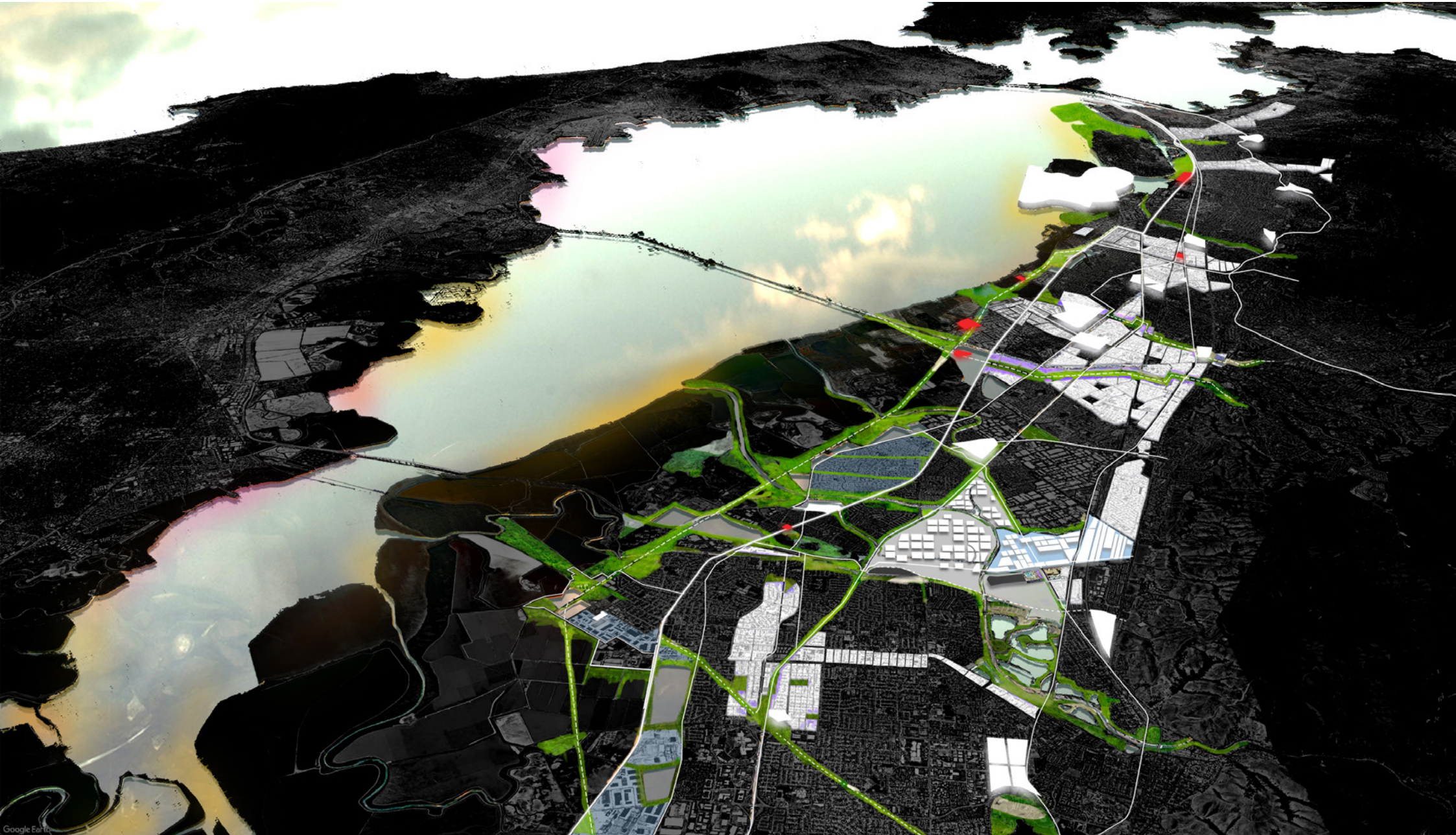
The Middle Ground

Spatial Planning Under Uncertainty

P5 Graduation Presentation : Supriya Krishnan / 4479572 : July 2017
(Mentors : Dr. ir.Taneha Kuzniecow Bacchin + Dr. ir. Egbert H. Stolk)
Delta Urbanism



Delta Interventions

Adaptation by Design : future of water landscapes
Risk and Landscape, Planning under undcertainties
Spatial Planning+Flood Risk management
Spatial response to a climate risk

2016-2017
San Francisco Bay
Resilience by Design
Designing for uncertain delta-landscape futures

In collaboration with/ joint Urban Design Studio
UC Berkeley College of Environmental Design

Delta Interventions
Graduation Studio
MS3 & MS4

Urbanism — Architecture — Landscape Architecture — Civil Engineering & Geosciences — Technology, Policy & Management

TU Delft, Department of Urbanism & Department of Architecture
Delta Urbanism Research Group

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Chair Environmental Technology & Design, TUD A+BE
Chair Complex Projects, TUD A+BE

Section Hydraulic Structures and Flood Risk, TUD CEG
Section Policy Analysis, TUD TPM
DIMI Delft Deltas, Infrastructure and Mobility Initiative, TUD

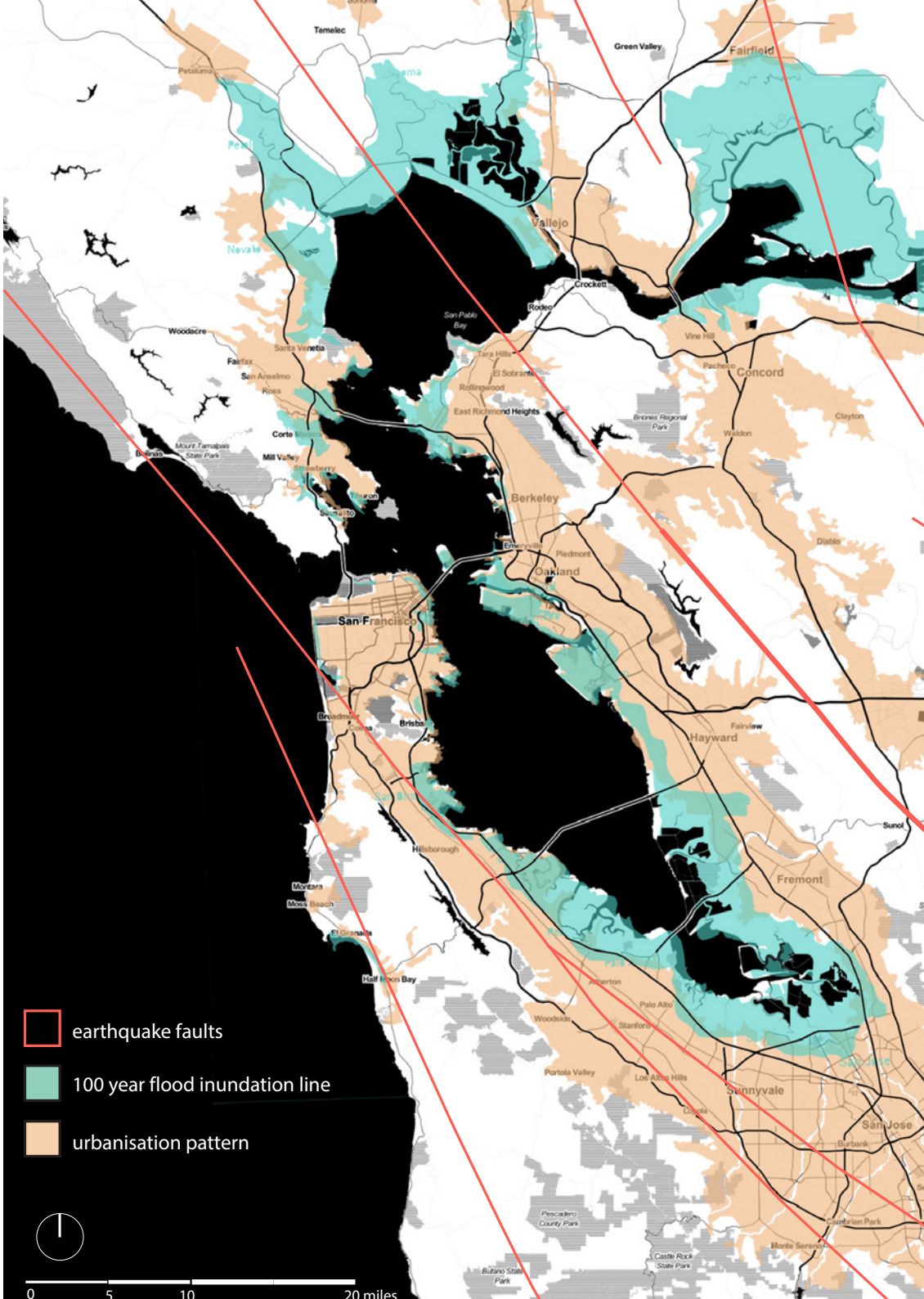
Delta Interventions

San Francisco Bay
Rapidly urbanising , technological pioneer

1.4 Meter Sea Level Rise scenario for 2100
High earthquake risk
SLR+EQ : Opportunity to co benefit

Multiple agencies at work to evaluate and plan
Lack of synergies

The redundant city v/s the efficient city
Resilience within a dense fabric
Socio economic disparity
Housing shortage
Insufficient Public Transport



Transformation

East Bay - San Franscisco

Spatial Coherence for Risk Reduction

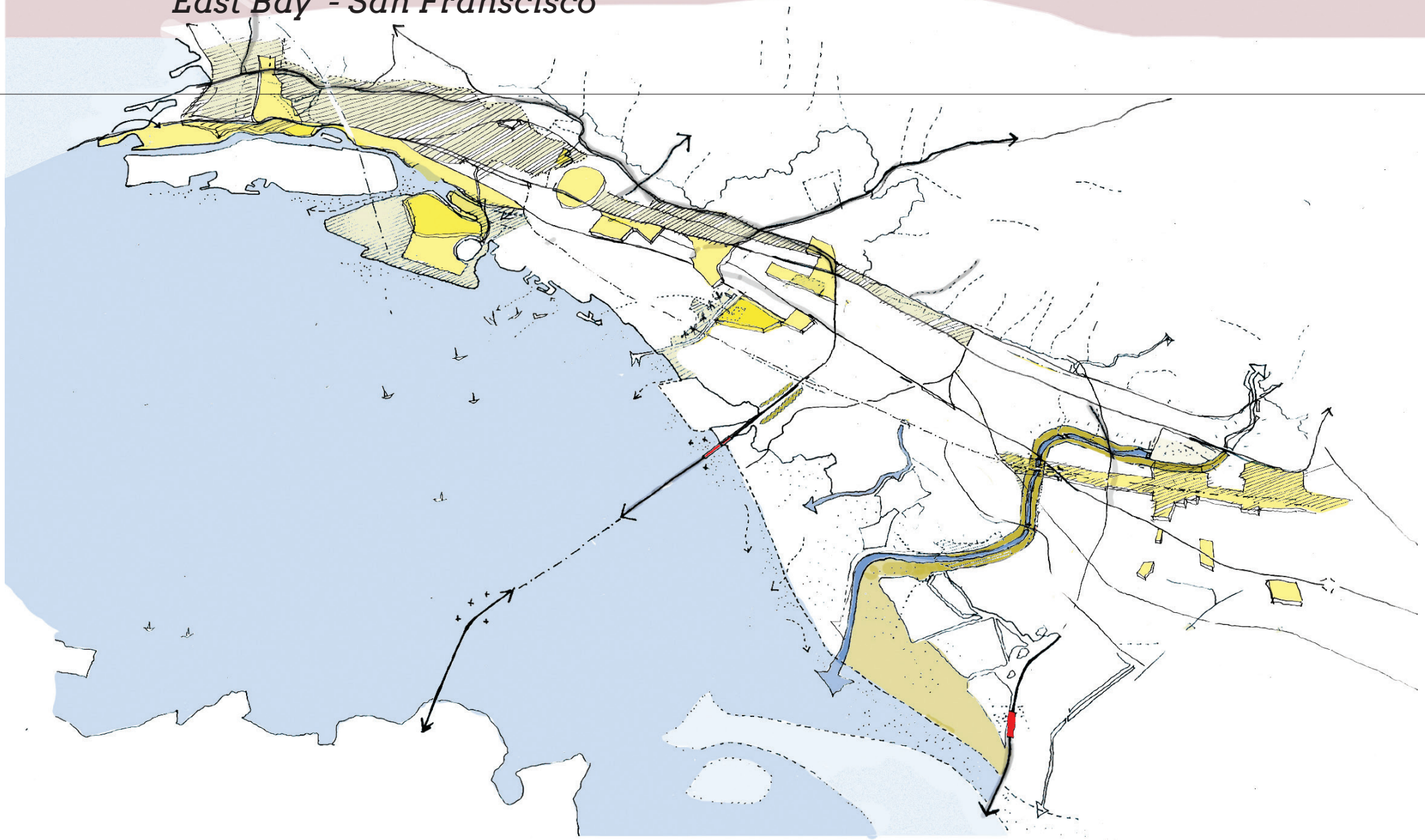
Keep the system alive to resist, respond and *grow with risks*

Reprogramming space to be long lasting in the face of hazard

Ideal spatial morphology and Suitability of Space to functions and risk

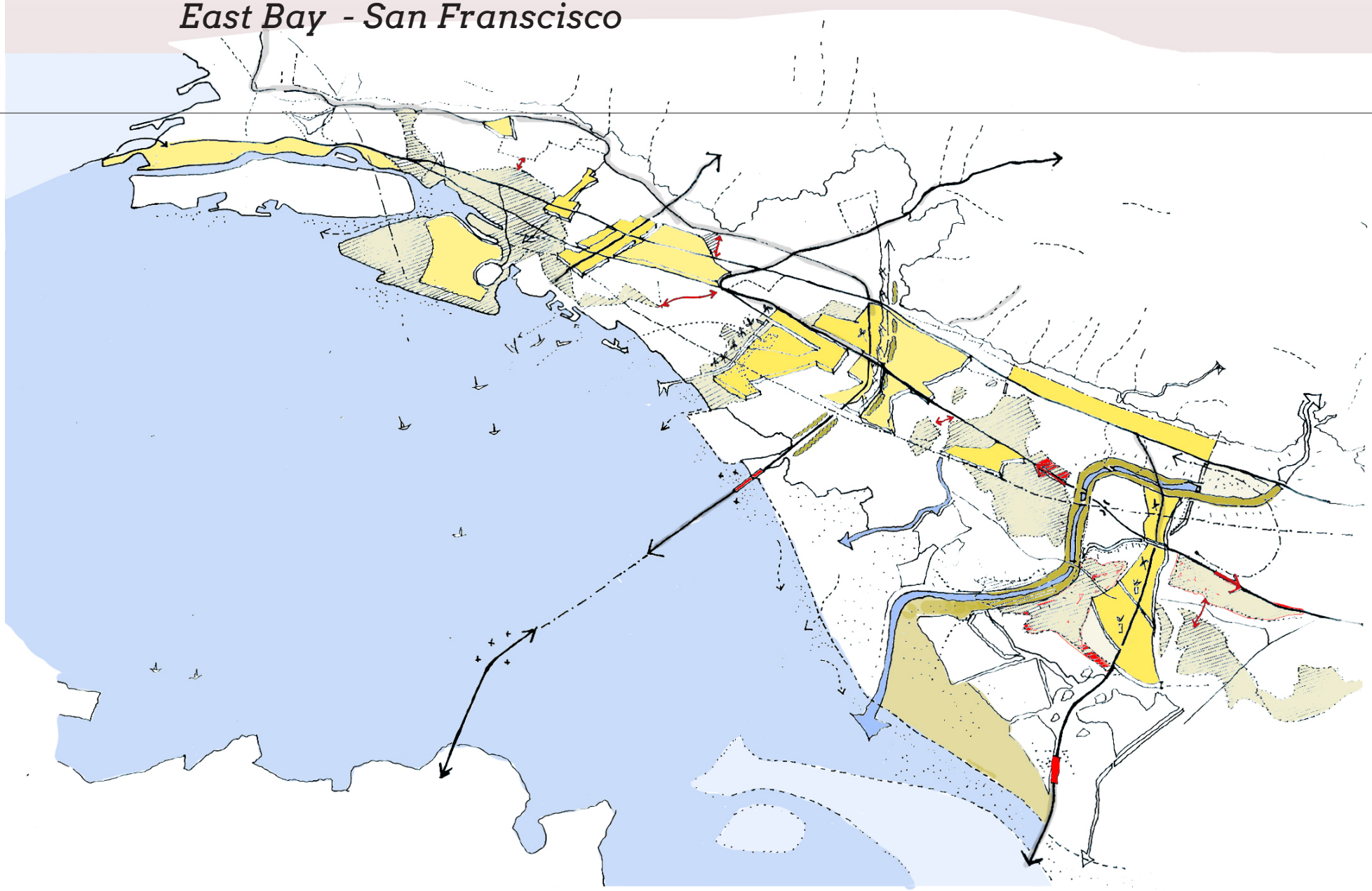
Transformation

East Bay - San Franscisco



Transformation

East Bay - San Franscisco

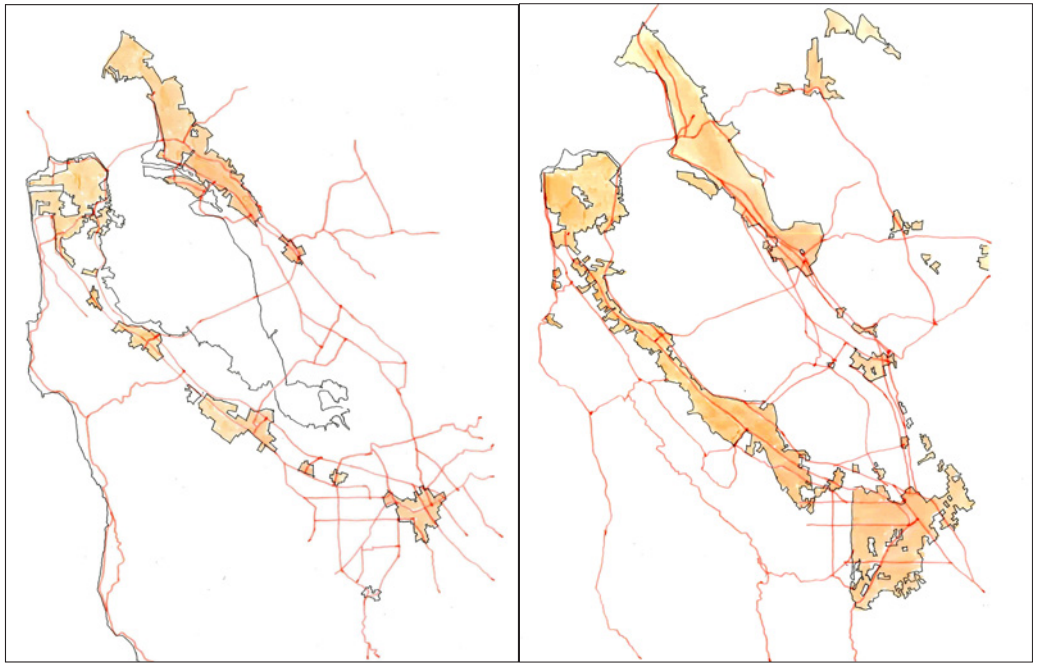


RISK

Systems approach ——— Design Thinking

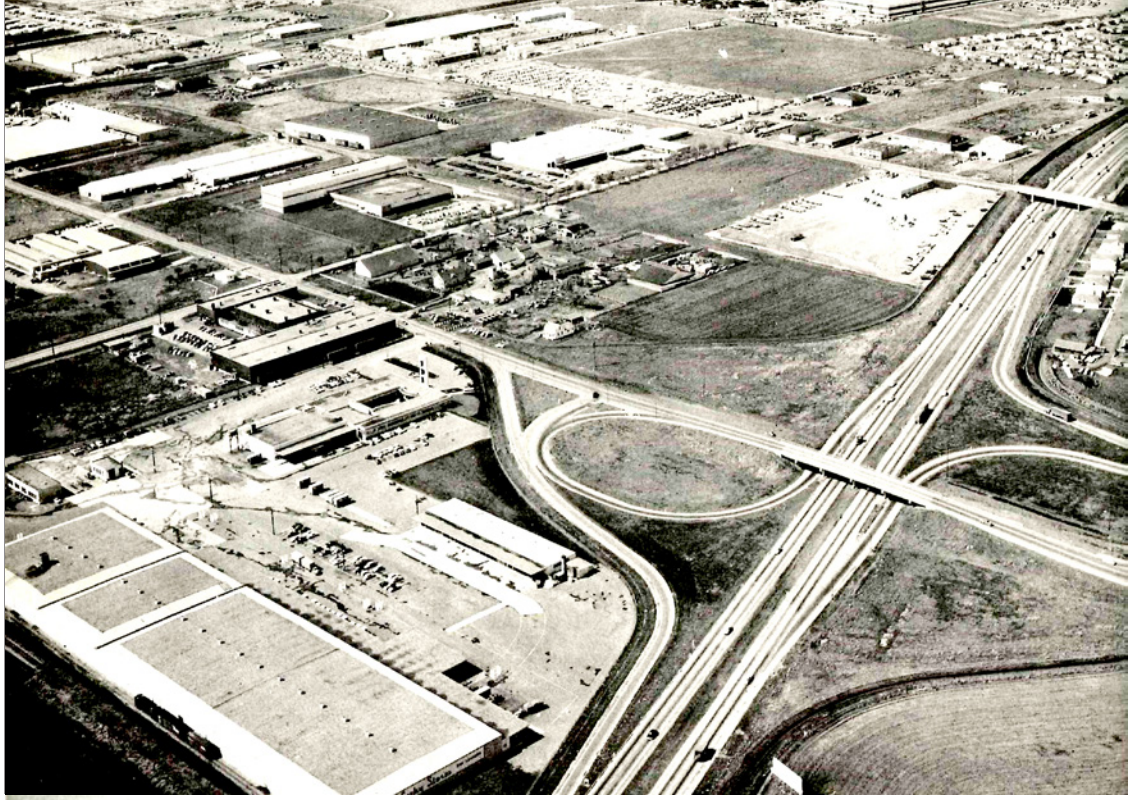
Engineered landscapes

Engineering defines expansion



1915 *infrastructure BEFORE the advent of the automobile*

1969 *infrastructure AFTER the advent of the automobile*

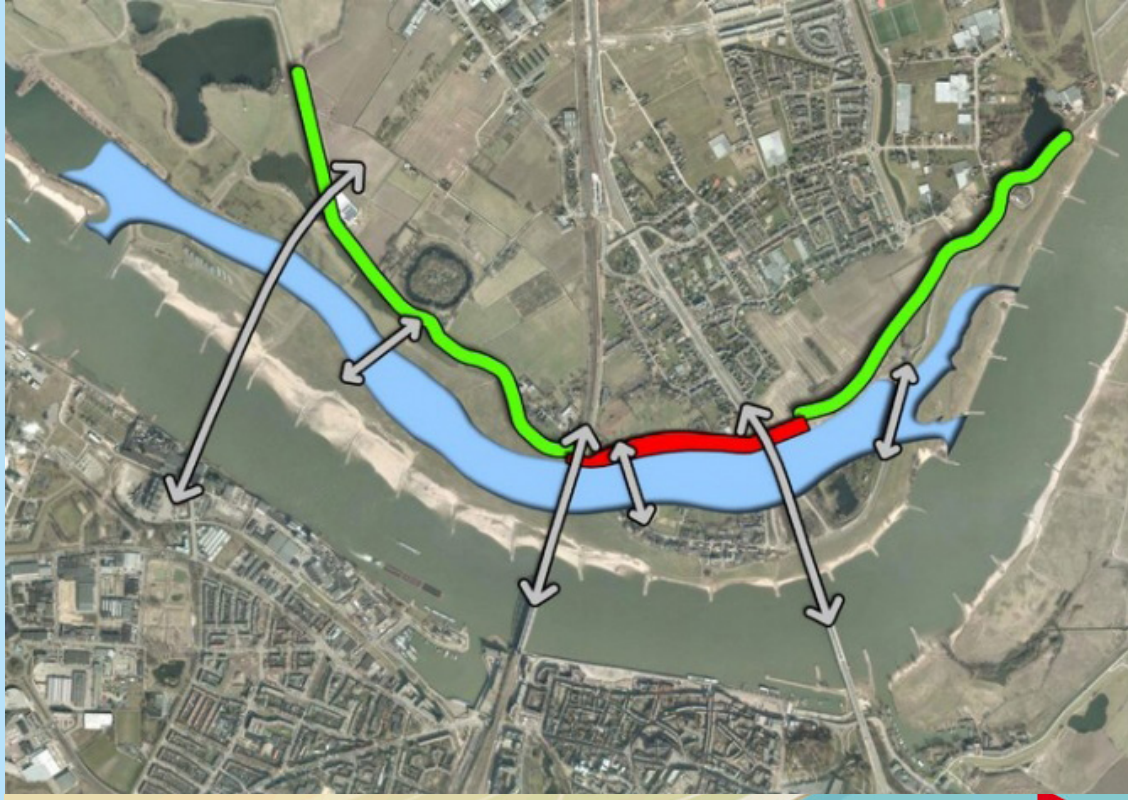


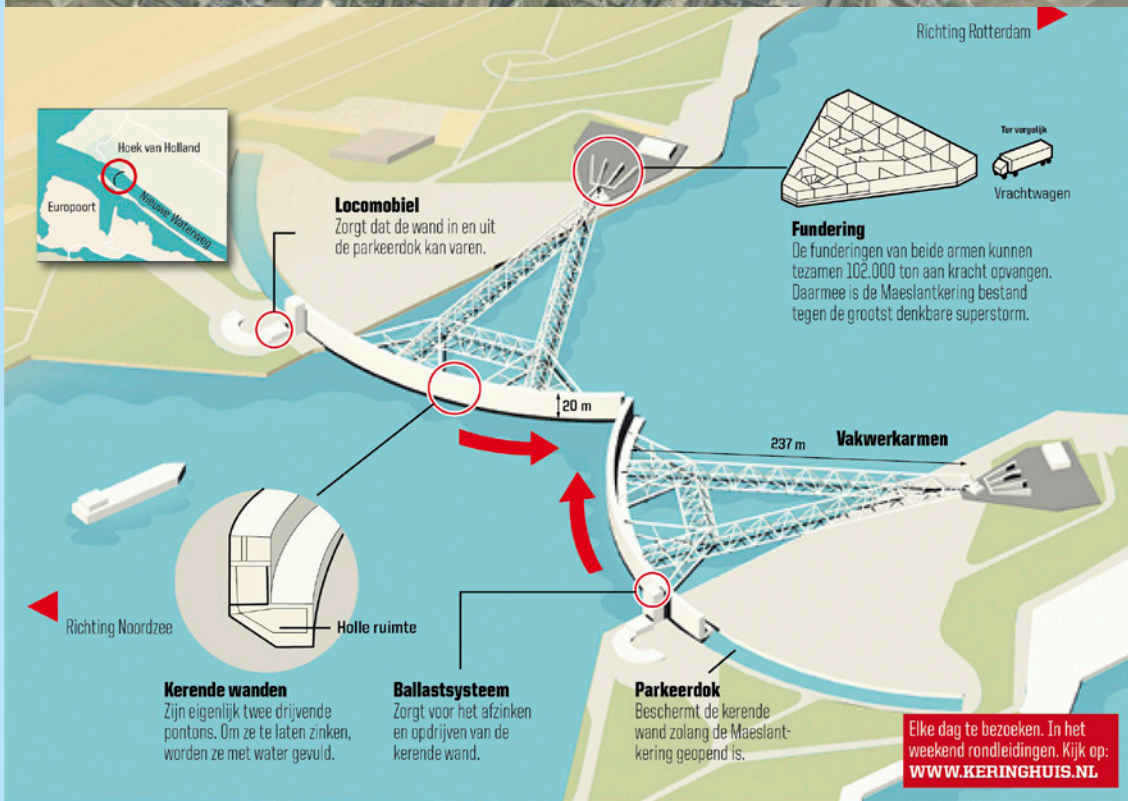
Approaches

Build layers of infrastructure (soft/hard)

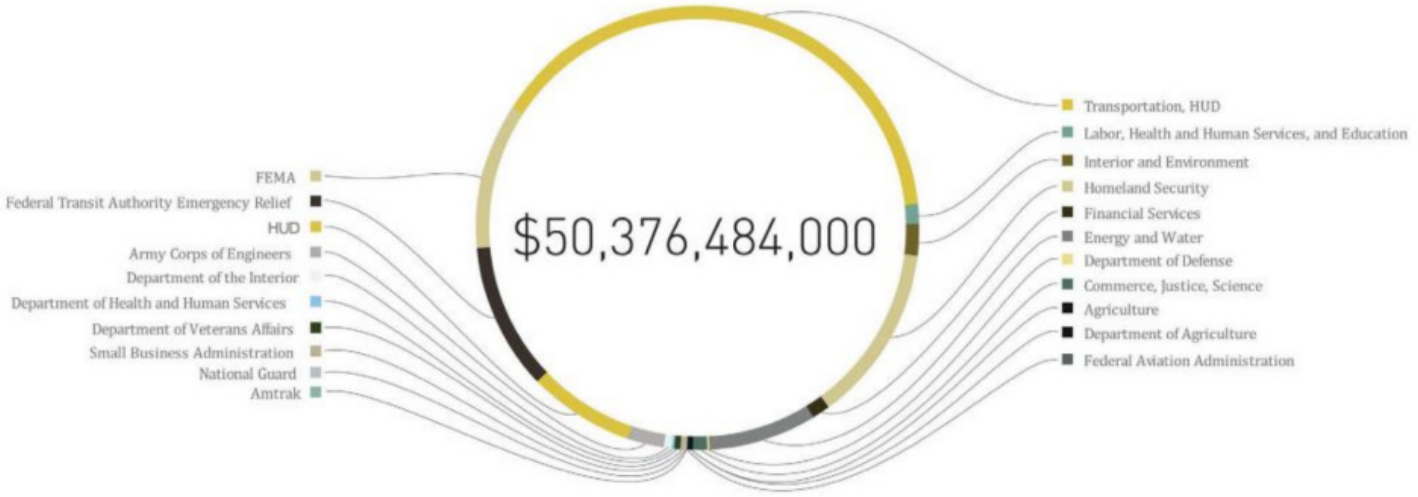
Protection

Adaptation



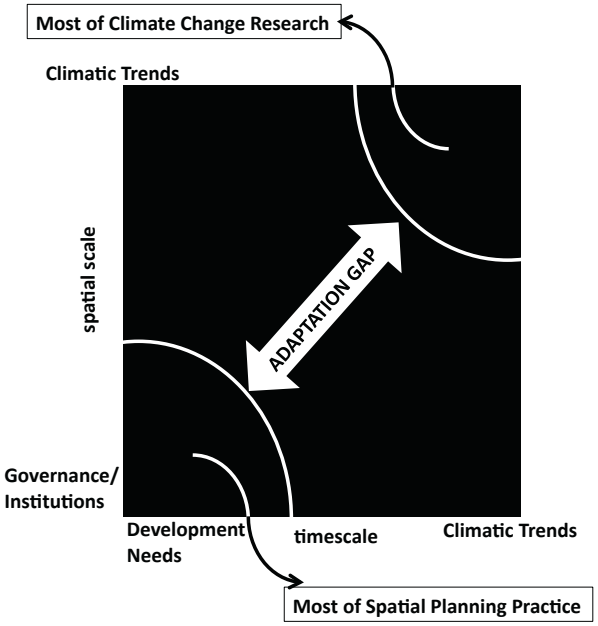


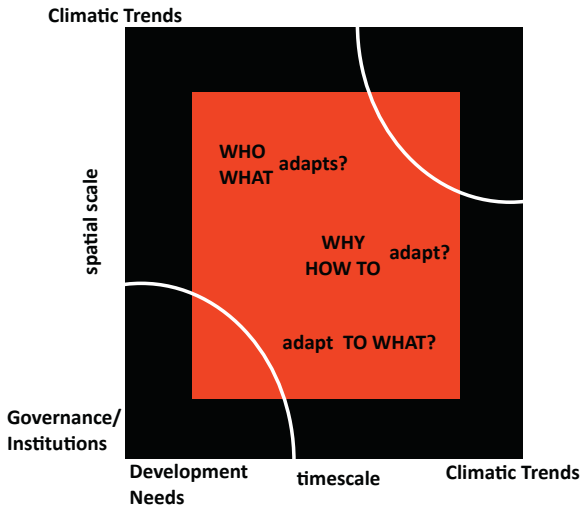
Building Back




SEGOB
José María Tapia Franco
Director General for Risk Management
We can't build back the same way, because we would
be doing the same thing that was done in the past.

Risk landscapes

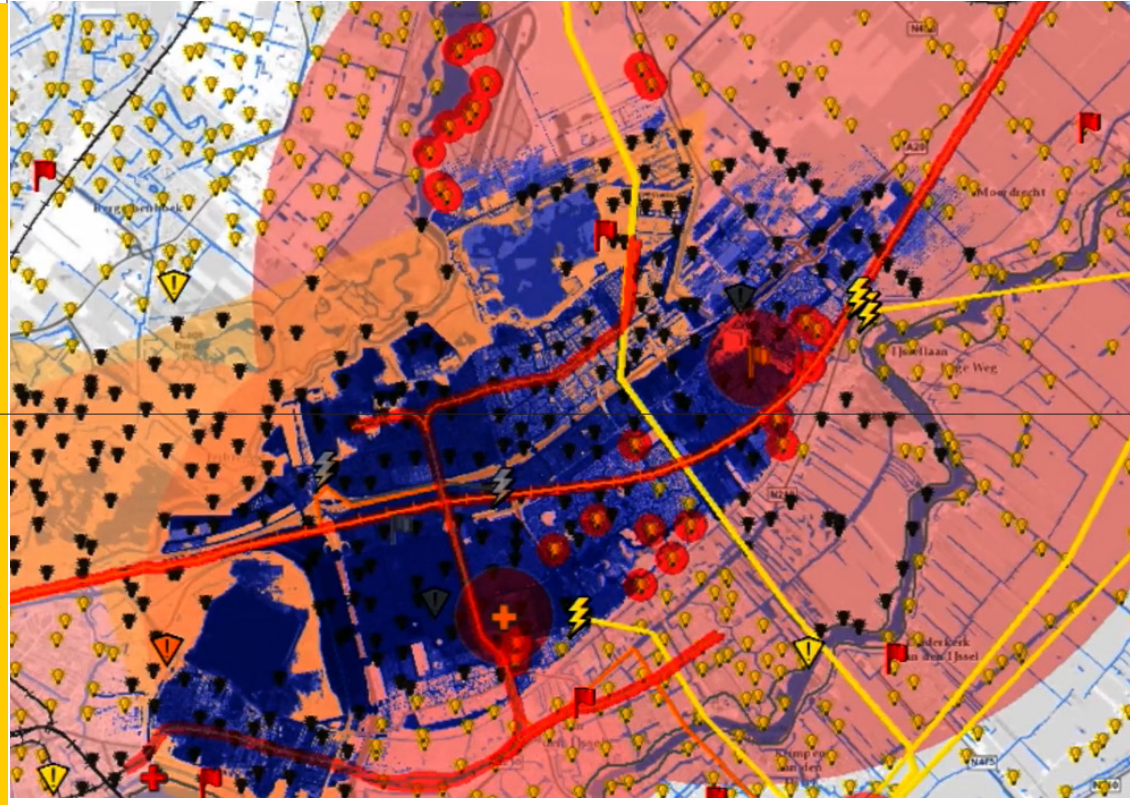




Coutesy: R. Roggema

Urban Disasters

Transforming civilisations
Damage/ Displacement in space
Higher vulnerability, economic and interconnectivity



http://www.3di.nu/crisisbeheersing/

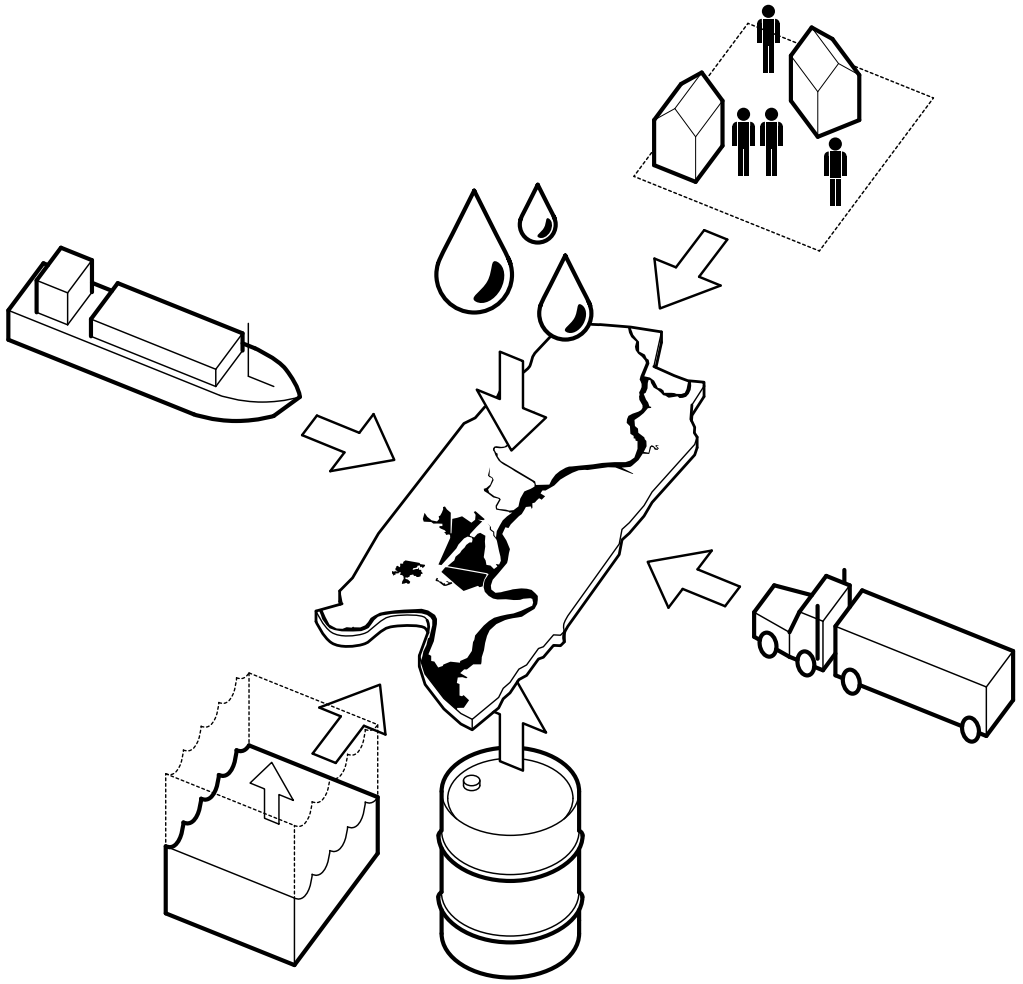
Challenge

urban planning governed by fear

focus on reducing ‘consequences’ of risk

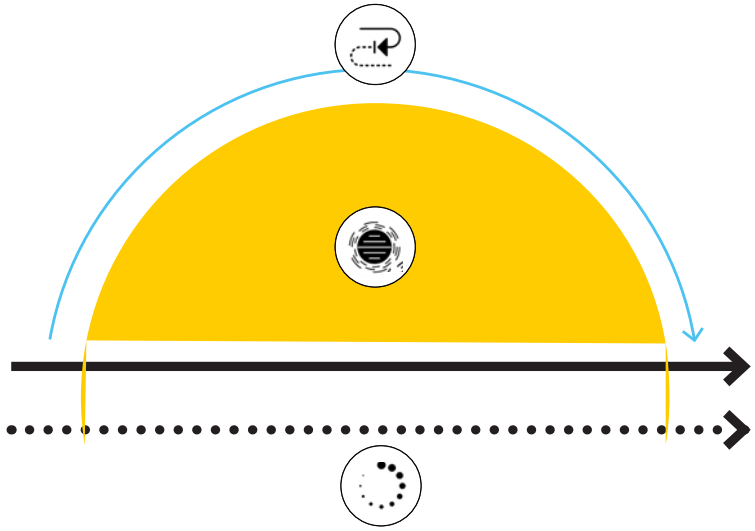
coherent spatial generation framework

Reduce recovery efforts in the event of a calamity



The City of Recovery

Connecting recovery systems to resilience in space



Rerouting

Attenuation

Redundancy

Bounce Forward

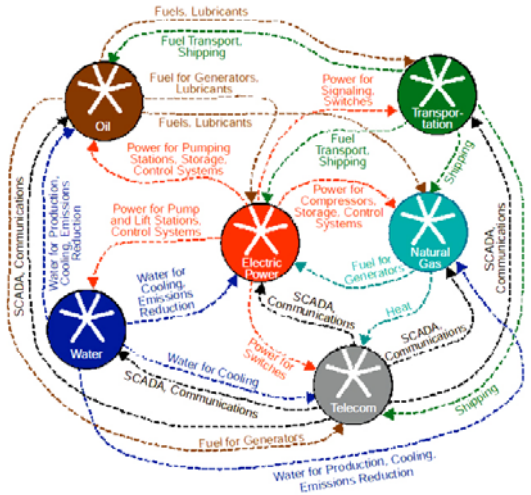
in space

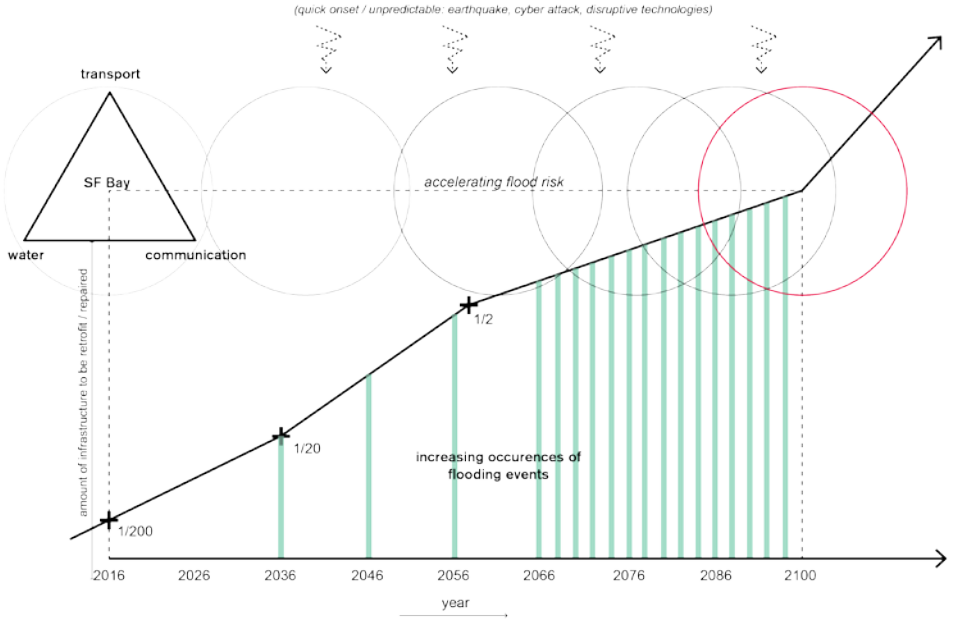
Objective

Embracing uncertainty from a spatial morphological point of view

How can understanding the effects of flooding and earthquake risk on critical urban systems (functions and networks) inform integrated

urban growth strategies for risk reduction?

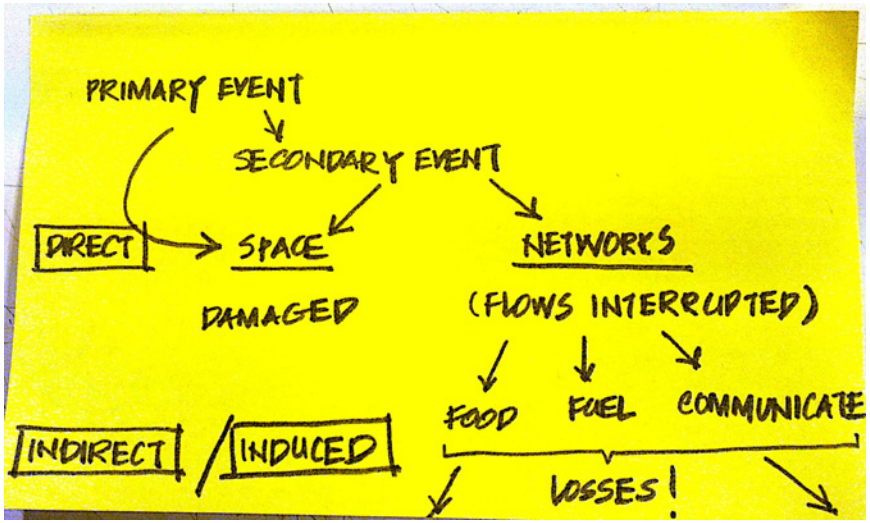


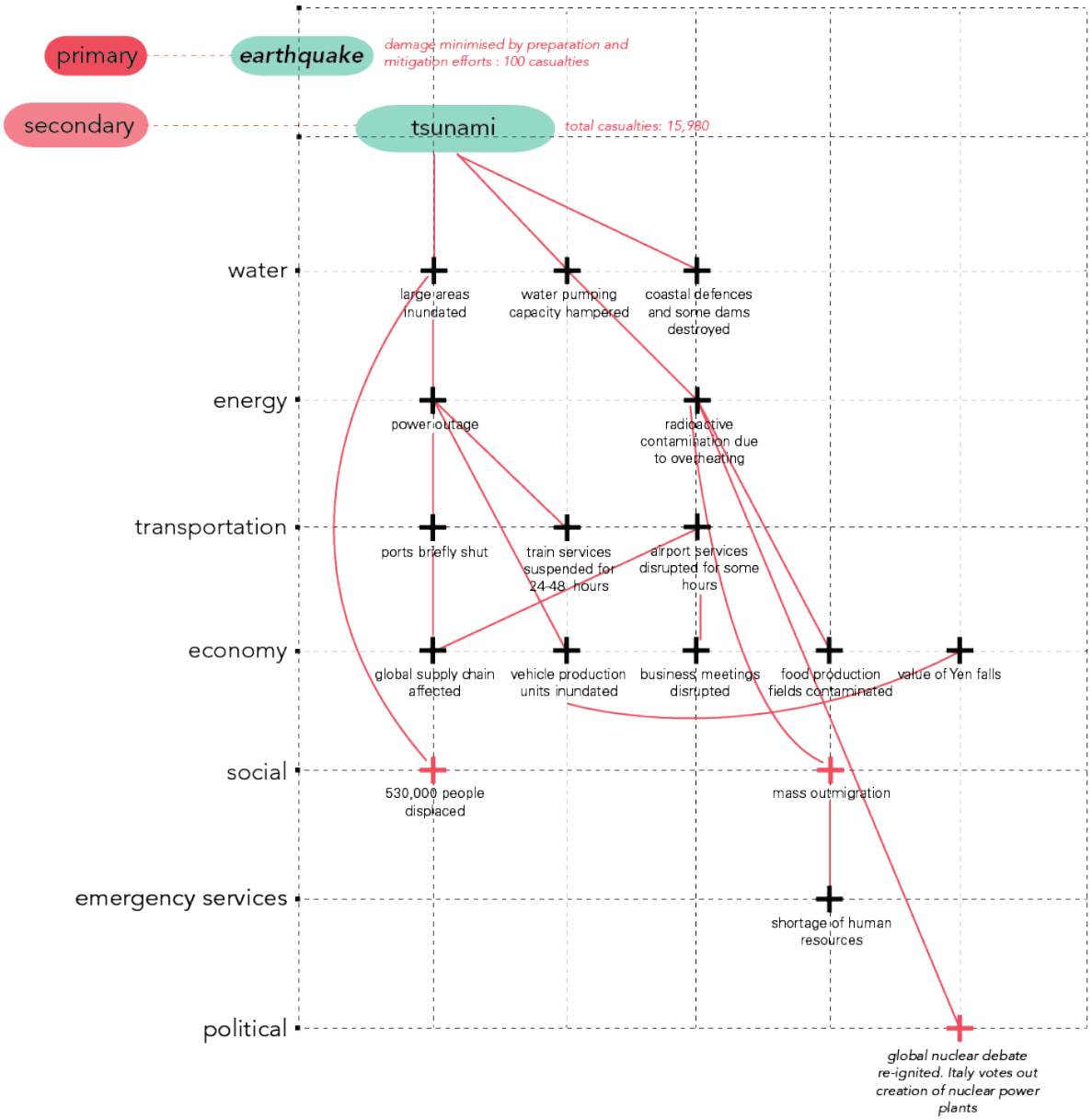


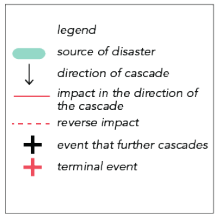
Disaster Evolution

Direct / Indirect
Points of transformation
Short term, Long term changes

Failure of Service
Communication: People, Data and Energy (Services, Supplies)
Tipping points
Primary, Secondary, Tertiary disasters




primary
earthquake
damage minimised by preparation and mitigation efforts : 100 casualties
secondary
tsunami
total casualties: 15,980
water
large areas inundated
water pumping capacity hampered
coastal defences and some dams destroyed
energy
power outage
radioactive contamination due to overheating
transportation
ports briefly shut
train services suspended for 24-48 hours
airport services disrupted for some hours
economy
global supply chain affected
vehicle production units inundated
business meetings disrupted
food production fields contaminated
value of Yen falls
social
530,000 people displaced
mass outmigration
emergency services
shortage of human resources
political
global nuclear debate re-ignited. Italy votes out creation of nuclear power plants


legend
source of disaster
direction of cascade
impact in the direction of the cascade
reverse impact
event that further cascades
terminal event

Accessibility
Food-Fuel-Communication

Critical Infrastructure Channels most important for recovery

$$\text{recovery period} \propto \frac{1}{\text{redundancy of critical infrastructure}}$$

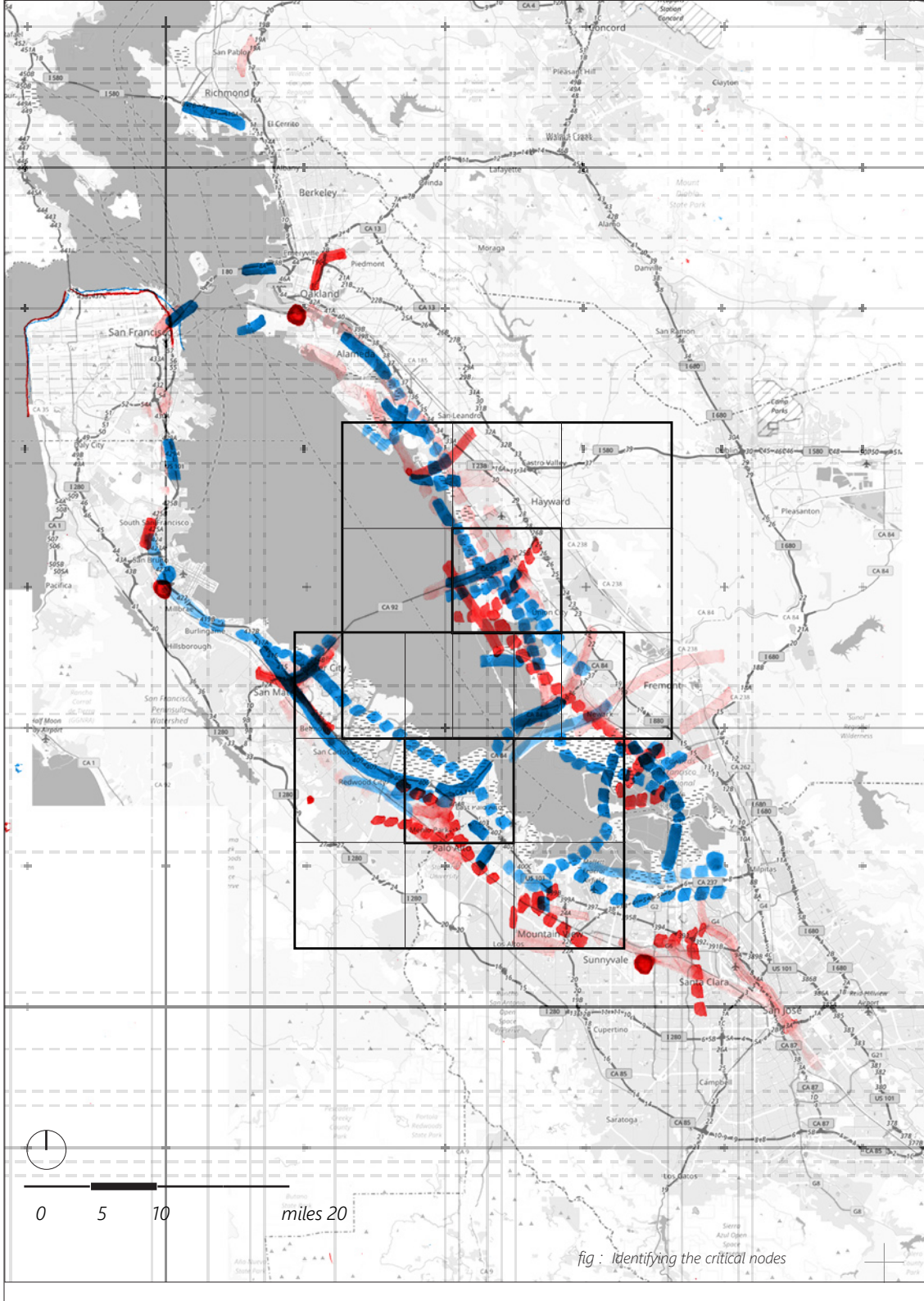


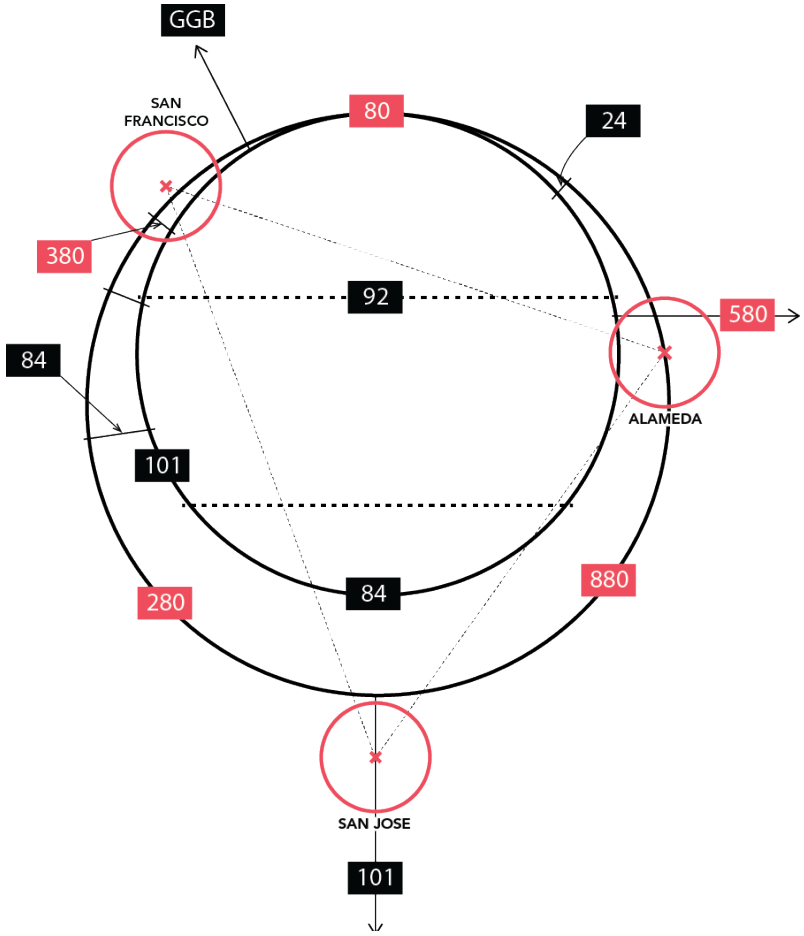
fig : Identifying the critical nodes

Systemic Approach

Accessibility
Food-Fuel-Communication

Critical Infrastructure Channels most important for recovery

$$\left[\text{recovery period} \propto \frac{1}{\text{redundancy of critical infrastructure}}\right]$$



Research by Design

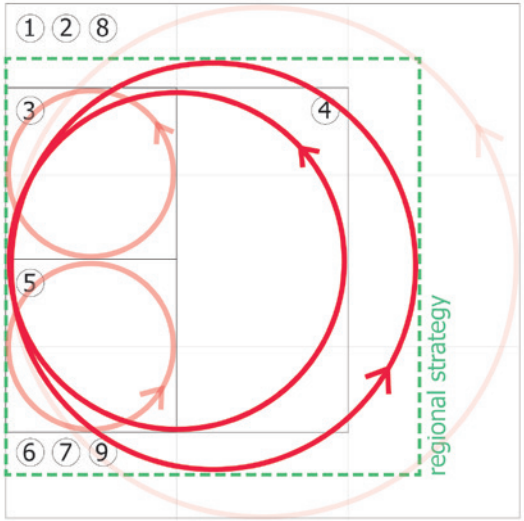
Iterative : Interscalar

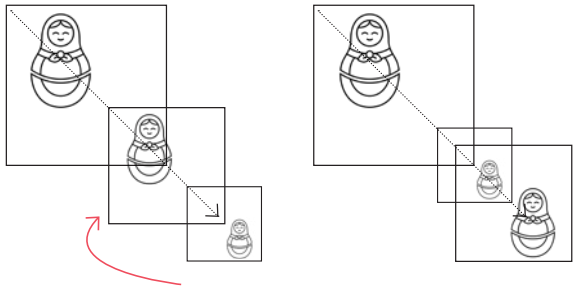
Determine choice of site: East Bay
High vulnerability to critical infrastructure networks and space

Finding the ‘critical lifelines’ and ‘critical mass’ of the site

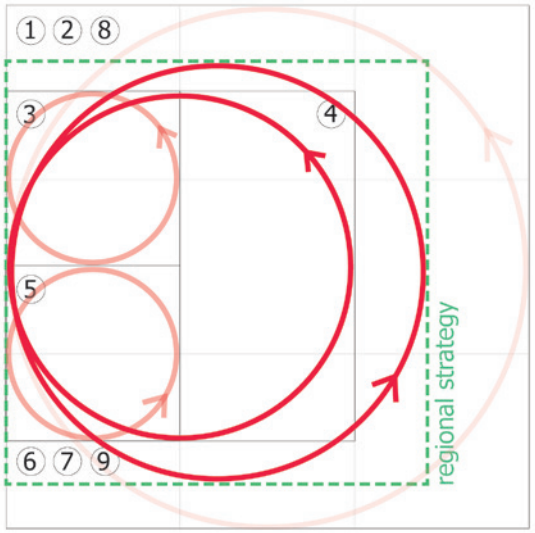
Finding point of transformation for ‘traditional - incremental’ and ‘transformational’ growth

MACRO-MICRO-MESO



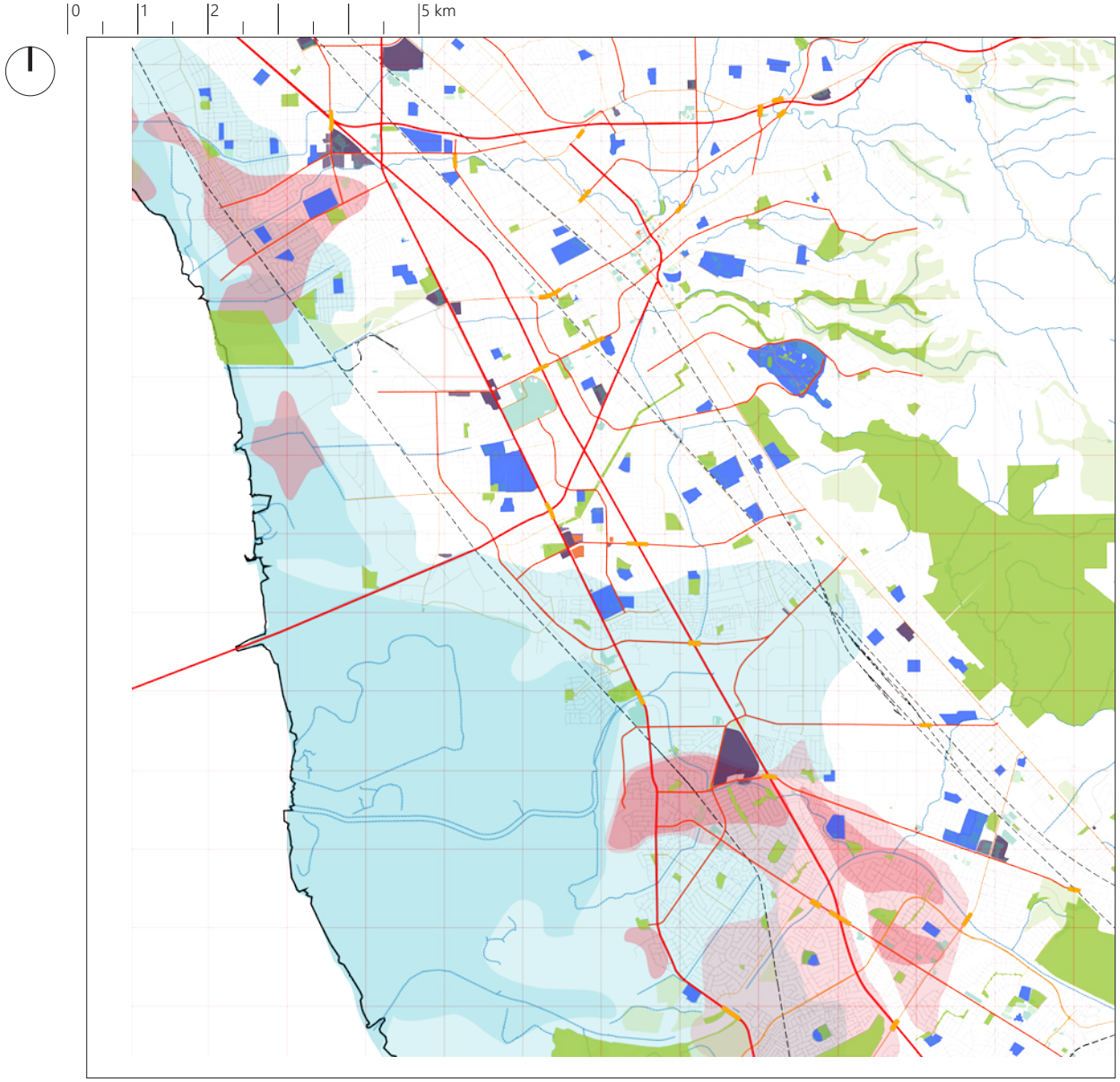


R&D Loops



Inductive I
Deductive D
Abductive A

Sr no	Reasoning	Scale	Methods	Tools	Learnings
1- Understanding context socio economic vulnerability)	A	MACRO	-3X3X3 approach (nature, occupation, infrastructure + socio economic vulnerability)	Hand drawings, ArcGIS	-urban system structure -broad overview of socio-economic vulnerability of the region in the face of projected hazards
2-Understanding System variables (transport, energy, water)	I	MACRO	-Critical Infrastructure Networks mapping in space (transport, energy, water)	Hand drawings, ArcGIS	-indications of area with a high density of critical networks at risk of direct damage
3-Understanding Spatial variables	A	MICRO	-1st iteration: Spatialising risk on an urban block	Hand drawings,	-direct impact on space to derive 'critical' safety routes and 'refuge parcels' in a crisis situation (Analysis of 1 network - transport)
4- Networks in space	I	MESO	-accurate mapping of transport ,water and power networks and simulating expected risks to understand vulnerable nodes and how they can be rerouted	ArcMap data+ Adobe suite	-understanding the critical accessibility routes that must be kept alive for evacuation in case of a crisis
5-Transformation	I	MICRO	-spatial impact of urban trends until 2100	Hand drawings	-modifications in urban components and its relationship to infrastructure changes
6	I	MESO	-5 layer approach to map the following layers (based on the framework by Roggema): Critical networks, Focal points of high density network zones, open space network ,land use patterns -mapping exercise to address 'State and Analytical Variables from the Risk Assessment Framework'	ArcMap data+ Adobe suite	-determine vulnerable network nodes (3 networks - Water, Transport, Energy) -formulate trajectories for future urban growth based on current land use patterns
7	D	MESO	-Iteration 2: Detailed simulation of 100 year Sea Level Rise and Earthquake Risk to understand redundancies and rerouting of road transport network.	ArcMap -Network Analyst Plugin	-'Critical' network determined for two risks. -direct and indirect impact of CI damage on space. -risk taxonomy to classify level of vulnerability on urban patches to determine next line of actions
8	I	MACRO	-Iteration 3: Utilising 'critical network' and risk taxonomy to establish urban transformation vision	ArcMap data+ Adobe suite	-backcast decremental sea level rise levels (1:50, 1:20) to determine probabilistic growth patterns -aim to establish a resilient 'patch-matrix' (network+urban patches) as the Middle Ground for priority resilience actions
9	I	MICRO	-spatialising temporal strategies on a selected urban clusters (identified from the risk taxonomy)	Hand drawings	-scaling down the implementation scheme and prioritising clusters for growth -land and infrastructure re-programming towards a resilient growth for 2100 -3 phases leading to the transformative vision
10	A	MESO	-mapping the 'Disruptive variables' from the 'Risk Assessment Framework'	ArcMap data+ Adobe suite	-finding deviations in the growth system to generate alternative ways of growing



hospital

fire station

religious block

cell / data tower

parks

commercial

schools

inundation risk

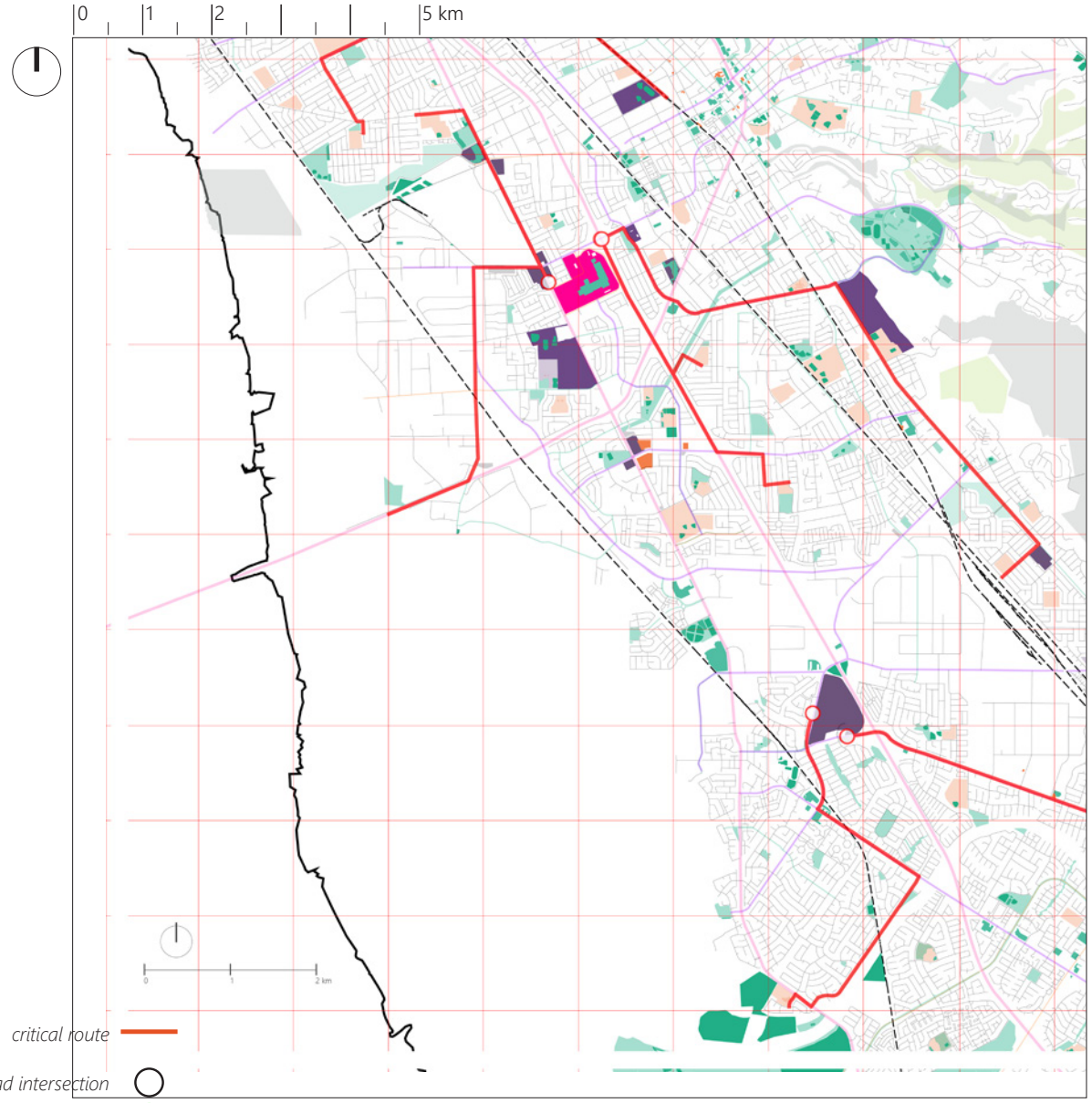
major road intersection

overhead bridge

primary - highway

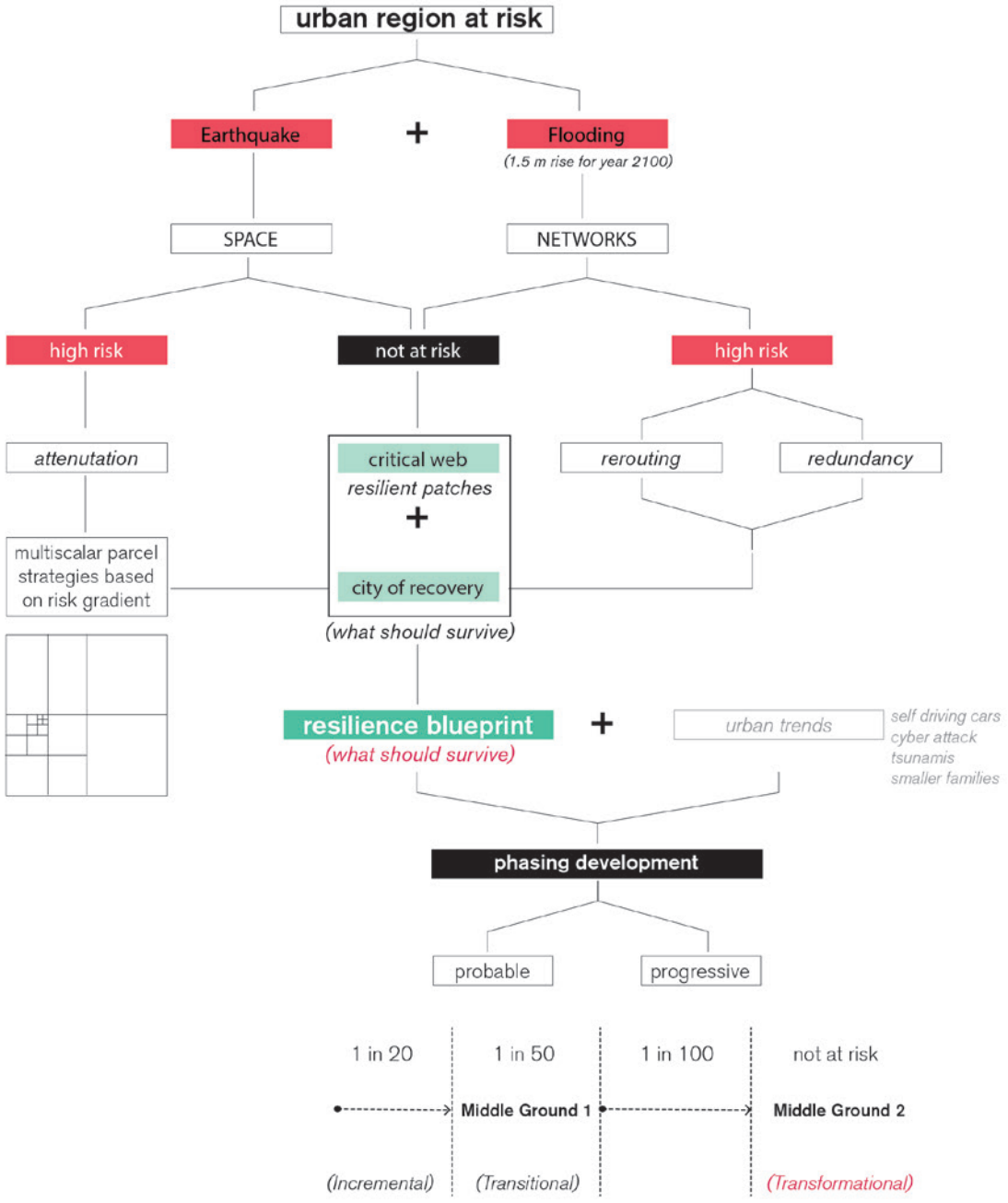
secondary - collector

tertiary - distributor

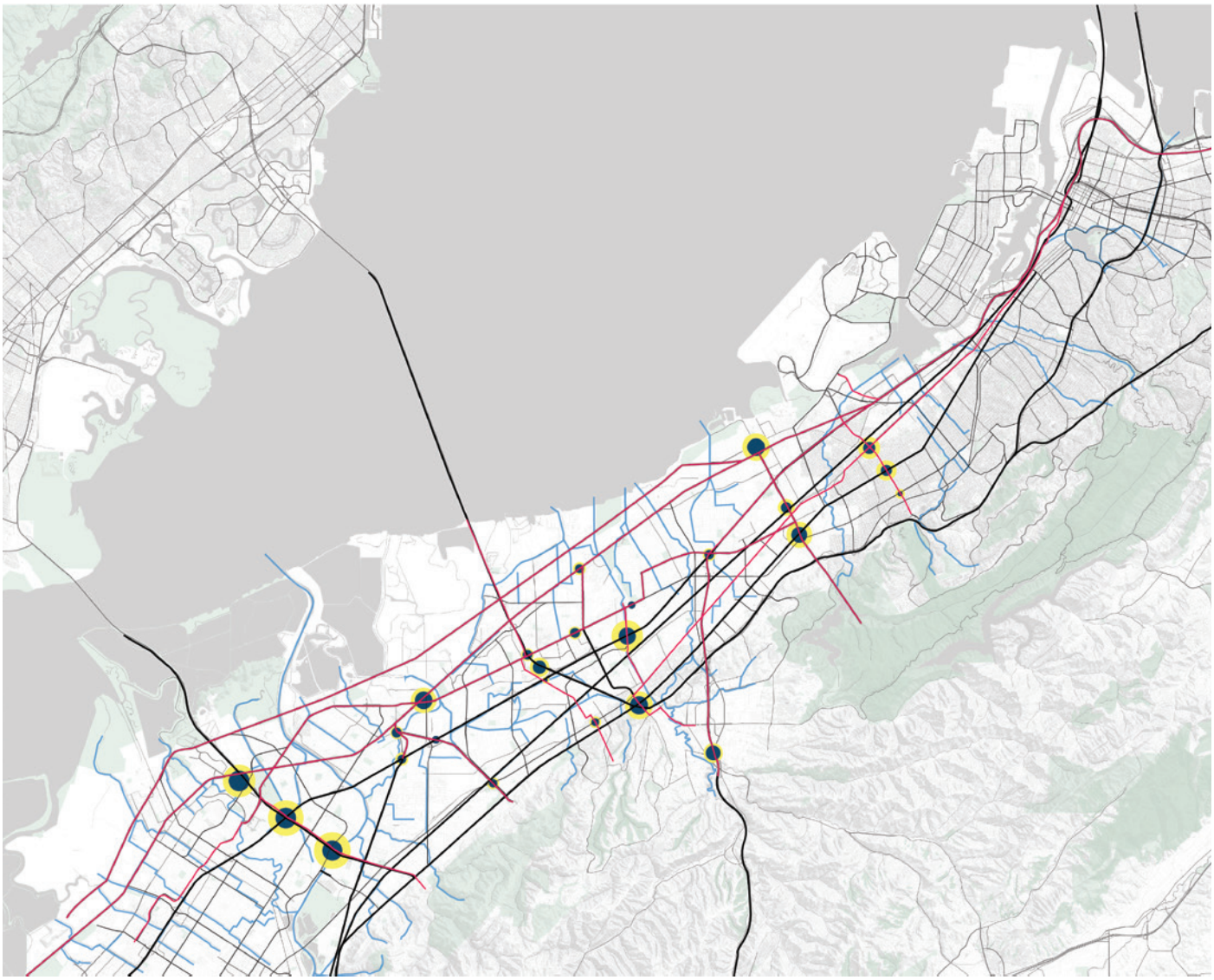

0
1
2
5 km
hospital
fire station
religious block
cell / data tower
Disaster control
commercial
schools/ emergency shelter
point of gathering
critical route
major road intersection
overhead bridge
primary - highway
secondary - collector
tertiary - distributor
local road

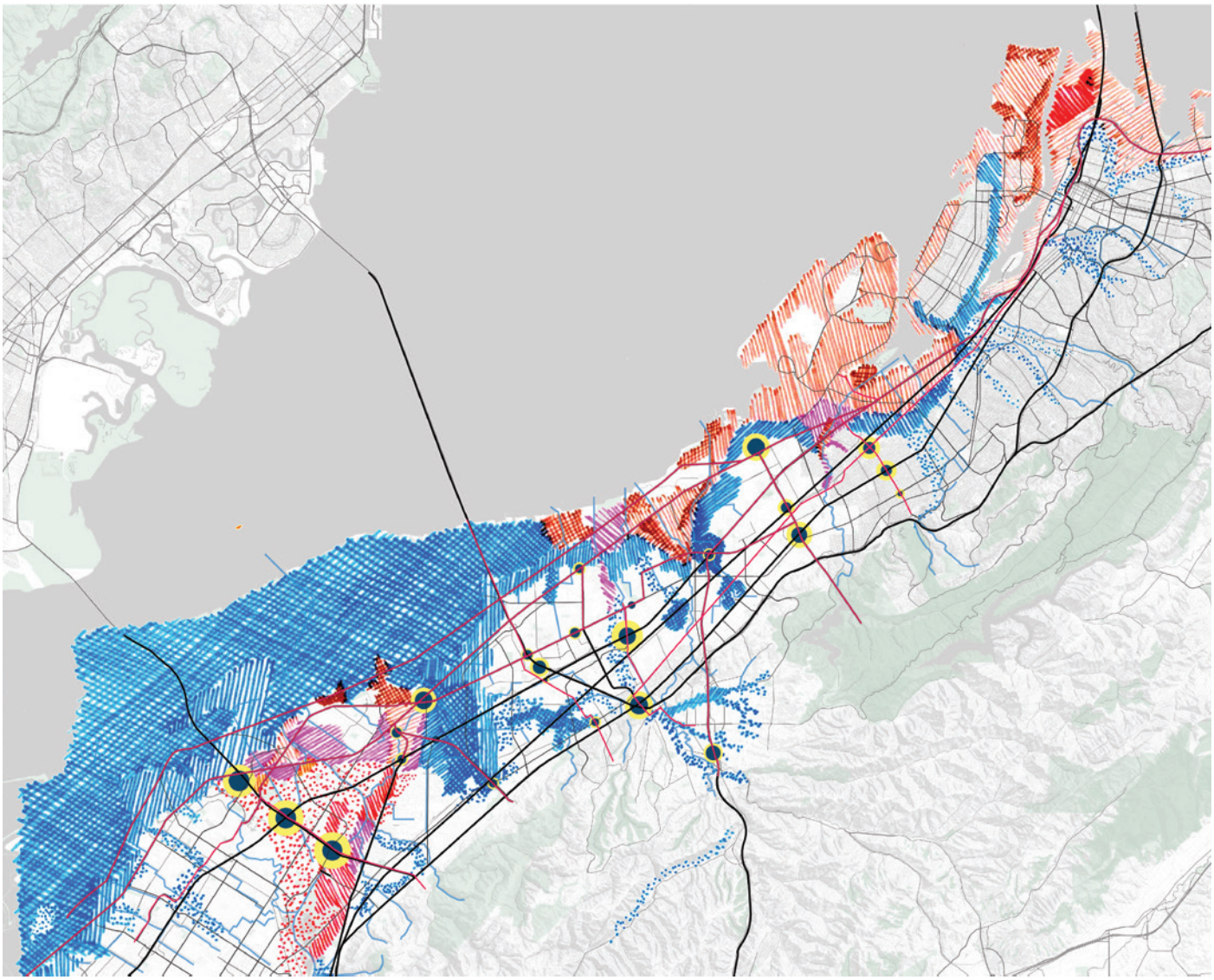
The Middle Ground

resilience and transition


urban region at risk
Earthquake
+
Flooding
(1.5 m rise for year 2100)
SPACE
NETWORKS
high risk
not at risk
high risk
attenutation
critical web
resilient patches
+
city of recovery
rerouting
redundancy
multiscalar parcel strategies based on risk gradient
(what should survive)
resilience blueprint
(what should survive)
+
urban trends
self driving cars
cyber attack
tsunamis
smaller families
phasing development
probable
progressive
1 in 20
1 in 50
1 in 100
not at risk
Middle Ground 1
Middle Ground 2
(Incremental)
(Transitional)
(Transformational)

0 2.5 5 10 20 km

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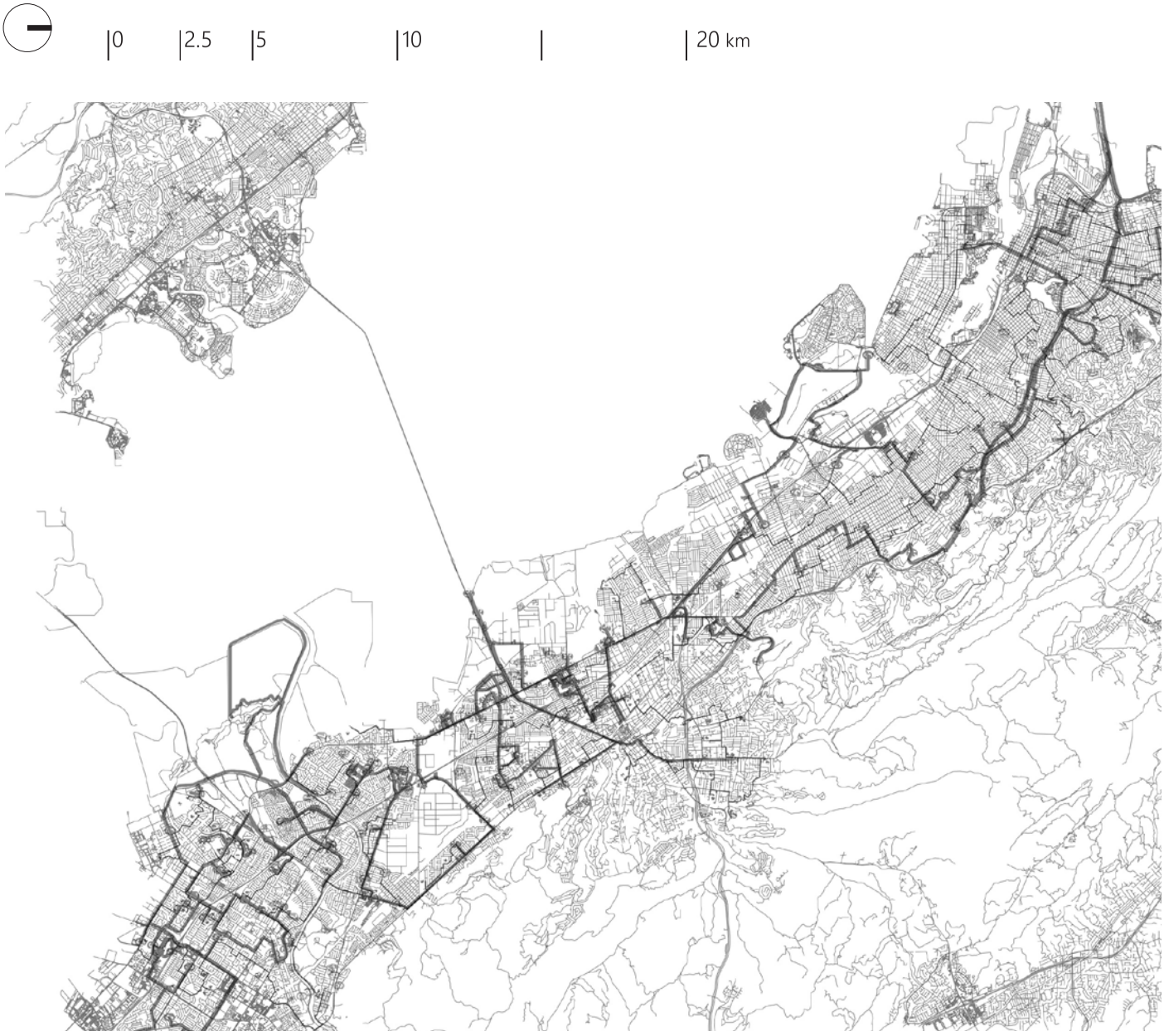
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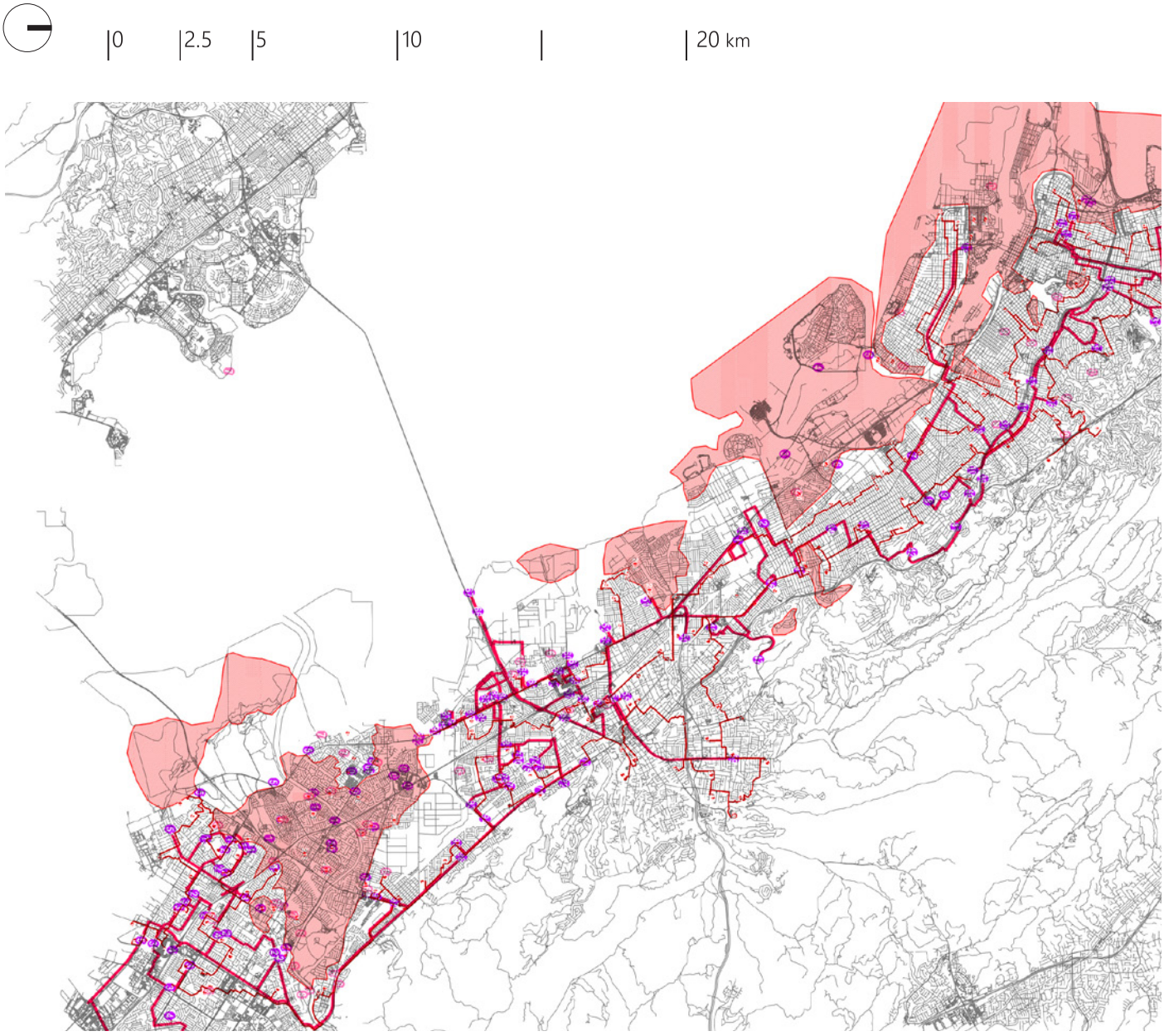
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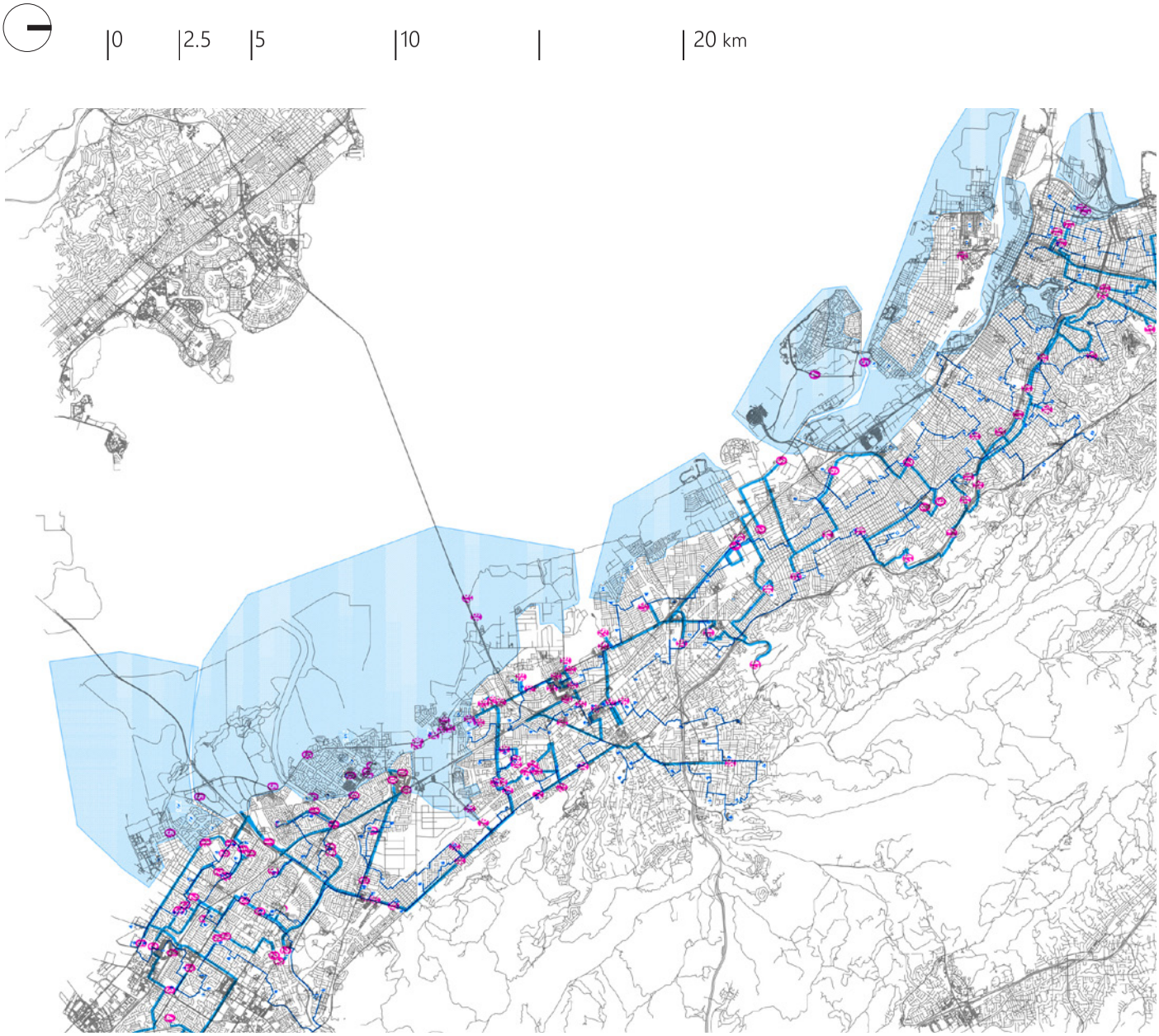
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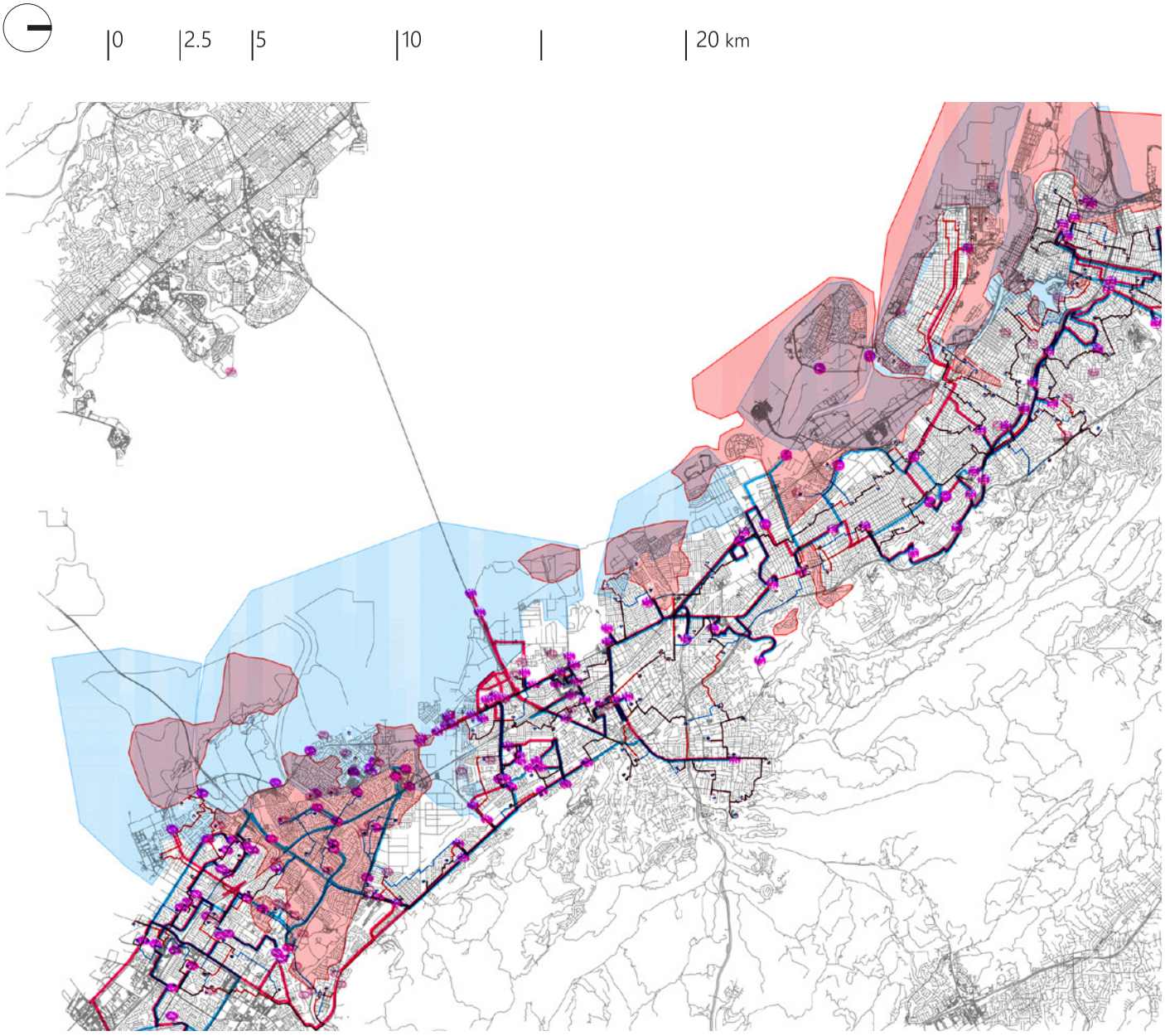
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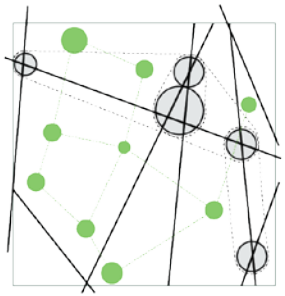
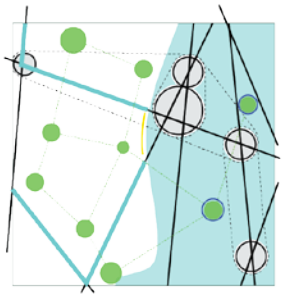
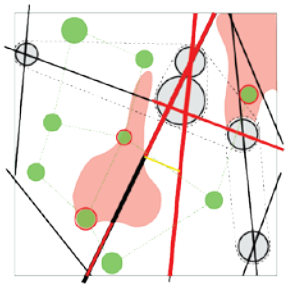


base



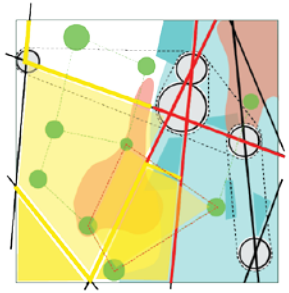
hazard 1

flooding due to sea level rise and pluvial water



hazard 2

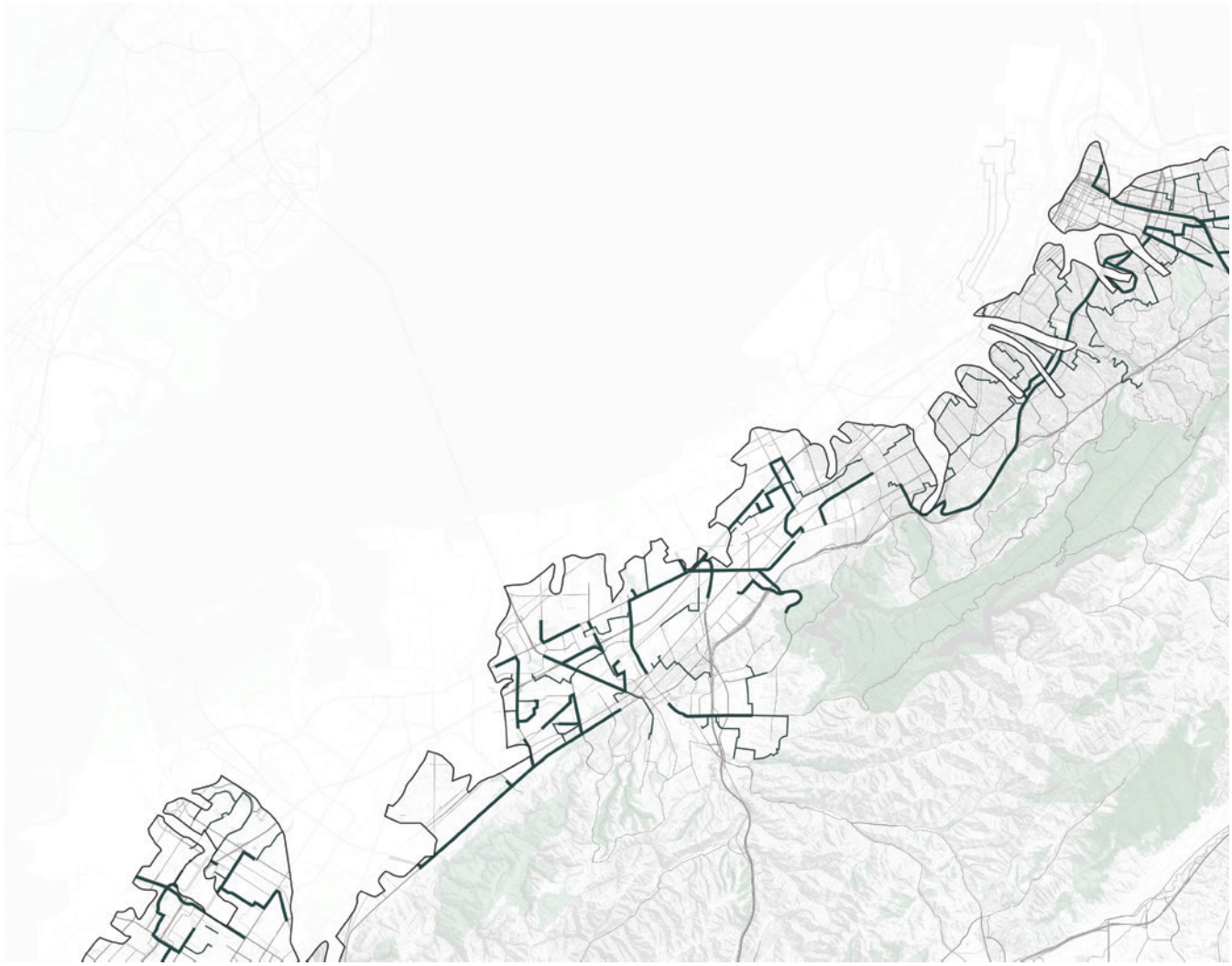
damage due to earth-quake and soil liquefac-tion



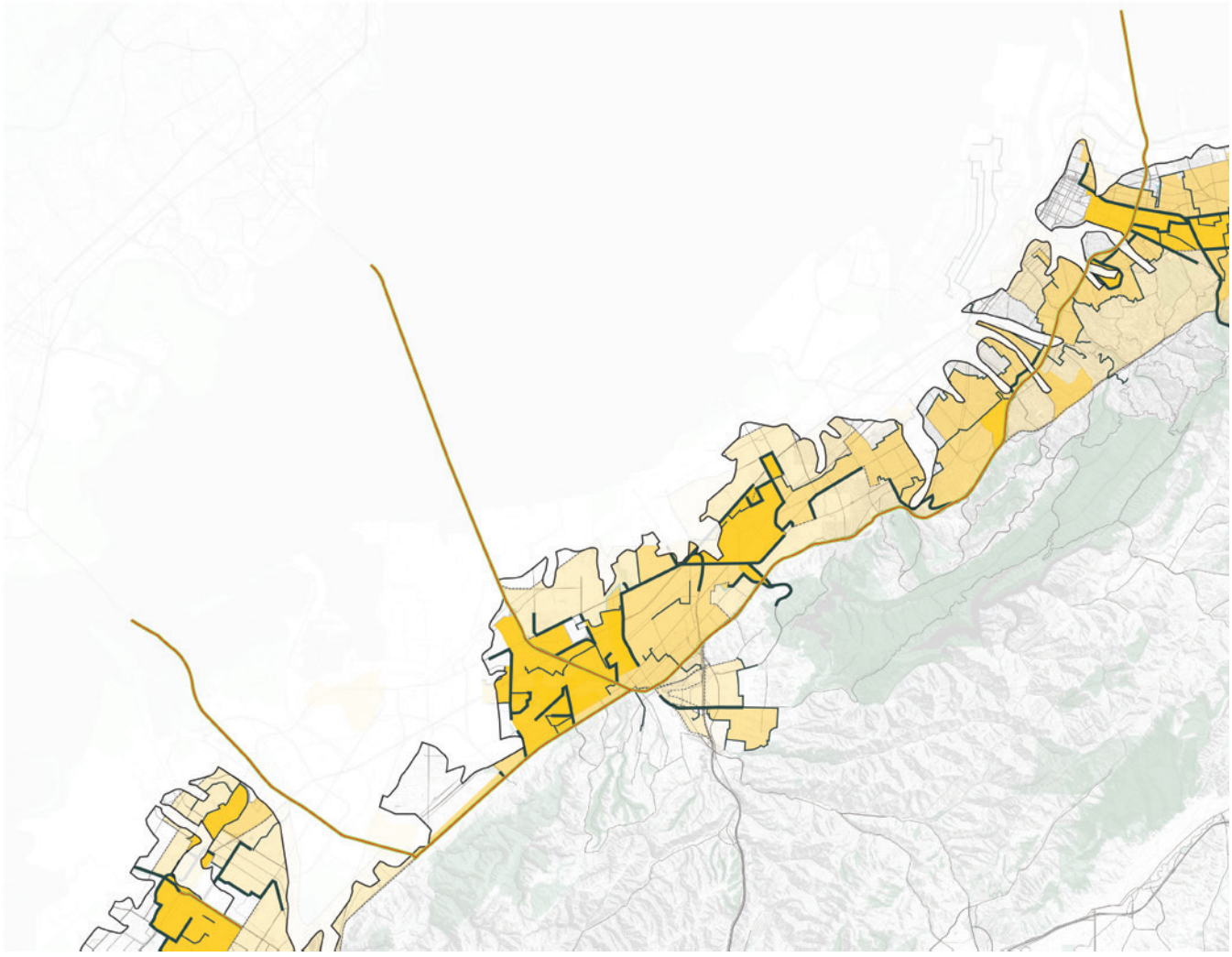
h1+h2

critical web

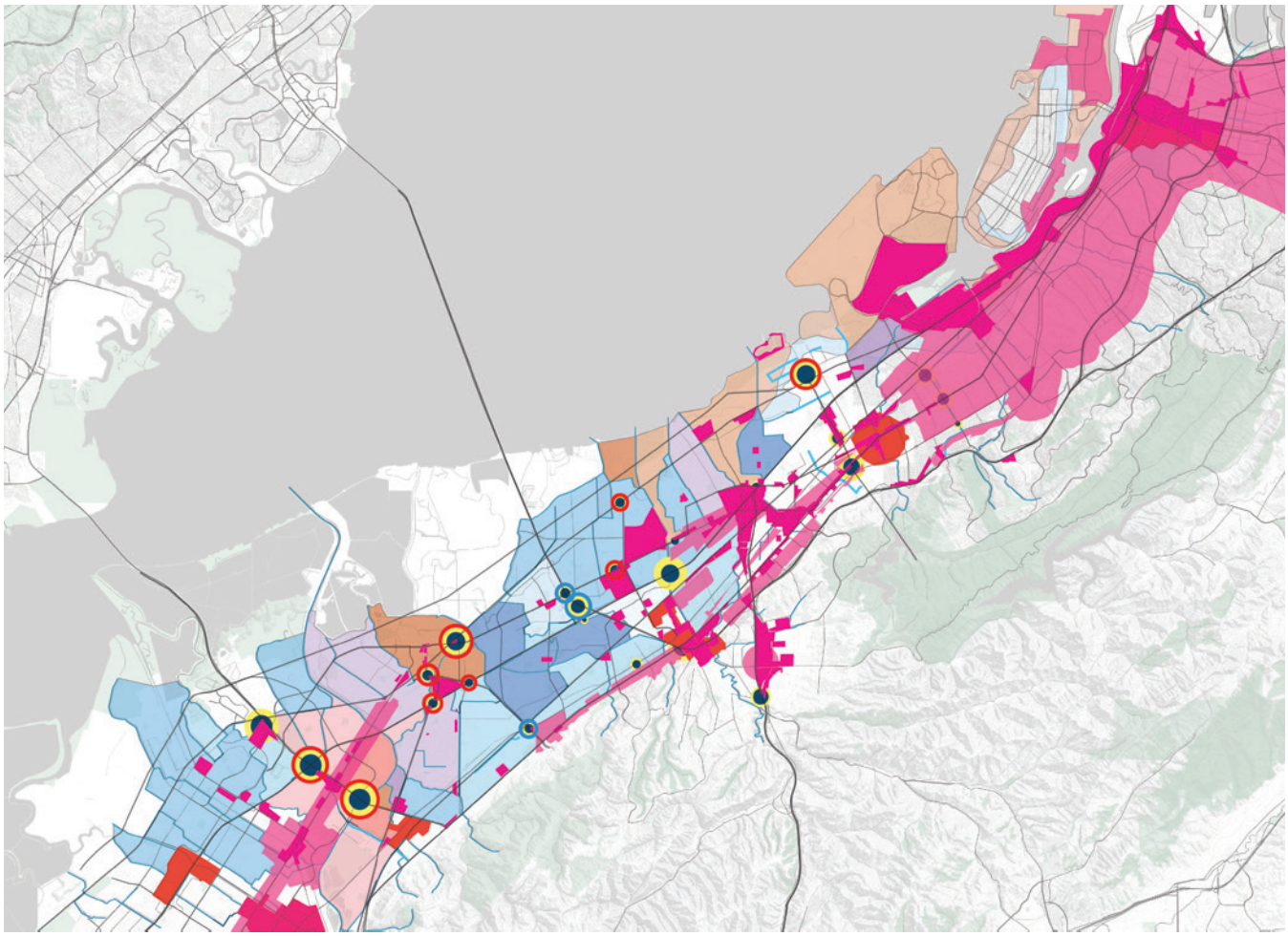
0 2.5 5 10 20 km



0 2.5 5 10 20 km



0 2.5 5 10 20 km



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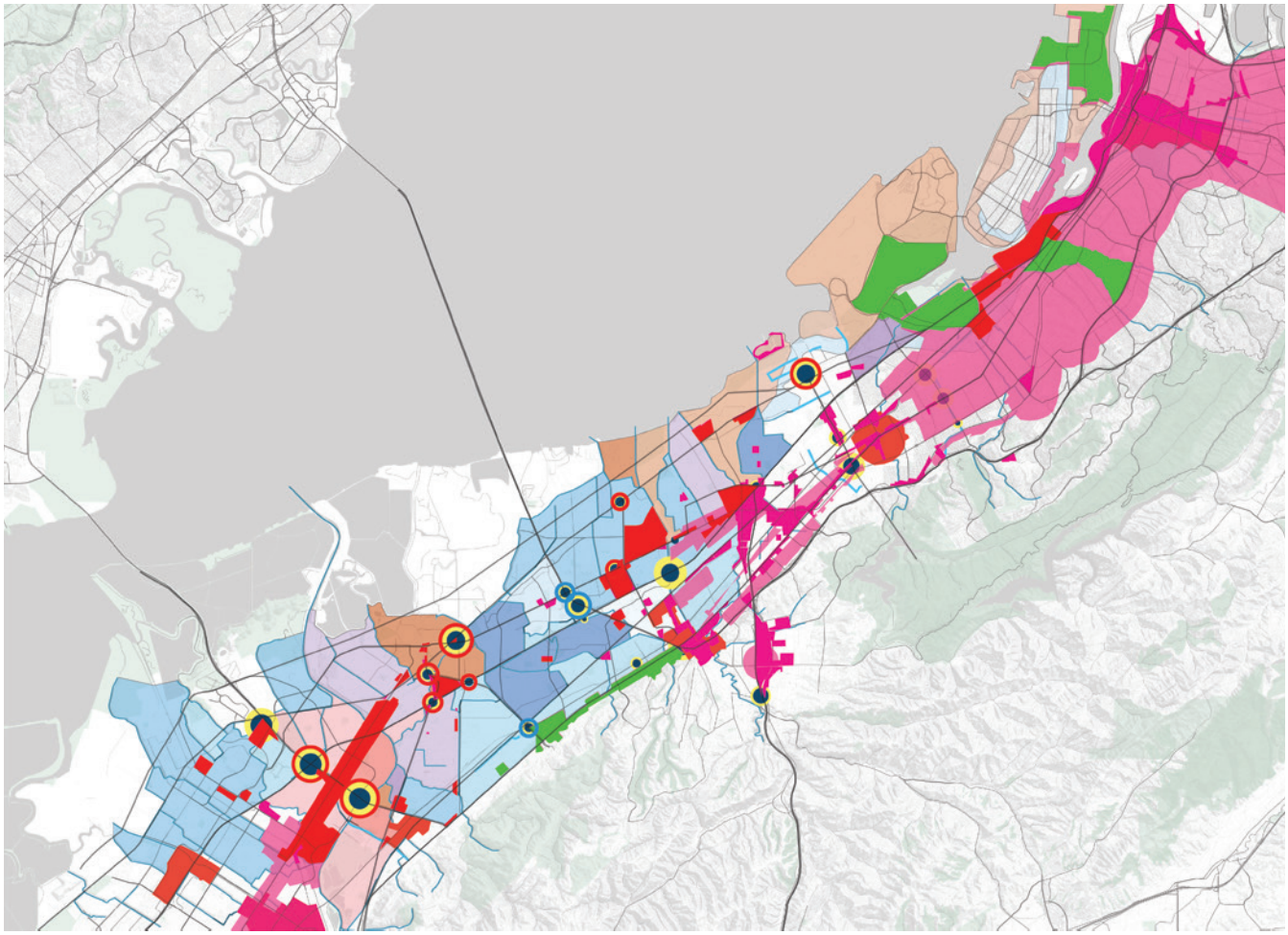
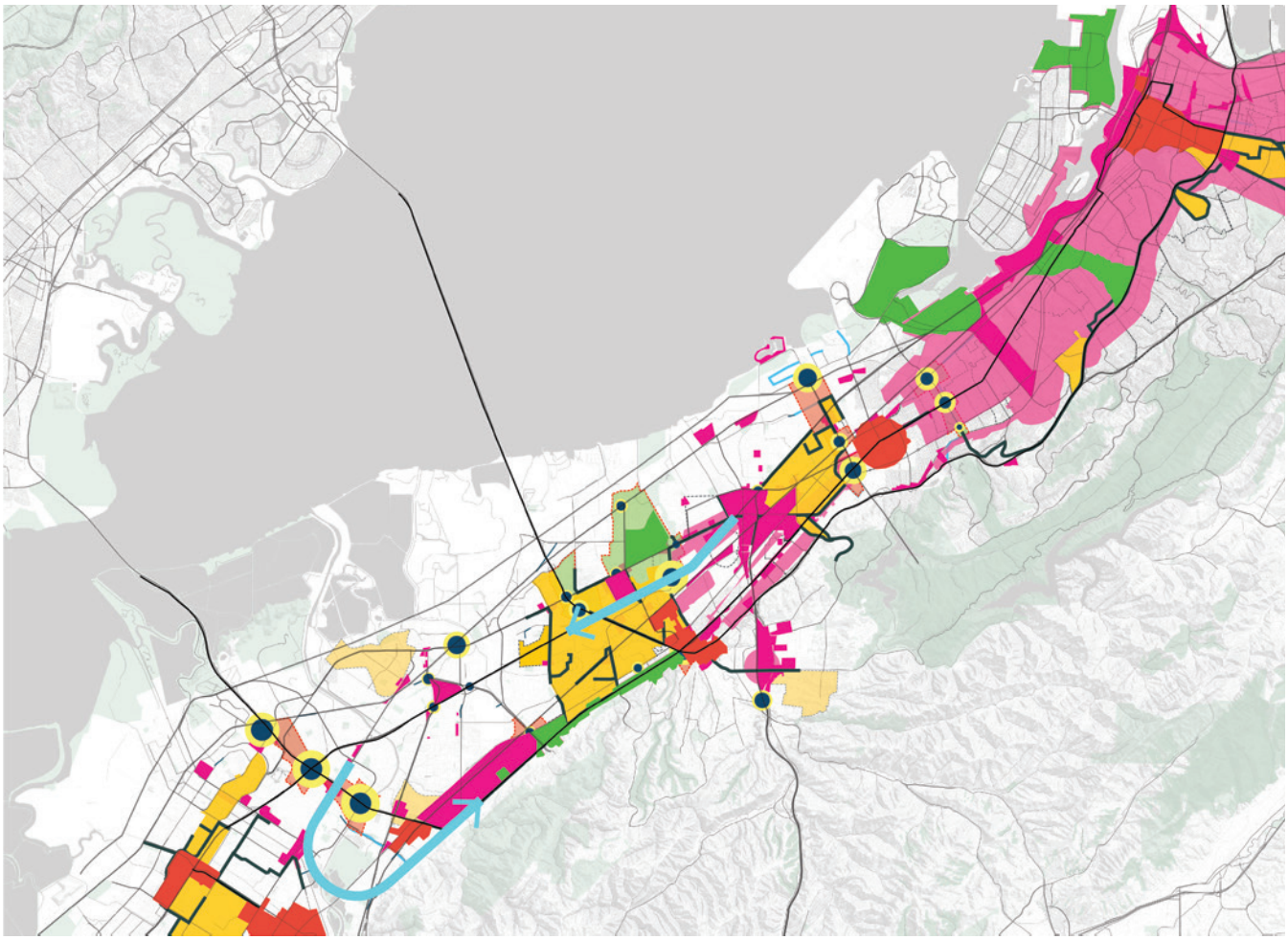
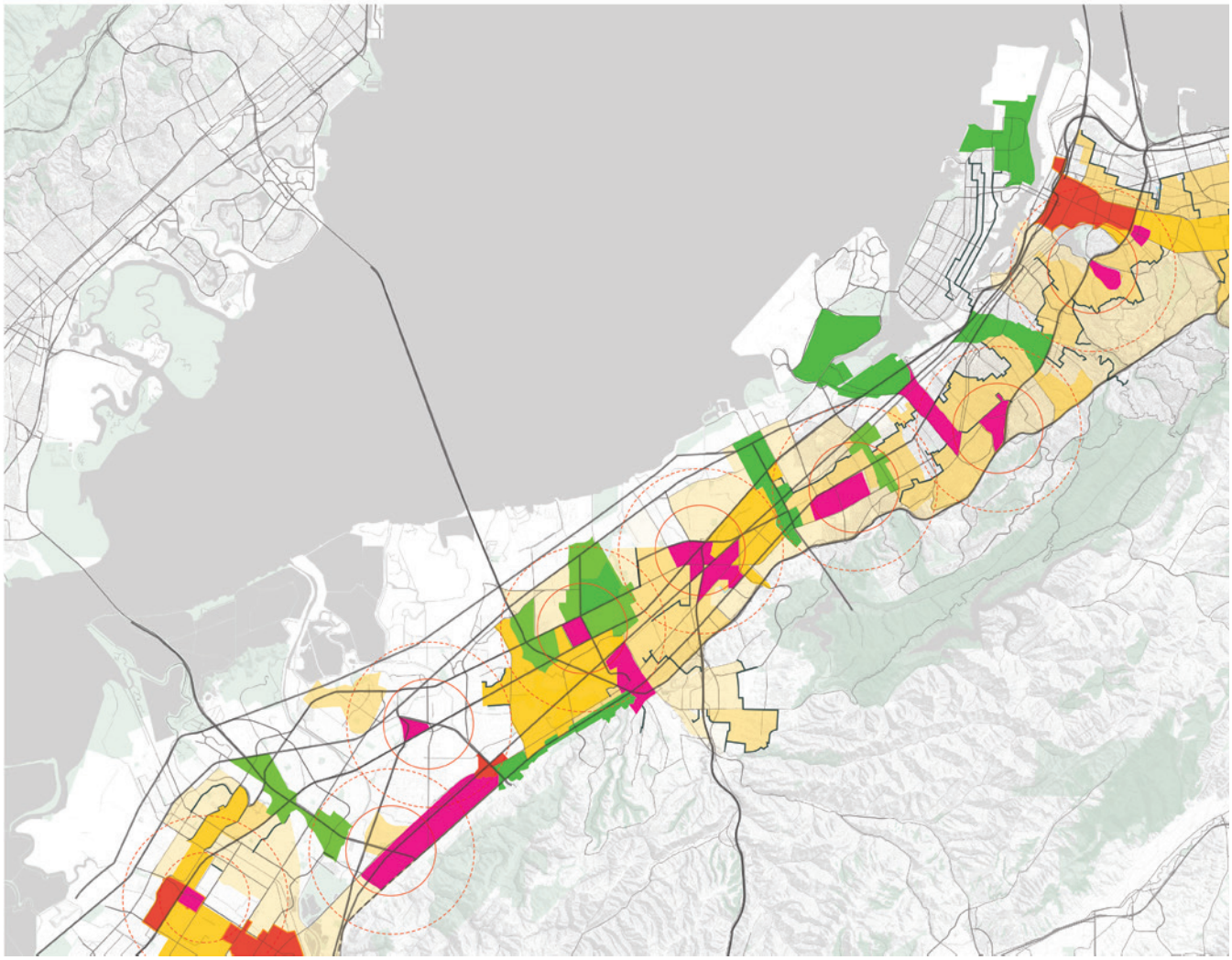


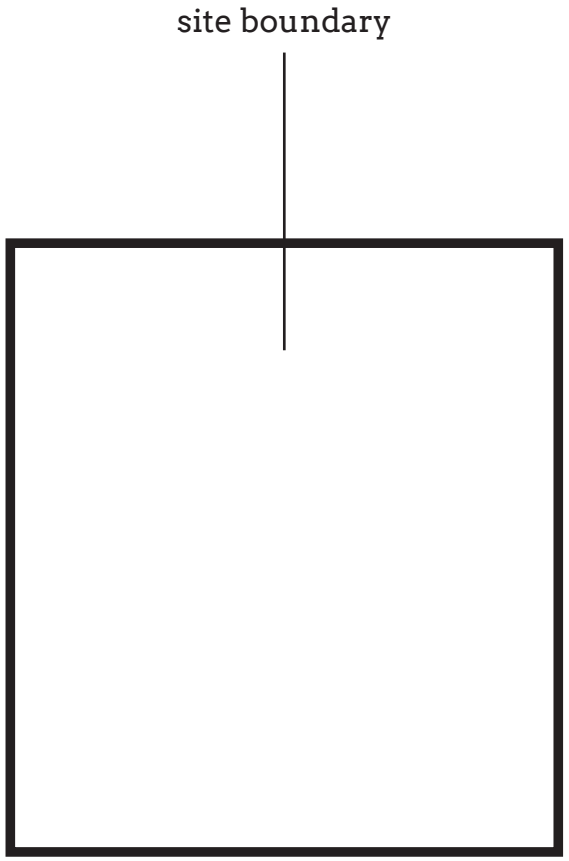
0 2.5 5 10 20 km

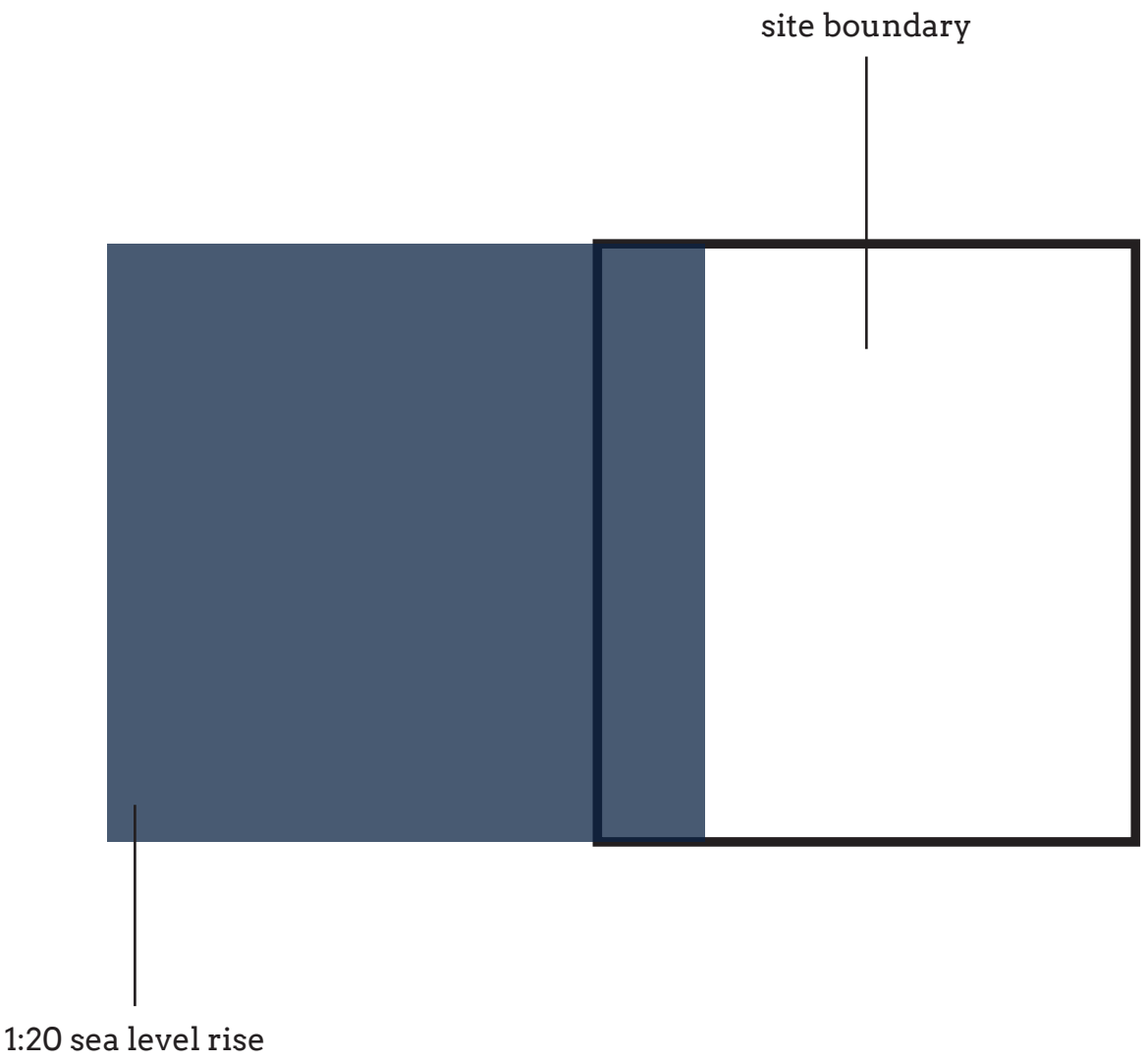


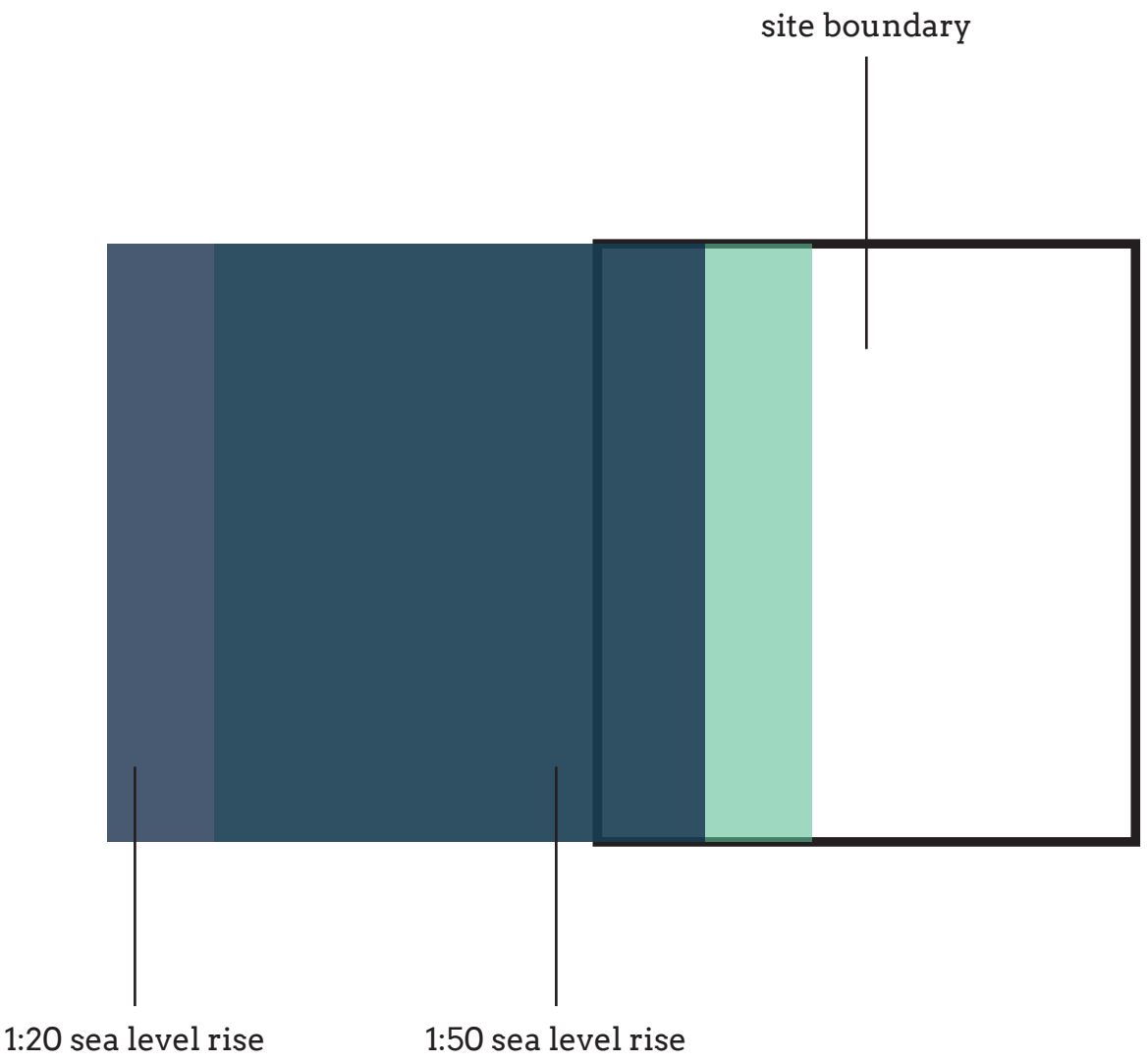
0 2.5 5 10 20 km

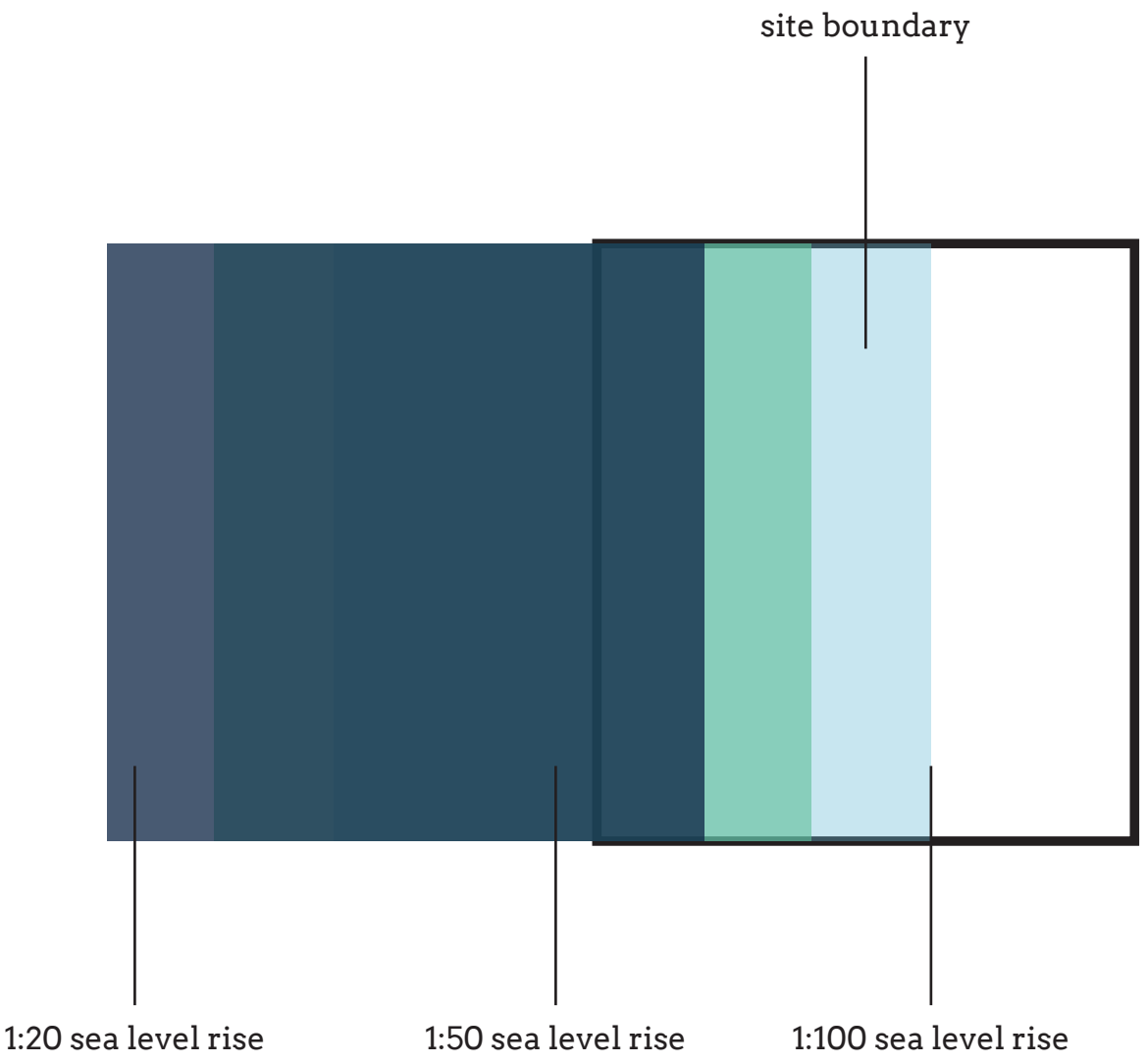


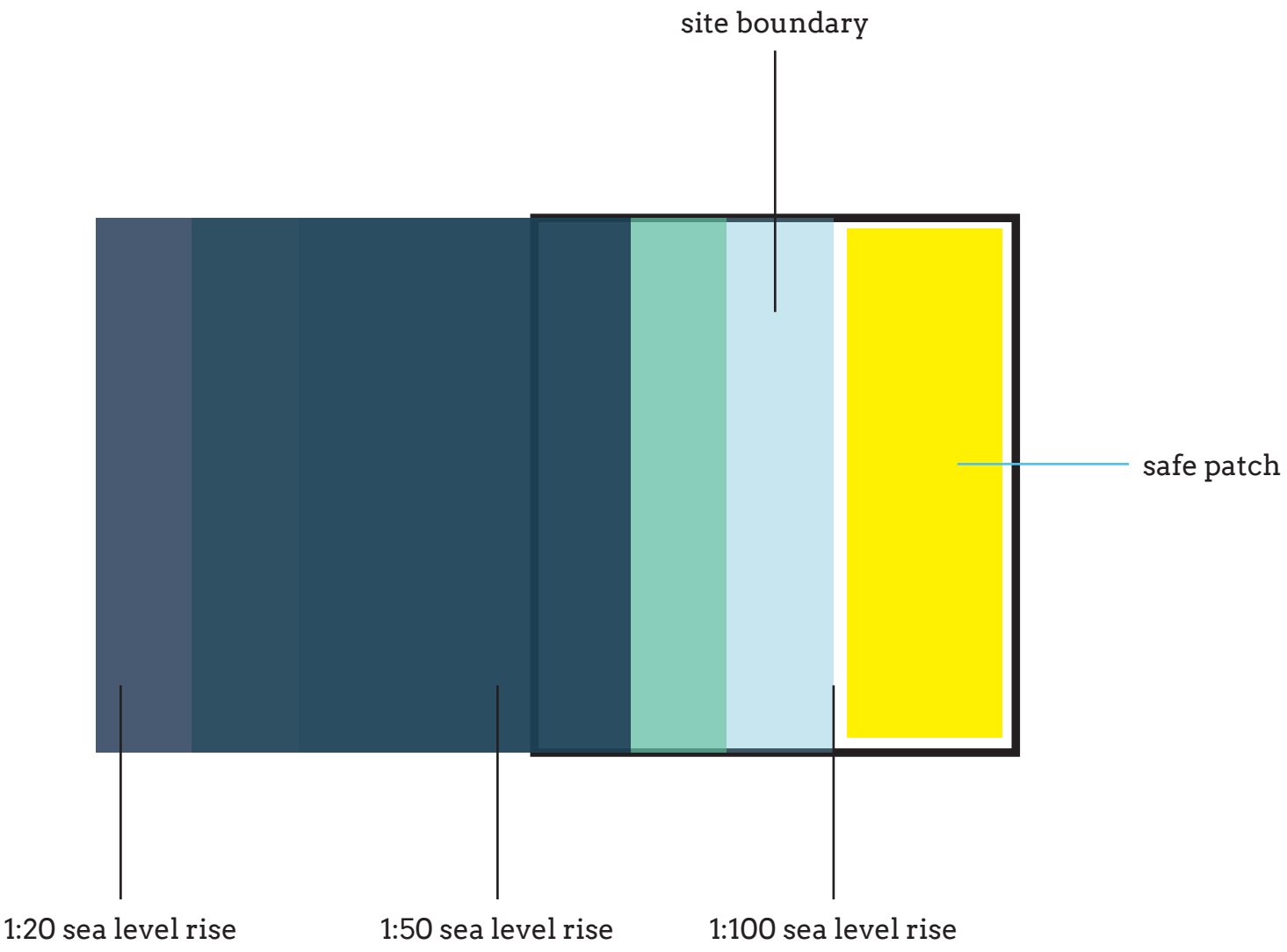
Finding the Middle Ground

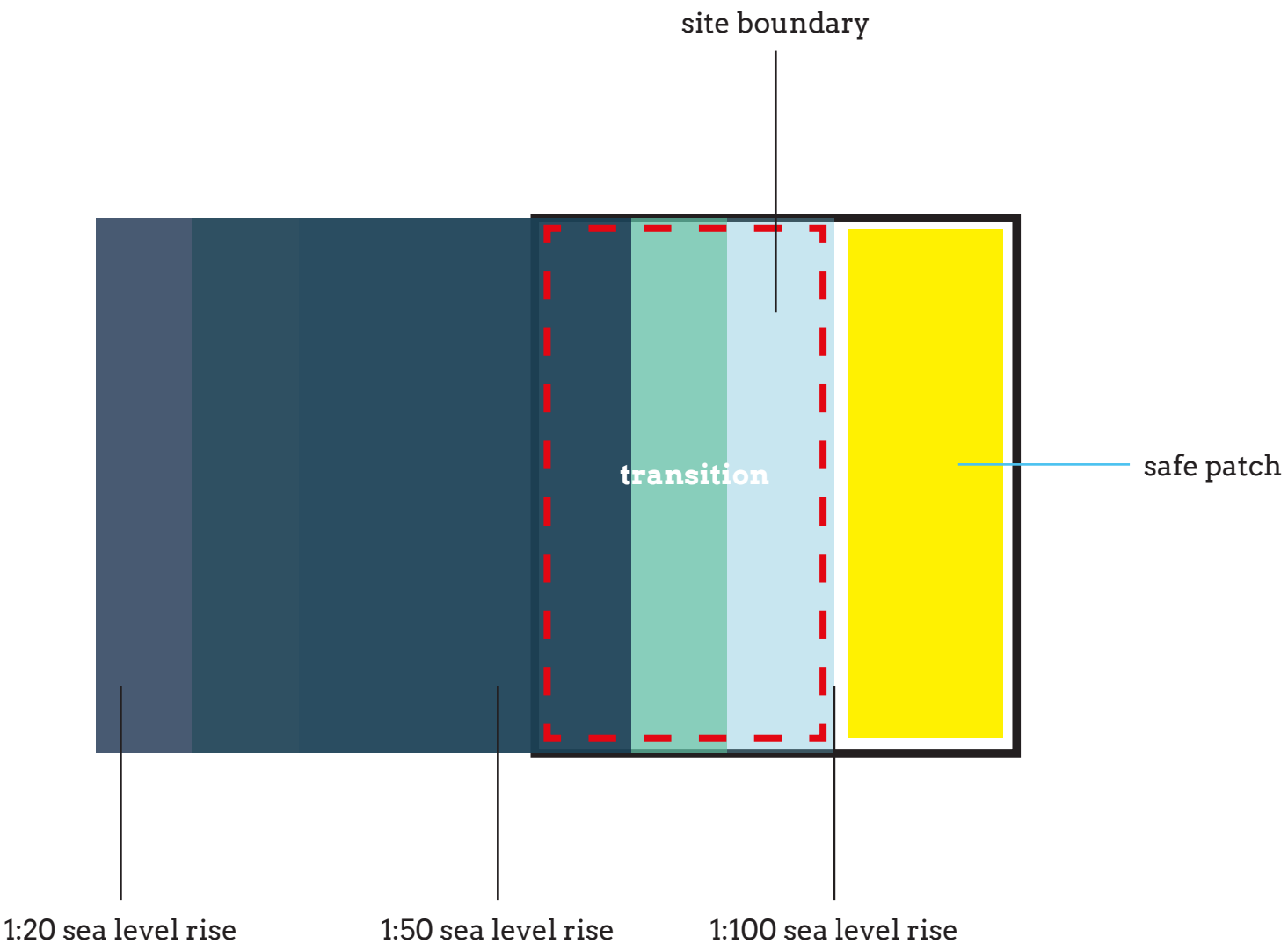

site boundary

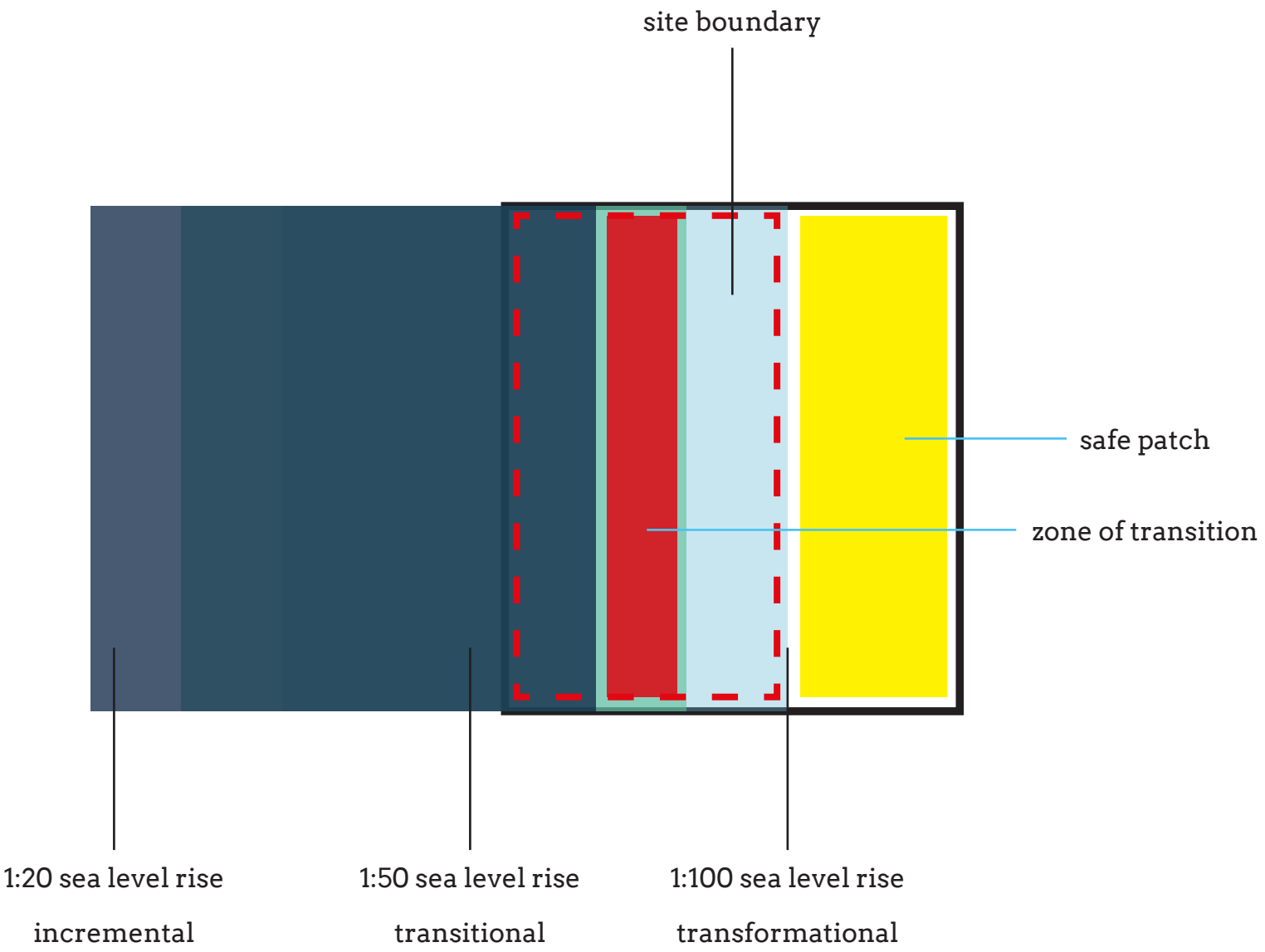

site boundary
1:20 sea level rise

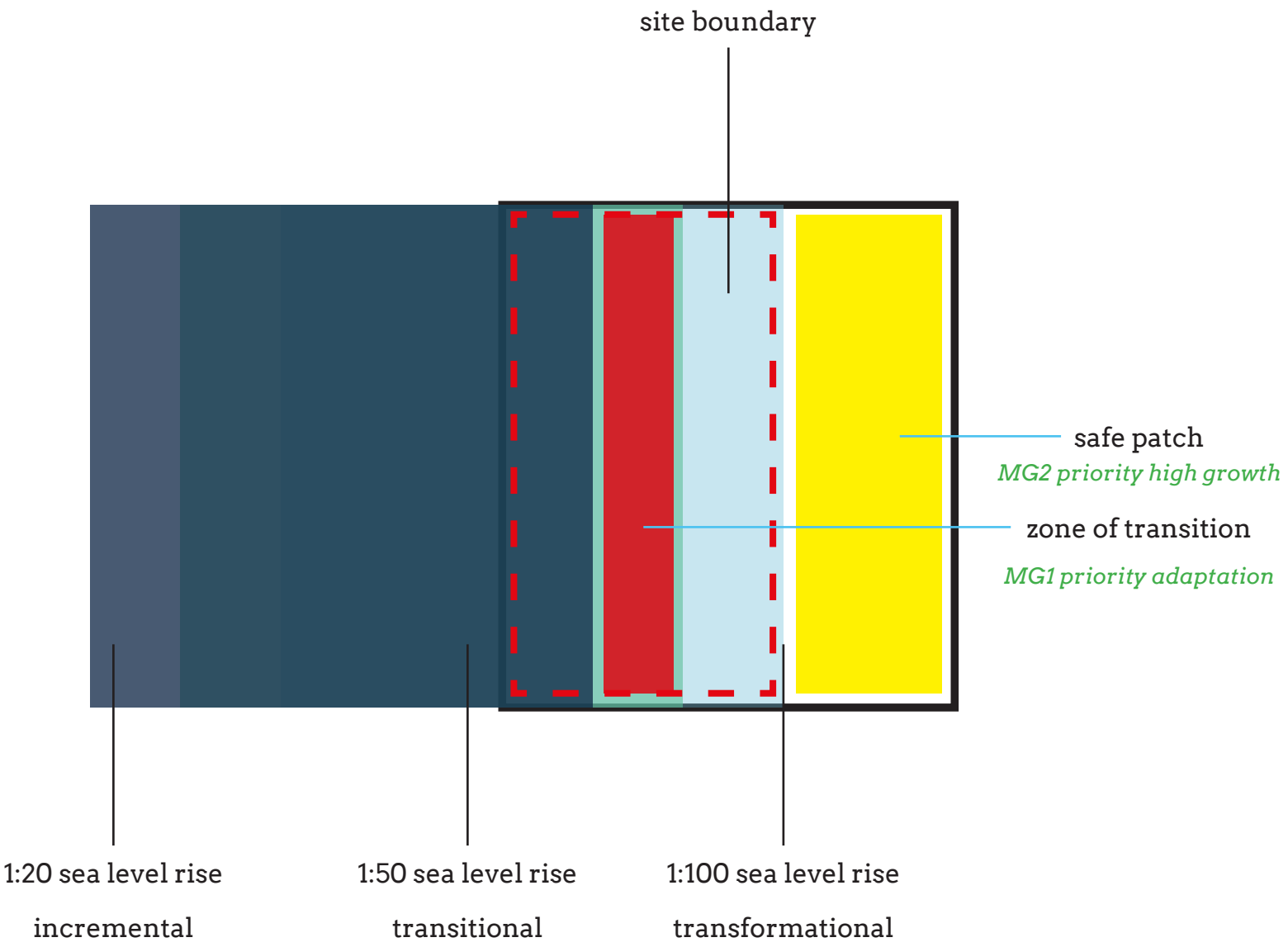

site boundary
1:20 sea level rise
1:50 sea level rise


site boundary
1:20 sea level rise
1:50 sea level rise
1:100 sea level rise


site boundary
safe patch
1:20 sea level rise
1:50 sea level rise
1:100 sea level rise


site boundary
transition
safe patch
1:20 sea level rise
1:50 sea level rise
1:100 sea level rise


site boundary
safe patch
zone of transition
1:20 sea level rise
incremental
1:50 sea level rise
transitional
1:100 sea level rise
transformational


site boundary
safe patch
MG2 priority high growth
zone of transition
MG1 priority adaptation
1:20 sea level rise
incremental
1:50 sea level rise
transitional
1:100 sea level rise
transformational

Parcel Transformation

@High risk

@low risk

Parcel Transformation

@High risk > risk taxonomy > adaptation
@low risk > intensify growth

=

new urban growth trajectories
new land programme
new network retrofit priority
new crisis management spaces

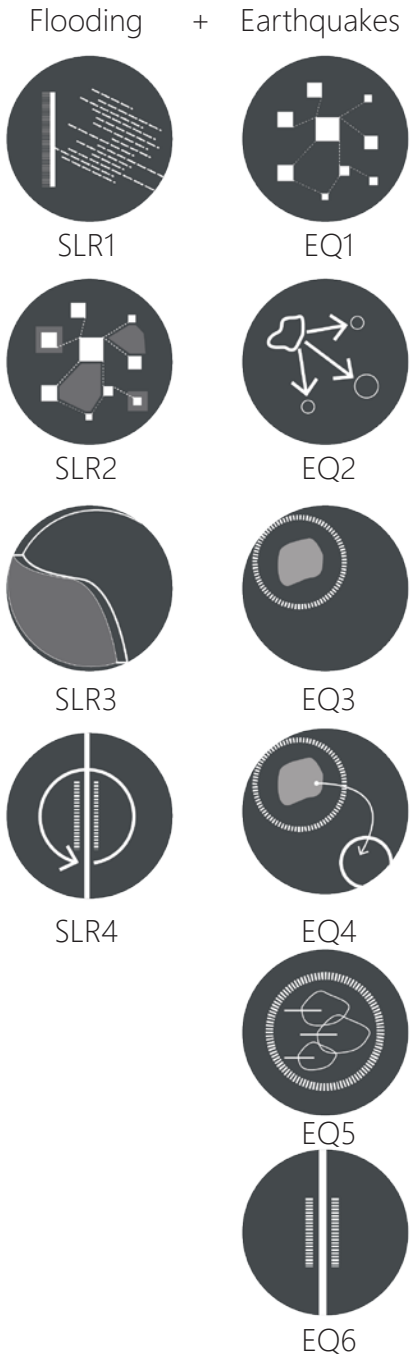
@High risk

Recommendations for parcels at risk of earthquake:

EQ1: Strong, accessible public space network to serve quality recreation and emergency evacuation.
—
EQ2: Quick and convenient access from seismic to non-seismic zones (by foot and by vehicles)
—
EQ3: Isolation of heavy soil liquefaction regions using landscape buffers
—
EQ4: Moving away high density development and centralities away from high seismic intensity zones
—
EQ5: Retrofit important occupation and infrastructure elements

Urban design characteristics:
Multi-functionality, permeability, strong elemental axis, visual accessibility, buffers

Recommendations for parcels at risk of flooding:
—
SLR1: Improve infiltration
capacity of ground (public spaces, unused spaces, roof tops)
—
SLR2: More space for surface water collection, wider streams and channels
—
SLR3: Elevated portions of land that inhabit critical functions and networks
—
SLR4: Retrofit heavy, immovable infrastructure to accommodate water or channelize water away from important zones
Urban design characteristics:
Green-blue network, corridors, porosity



@High risk

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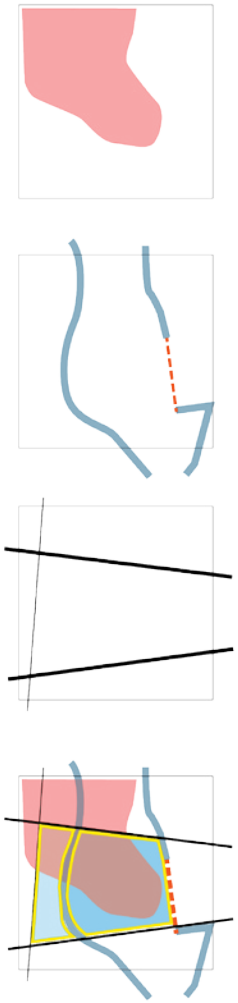
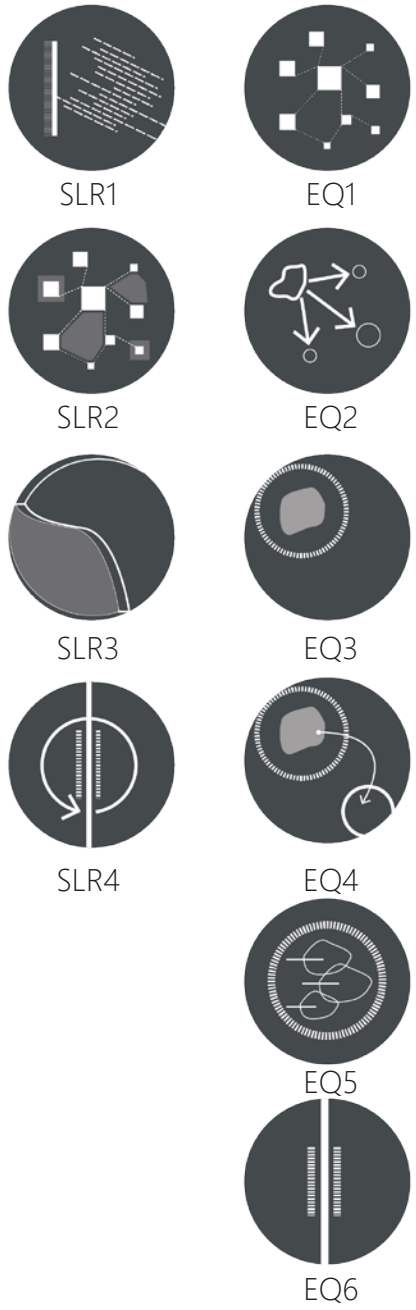
COMBINED RISKS





Current Centralities, Critical Nodes, 2 Hazards

AT RISK: Current Centralities, Critical Nodes, 2 Hazards

Urban Transformation RESILIENT PATCH MATRIX toward 2100

N1- Intersection of critical networks (water/transport/energy)

Sea Level Rise Risk - HIGH

Sea Level Rise Risk - MEDIUM

Sea Level Rise Risk - LOW

Sea Levl Rise+Earthquake RISK (refer Risk Taxonomy Map)

Earthquake Risk

Critical network intersections at risk of hazard impact

current+proposed centralities

centralities at high risk of hazards

centralities at moderate risk of hazards

N1- Intersection of critical networks (water/transport/energy)

zones for critical functions

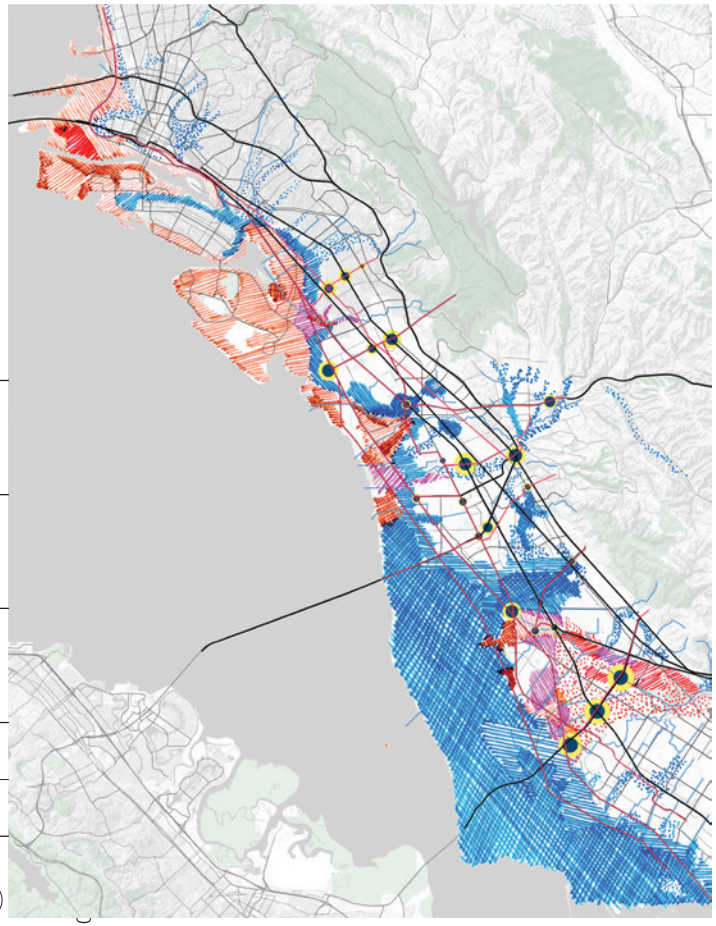
patches of high densitty critical network intersections

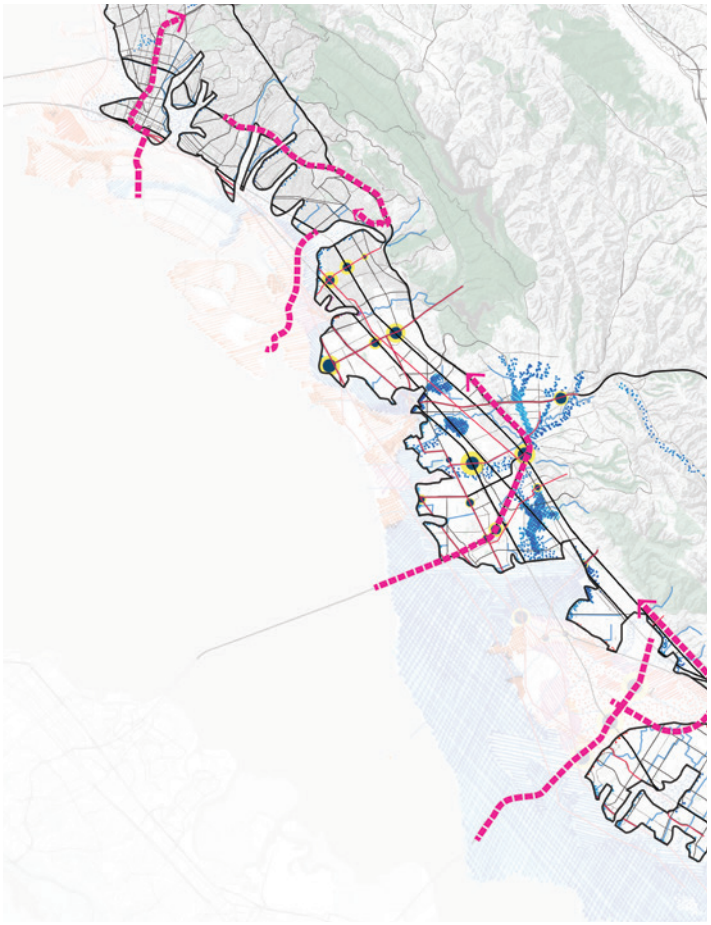
current+proposed centralities

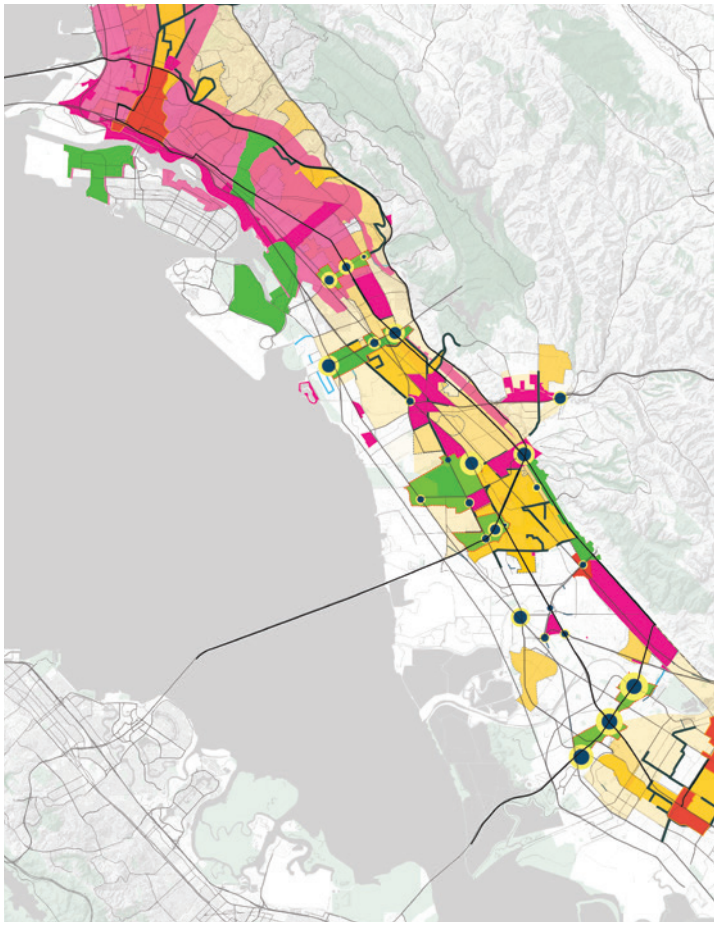
proposed centralities

Points of transformation

Middle Ground 1 > SAFE >Intensive Growth







20
10
5
2.5
0

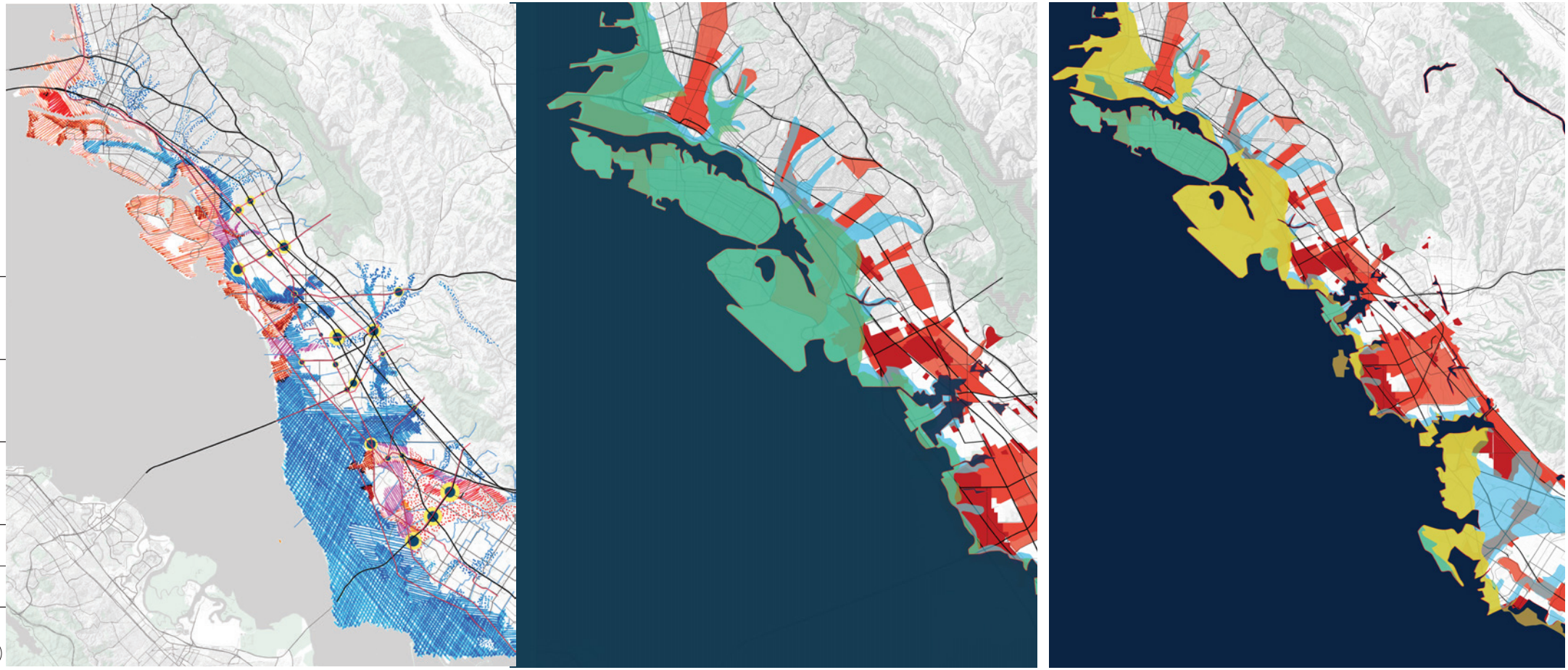
1 in 20 year flooding extent

1 in 50 year flooding extent

1 in 100 year flooding extent

Centralities and non-housing functions

Middle Ground 1 > AT RISK >Adaptation



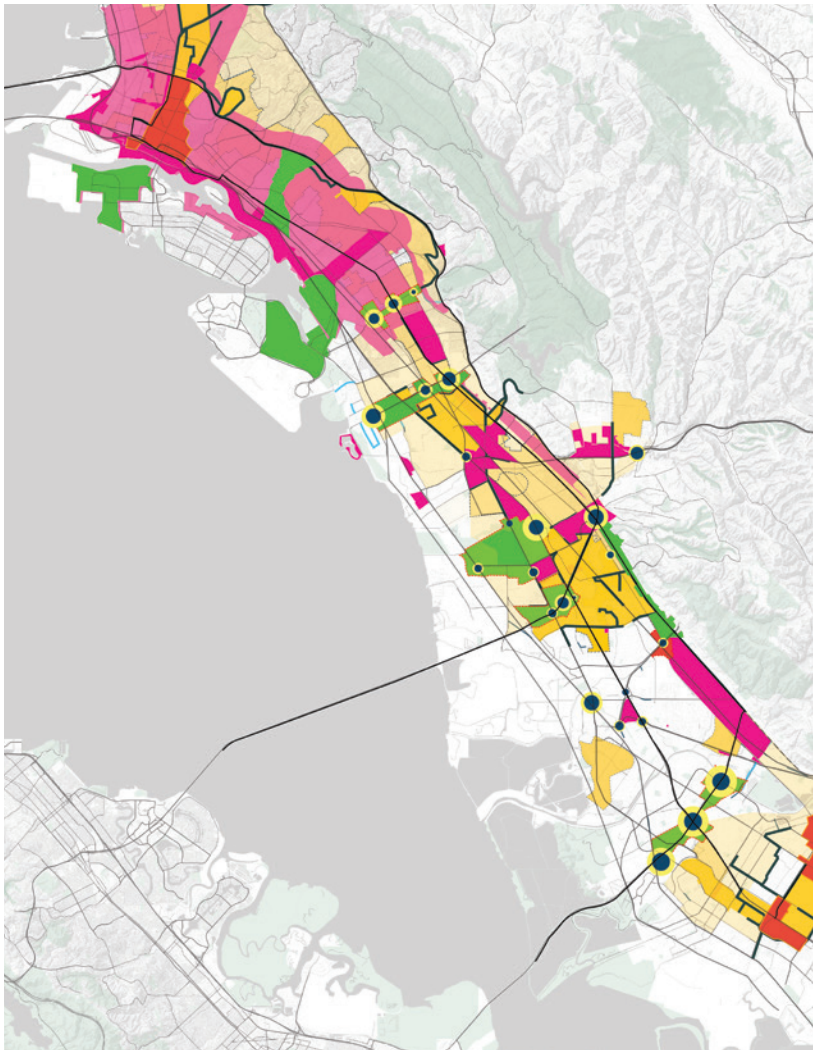
1 in 20 year flooding extent

1 in 50 year flooding extent

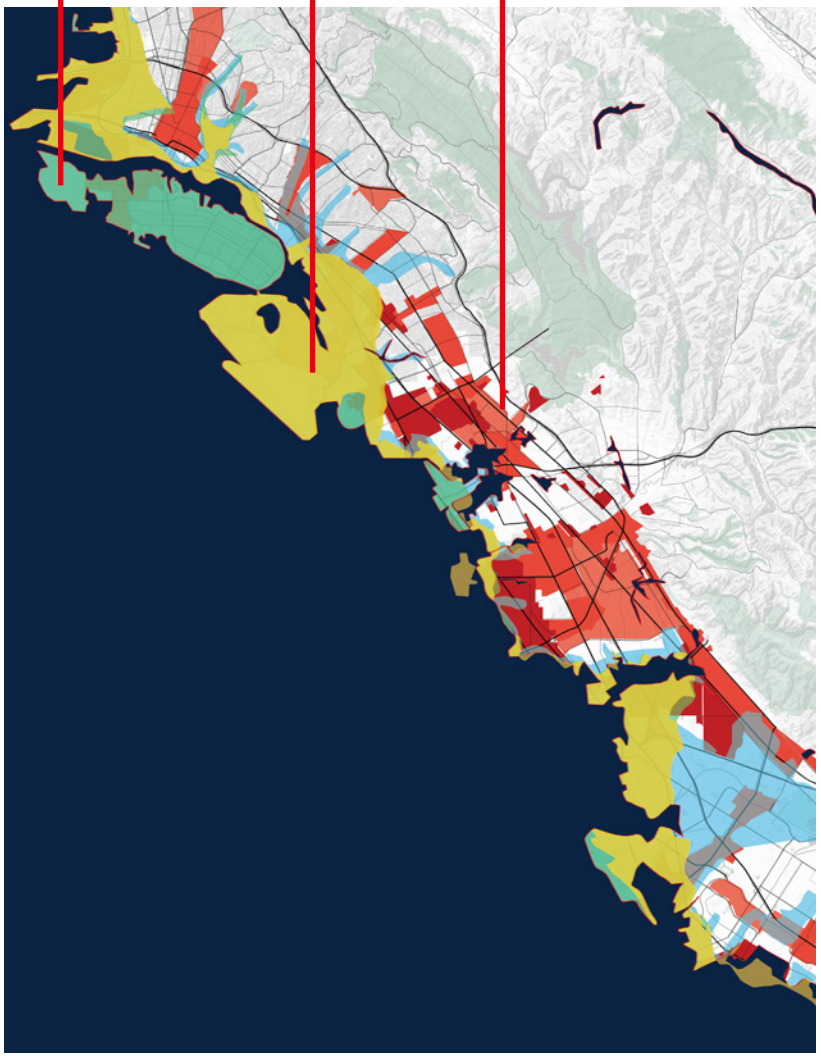
1 in 100 year flooding extent

Centralities and non-housing functions

MG1+MG2

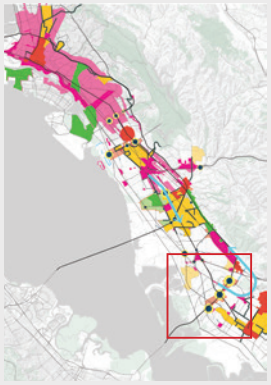


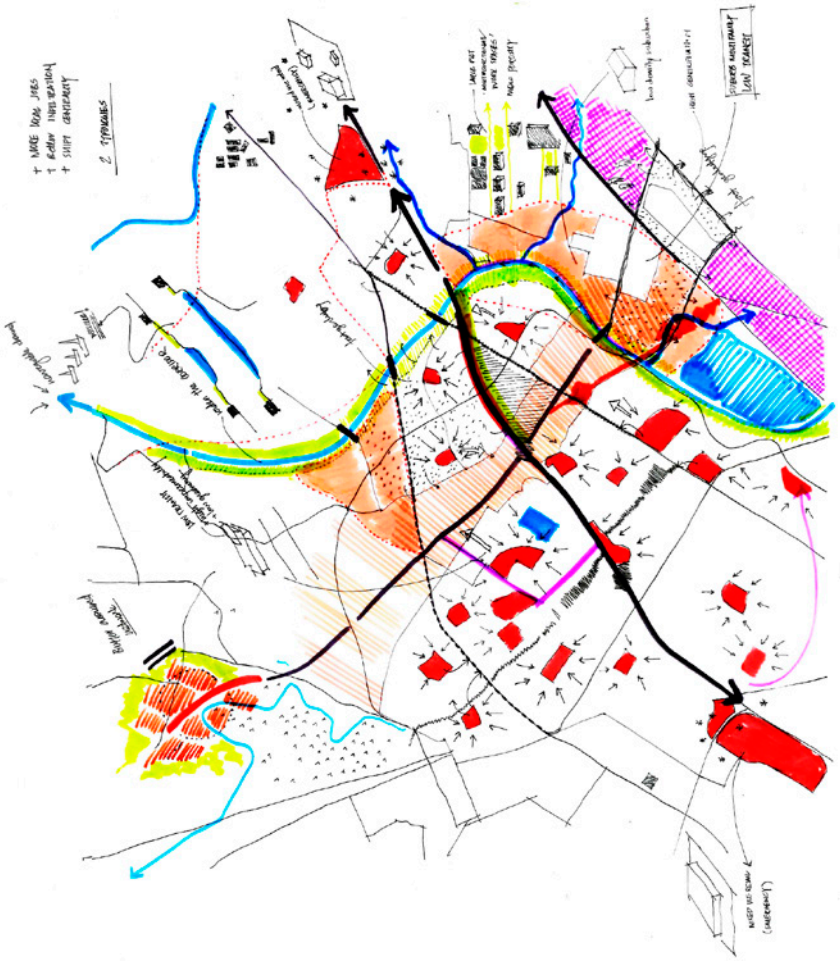
Incremental 1:20 | Transitional 1:50 | Transformational 1:50



MG1+MG2

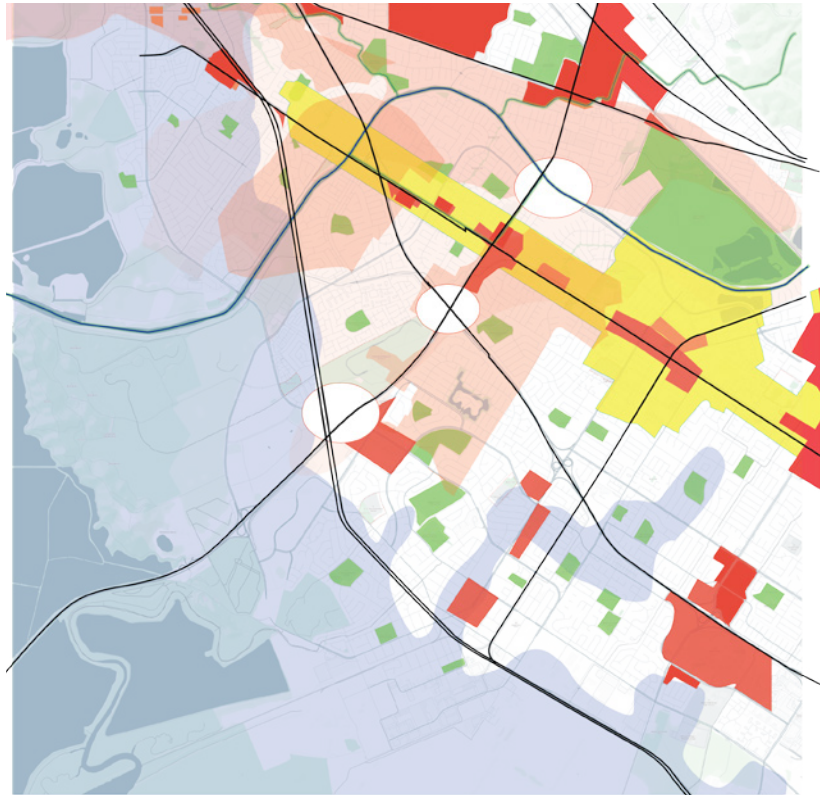
Node Transformation

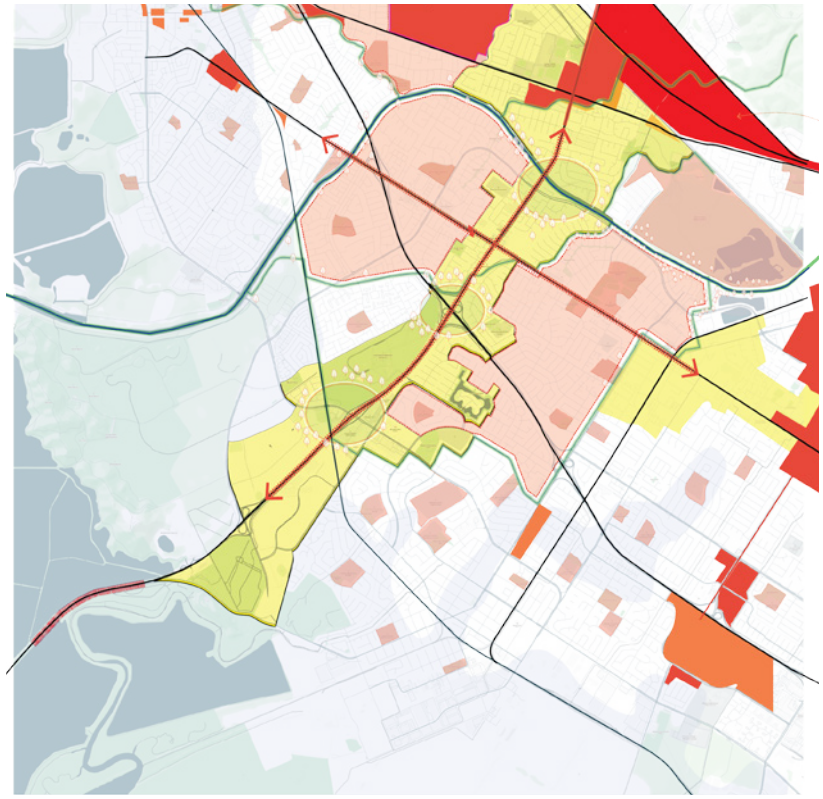




Node Transformation

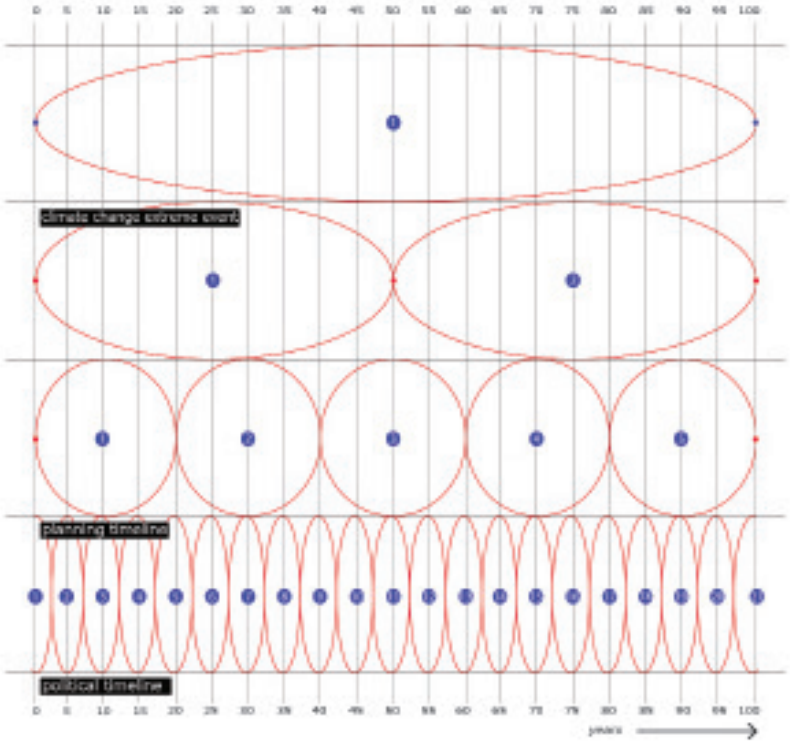
New Axis
New Centrality
Retain- Retrofit- Protect strategy

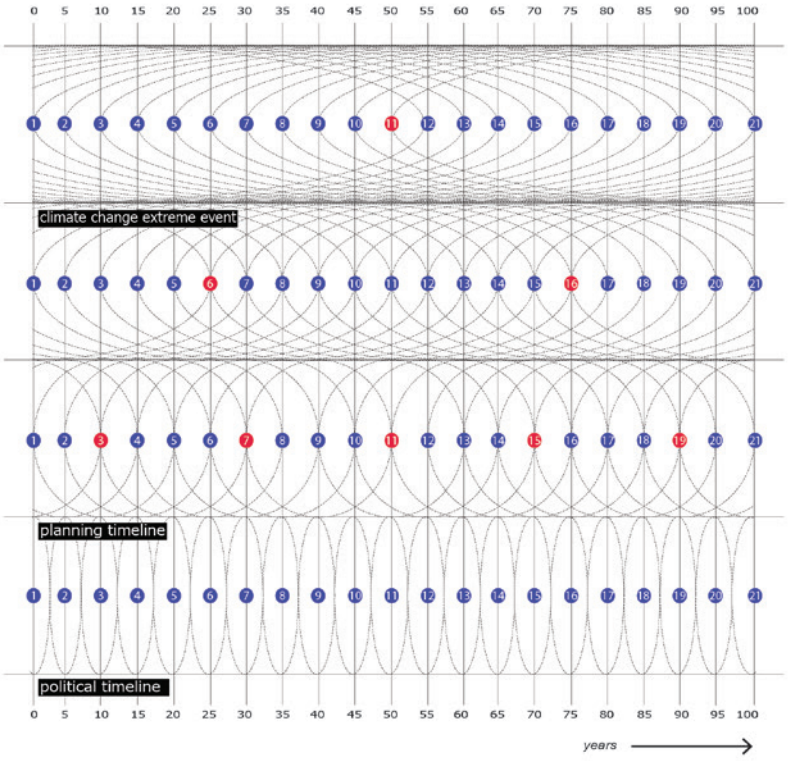




Challenges and Application

Probabilistic v/s Progressive



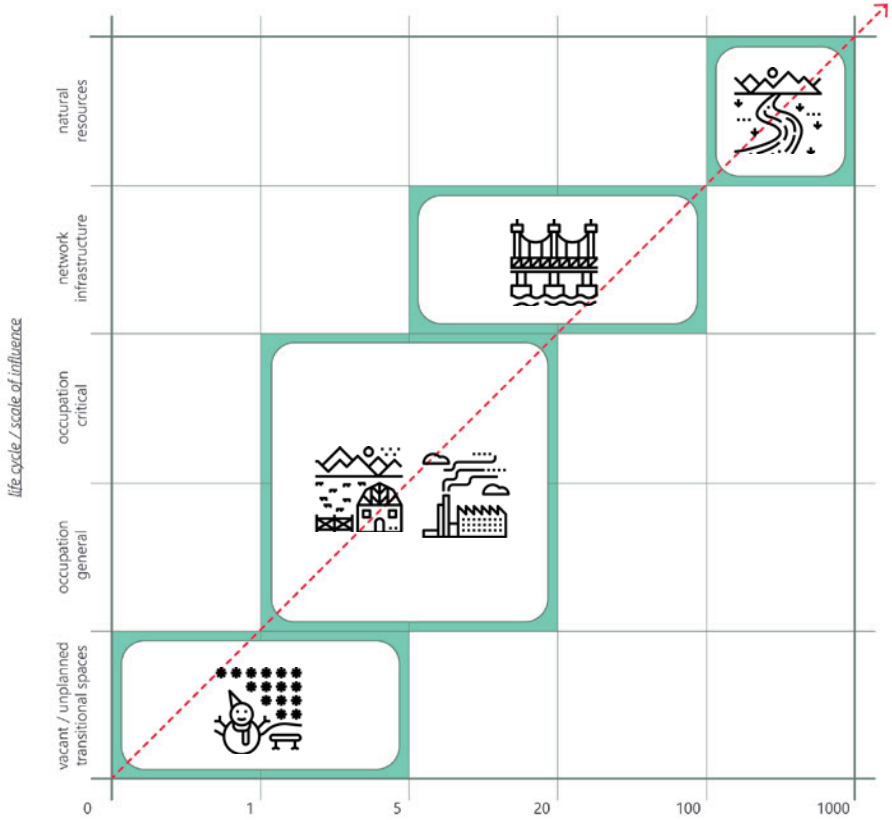


Space Time Model

CORRELATING URBAN LIFECYCLE TO CLIMATE RISK RETURN PERIOD
Transformation space recognised
How can urban elements respond to this?
Flexibility Matrix of Urban Space

PHASING

Nature-Infrastructure-Occupation



Disruptions

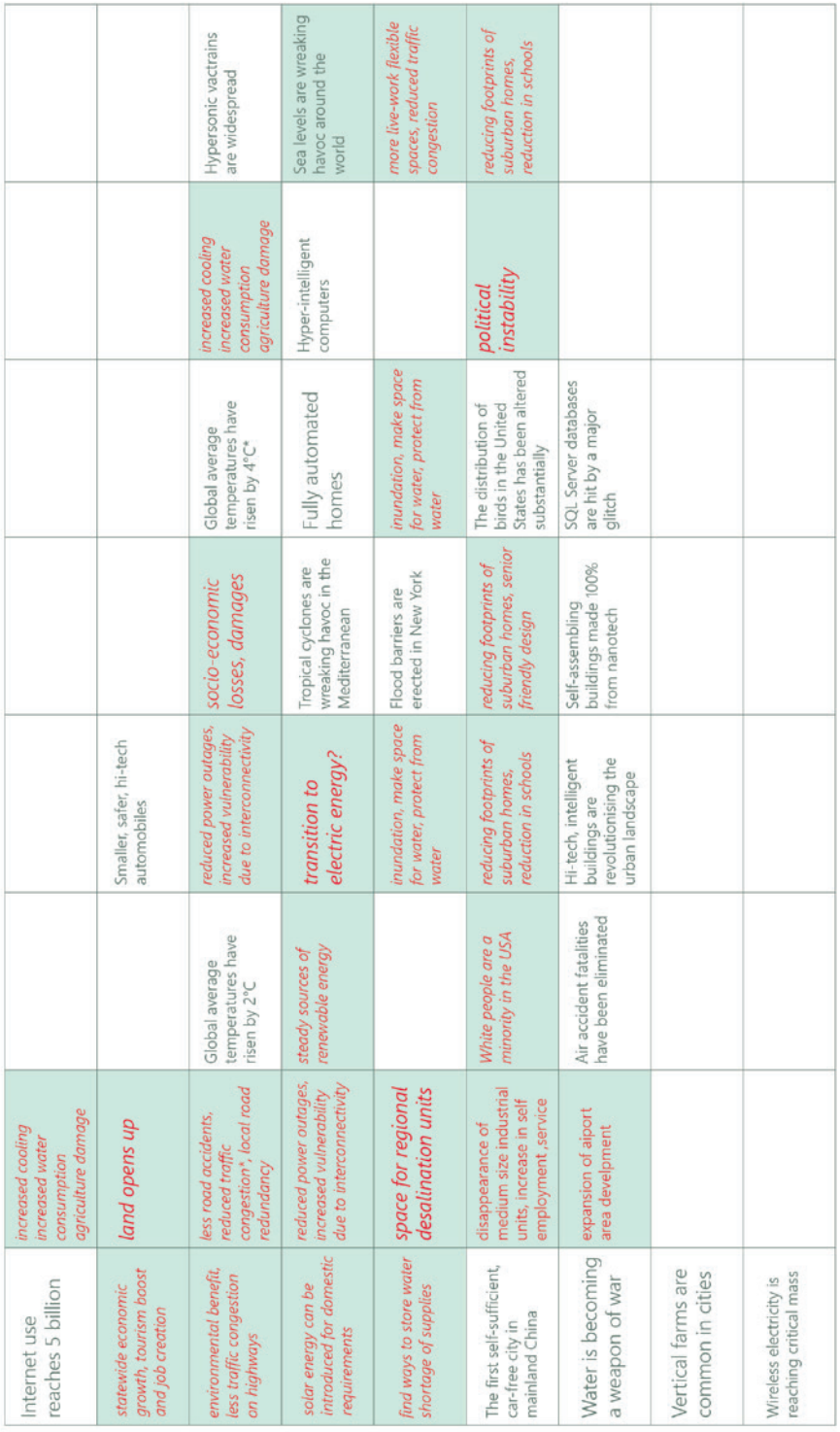
spatial configuration and the observed functioning of the built environment

Regularities / Man made

Self Driving Car+ Car Sharing

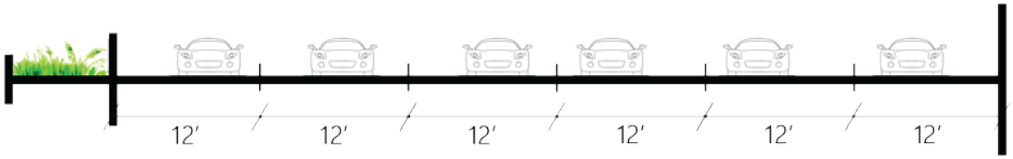
Irregularities / Natural

Tsunami



Scenario 1

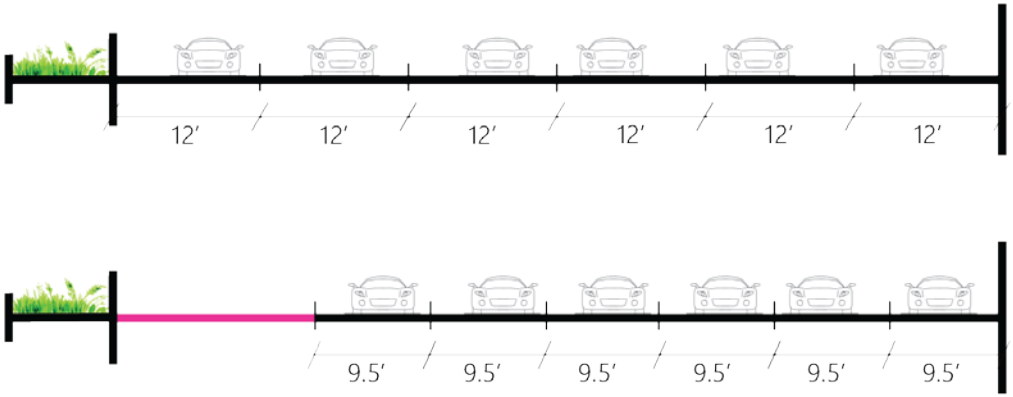
manmade disruption: car sharing



Primary evacuation channel

Scenario 1

manmade disruption: car sharing

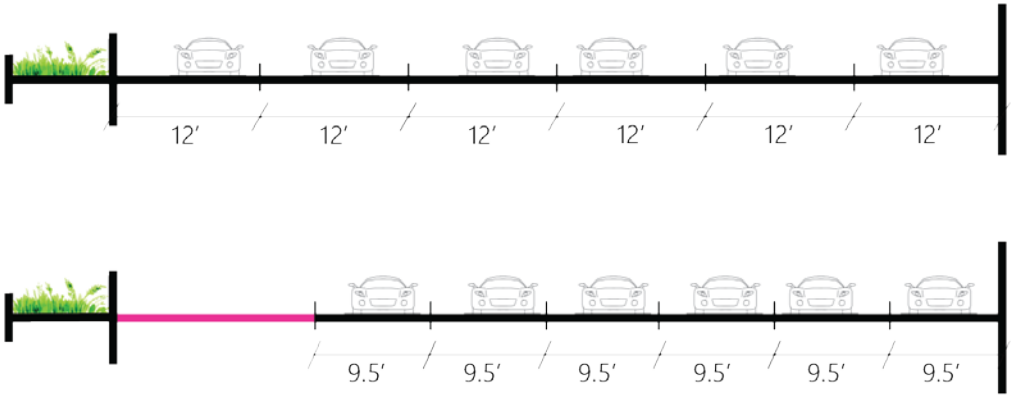


Primary evacuation channel

20%

Scenario 1

manmade disruption: car sharing



more green space

Off grid energy for a crisis

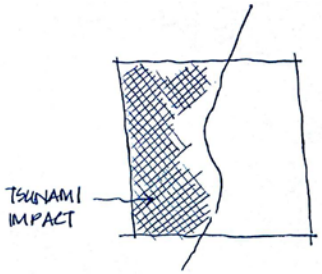
Space for flooding

Primary evacuation channel

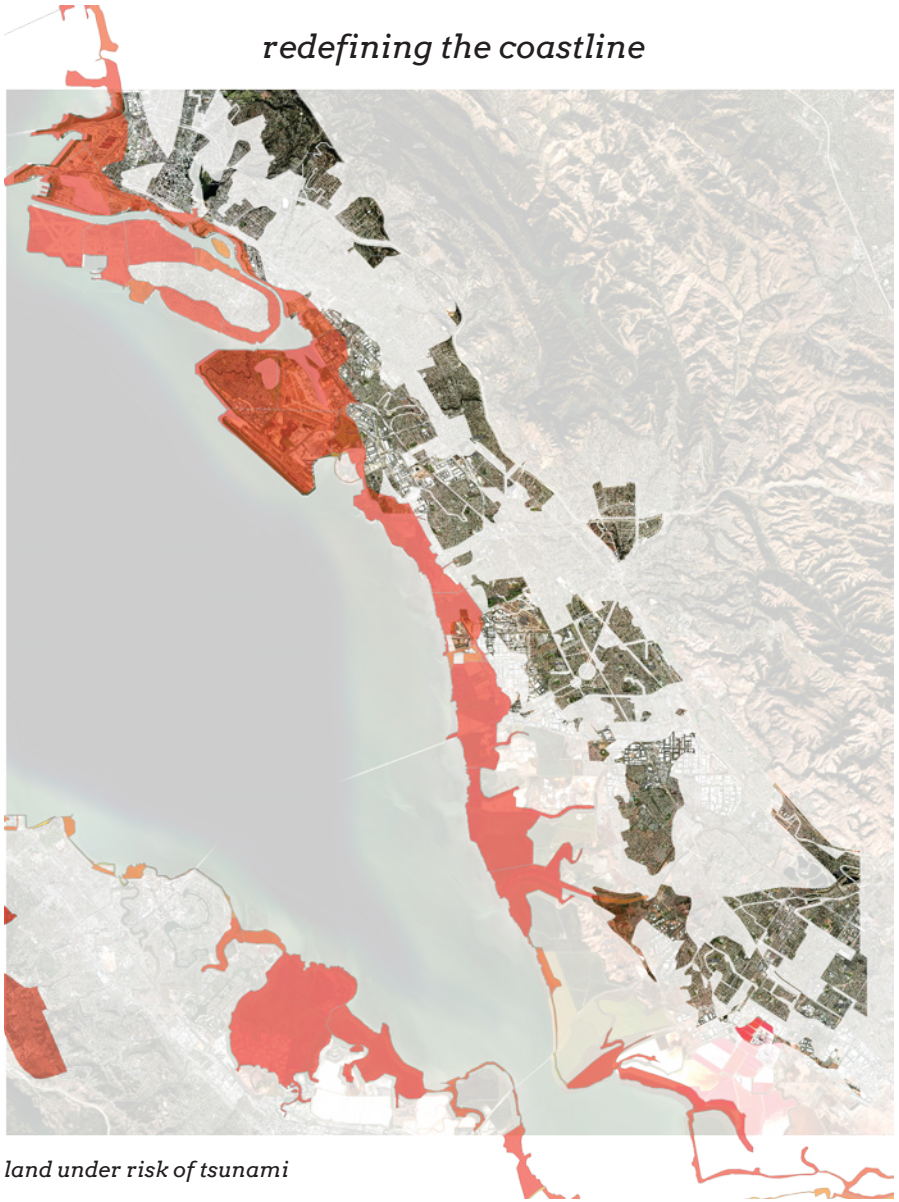
20%

Scenario 2

natural disruption: tsunami



redefining the coastline

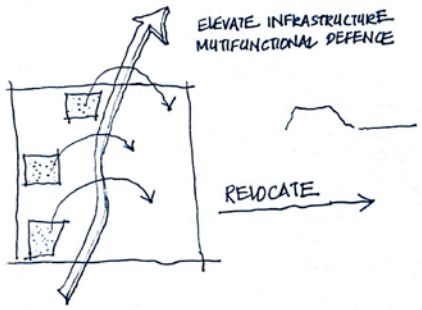


land under risk of tsunami

Scenario 2

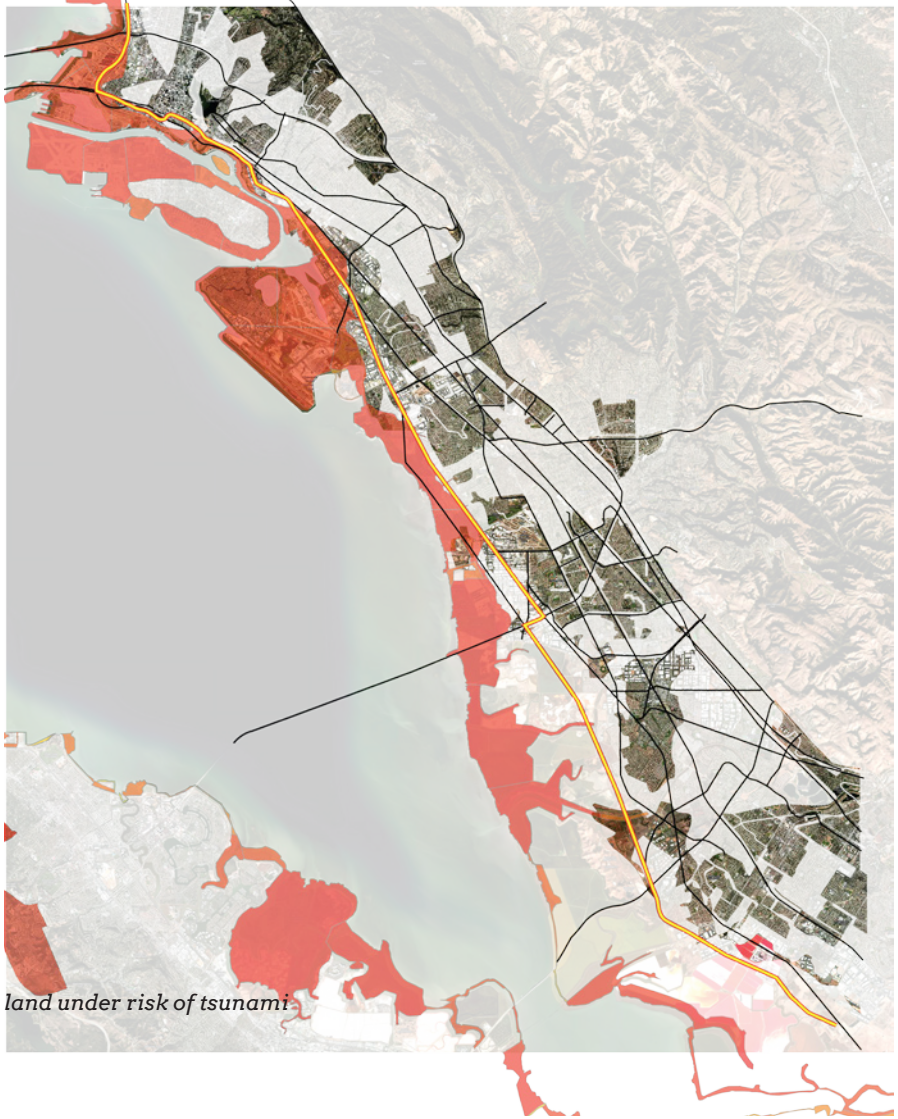
natural disruption: tsunami

relocate from vulnerable land. retrofit infrastructure to keep water out



Courtesy: BIG Architects

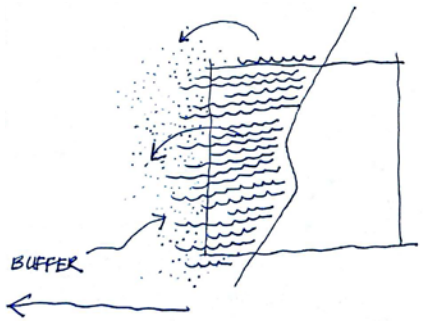
redefining the coastline



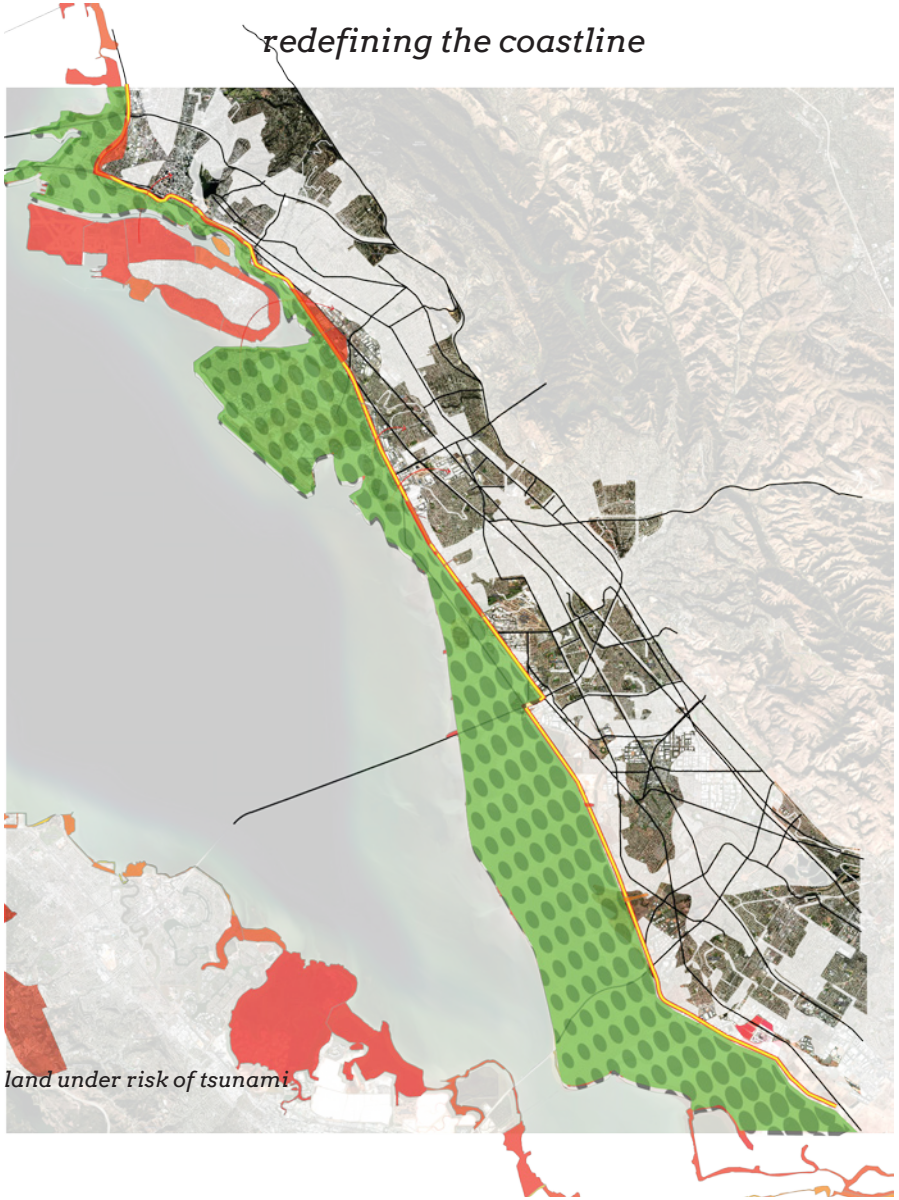
Scenario 2

natural disruption: tsunami

extend land out: buffer / nature

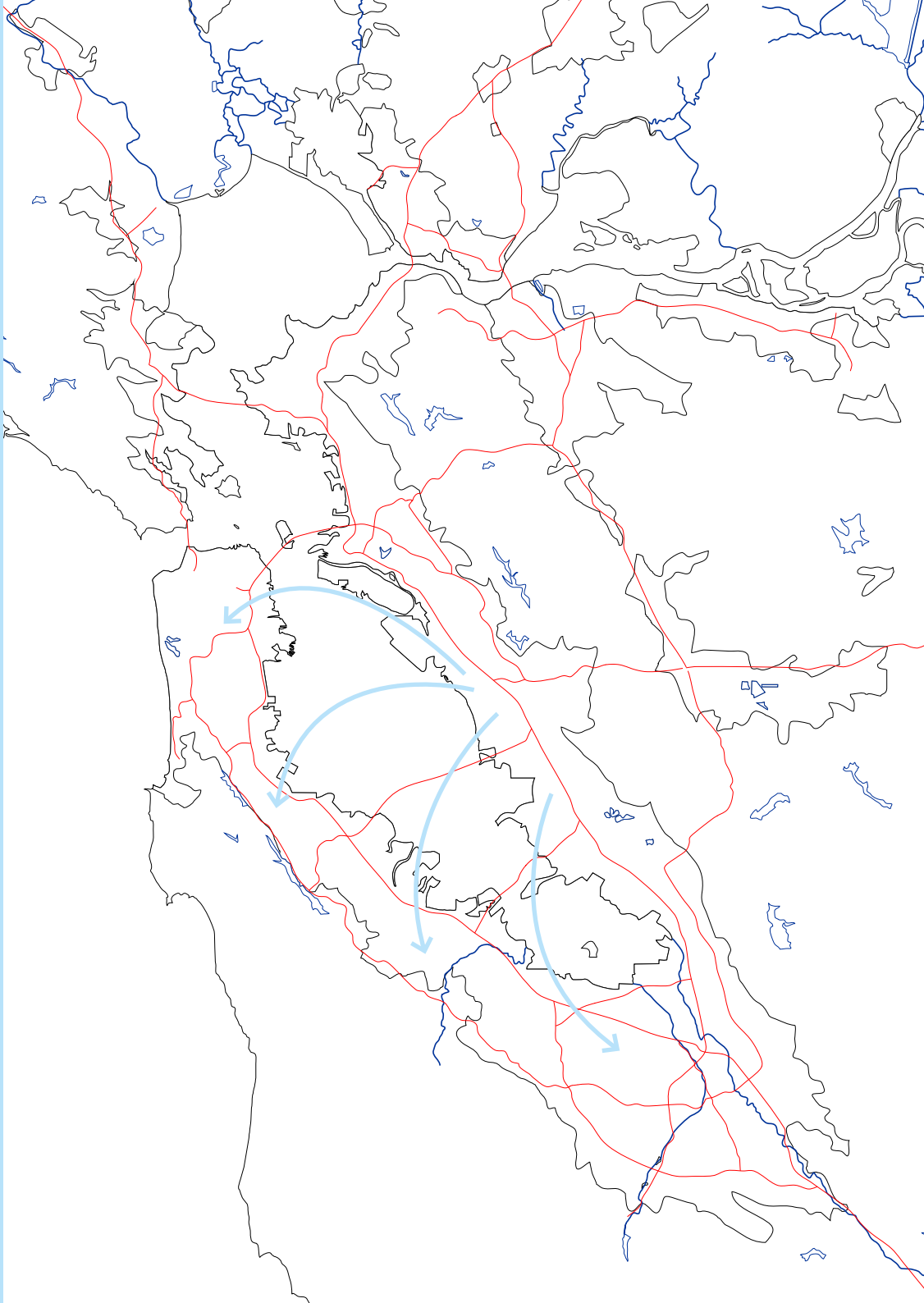


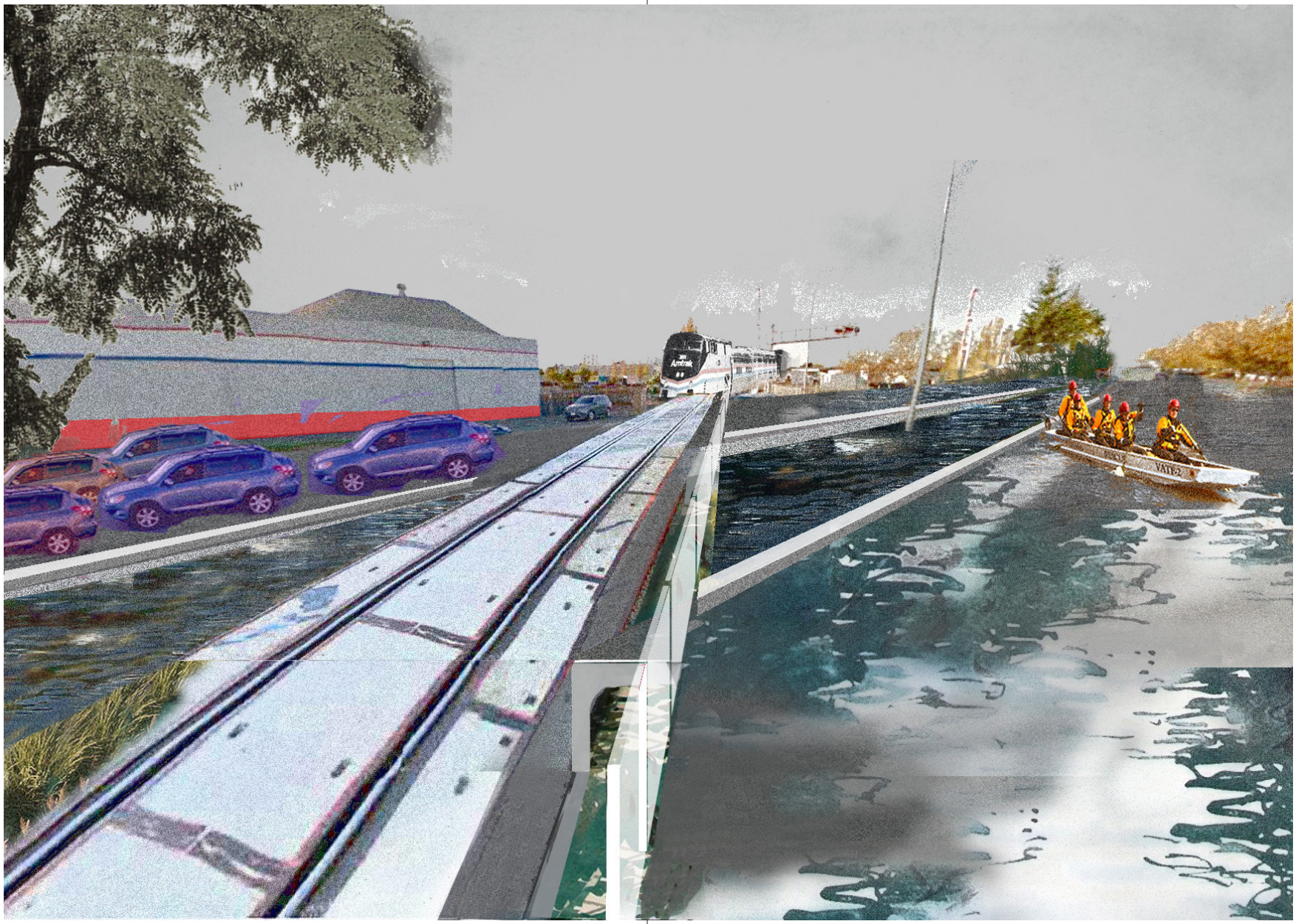
redefining the coastline



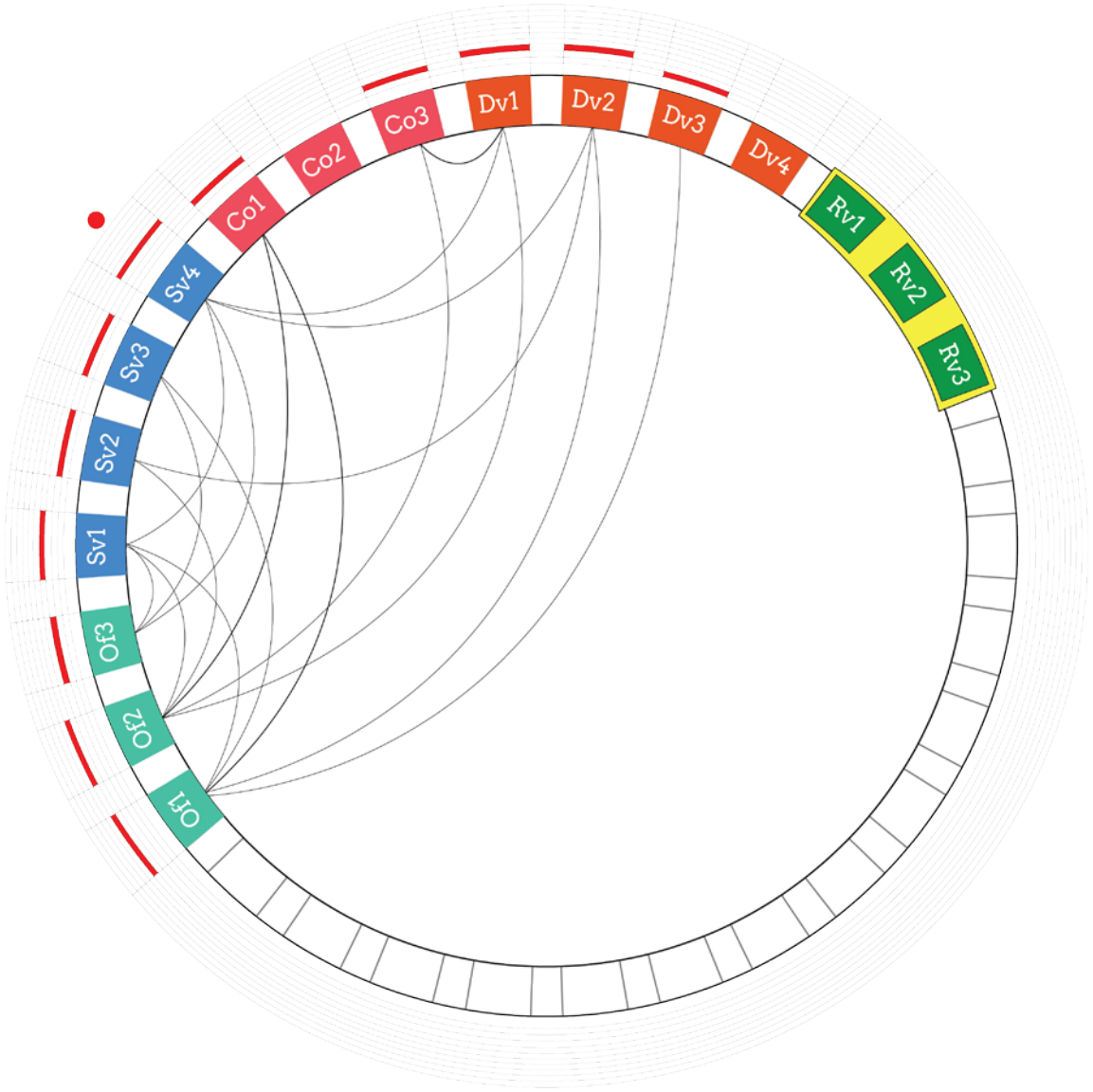
Transferability

Utilising the logic of risks in space for other sites




Amtrak

Spatial Risk Assessment framework



Of1	Minimize damage to critical functions and infrastructure assets
Of2	Maintain continuity of critical services
Of3	Minimize Cascading Failures
Sv1	Location and characteristic of high density of critical infrastructure systems
Sv2	Accessibility: Distance and available redundancy to travel for safety/ emergency services
Sv3	Landscape characteristics
Sv4	Urban Design
Co1	Frequency and intensity of hazards (sea level rise, earthquakes)
Co2	Regulatory constraints
Co3	Transition between different modes of transit, obstacles in accessibility
Dv1	Movement behavior compared for normal conditions and under crisis (people, supplies, energy)
Dv2	Volume of people to be evacuated and the carrying capacity of the channels
Dv3	Socio-economic demography (Population, Community structure, school schedules)
Dv4	Governance and organization structure
Rv1	Critical Infrastructure reliability: State of Performance (0 to 100%) – based time/season/type of threat
Rv2	Deep uncertainty due to extreme weather
Rv3	Disruptive elements (technological, cyber-attacks, tsunamis)

Fundamental learning

Design Outcome

Integrating risk management in land use Identifying critical backbone infrastructure for regional growth

Spatial Risk Assessment framework

The zone of transitional growth to prioritise high and low investment: assess disaster impacts to help governments adjust their financial planning scenarios and economic growth rate projections

Synergies between Quantitative+Qualitative in Spatial Planning
Network Analyst in conjunction with evacuation behaviour layer: Critical Mapping (perhaps a new plugin?)

Design Thinking

Heuristic Thinking / Aggregation to combine learnings from disciplines

Directions for priority ‘gap’ research areas for **active implementation**

Limitations/ Challenges

Overview

-lack of thorough knowledge about technical domains
-lack of a concrete 'spatial' output validation model
-validation of the spatial outcome and implications
-issues in real world implementation
(multijurisdictional issues, intragency collaboration)

How can we evaluate return periods several times higher than the length of the data available?

Process

Data Collection
Iterative research and analysis methods
Feasibility models

Design

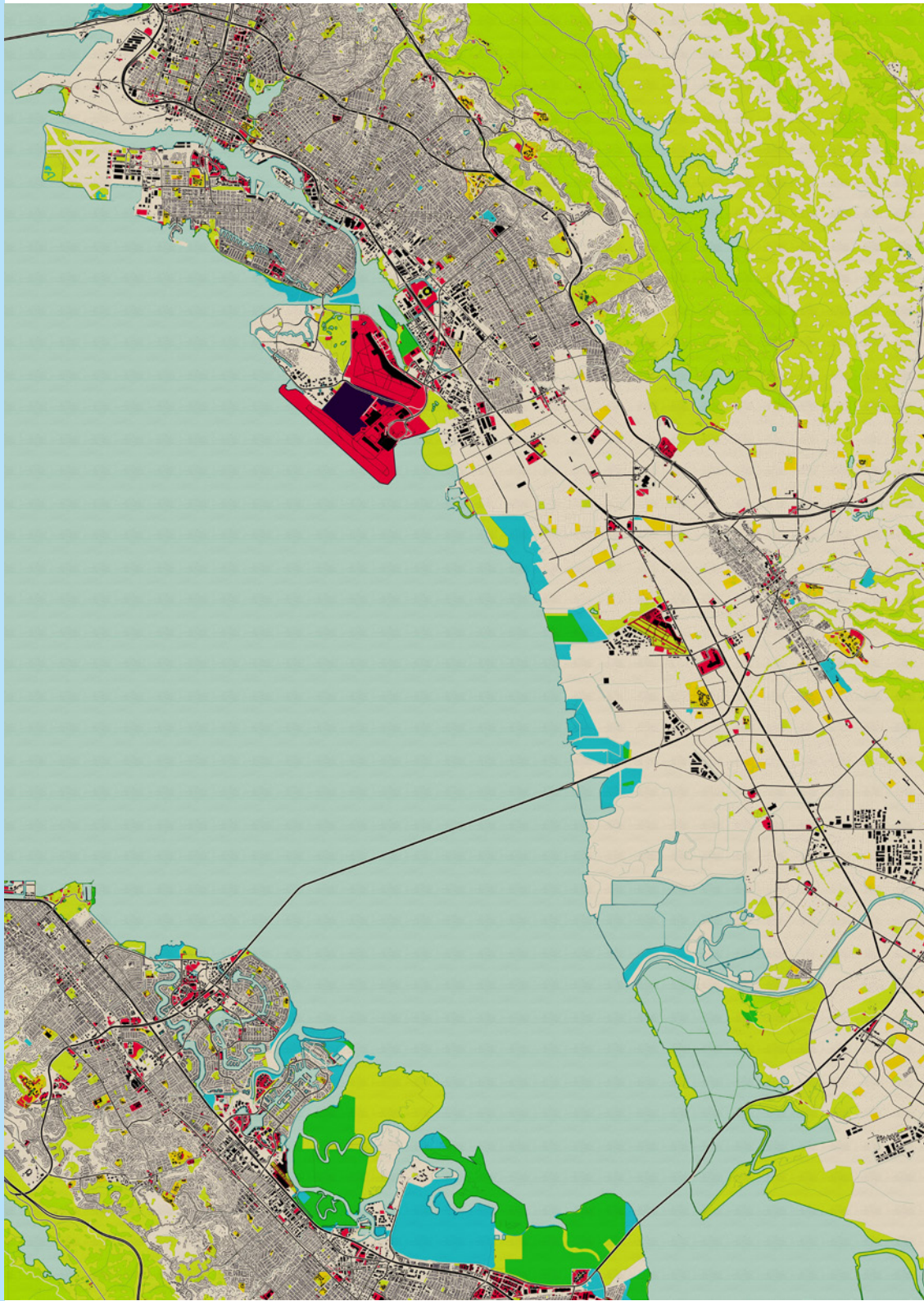
Making the leap from strong network analysis to space
Peripheries of urbanism : aggregation of concepts in many areas

Conclusions

A temporal growth strategy that can grow in sync with intensifying climate change towards 2100.

A ‘spatial risk assessment framework’ highlighting tangible urban design parameters to systematically evaluate spatial resilience .

A Space-Time incremental planning method, phasing the resilience investment for a region based on the probability of flooding event. Each phase (P1, P2, P3) has associated spatial actions based characteristic of the plot and exposure to risk



Thank you