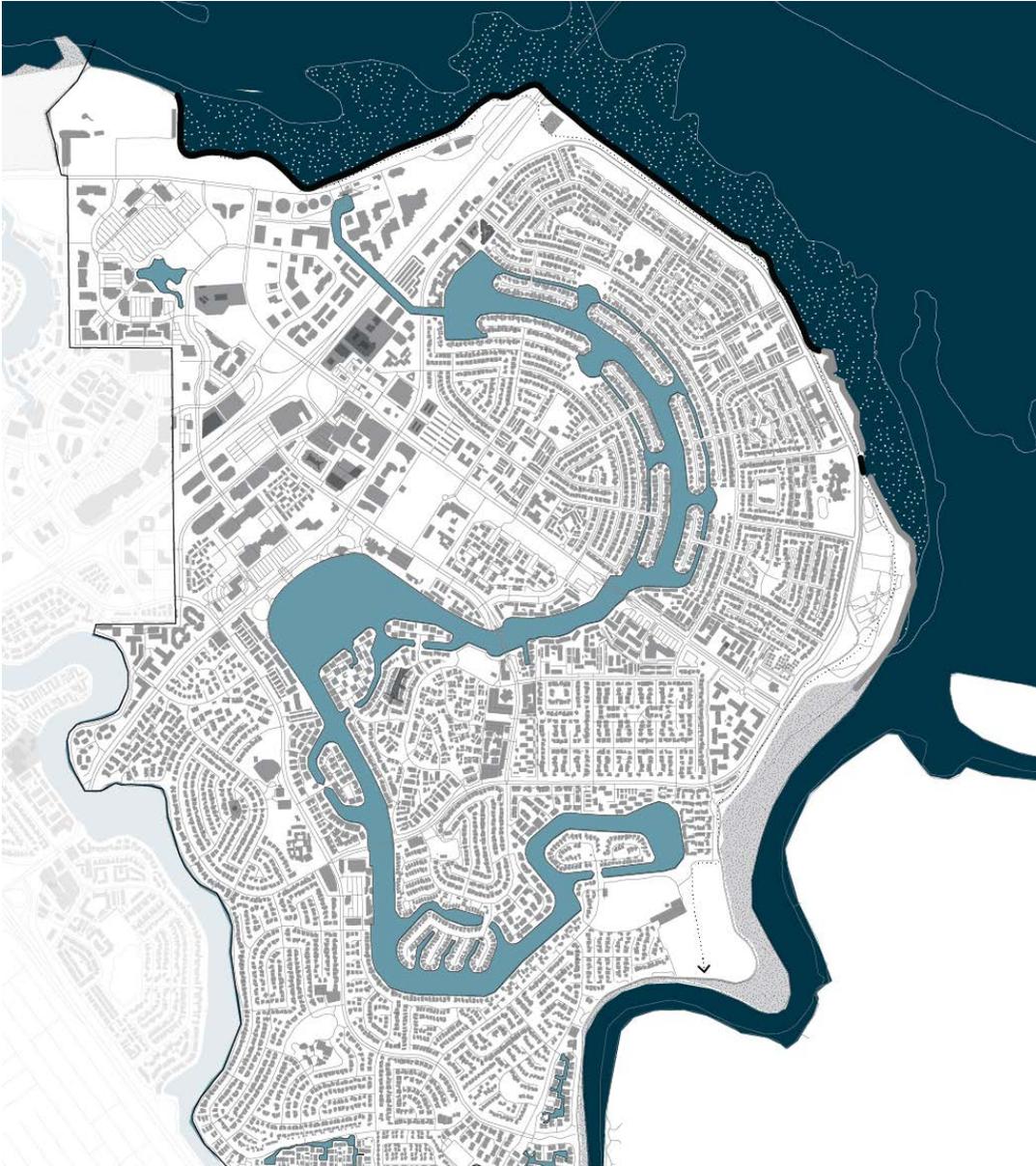
Foster City

Growth towards Bay

Brewer Island

Expansion of
City of Palo Alto

1850 c.a

Gold Rush

Agriculture

Pre - industrialization

Post - Industrialization

Brewer Island

1950 c.a

Post war - development

Development of
City of East
Palo Alto

Foster City

Silicon valley

Foster City

2010 c.a

City of East
Palo Alto

East Palo Alto

Foster City

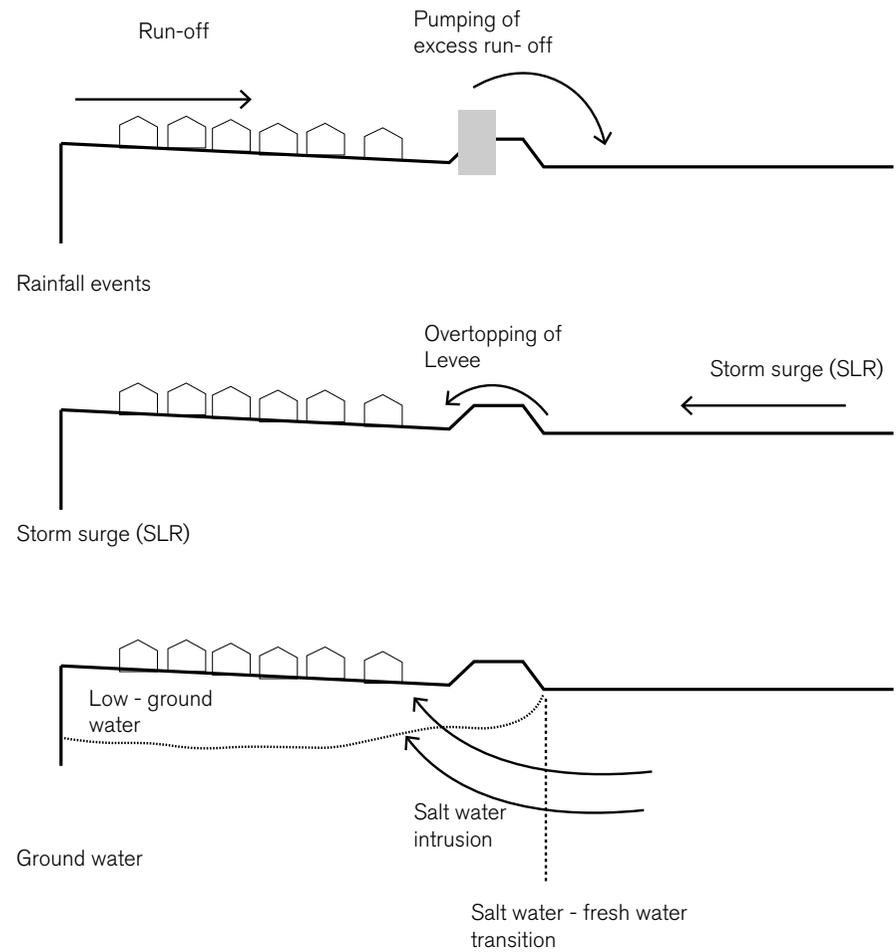|	Social	Economy
East Palo Alto	Agriculture neighbourhood - poultry Farmers	Agriculture, salt ponds (mining)
Foster city	Runnymede Community (Farmers) Residents from nearby towns	Light industries , Fertilizer waste industries Green house farming
	War vetrens , Migrant communities	Commercial centers , Light industries
East Palo Alto	Low - income migrant population Runnymede farming community	IKEA - commercial center Gateway 101 - commercial center Light industries, salvage yards Green house farming
Foster city	High - income communities, silicon valley employees	Bio technology, Pharmaceutical companies, Silicon valley companies Light industries

Historical transformation

East Palo Alto - *Has lost its economic resilience due to change in regional economy and demographic influence. - Urban sprawl*
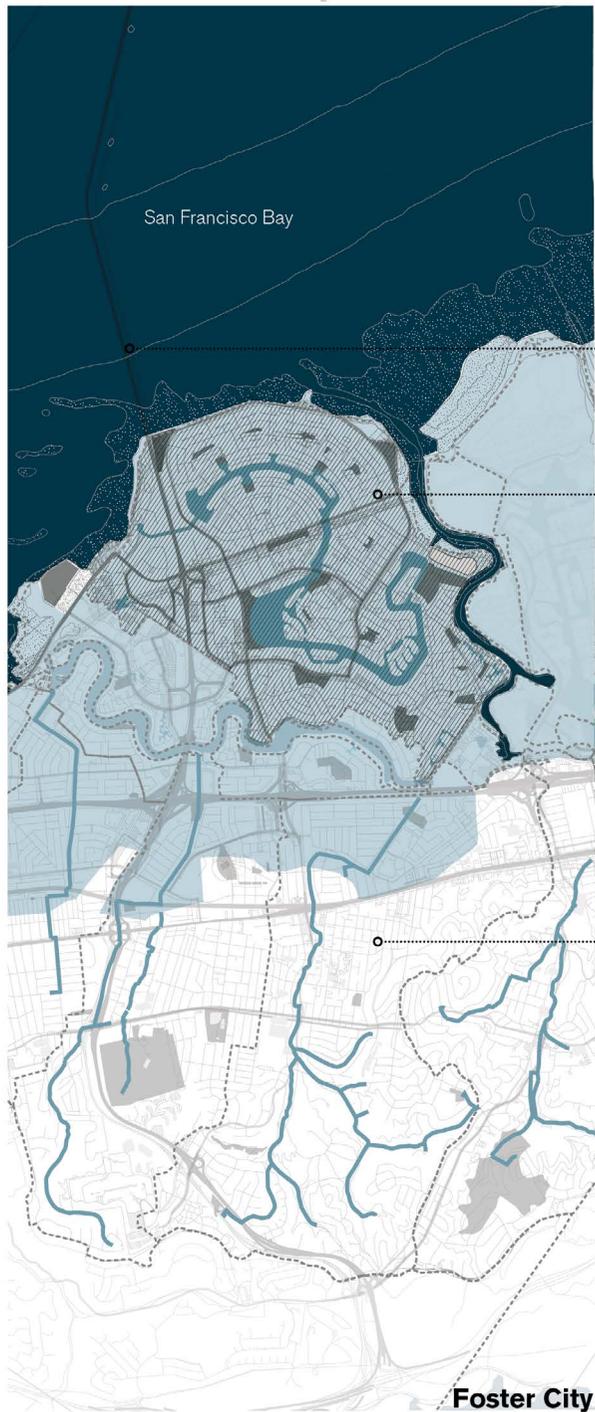
Foster City - *New town with careful planning. stable economy*
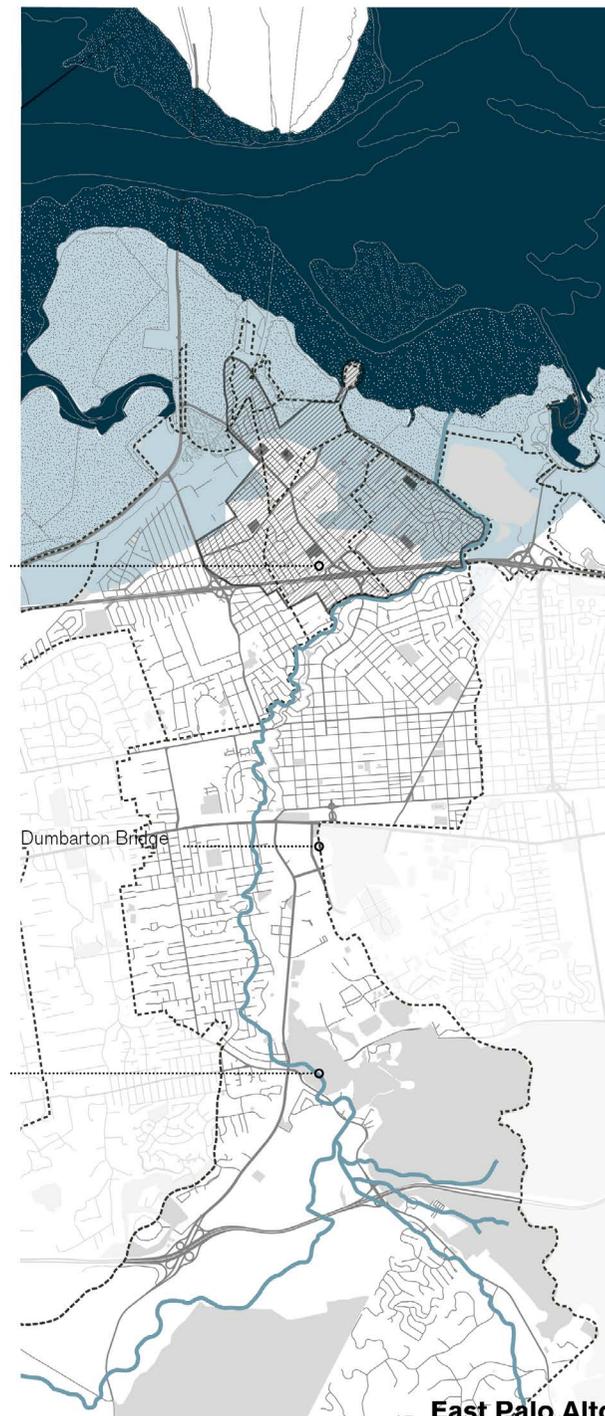
Socioeconomic system to the concept of resilience
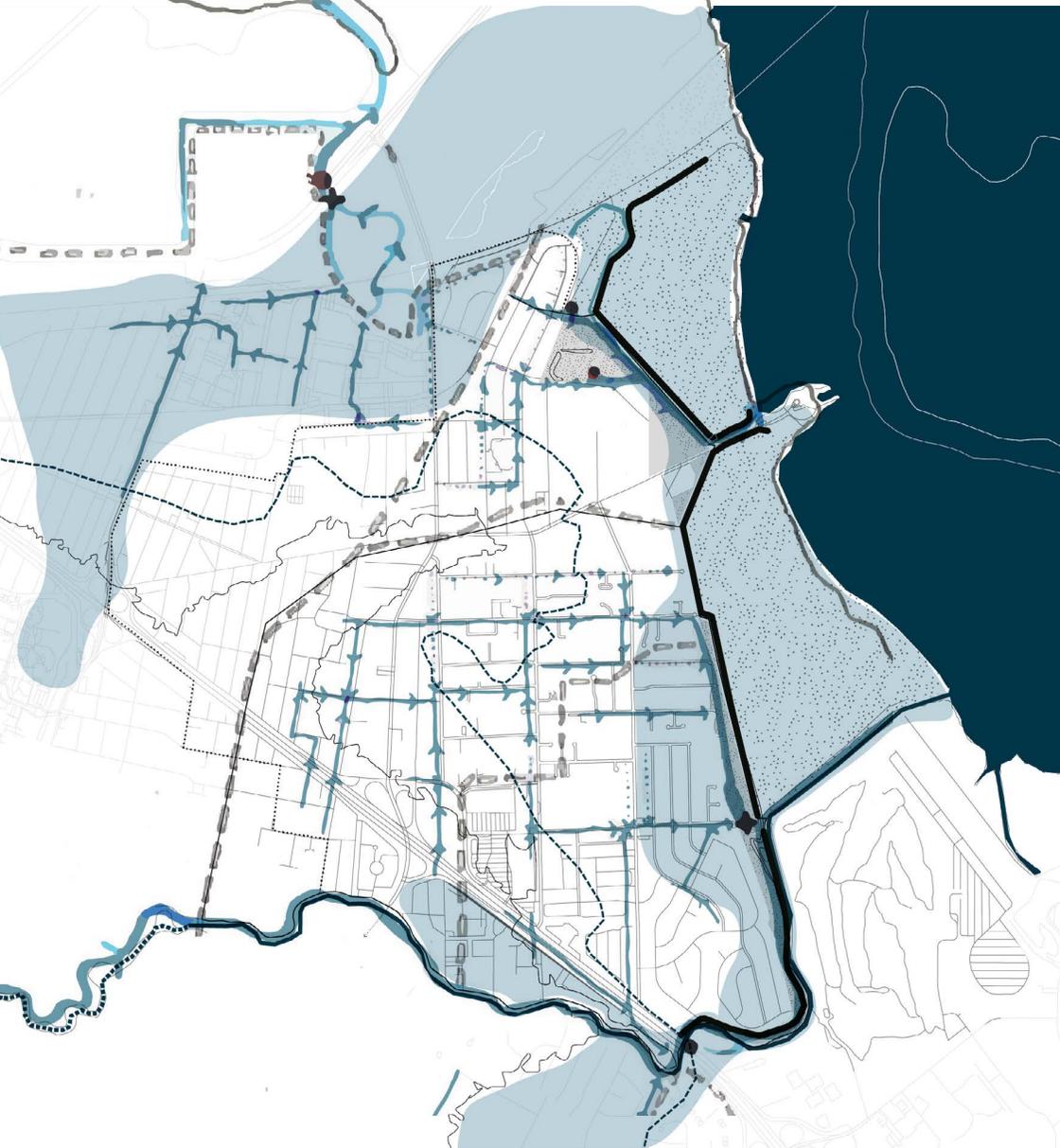
Defined by risk equation and understanding capacities

Run-off

Pumping of excess run- off

Rainfall events

Overtopping of Levee

Storm surge (SLR)

Storm surge (SLR)

Low - ground water

Salt water intrusion

Salt water - fresh water transition

Ground water

Flood risk from 3 directions

San Francisco Bay

Dumbarton Bridge

Foster City

East Palo Alto

0   1   3 km

◼ Bay waters
▤ Administrative boundary
▨ Inundation due to SLR of 1.5m
▢ Large open spaces
▨ City parks and open spaces
▨ Tidal flats
— Creeks
···· Watershed boundaries
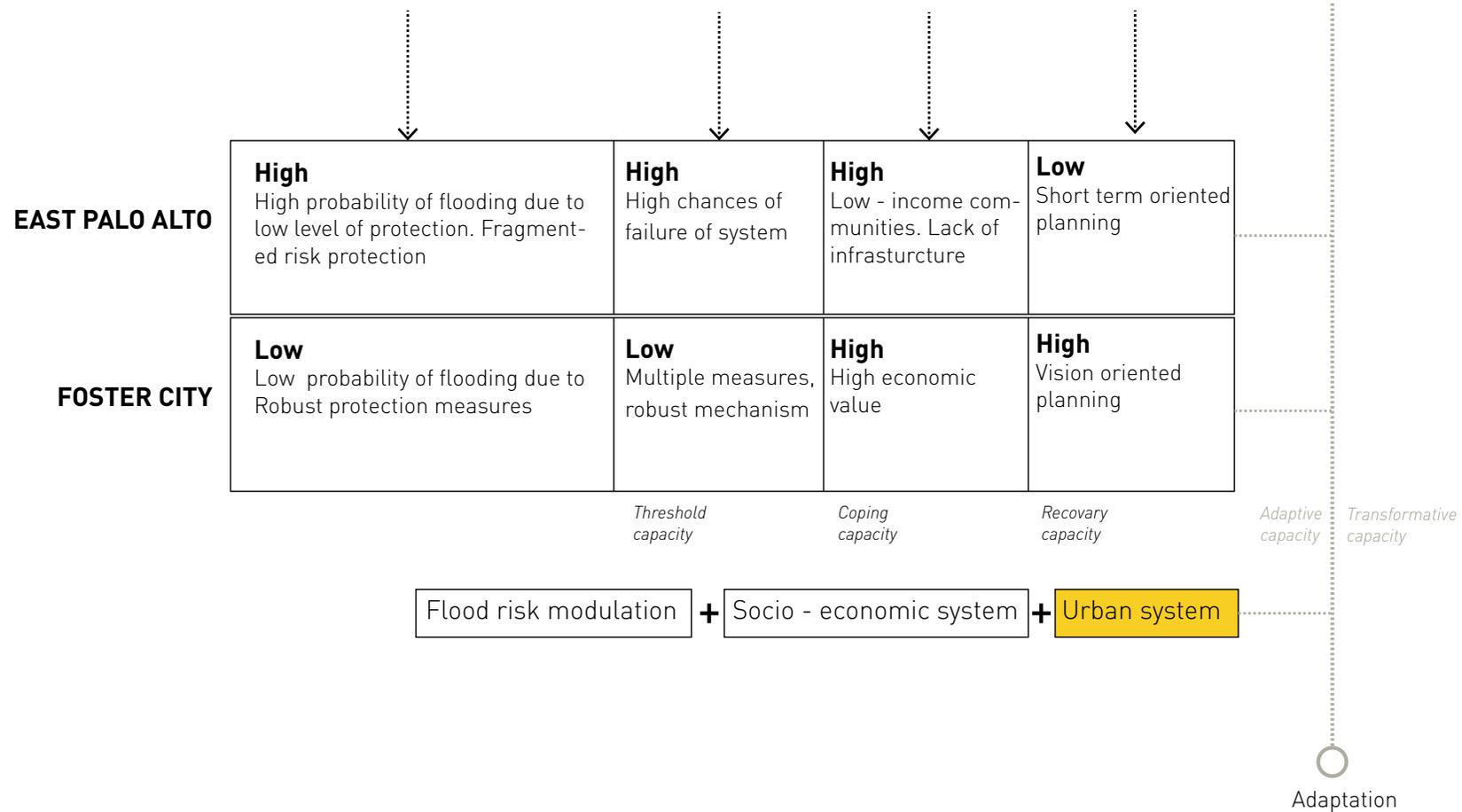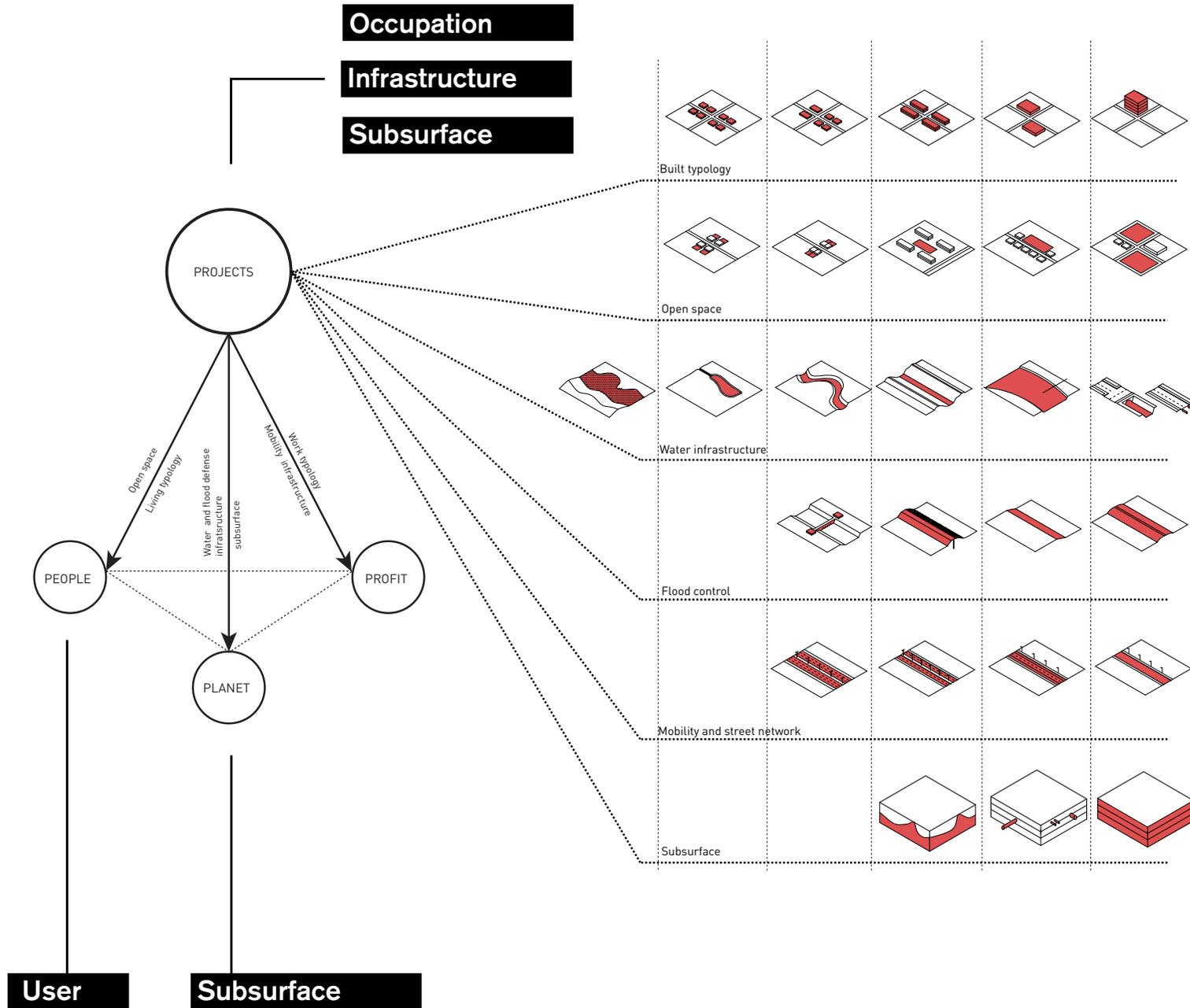▨ Northern coastal salt marsh

100 year flood plain

500 year flood plain

East Palo Alto

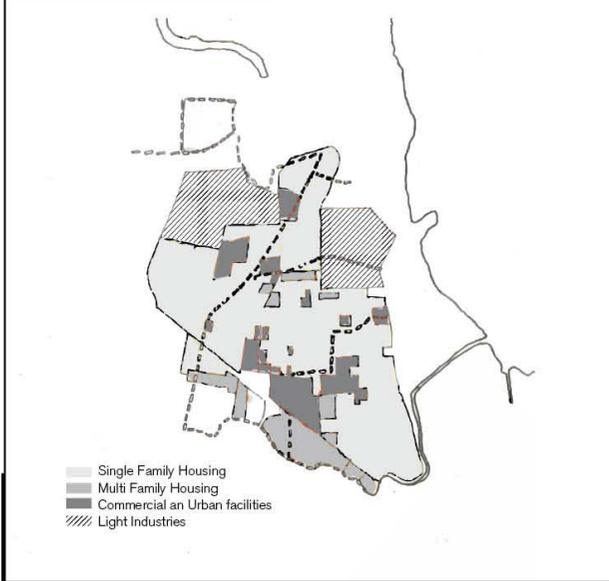Foster City

Risk in both cases due to SLR (1.5m)

Social layer

Built environment - layer

Infrastructure layer

| Population density | Economic value | Urban facilities | Built density | Critical infratrcture |

Foster City

East Palo Alto

!

Areas under risk
Medium risk zone
High risk zone
Concentration of low income
population in East Palo Alto

Fig 5.11 .Risk Analysis in Foster city and East Palo Alto (maps by author)

Risk = [Hazard probability **X** Exposure **X** Sensitivity **X** Response] **X** *Adaptability*

EAST PALO ALTO	**High** High probability of flooding due to low level of protection. Fragmented risk protection	**High** High chances of failure of system	**High** Low - income communities. Lack of infrasturcture	**Low** Short term oriented planning
FOSTER CITY	**Low** Low probability of flooding due to Robust protection measures	**Low** Multiple measures, robust mechanism	**High** High economic value	**High** Vision oriented planning

Threshold capacity   *Coping capacity*   *Recovery capacity*   *Adaptive capacity*   *Transformative capacity*

Flood risk modulation **+** Socio - economic system **+** Urban system

Adaptation

Urban systems

Occupation

Infrastructure

Subsurface

PROJECTS

Open space
Living typology

Water and flood defense
infrastructure
subsurface

Work typology
Mobility infrastructure

PEOPLE

PROFIT

PLANET

User

Subsurface

Built typology

Open space

Water infrastructure

Flood control

Mobility and street network

Subsurface

Urban systems

Occupation

Built space

Legend:
Single Family Housing
Multi Family Housing
Commercial an Urban facilities
Light Industries

Open space

Legend:
Private vacant plots and parks
Marsh land

Infrastructure

Water infrastructure

Legend:
Creek and surface water
Urban drainage pattern and flow direction
Nano drainage catchments
Water control structure

East Palo Alto

Infrastructure

Mobility infrastructure

Legend:
Major roads
Minor roads
Railway infrastructure

Levees and flood control

Legend:
Levees
Slopes and embankments

Subsurface

Subsurface
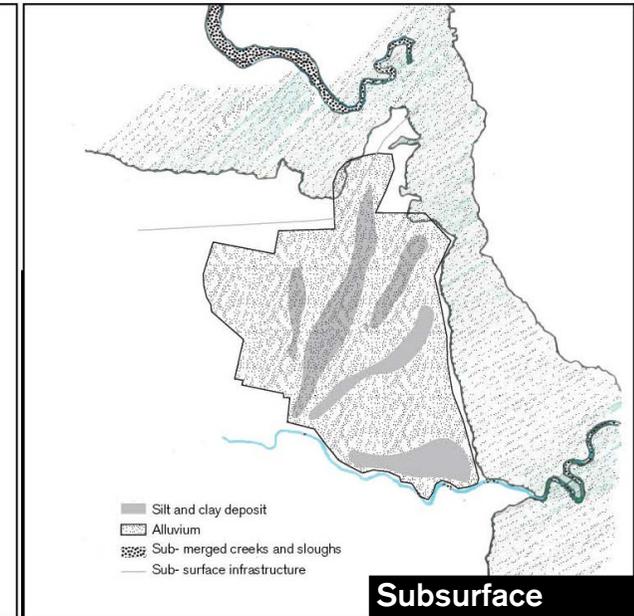
Legend:
Silt and clay deposit
Alluvium
Sub- merged creeks and sloughs
Sub- surface infrastructure
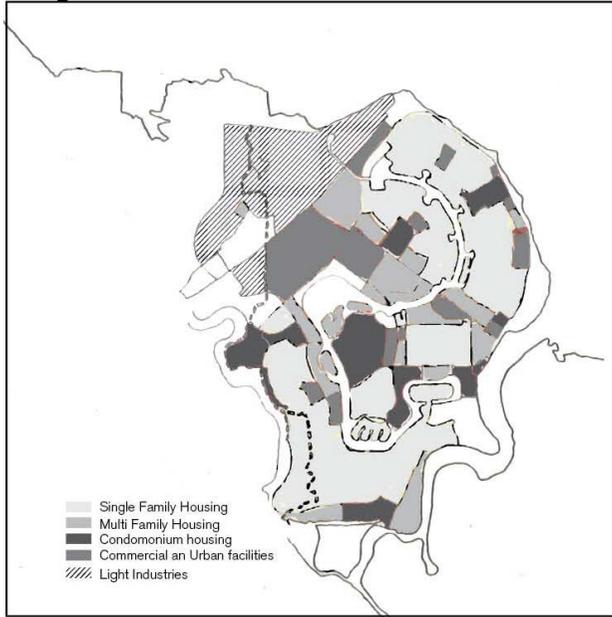
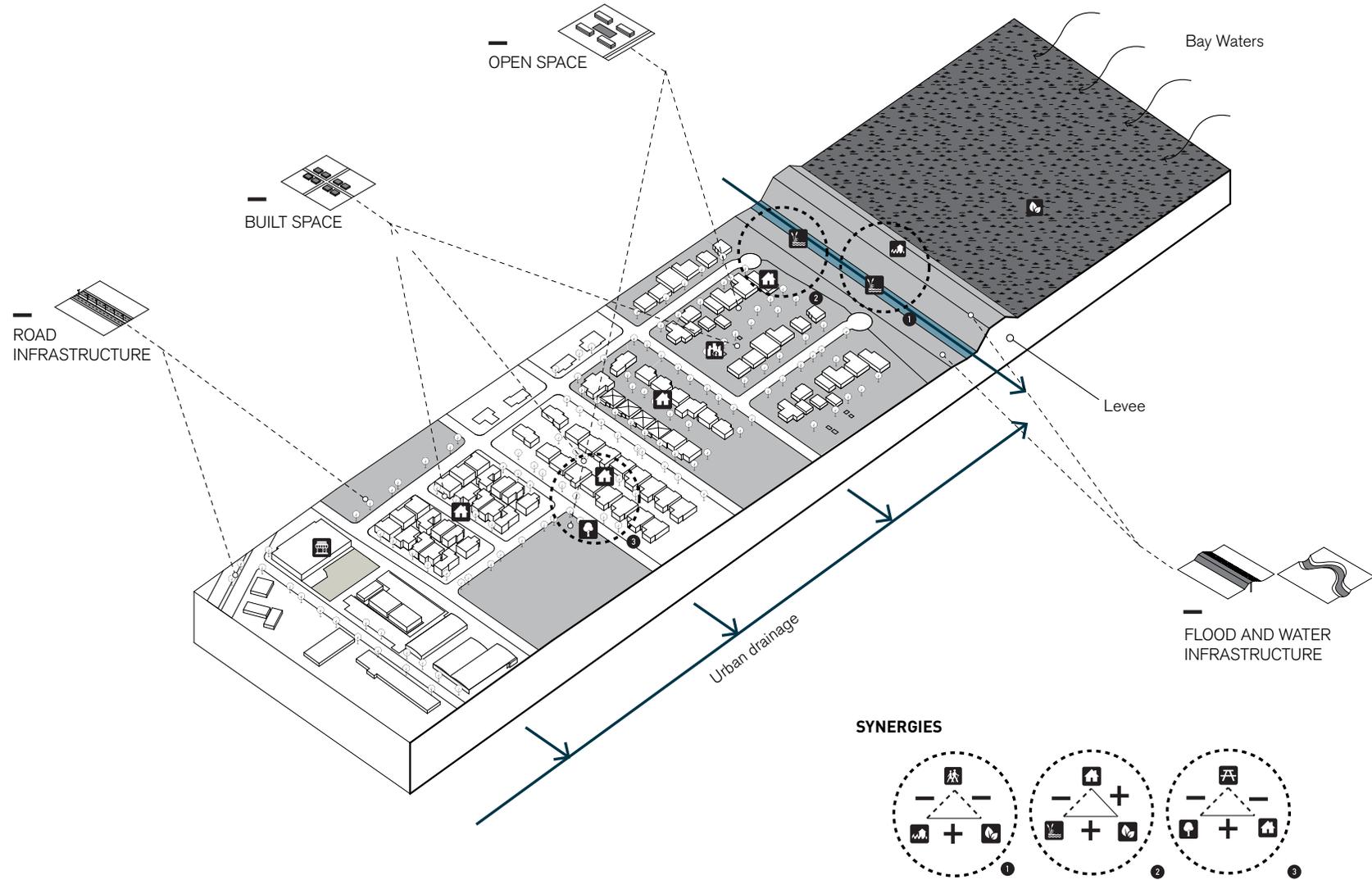Built space

Open space
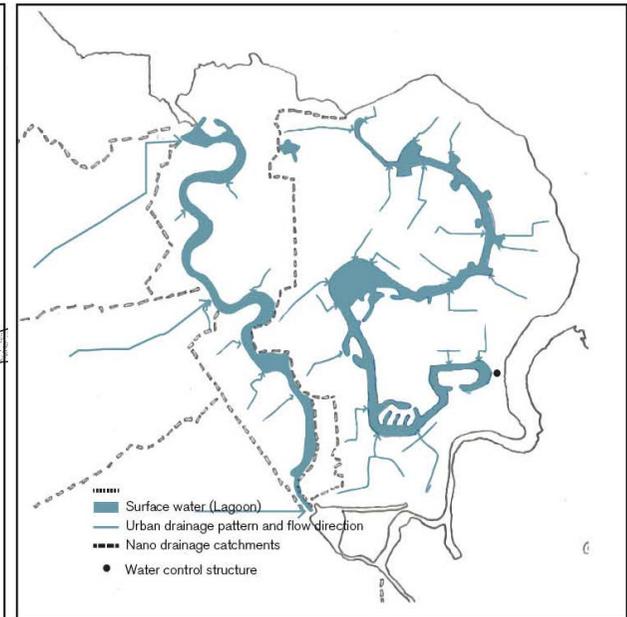
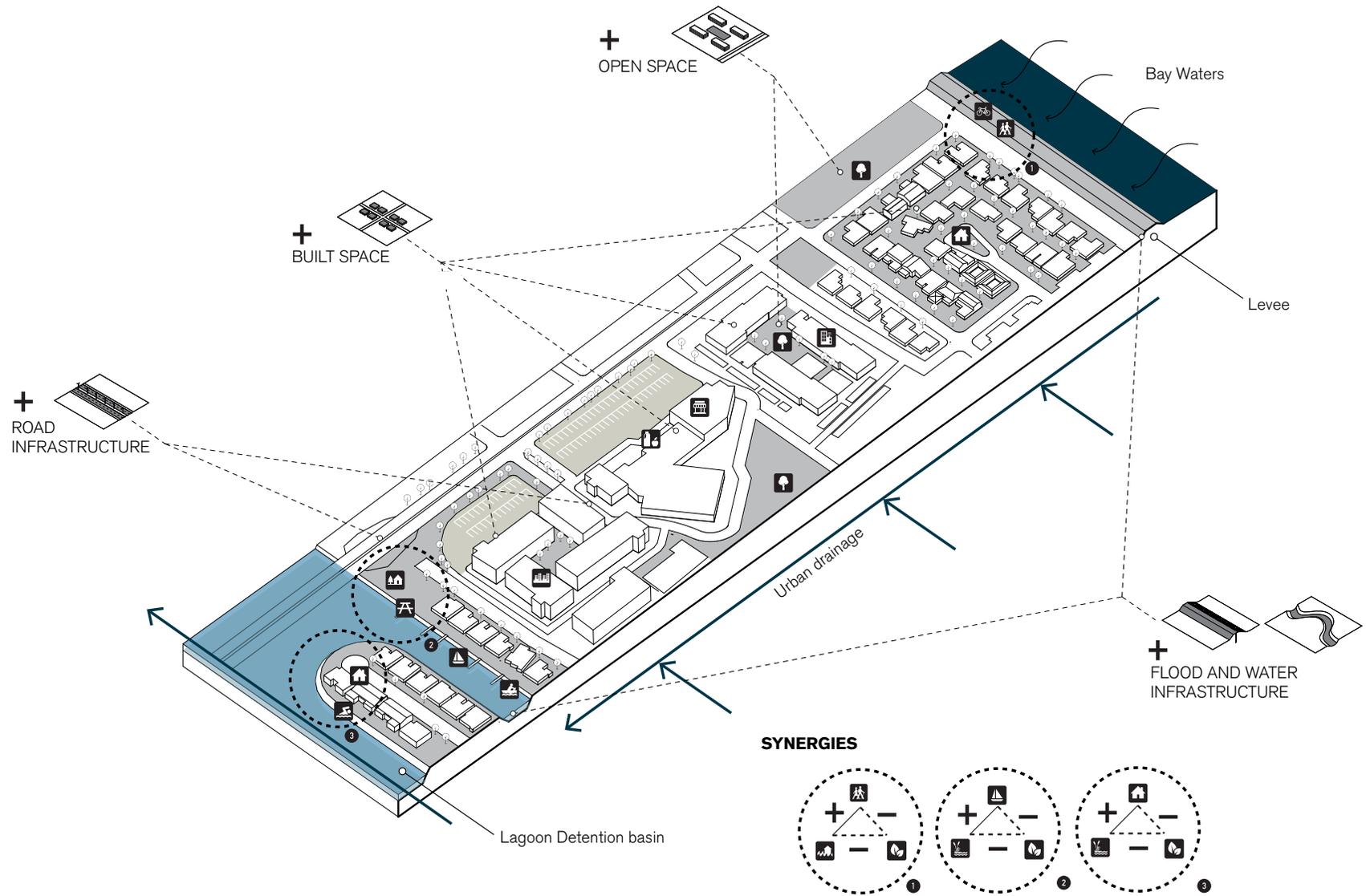Water infrastructure
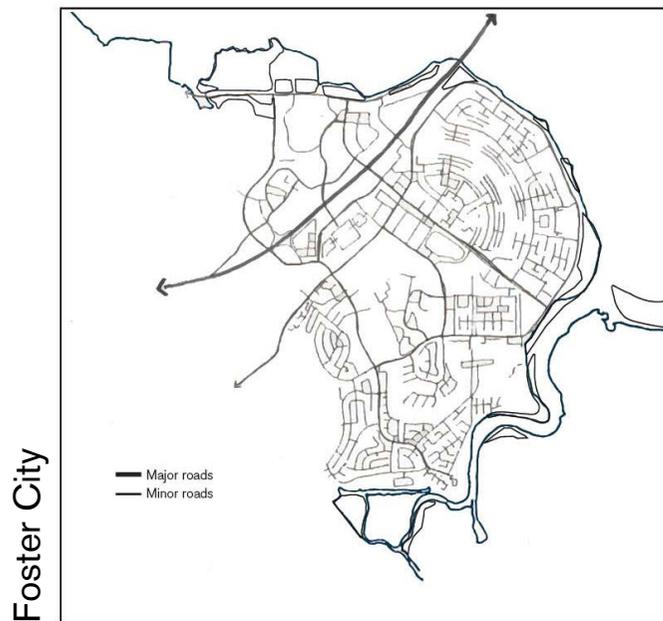
Foster City

Mobility infrastructure
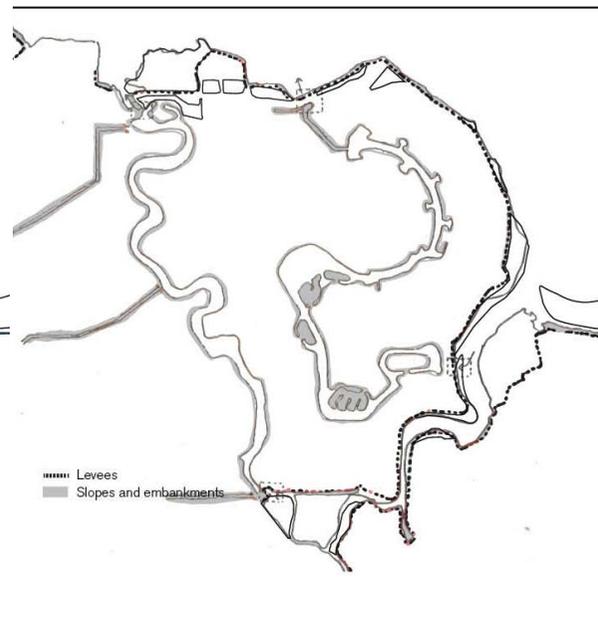
Levees and flood control

Subsurface

Legend (Built space):
- Single Family Housing
- Multi Family Housing
- Condomonium housing
- Commercial an Urban facilities
- Light Industries

Legend (Open space):
- Private vacant plots and parks
- Marsh land

Legend (Water infrastructure):
- Surface water (Lagoon)
- Urban drainage pattern and flow direction
- Nano drainage catchments
- Water control structure

Legend (Mobility infrastructure):
- Major roads
- Minor roads

Legend (Levees and flood control):
- Levees
- Slopes and embankments

Legend (Subsurface):
- Bay fill
- Sub- merged creeks and sloughs

Synthesis - East Palo Alto

OPEN SPACE

BUILT SPACE

ROAD INFRASTRUCTURE

Bay Waters

Levee

Urban drainage

FLOOD AND WATER INFRASTRUCTURE

SYNERGIES

+ OPEN SPACE

+ BUILT SPACE

+ ROAD INFRASTRUCTURE

+ FLOOD AND WATER INFRASTRUCTURE

Bay Waters

Levee

Urban drainage

Lagoon Detention basin

SYNERGIES

Socio spatial structure

East Palo Alto

Foster city

| Street character | Importance to public space and open water | Access to bay edge |

Car oriented community

Walkability

Social structure

East Palo Alto

Foster city

Demographic character

Cultural landscape adding existing quality

East Palo Alto

Foster city

Comparision narrative - Understanding the differences in spatial quality

In terms of system evaluation - Foster City

SOCIAL

Diversity and access to infrastructure

Open spaces and recreation

Protection against floods

ecological conservation

Spatial quality

Water sensitivity

ECOLOGICAL

Strong synergy

Weak synergy
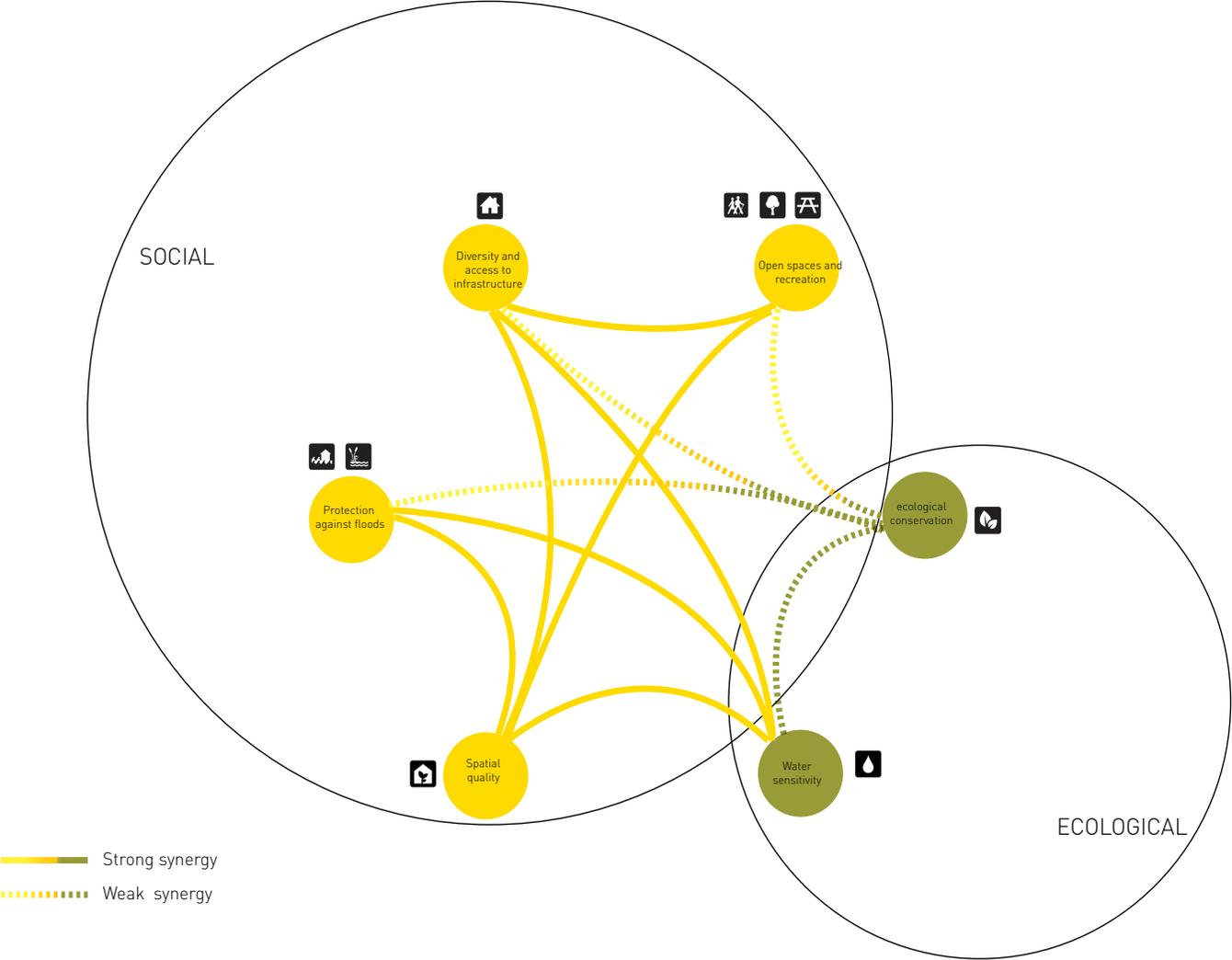
Week ecological sensitivity but good livability aspect

In terms of system evaluation - East Palo Alto

SOCIAL

Diversity and access to infrastructure

Open spaces and recreation

Protection against floods

Spatial quality

ecological conservation

Water sensitivity

ECOLOGICAL

Strong synergy

Weak synergy

Strong ecological sensitivity but week flood protection and livability aspect
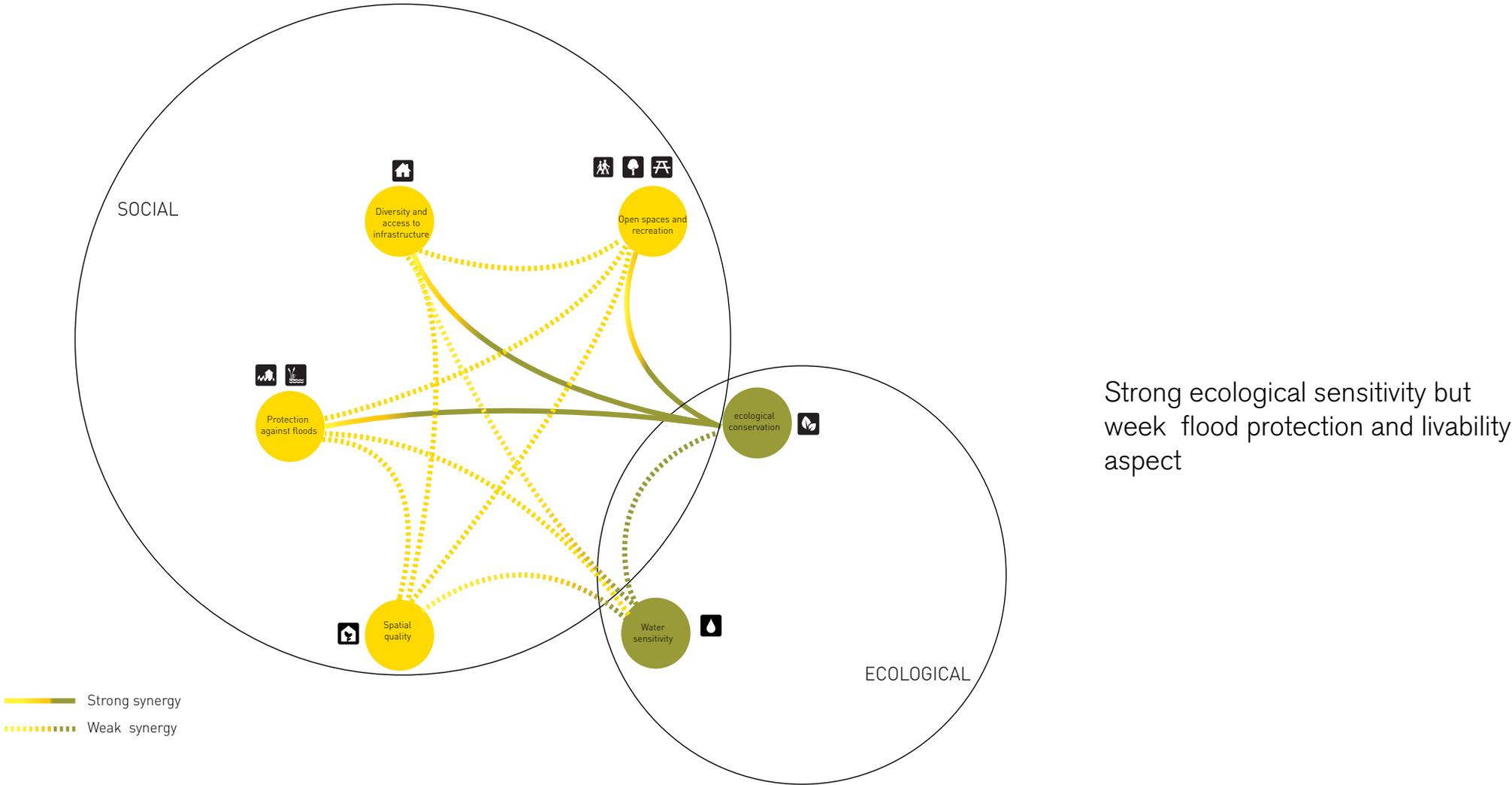
Comparing values

Process of learning from each other

FOSTER CITY

EAST PALO ALTO

Improve living quality for communities

SOCIAL

Add Bio-diversity and ecological Value

ECOLOGICAL

New developmets and sustained growth

EONOMICAL
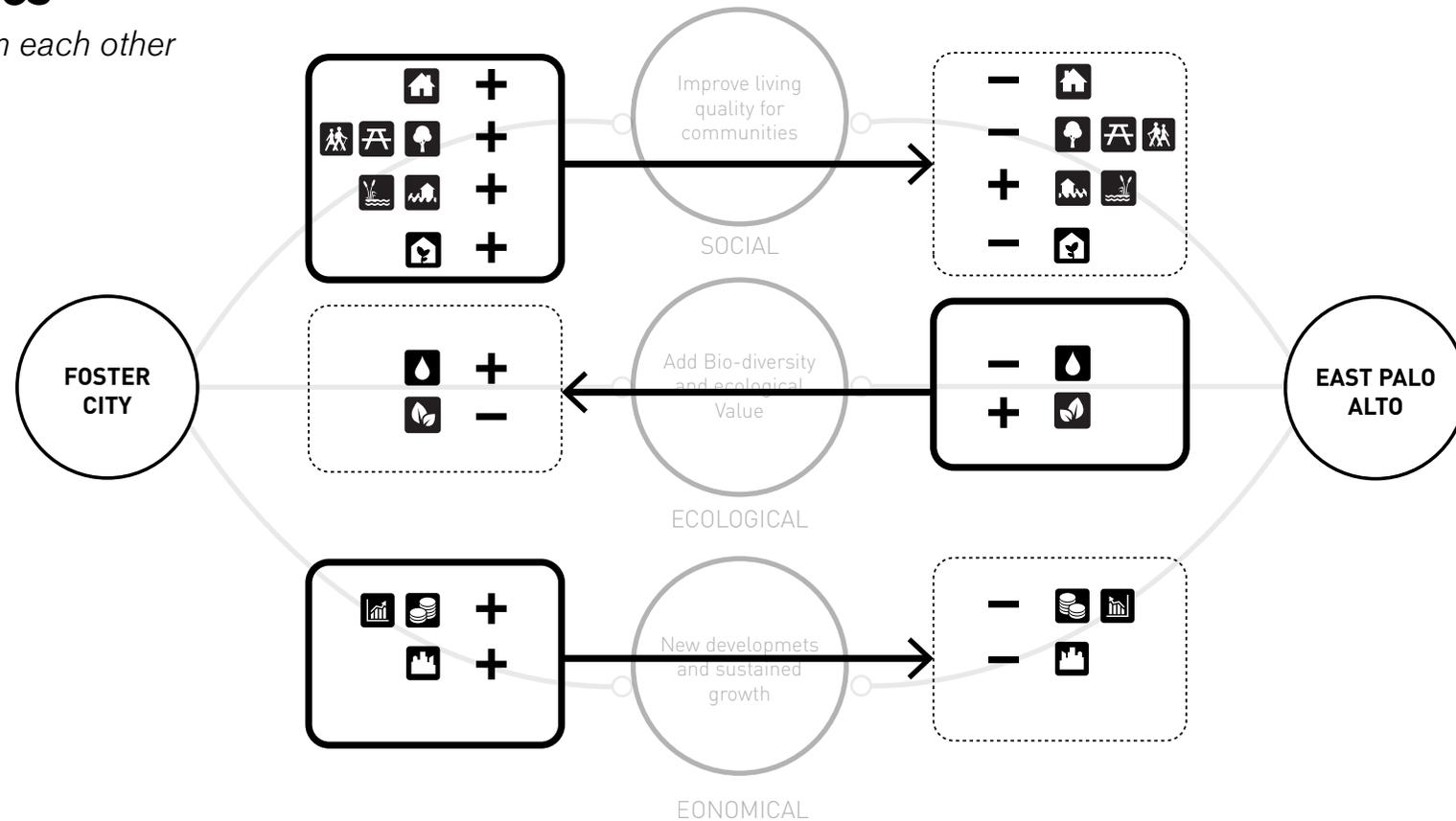
Designing for future uncertanities in both cases

Design narrative - Comparitive values + Historic identity + Adaptation design principles

Vision for adaptation

Social

Ecology

Economy

Nature based infrastructure - building multiple hazard reduction layers
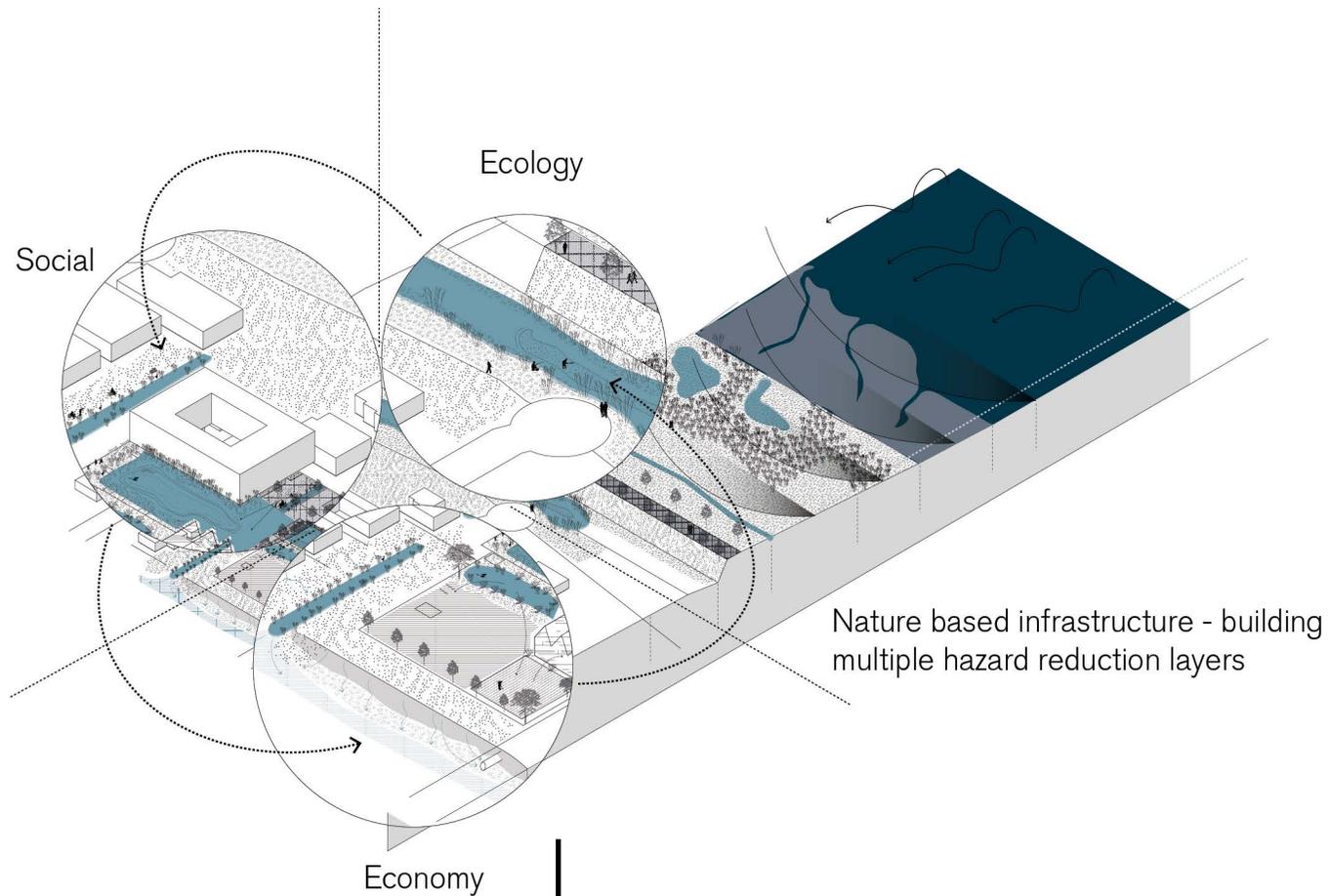
East Palo Alto

Revitalize the past agriculture identity of East Palo Alto

Foster City

To induce natural processes by introducing more informal land- water gradients.

Operationalizing vision in the context of East Palo Alto

Area under high vulnerability
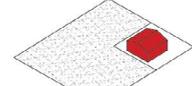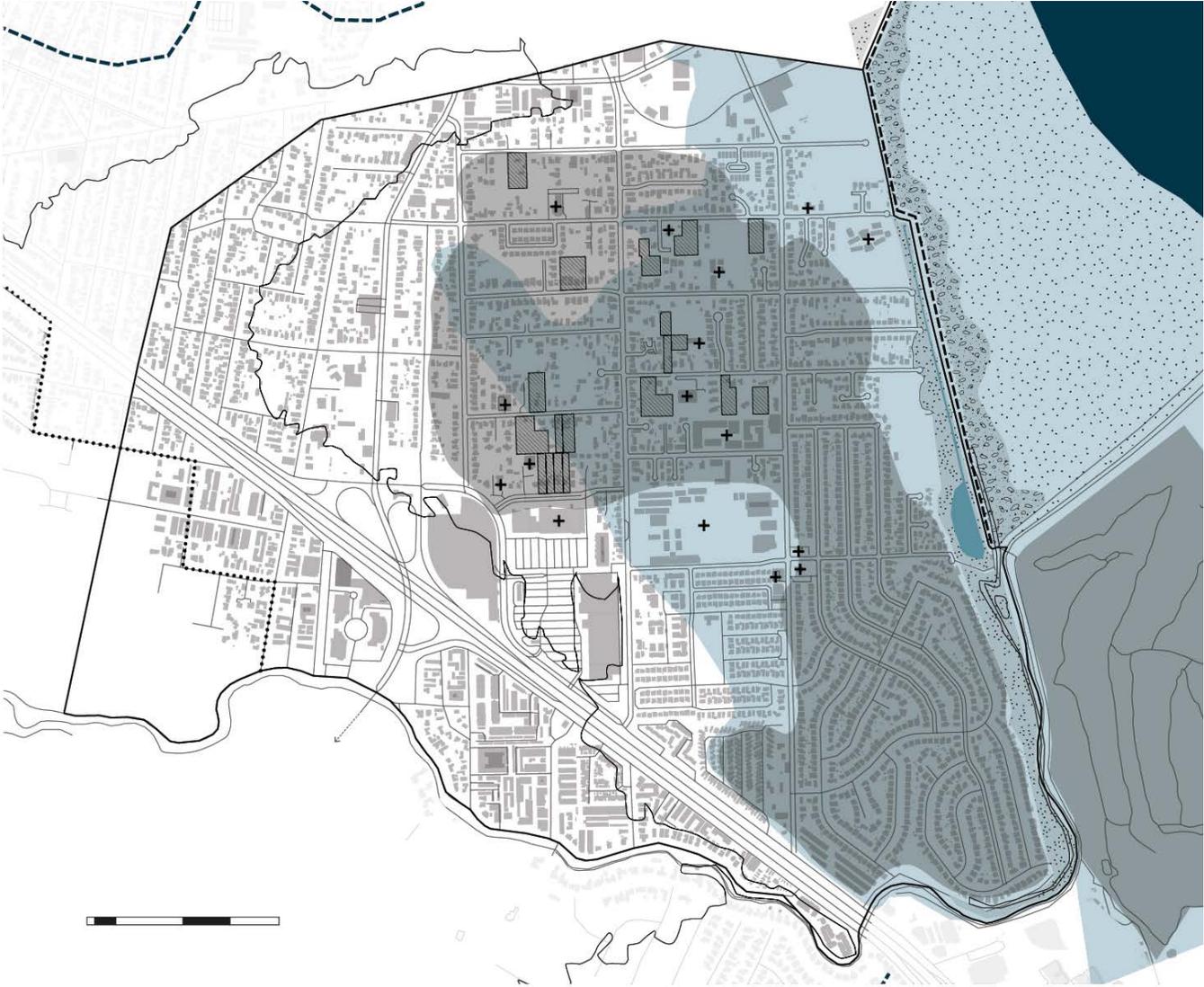
Agriculture plots
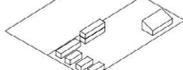
Underutilised open plots - mostly informal car parks
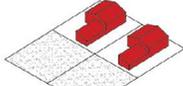
Farmstead houses
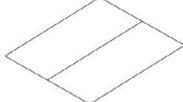
Underdeveloped open plots

Important urban function and low income vulnerability

Vision - East Palo Alto

Public open space
Water storage infrastructure
Vacant plots identified for infill development
Urban agriculture land
New infill development with water storage
Urban nodes with shared facilities
Riparian vegetation/ brackish marsh
Fresh water/ brackish marsh
Northern coastal Salt marsh
Inundation due to 1.5 m of SLR

Urban Block scale transformation - East Palo Alto

Urban 'In-fill development combined with agriculture economy and slow mobility

New urban infill that host several new functions

New streets with water management strategies integrated into them

Storage facilities in farms

Bio- swales on streets

New blocks integrated with water management
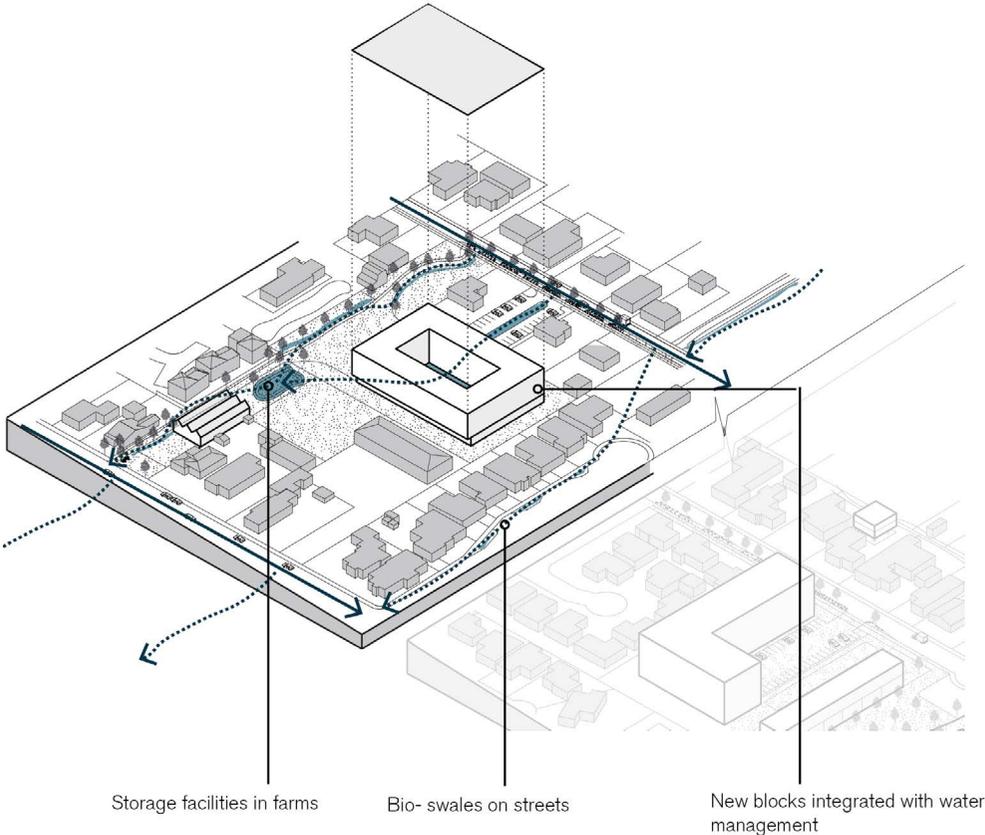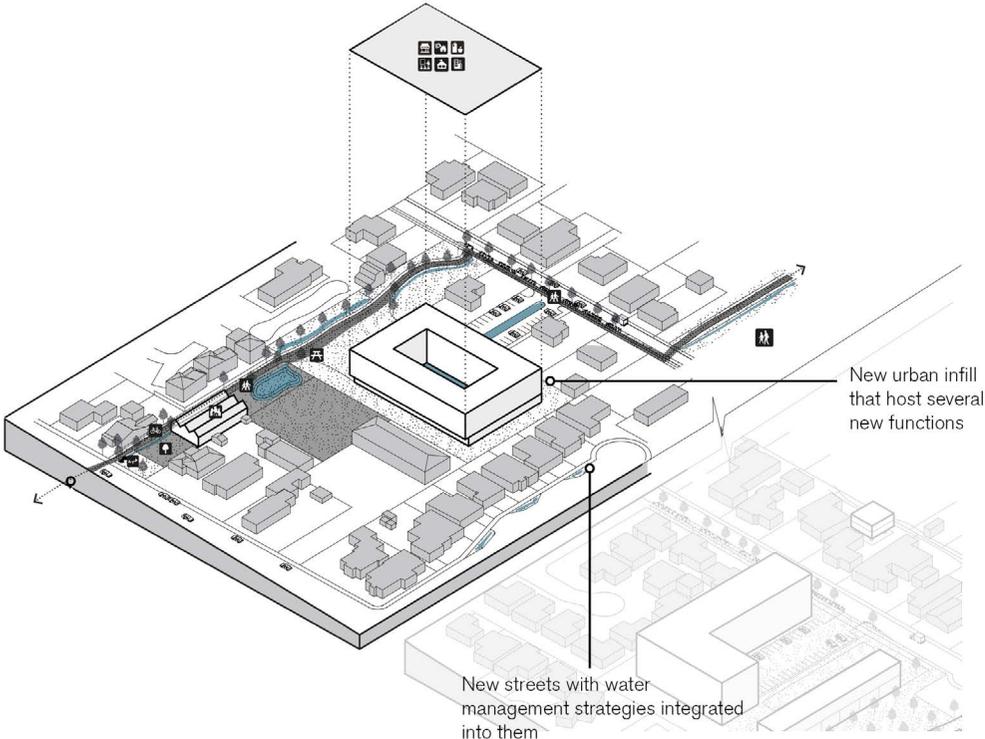
Urban Block scale transformation - Edge blocks

Vacant plots towards the edge integrated with wetland park and enhanced levee system

Large plots with open spaces are allowed to densify with new elevated structures

Fresh water detention pond regenerated into marshland
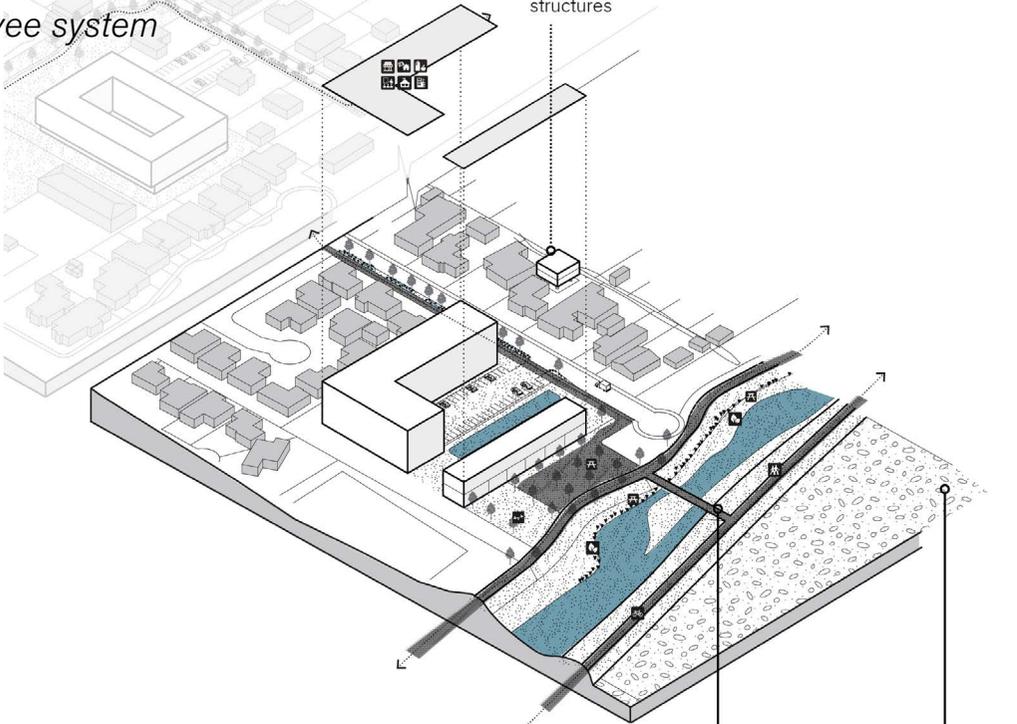
New program that is integrated with the Wetland function

Northern coastal Salt marsh
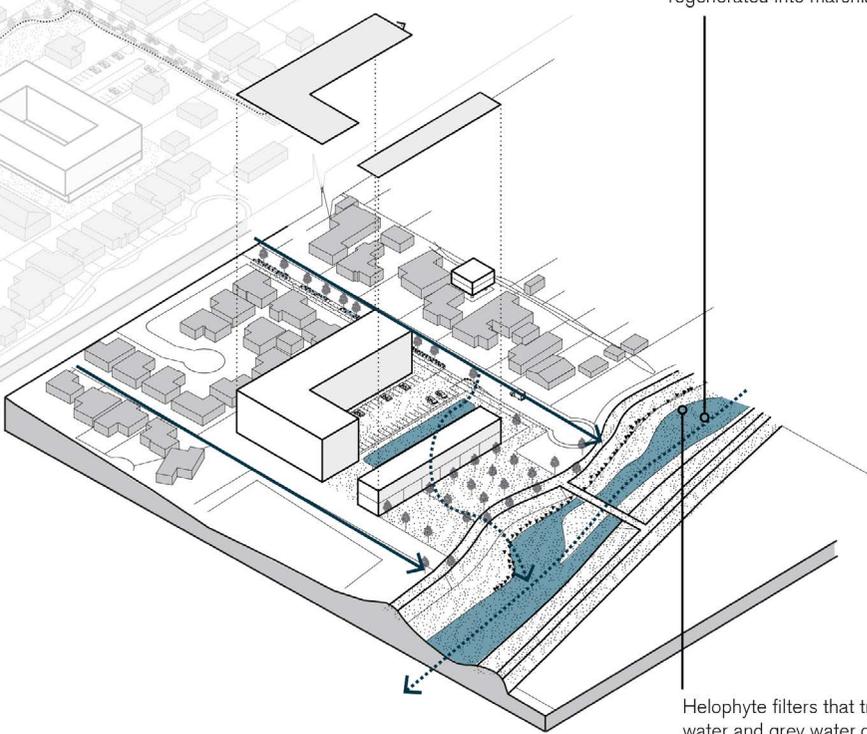
Helophyte filters that treat Storm water and grey water during dry season
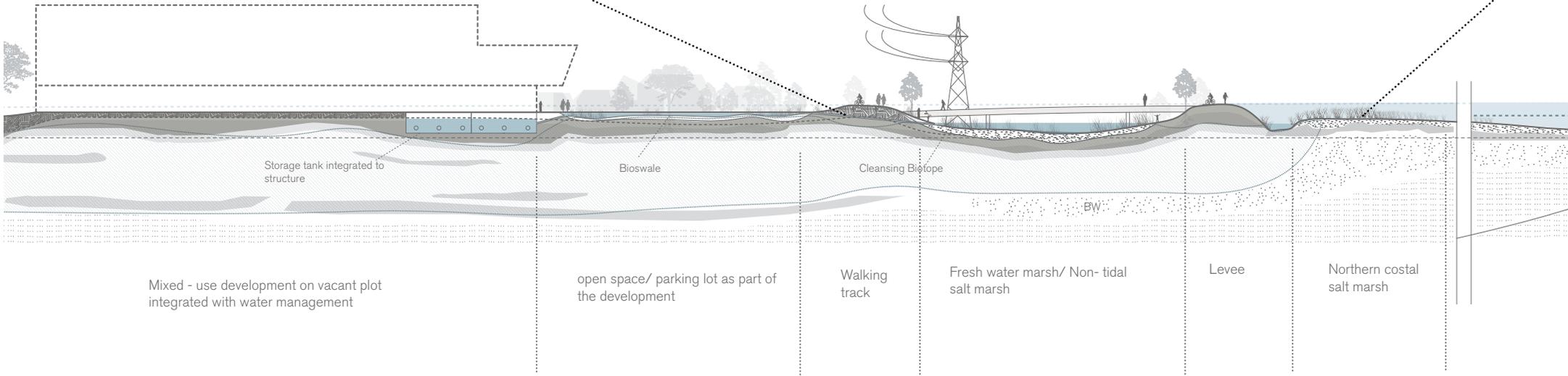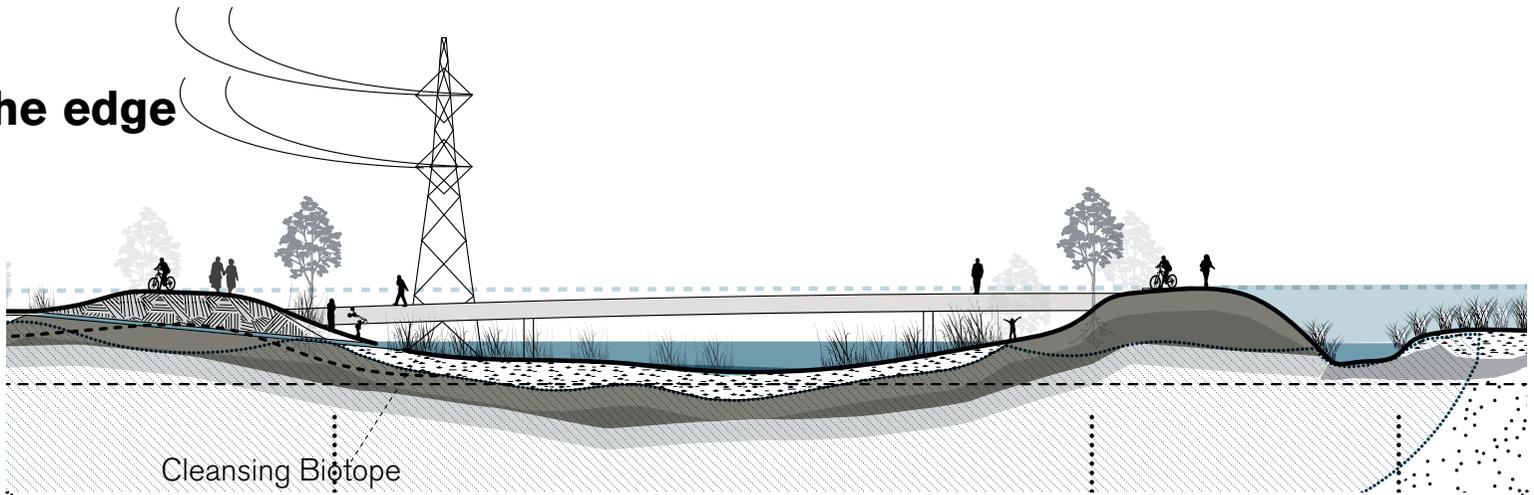
New slow mobility connections

Parks and play ground
Vacant plots
Important community facilities (Schools, church play a
Agriculture plots

Exisitng seperated sewer lines
Direction of flow (Drainage slope)

0   500
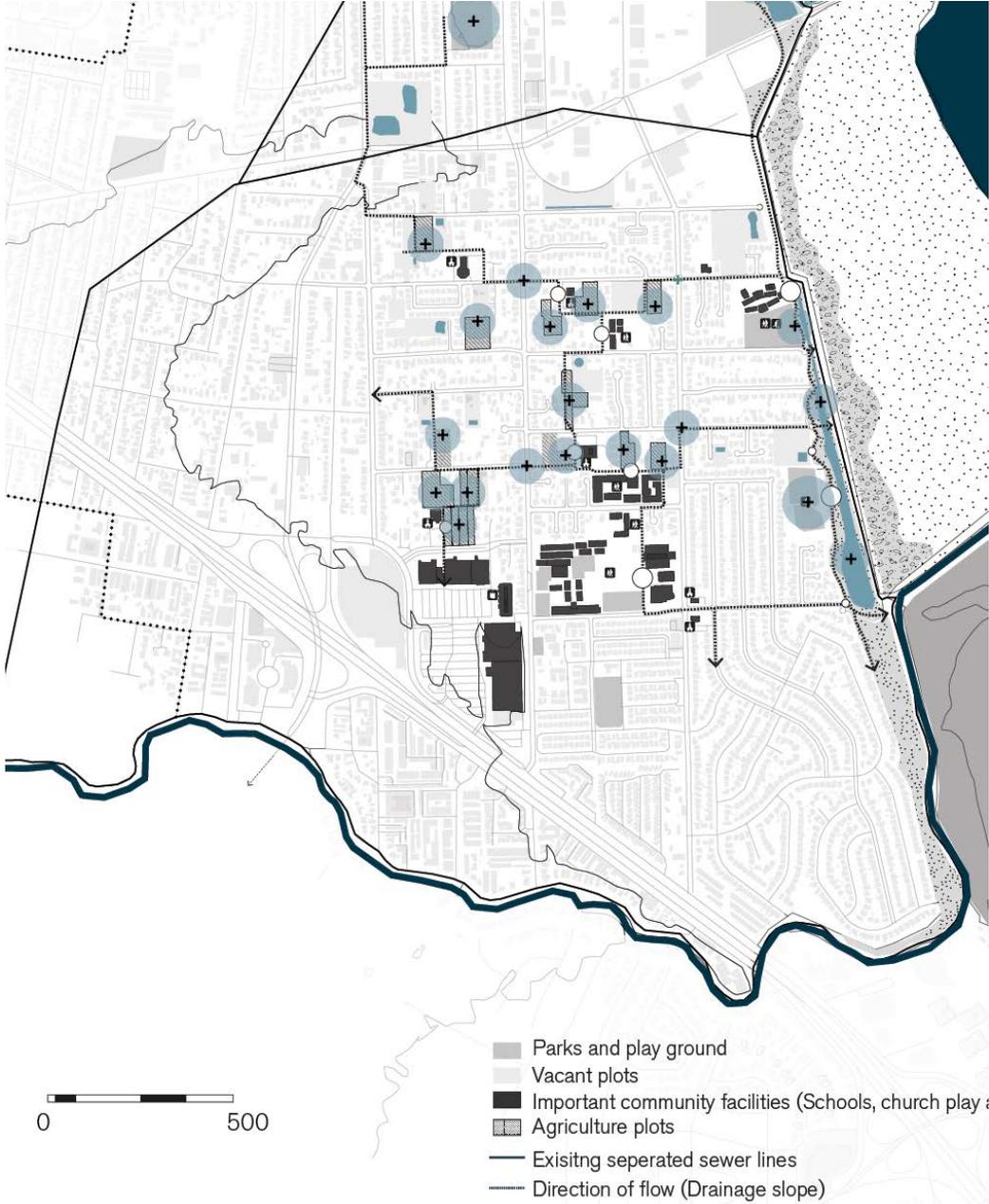
Operational section- inner city block
New Block water management

Storage tank integrated to structure

Bioswale

Cleansing Biotope

Bioswale on streets

Silt and Clay (Alluvium)

Unconfined aquifer

Bay mud

Confined aquifer

Bioswale

bio-retention swale and water storage tank for farming

Storage tank integrated to structure

Bioswale

Cleansing Biotope

Bioswale on streets

street

Play ground \ Farm

Walking track

Farm

Mixed - use development on vacant plot integrated with water management

open space/ parking lot as part of the development

street

Exisiting development

4

0

Operational sections - at the edge of the bay East Palo Alto

Utilizing potential of freh watre marsh and buffer to build recreation and spatial quality

Cleansing Biotope

Storage tank integrated to structure

Bioswale

Cleansing Biotope

BW

Mixed - use development on vacant plot integrated with water management

open space/ parking lot as part of the development

Walking track

Fresh water marsh/ Non- tidal salt marsh

Levee

Northern costal salt marsh

Operationalizing vision in the context of Foster City

Utilizing natural elements to build resilience

Legend:
- Tidal Flat
- Introduction of dredge to build ecotone slopes
- Exisitng 1970 single family housing
- Hard bay edge (rip rap)
- Soft edge (shell deposit on shore)

0   500

Mobility infrastructure

- Major roads
- Minor roads

Open space

- Private vacant plots and parks
- Marsh land

Water infrastructure

- Surface water (Lagoon)
- Urban drainage pattern and flow direction
- Nano drainage catchments
- Water control structure

Infrastructure system

+

Vision - Foster City
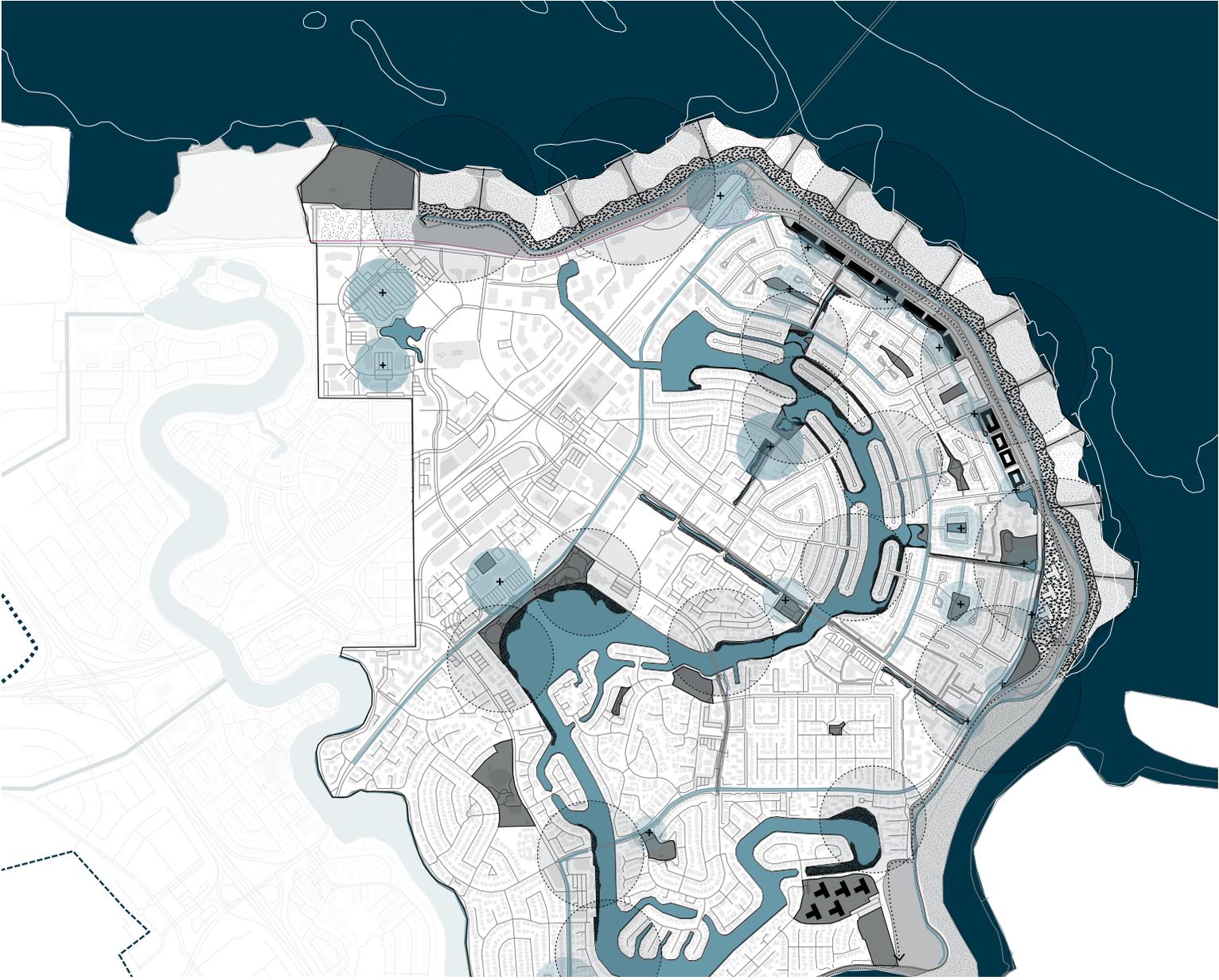
Urban Block scale transformation - Edge blocks

Building a new levee network that enhances ecology and robust structures
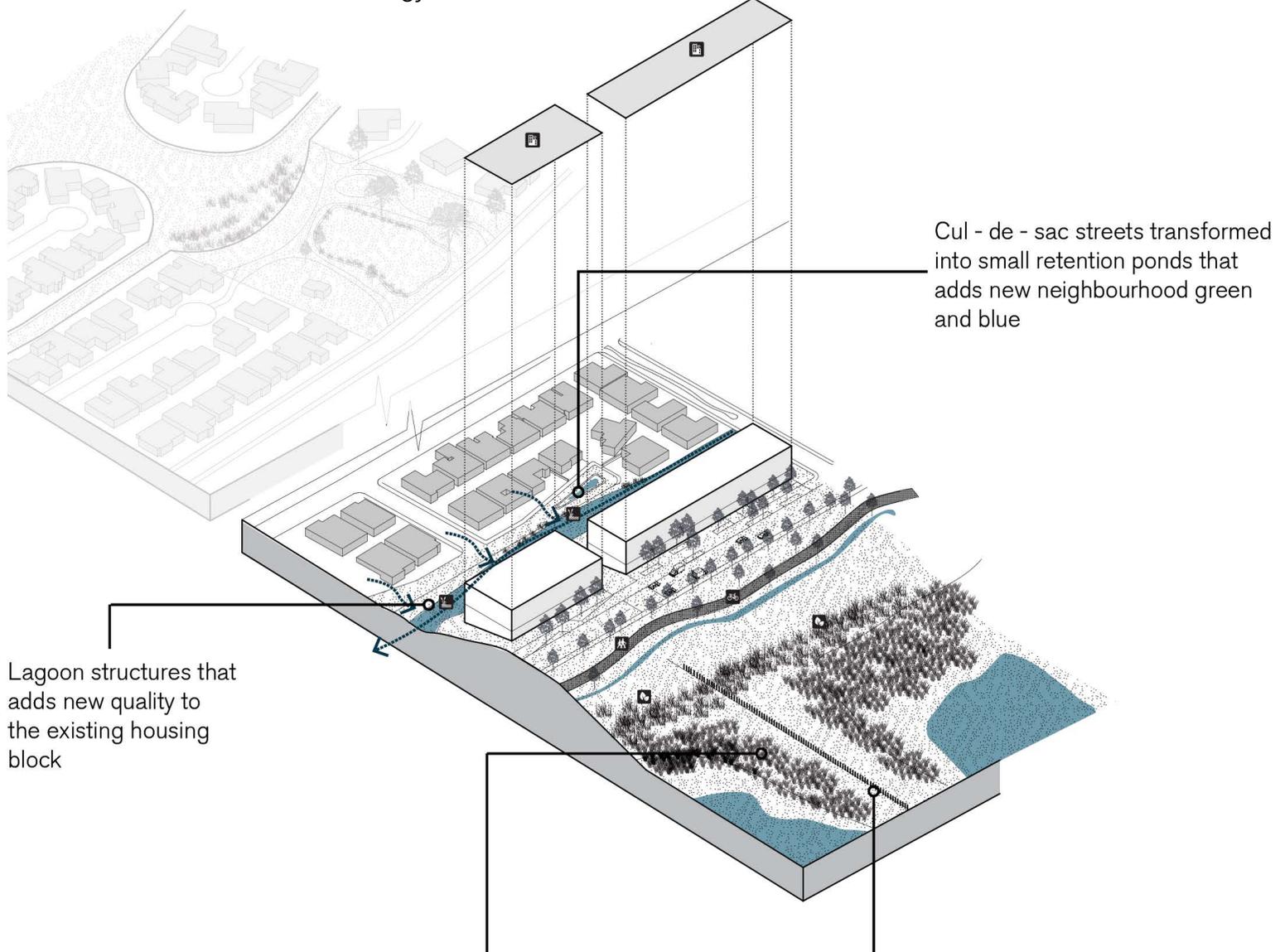
Cul - de - sac streets transformed into small retention ponds that adds new neighbourhood green and blue

Lagoon structures that adds new quality to the existing housing block

Breakwaters trap sediments that helps to build levee and encourages regrowth of marsh

Regrowth of marshland also new cultural value and recreation towards its communities.

Urban block scale transformation- Lagoon

Naturalizing embankement of Lagoon , adding new water retention along open spaces at the edge
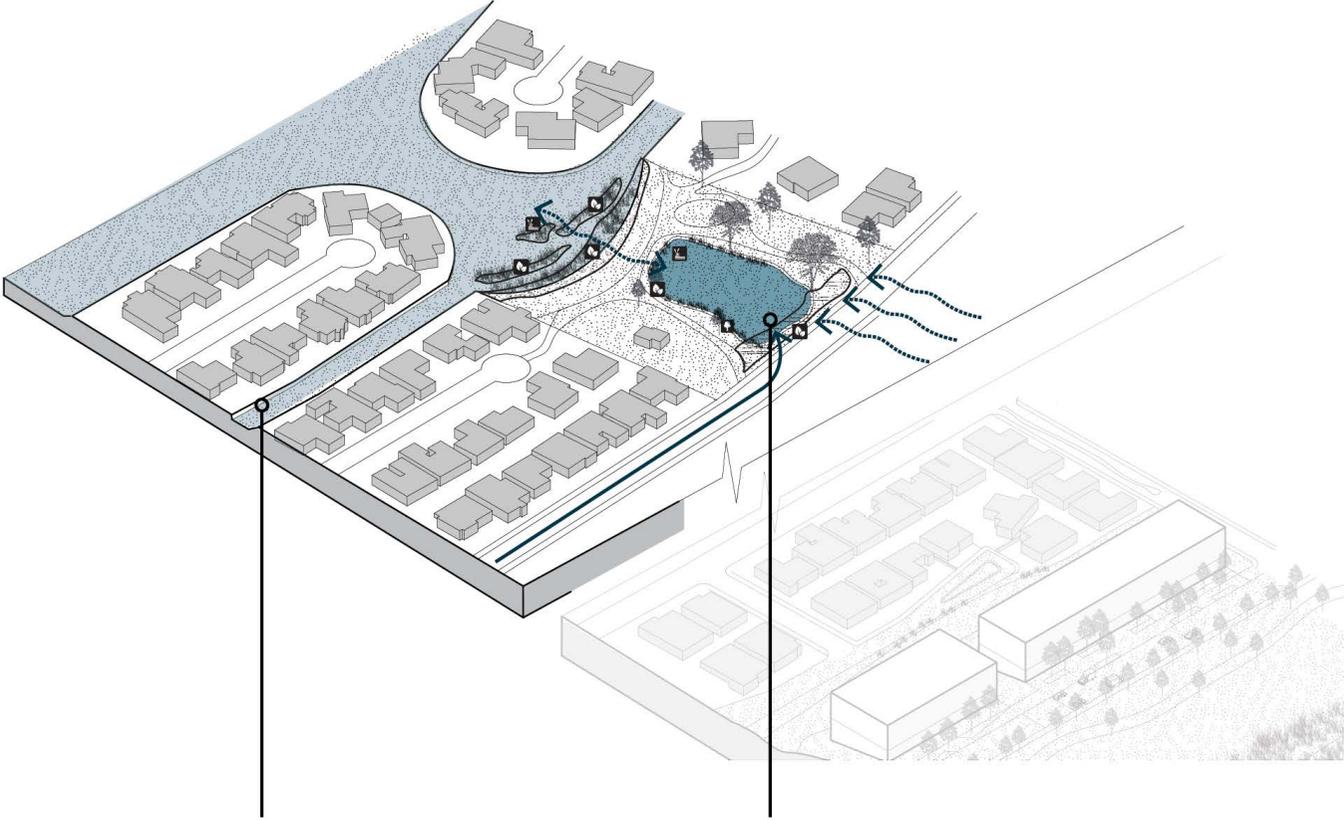
Natural embankments adds ecological quality and natural water filtration

Water from inland urban areas can be detained in pond for filtration and let into the lagoon. These detention areas add increased capacity and allow natural process to occur
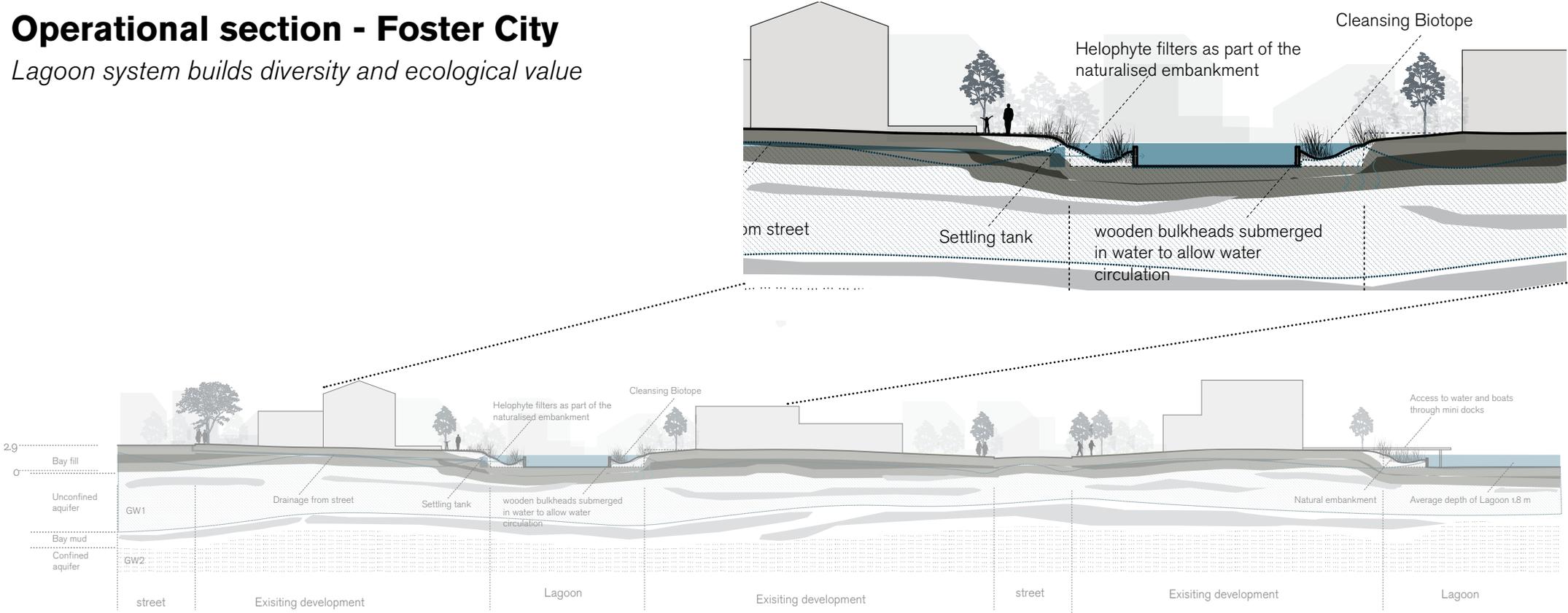
Operational section - Foster City
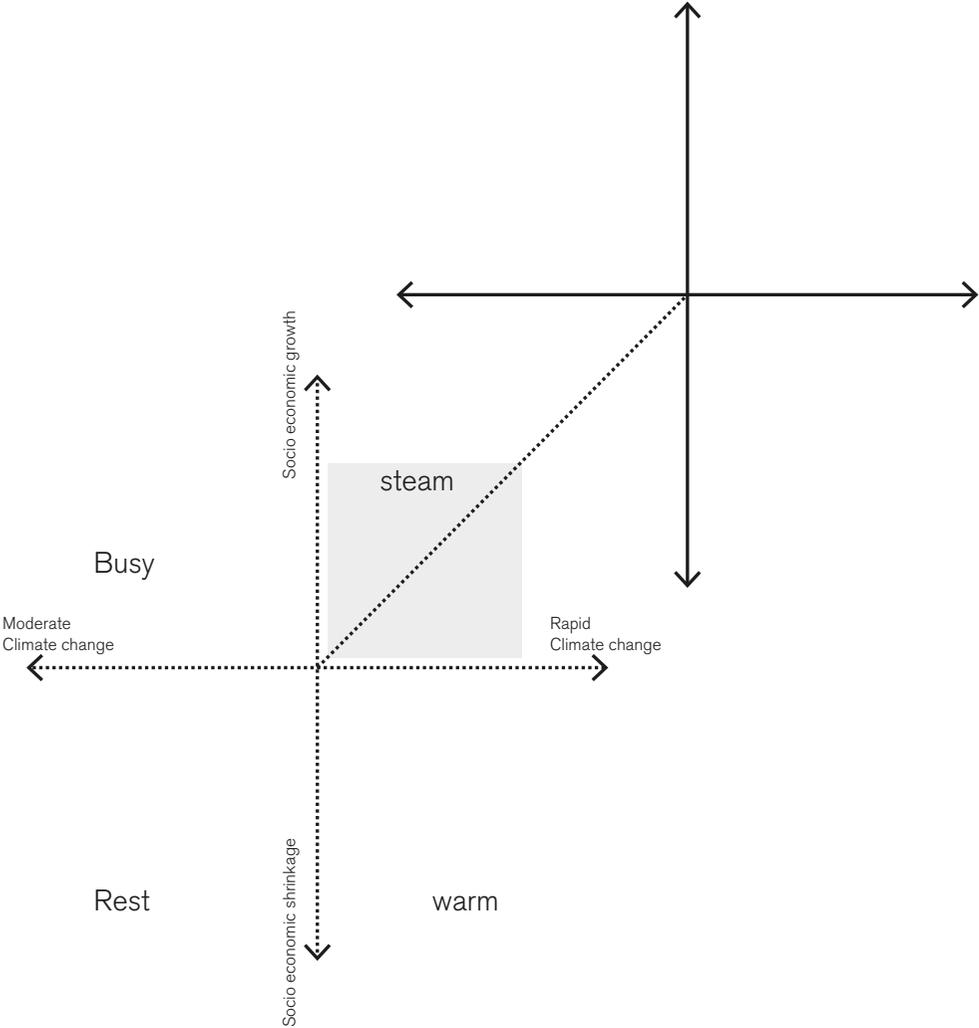
Adding new destination to the edge with ecological functions
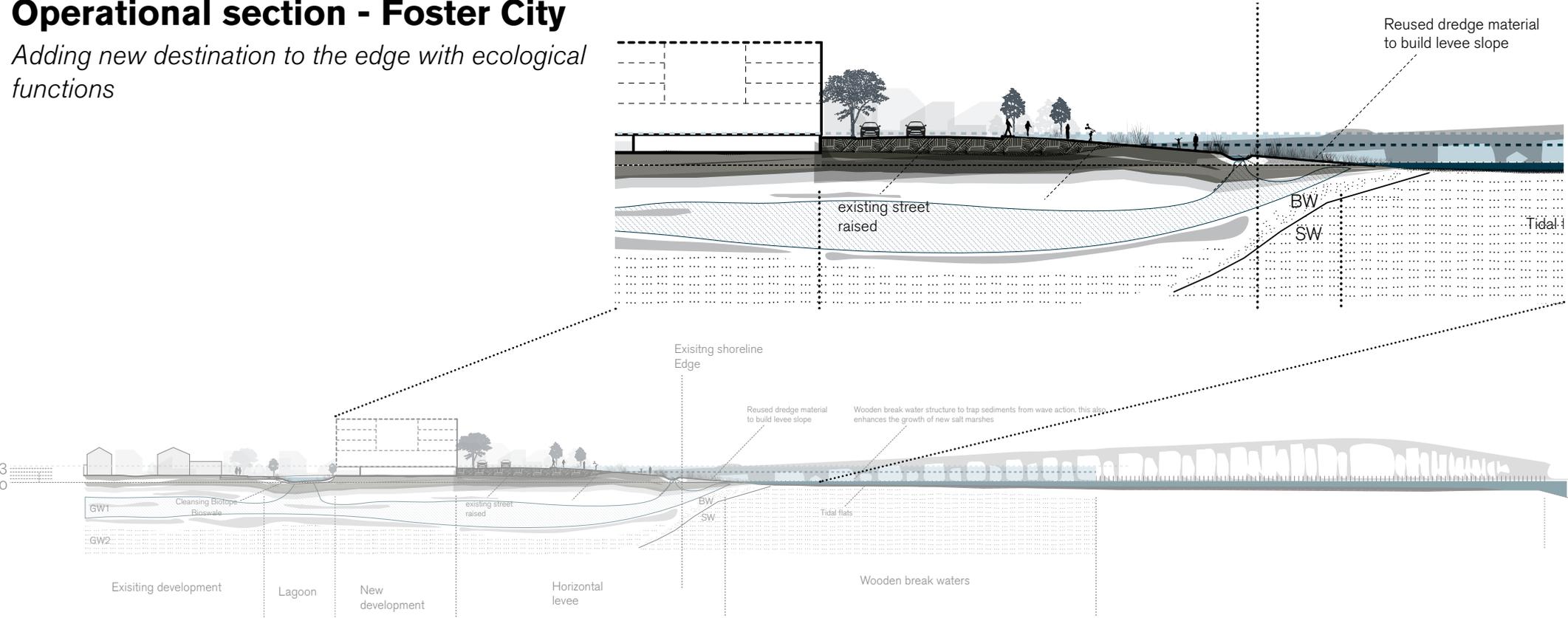
Operational section - Foster City
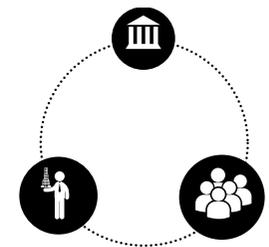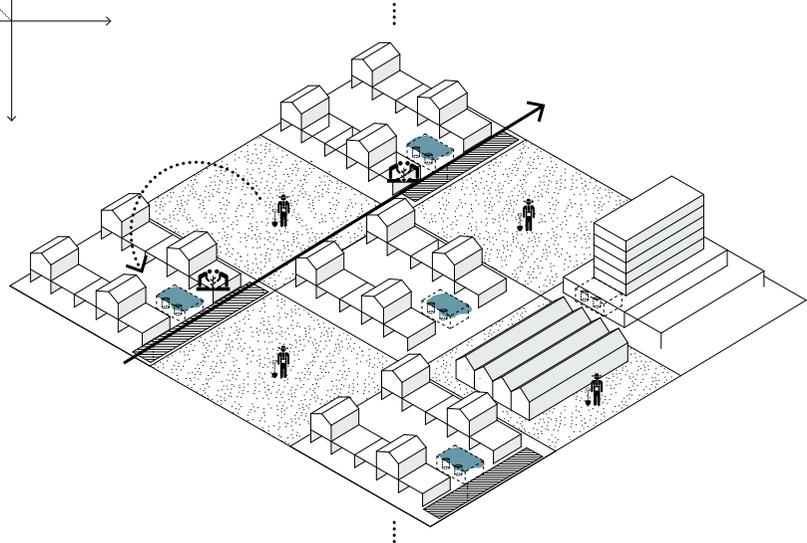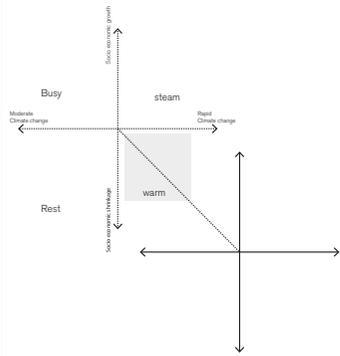*Lagoon system builds diversity and ecological value*

Cleansing Biotope

Helophyte filters as part of the
naturalised embankment

...om street

Settling tank

wooden bulkheads submerged
in water to allow water
circulation

Helophyte filters as part of the
naturalised embankment

Cleansing Biotope

Access to water and boats
through mini docks

2.9

Bay fill

0

Unconfined
aquifer

GW1

Bay mud

Confined
aquifer

GW2

Drainage from street

Settling tank

wooden bulkheads submerged
in water to allow water
circulation

Natural embankment

Average depth of Lagoon 1.8 m

street

Exisiting development

Lagoon

Exisiting development

street

Exisiting development

Lagoon

scenario study

Designing for uncertainity

steam

Socio economic growth

Busy

Moderate
Climate change

Rapid
Climate change

Socio economic shrinkage

Rest

warm

WARM scenario

City Council   Community   Farmers   Vacant plot owners

City Council   Community   Farmers   Vacant plot owners

Possible outcome

Block transformation of inner city

STEAM scenario

policy with new

| City Council | Community | Farmers | Vacant plot owners |

To encourage establishment of small scale tech industries that generate employment as well as support agriculture economy. Controlling land development with strict policies to risk

Generate employment and self sufficiency, build upon water quality and livability

Build diverse robust typologies that provides new living qualities and facilities.

| City Council | Community | Farmers | Vacant plot owners |

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Generate employment and self sufficiency, build upon water quality and livability

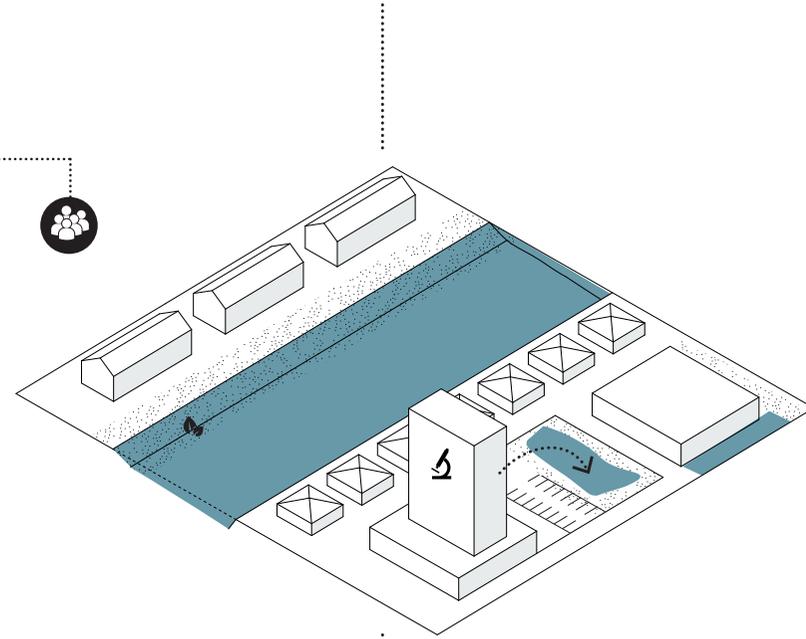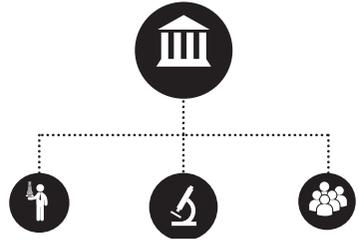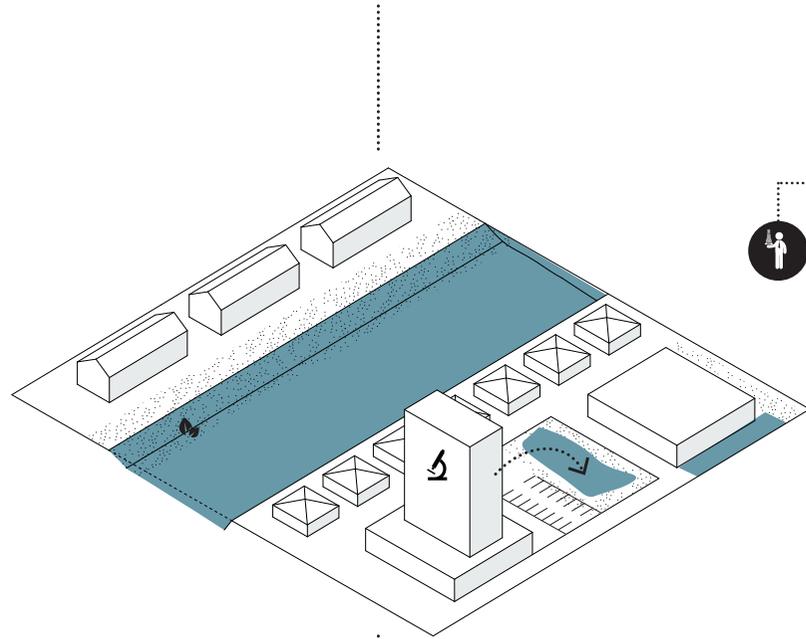Build diverse robust typologies that provides new living qualities and facilities.
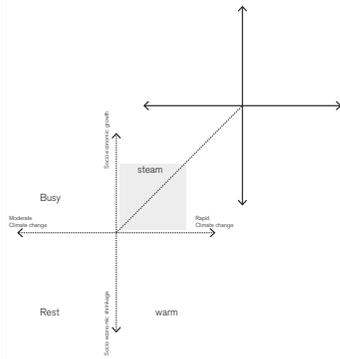
Possible outcome

Block transformation along the edge with wetland park

East Palo Alto

STEAM scenario

Foster City

steam

Busy

Rest   warm

Moderate
Climate change

Rapid
Climate change

| City Council | Community | Private real estste | Silicon valley companies |

| City Council | Community | Private real estste | Silicon valley companies |

Initiate building of natural embankments and restore water quality through natural processes

Improve water storage and living quality by embracing nature

To boost self sufficiency and re-use water for non - household purpose to reduce demand

Integrate high level protection and bring new quality to the edge

To respond to new natural conditions by expidating process and development

build and facilitate new robust typologies with mixed use to accomodate future demand in housing and employment
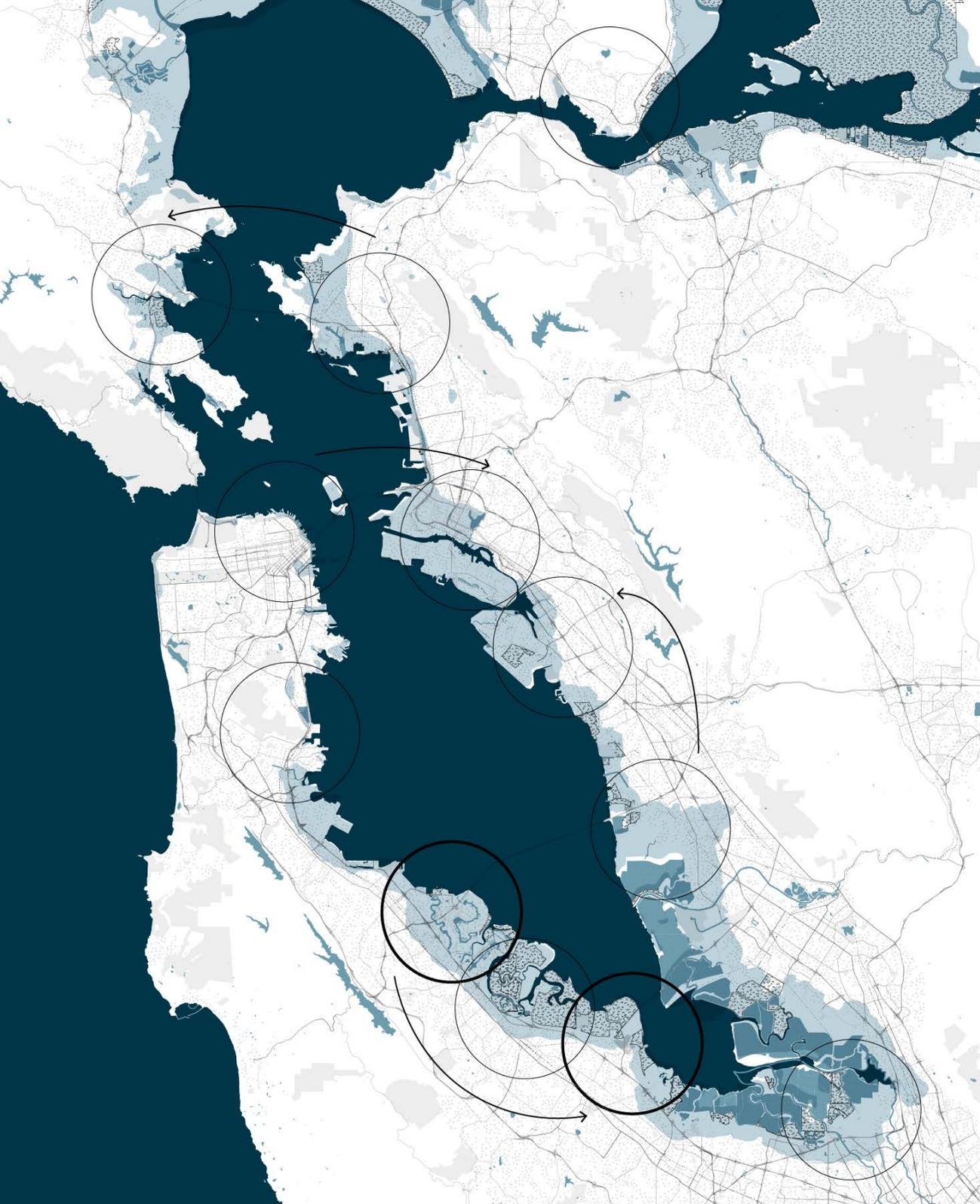
Possible outcome

Block transformation along the edge with new marsh land

Foster City

Possible outcome

Naturalizing embankments along Lagoon

Foster City

Towards building a
sustainable region system
from cross learning

Thank you for listining