

MUD BAY SURREY

DESIGN RESEARCH
CONCEPT VERSION
DECEMBER 2017



THE UNIVERSITY
OF BRITISH COLUMBIA

LINT
landscape interventions

MUD BAY SURREY

Date 19th December 2017

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CONTENTS

1. Analysis	7
2. Assignment	21
3. Design Workshop	25
4. Design Models	27
5. Vision Mud Bay	51
6. Matrix of interventions	53
7. Spatial Design strategy	63
Attachments	
- Workshop report	
- Workshop results	
- Design models	
- Infrastructure study	



1. ANALYSIS

The landscape of Surrey was formed during the last Ice Age, large ice slabs pushed sediments upwards, forming the higher grounds of the area of Surrey. The majority of residential and commercial development occurs on these high grounds. Below lays the floodplains of Surrey, formed through the deposit of modern sediments.

The Semiahmoo, Katzie and Kwantlen First Nations People have lived in the area for thousands of years, till the late 1800's when settlers arrived in the area. In 1880, Surrey had a population of 200 people, this amount has grown significantly over time. Currently Surrey is the second largest City in British Columbia. It has a population of over 500.000 people and it is expected to grow even further in the coming century.

The floodplains of Surrey have a range of different land uses with agriculture being the most dominant land use. The floodplain is being influenced by the Serpentine and the Nicomekl river, that are passing through the landscape. The rivers flow into the Boundary Bay, an important area for both resident and migratory birds. The coastal areas such as the Colebrook Dyking District, the Mud Bay Dyking District and Crescent beach, are under the influence of both the freshwater rivers, and the Boundary bay, resulting in a highly dynamic coastal area.

COLEBROOK DYKING DISTRICT



Tidal zone



Dyke + BNSF Railway bridge



Mud Bay Park

MUD BAY DYKING DISTRICT



Local farm



Dyke structure agricultural land



Land eroding outside dyke

CRESCENT BEACH



Crescent Beach



Houses along the shoreline



Dyke Crescent Beach



Nicomekl Seadam



BNSF Railway



View from Mud Bay Dyking District

BEFORE EUROPEAN CONTACT
Kwantlen and Semiahmoo people lived in villages along Fraser river and Boundary Bay for more than 6000 years. Decimated by disease after the arrival of Europeans.



EUROPEAN FIRST CONTACT (1791-1972)
Spanish exploring the Straight of Georgia were the first who saw South Surrey. In the beginning they thought it was an archipelago. Captain G. Vancouver began a detailed survey of the Coast of British Columbia. Spanish and England explorers met and exchanged information about their surveys.



FIRST LANDSCAPE DESCRIPTION (1858 CA.)
Lowland appears flat, the bay appears to be shallow. Willows, pine, cedar, birch, alder and some other trees. The plain with weighty rain become like a swamp. Every hollow was a pool of water. The soil appear very rich for agriculture.



THE GOLD RUSH (1856)
After discovered of gold in Fraser river, trading, as well as boarding of horses was a well respected business. Some farmers started to raise horses.



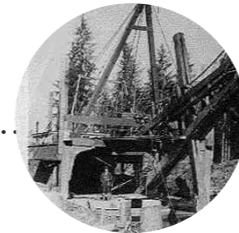
SURREY'S AGRICULTURE INDUSTRY (1870)
It began with pioneers farms located in Serpentine and Nicomekl lowlands. Raising vegetables, dairy cattle, beef cattle, hogs, chicken and horses. Hay and light grains were the major cash crop.



SURREY'S DISTRICT (1879)
Thomas Shannon delivered the Letters Patent to the Legislature applying for Incorporation of Surrey as a District Municipality in 1879. Shannon was the first Warden of the new incorporated Surrey.



FIRST MACHINE-MADE DYKES (1898)
Initially all dykes were built with hand labour, some of them reached a height of three feet. In 1898, the first machine-made dykes were created on the north bank of the Nicomekl from the Semiahmoo Road Bridge, around Mud Bay and up the Serpentine to the Woodward farm and the Semiahmoo Road. The dredge was a floating rig that took material from the river bottom for the construction of the dyke.



THE GREAT NORTHERN RAILWAY (1909)
The sealine route was completed, making Crescent Beach and White Rock popular summer destinations.



SURREY'S CITY (1993)
In September 1993, Surrey became an official city. Since that date, the city has undergone tremendous change and growth.



TERRITORY

1791

European first contact

1800

First Nicomekl river map

First Surrey interior map

CITY AND POPULATION

Surrey's District Municipality incorporation

Crescent Beach became summer destination

AGRICULTURE

Surrey's agriculture industry

Largescale lumbering

Surrey Farmers Institute

Key sector: Dairy farming

City of Surrey establishment

35% of land still actively farmed

WATER

Navigation on Nicomekl river

Water as dominant transportation

Decline of water transportation

DYKING

Surrey Drainage and Dyking By-law

First Machine-made Dyke

Great Northern Railway (sea wall)

Cement dams and flood gates

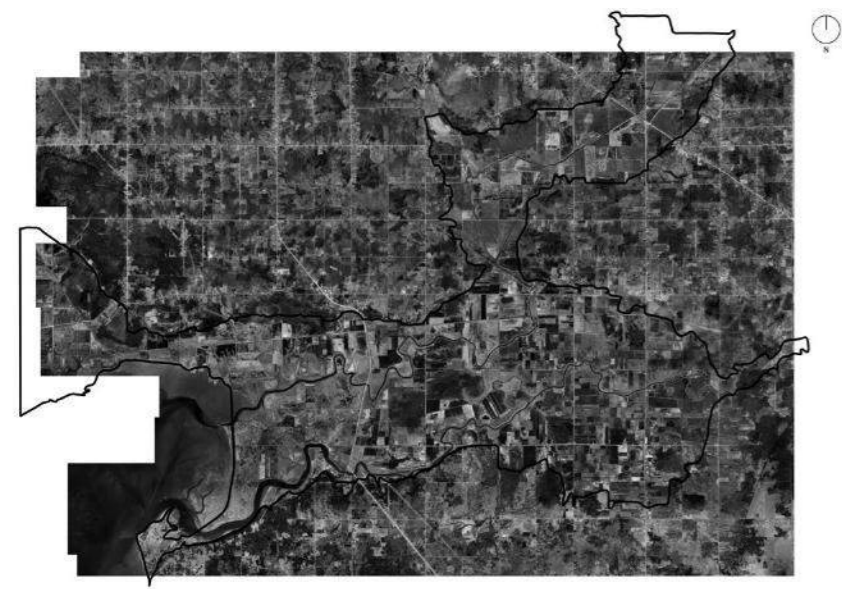
Surrey Diking District

46 miles of dykes made by Surrey Dyking Commission/Federal Government

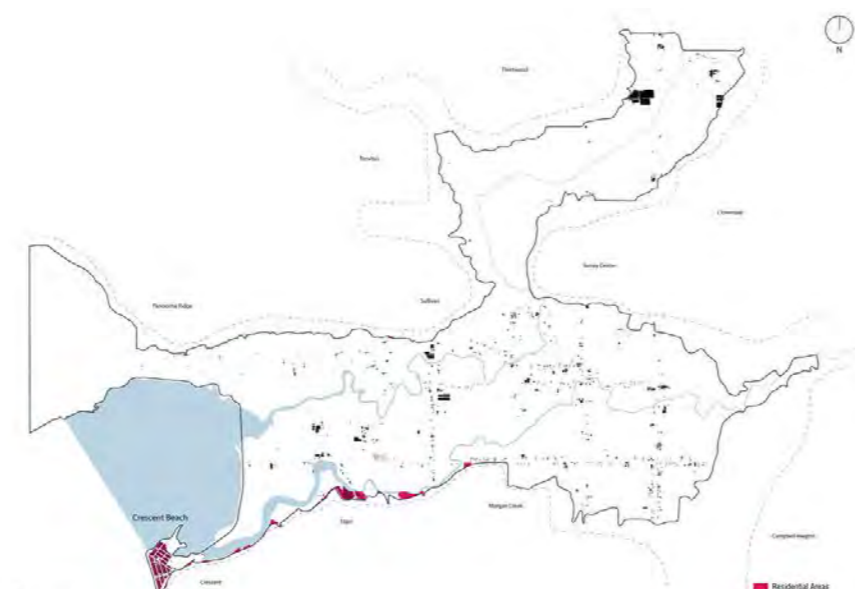
Mud Bay Dyking Commission

Innauguration non-stop dredging/dyke building

City of Surrey built Surrey Lake



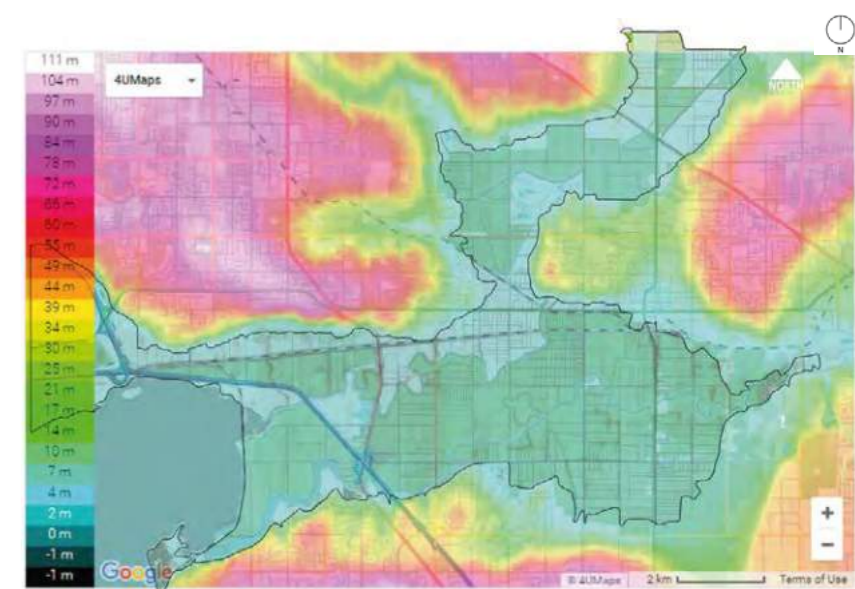
Surrey in 1949



Housing floodplain



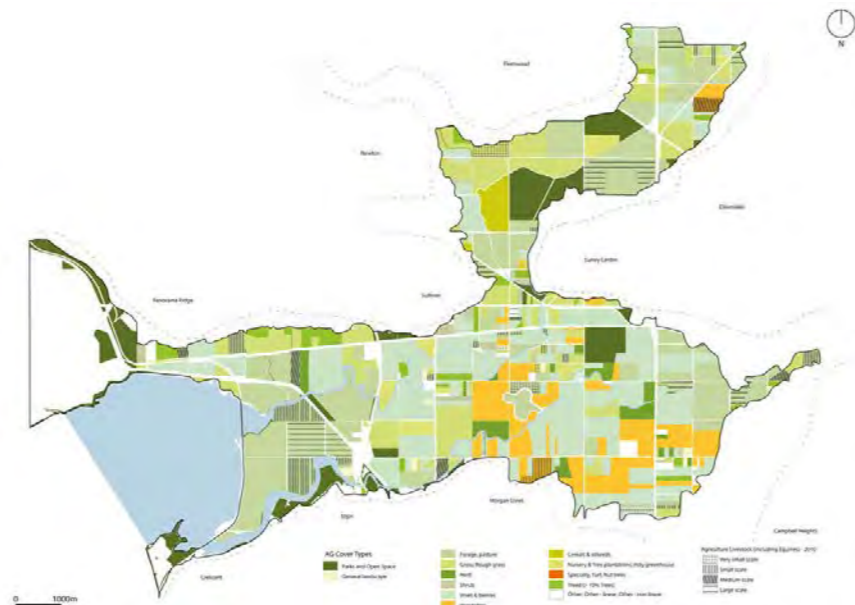
Habitat



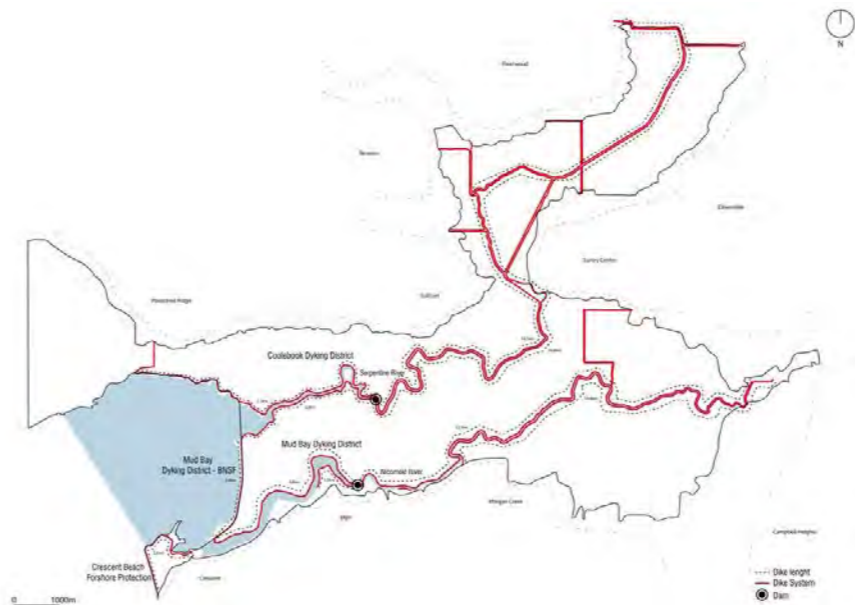
Elevation



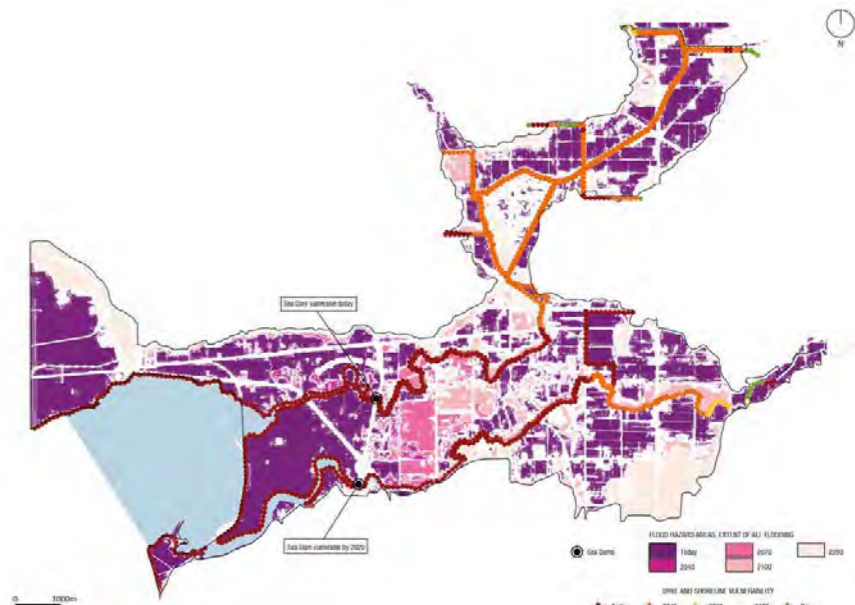
Infrastructure



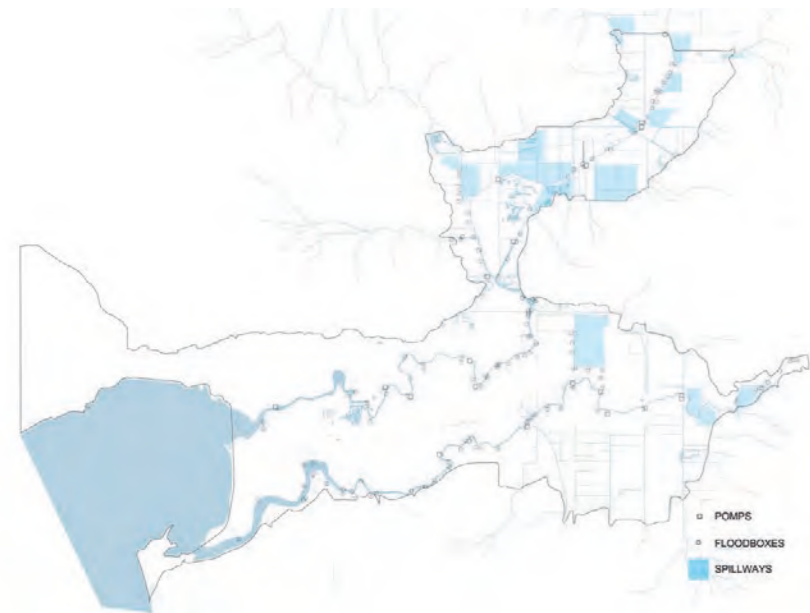
Vegetation types



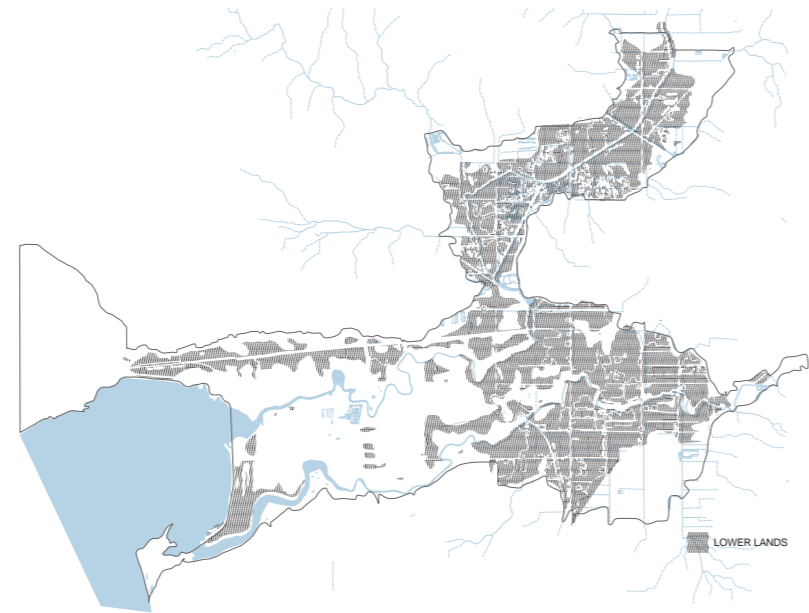
Dyke system



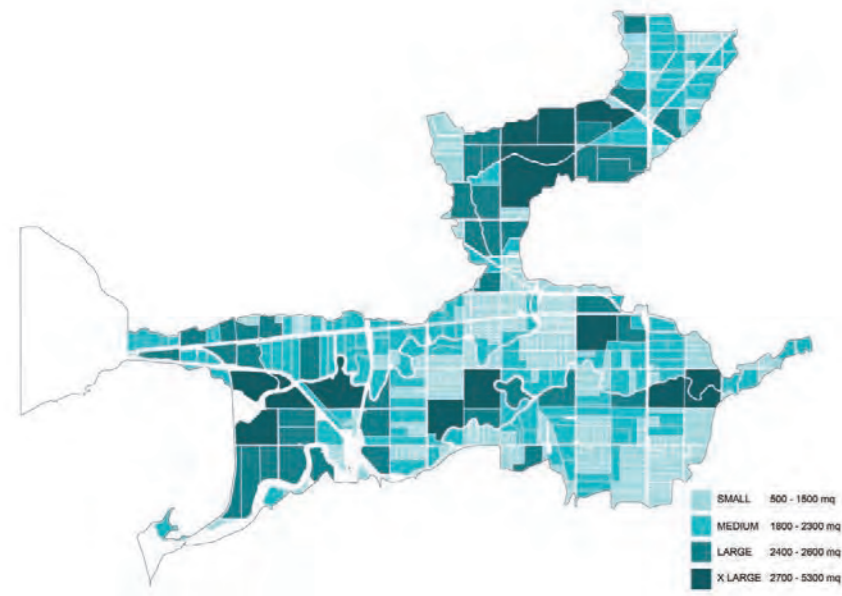
Flood hazard



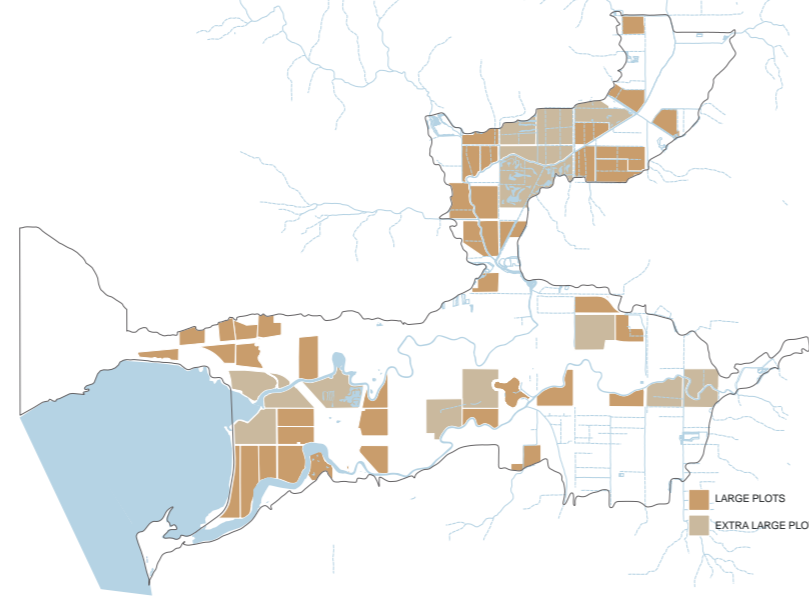
Water system



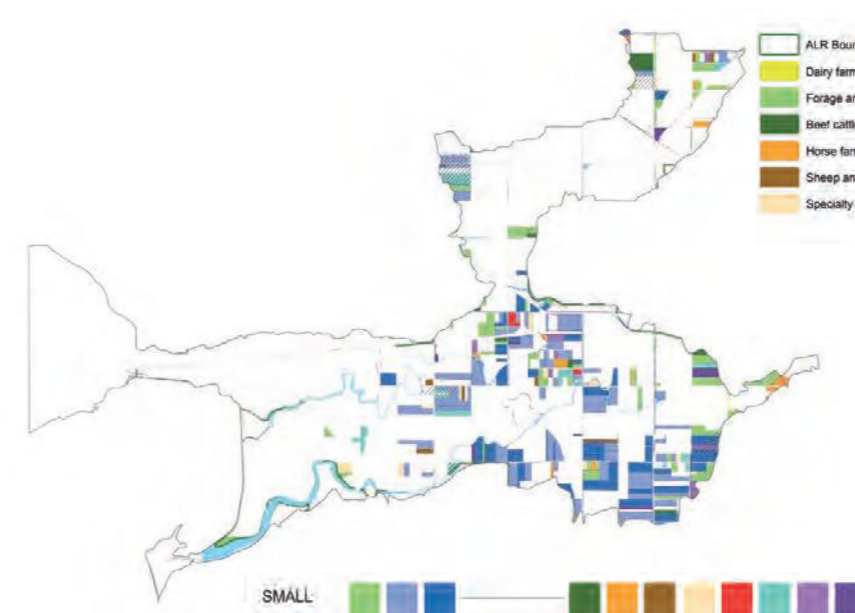
Lower lands (> 0.50 m. Source: *Serpentine - Nickomekl Lowlands Contour Map, UMA Engineering Ltd.*)



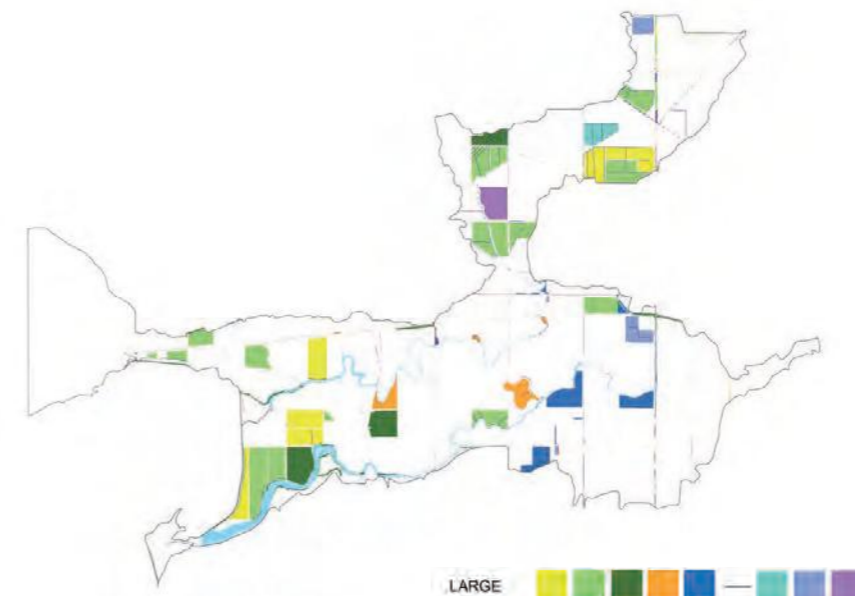
Plots size



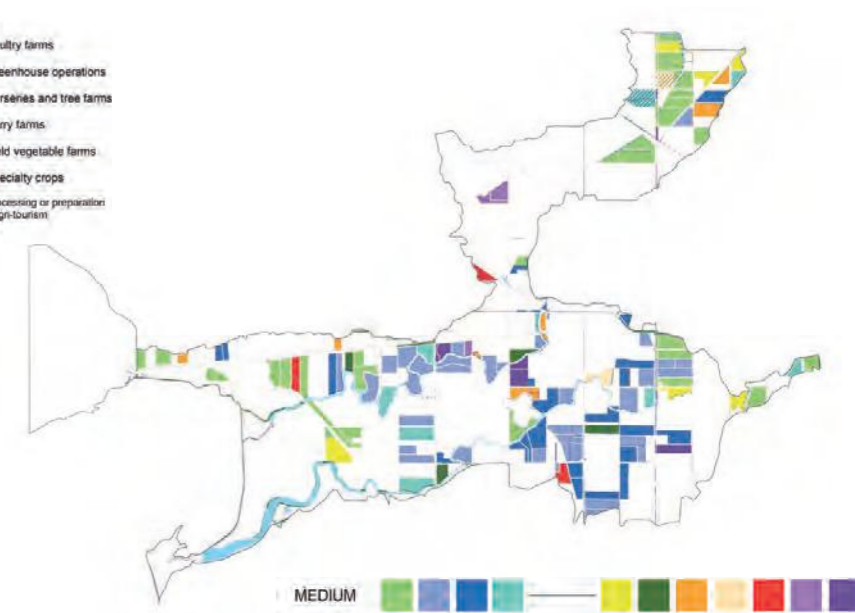
Large and extra large plots



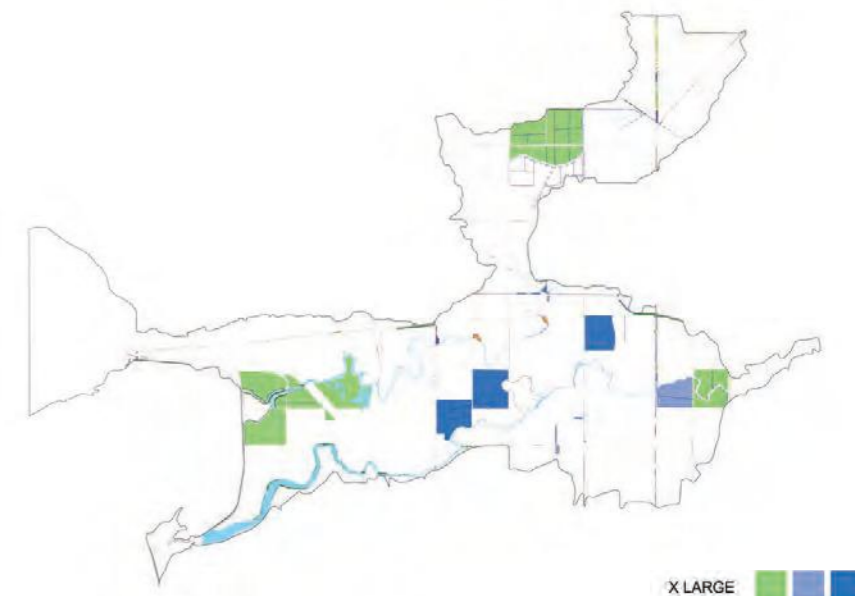
Land use for size | SMALL PLOTS (Mostly Forage and pasture, Berry farms and Field vegetable farms)



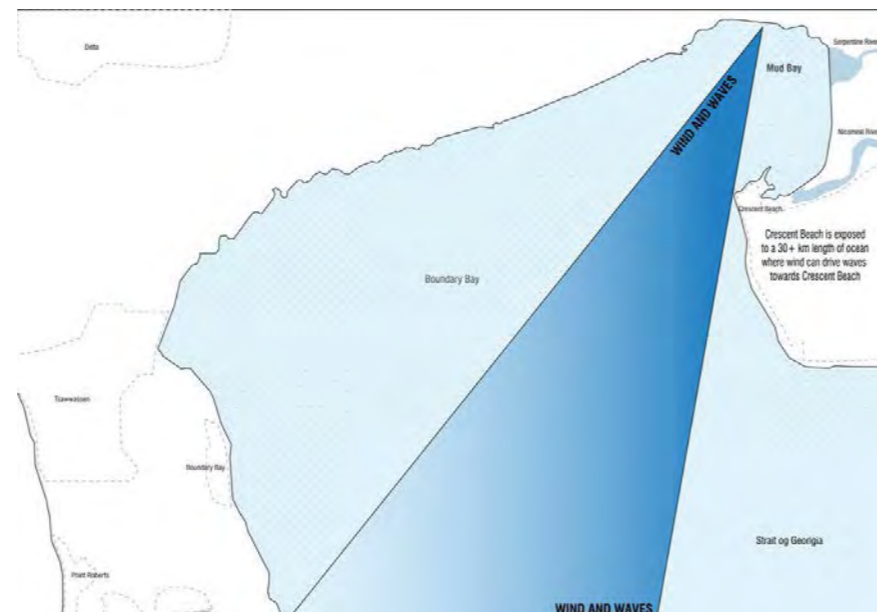
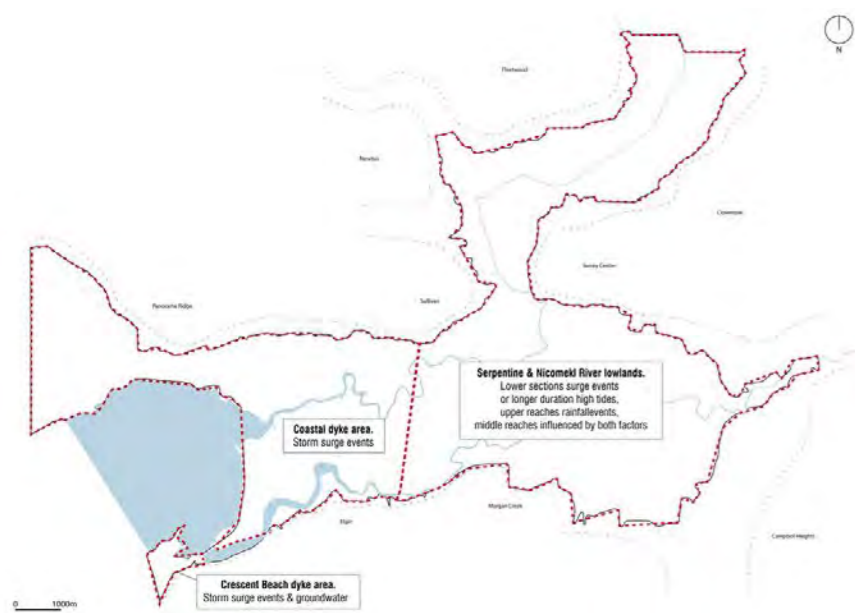
Land use for size | LARGE PLOTS (Mostly Dairy farms, Forage and pasture, Beef cattle farms, Horse farms and Field vegetable farms)



Land use for size | MEDIUM PLOTS (Mostly Forage and pasture, Berry farms, Field vegetable farms and Nurseries and tree farms)



Land use for size | EXTRA LARGE PLOTS (Mostly Forage and pasture, Berry farms and Field vegetable farms)



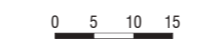
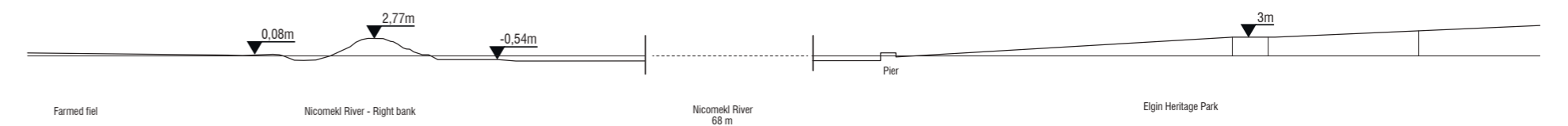
SECTIONS



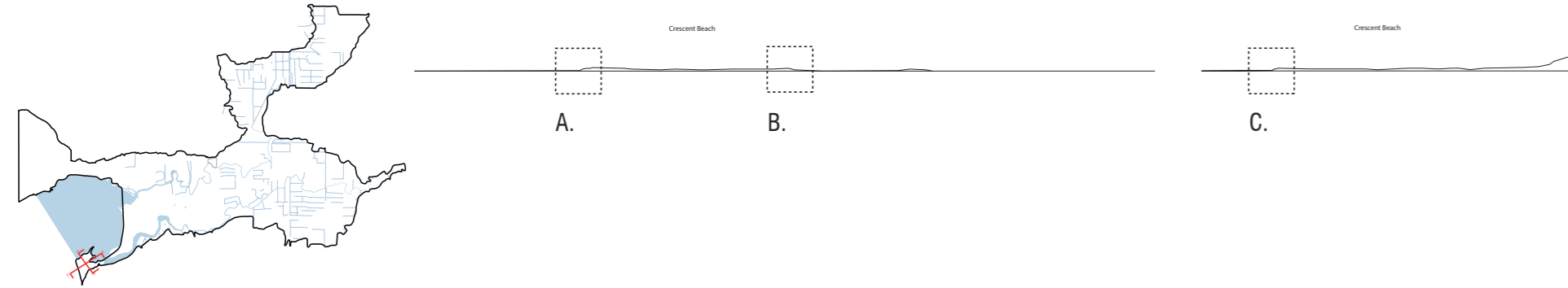
A. Colebrook Dyking District



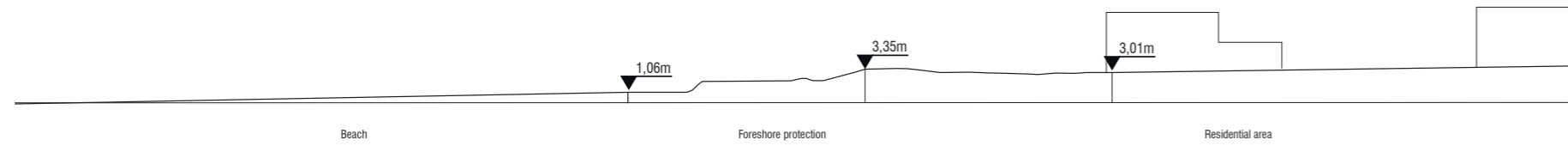
B. Mud Bay Dyking District



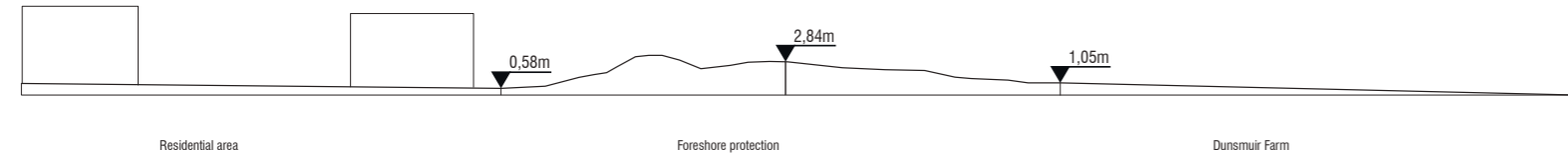
SECTIONS



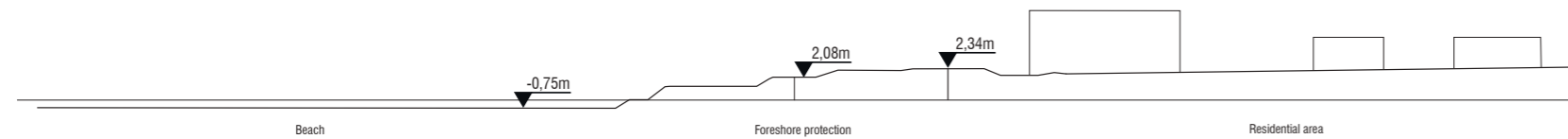
A. Crescent Beach



B. Crescent Beach



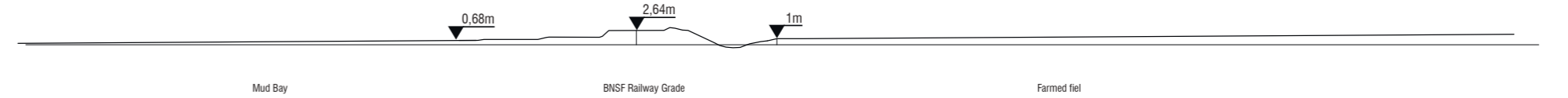
C. Crescent Beach



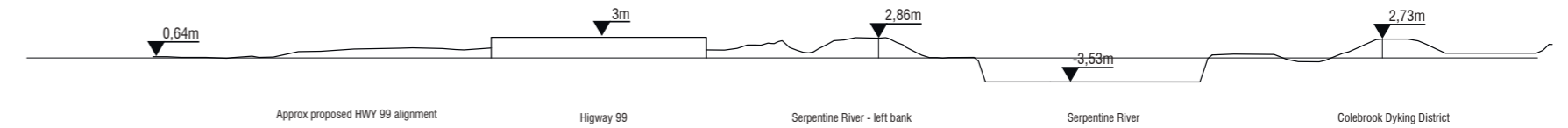
SECTIONS



A. Mud Bay Dyking District - BNSF



B. Colebrook Dyking District





2. ASSIGNMENT

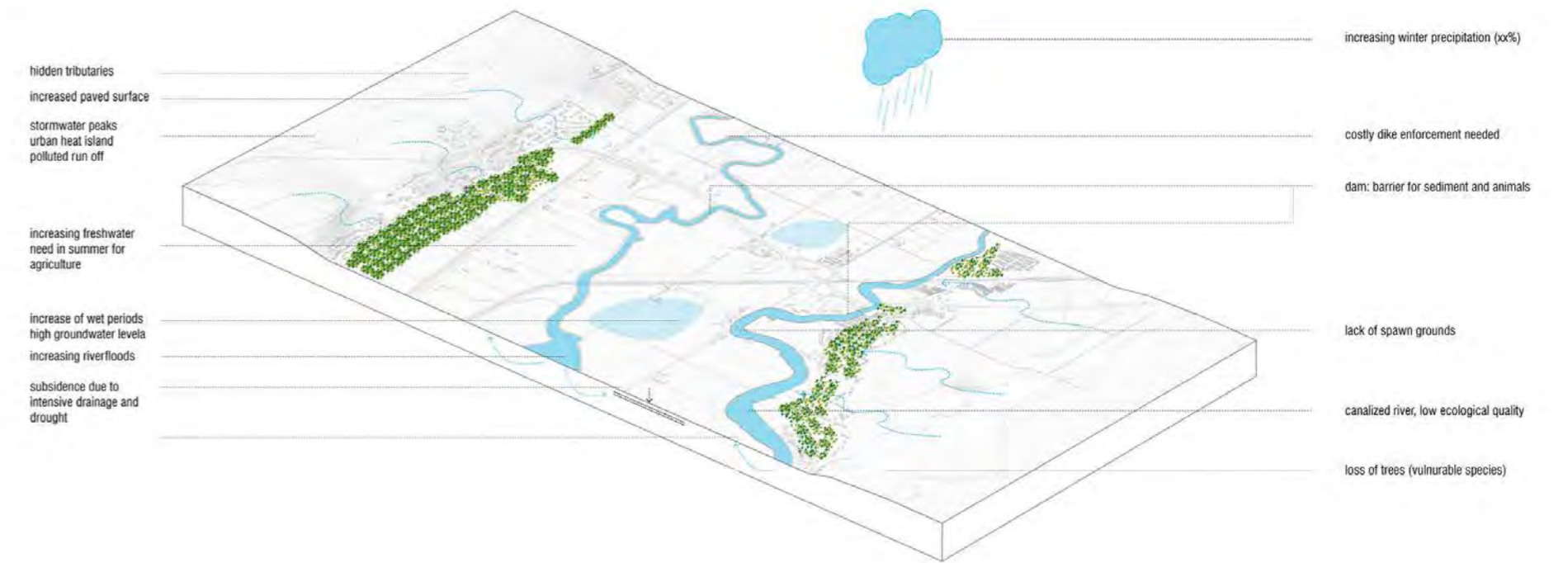
The floodplains have been prone to flooding since the moment the first settlers have arrived. Through the creation of dykes, sea dams and pumps, efforts have been made in order to keep the area safe of flooding. However, climate change is resulting in an increase in pressure on its current system. Sea level rise, population growth, storm surges and increase of precipitation are resulting in a need for the landscape to adapt in order to maintain a livable and vital area. We see the following key assignments for the floodplain of Surrey as a base for the research:

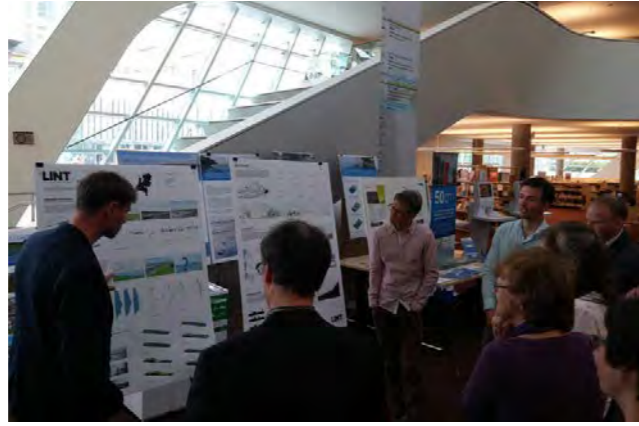
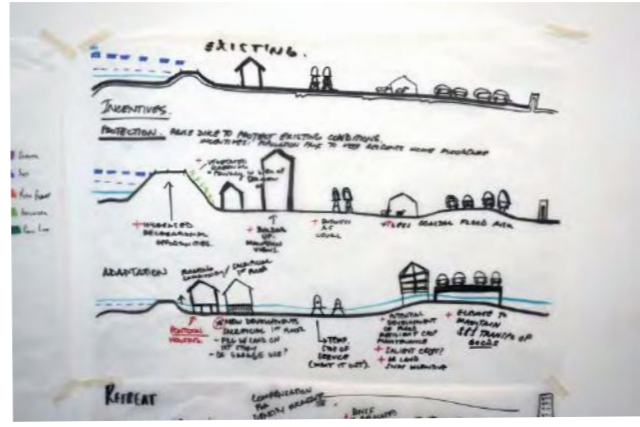
1. Necessity coastal reinforcement
2. Necessity dyke reinforcement
3. Increasing salt seepage causes problems for agriculture
4. The growing city
5. Limited accessibility of the floodplain
6. Limited recreational options in the floodplain
7. Need for future perspective for the agricultural sector in the floodplain
8. Freshwater scarcity in the future

HAZARDS COASTAL ZONE



HAZARDS RIVER & FLOODPLAIN





3. DESIGN WORKSHOP

As part of the research a workshop week was being organised in the end of April. The workshop lasted for five days in which the team got the opportunity to explore the study area and meet some of the local stakeholders involved in the area. The first two days were used for excursions in order for the team to get to know the study area, several parts of the floodplain were visited and analysed. One of the main events during the excursions was a kayak-tour, organised by the City of Surrey. The tour was held by an organisation connected to the First Nations. The kayak-tour gave new perspectives on the coastal areas and its history.

An important part of the week was the organisation of a design workshop for the city staff of Surrey and other people involved in the study area. The set up of the design workshop was as following, the participants were divided among five groups. Each group was assigned a specific theme through which they approached the assignment. The following themes were assigned: Infrastructure, Retreating, Incentives, Dyking, and Water storage. For further information on the workshop, see the attachment.

During the evening, LINT and Royal HasoningDHV held a presentation about flood-adaptation related projects which they have been working on. The presentations were held during the public open house for local residents who were interested.

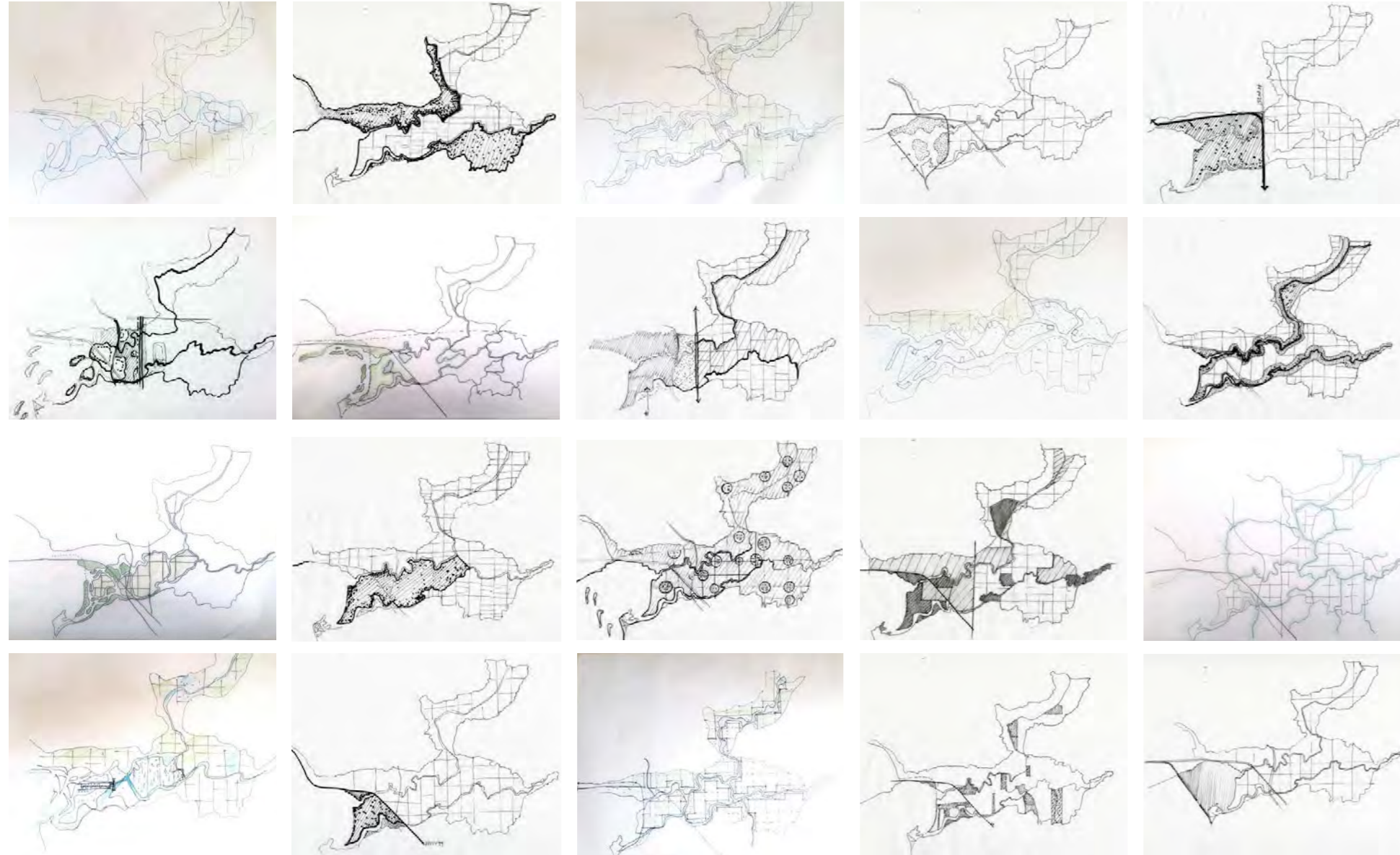
The next days the team of UBC, LINT and Royal HasoningDHV analysed the results of the workshop and came up with four main concepts that summarized the workshop results. The concepts were presented to the City Staff and formed the base for the discussion held afterwards, to formulate the next steps that should be taken in the research.

4. DESIGN MODELS

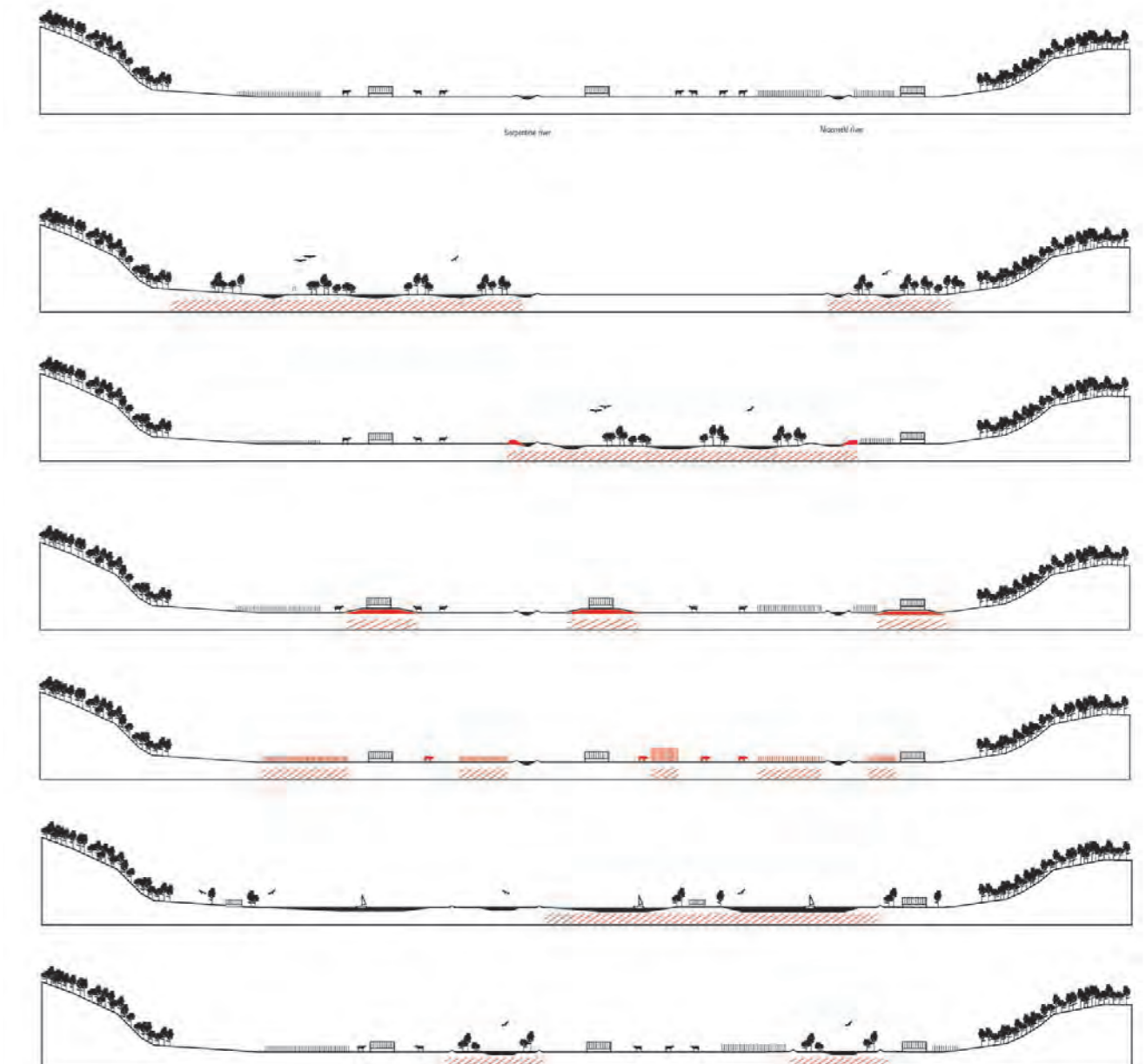
Following the design workshop, the teams of LINT and UBC had sketch sessions, using the results from the workshop week. The result was a wide range of different sketches with different themes. In general the sketches can be divided among seven main approaches/strategies. These approaches/strategies are as following:

1. Adaptive Barrier (2050/2100)
2. River Islands (2050/2100)
3. Coastal Realignment
 - A. Highway 99,
 - B. 152nd Street
4. Edge Realignment
5. Status Quo (keep upgrading the dykes)
6. Do Nothing (eventual retreat)
7. Managed/Planned Retreat (designed retreat)

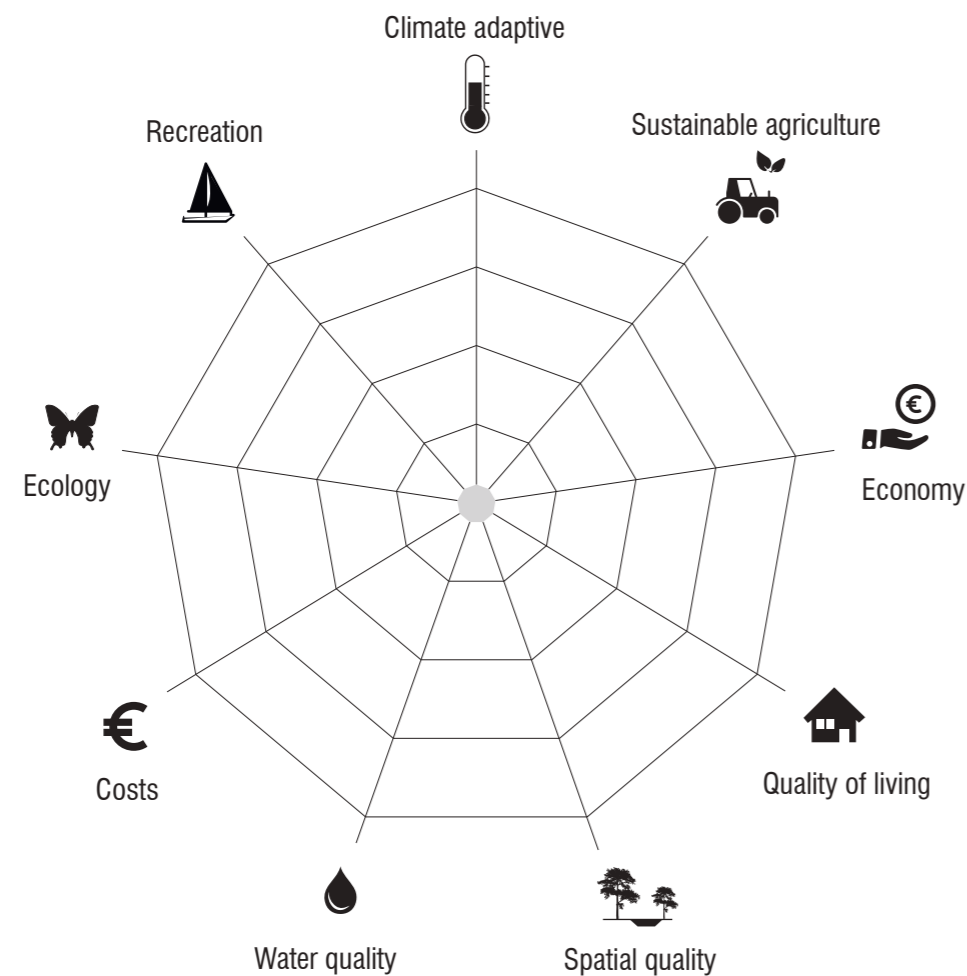
The different approaches are further elaborated on the following pages, an overview of all the sketches made, can be found in the attachments.



Overview of different sketches



Schematic sections of sketches



EVALUATION CRITERIA



Climate adaptive

The model provides an answer to future climate-related assignments, such as sea level rise, higher fluctuations in river discharge, freshwater scarcity and global warming.



Sustainable agriculture

The model stimulates the use of the floodplain as valuable agricultural land. An effort is being made to search for sustainable and innovative solutions to the current and future development developments in the rural sector.



Economy

The model is valuable for the economy, both short-term and long-term. It stimulates the commercial activities and provides income to compensate for the investments which have to be made now and in the future.



Quality of living

The model improves the quality of living for both the urban and rural areas in and around the Mud Bay. Furthermore it also provides opportunities for new types of housing development.



Spatial quality

The model provides high spatial quality. It exists out of a varied landscape with a strong landscape structure.



Water quality

The model improves the water quality within the floodplain. It makes use of different watersystems in a smart way, it also provides an answer to different water-related issues, such as salt seepage and freshwater shortage.



Costs

The costs for the creation of a flood adaptive landscape and other spatial interventions are relatively low.



Ecology

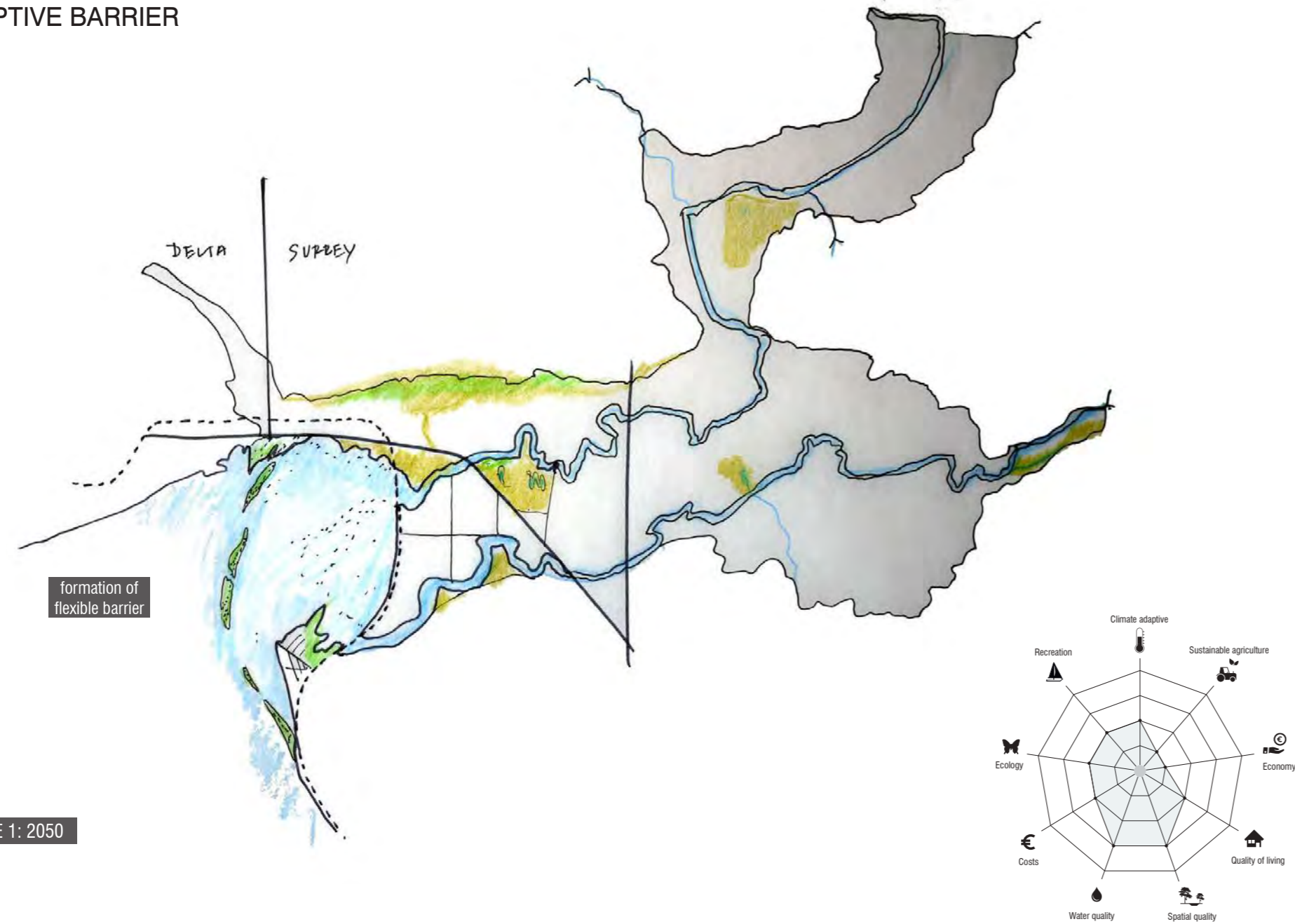
The model contains a large variation of ecosystems, this improves the biodiversity and makes space for new nature development.



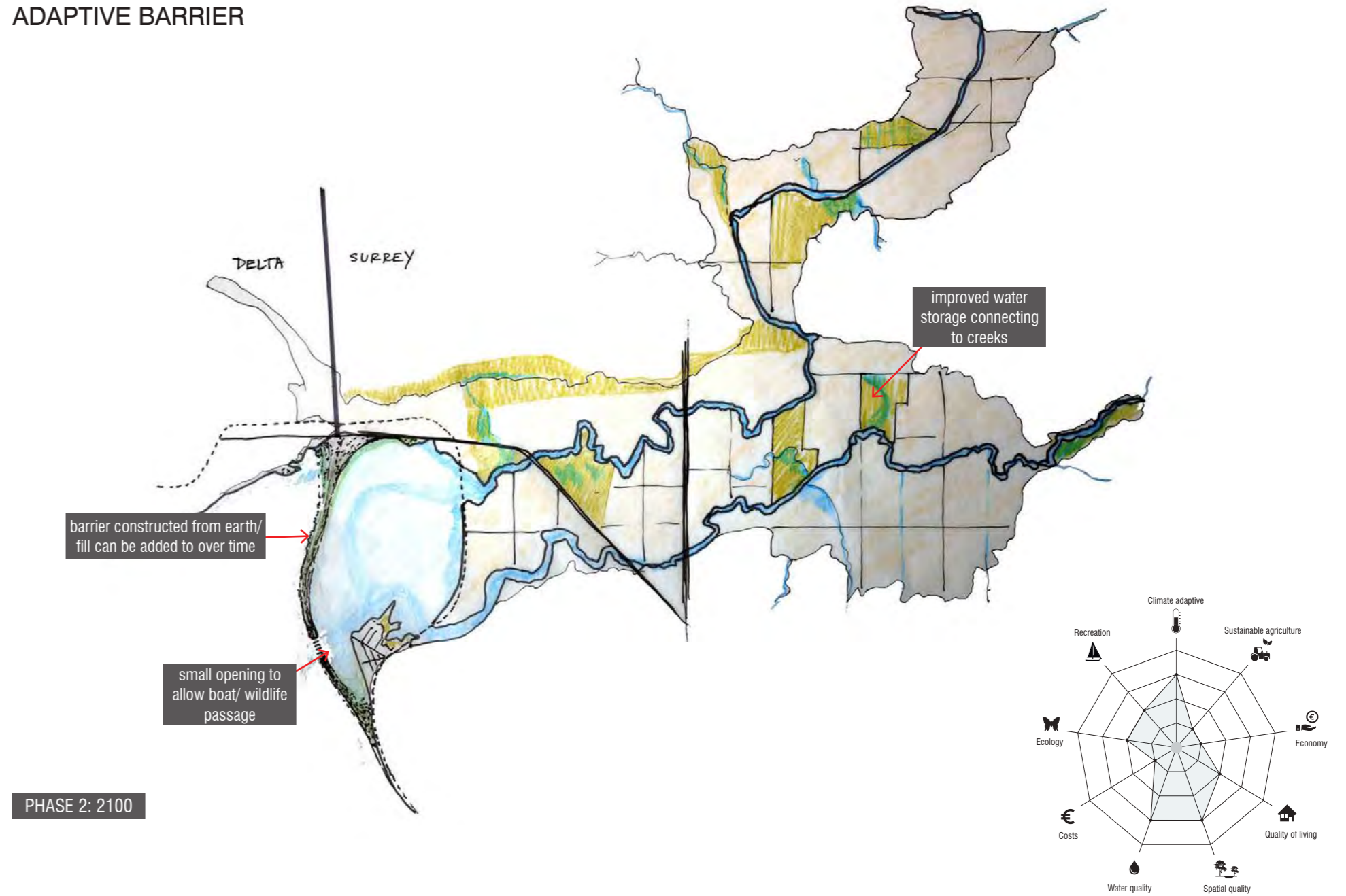
Recreation

The model provides a boost for the recreation in floodplain area, on both local and regional scale. It connects the urban areas with the rural areas of the floodplain and provides opportunities for new recreative developments.

ADAPTIVE BARRIER



ADAPTIVE BARRIER



ADAPTIVE BARRIER

Barrier constructed from flexible materials, spanning from the border of Delta to south of Crescent Beach.

In a normal situation, the dam is open to let out the freshwater coming from the rivers. During high water levels, the dam can be closed off from the ocean, providing flood safety while also serving as a wave breaker during storm surges.

Phasing: The barrier can be constructed in a phased approach so as to allow for greater flexibility to adapt to changes. In the early phases, the barrier may act more as a breakwater for waves. In the later phases the barrier may be extended to perform more like a dam with a small opening that controls water levels within Mud Bay.

Flood Control: Additional “spillways” and park spaces should be constructed along the creeks and rivers to provide flood control and water storage.

Recreation: The flexible barrier could combine different recreational functions (trails/ lookouts / kayak launch) or design elements to make the barrier a destination.

Environment: The brackish ecology of Mud Bay will be impacted as the barrier is constructed. However, the barrier may slow the erosion of the salt marsh.

Infrastructure: The complete barrier will protect highways and rail from flooding.

Agriculture: This may be the preferred option for ag. as it does not involve retreat and reduces the ongoing maintenance of dykes.

PRECEDENT IMAGES:



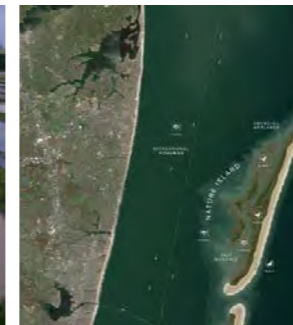
Openings in dam, Oosterscheldekering
image:<http://www.amusingplanet.com/2014/04/the-netherlands-impressive-storm-surge.html>



Flexible barrier, Semiahmoo Bay, Washington
image: Google Maps

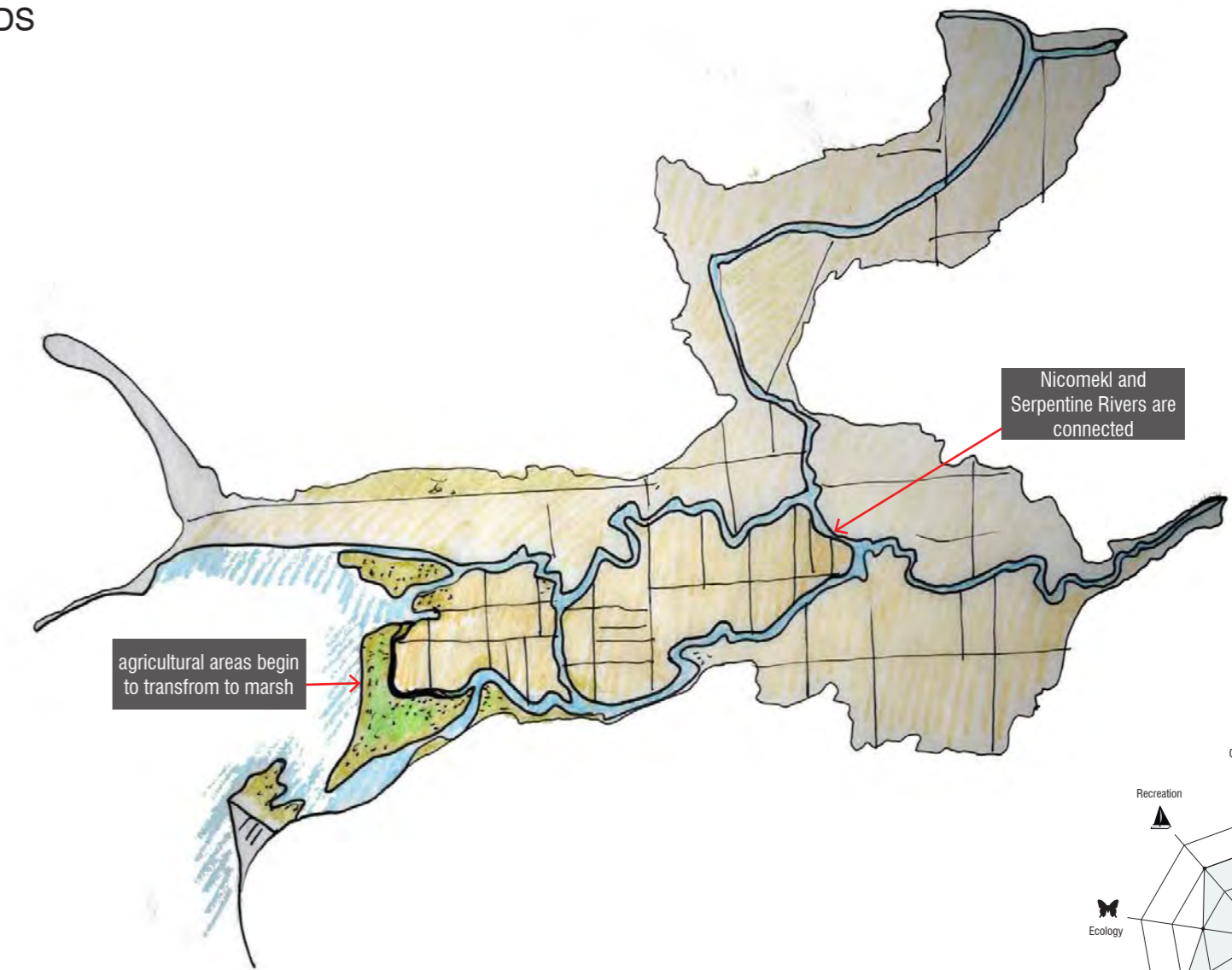


Extended ‘spillways’, Menomonee River Valley Redevelopment, Wenk Landscape Architecture
image:<http://www.wenkla.com/projects/urban-water-green-infrastructure/menomonee-river-valley-redevelopment/>

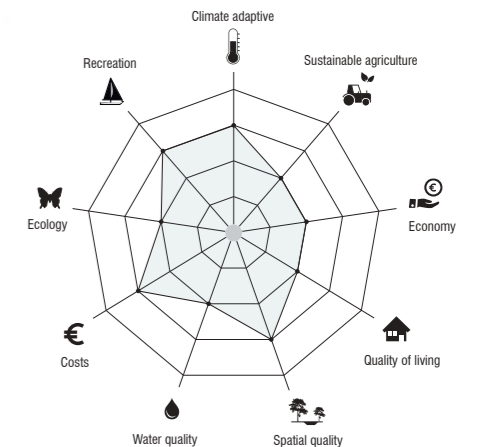


Blue dunes, West 8, US
image:http://www.west8.nl/projects/resilience_strategies_sustainability/blue_dunes_the_future_of_coastal_protection/

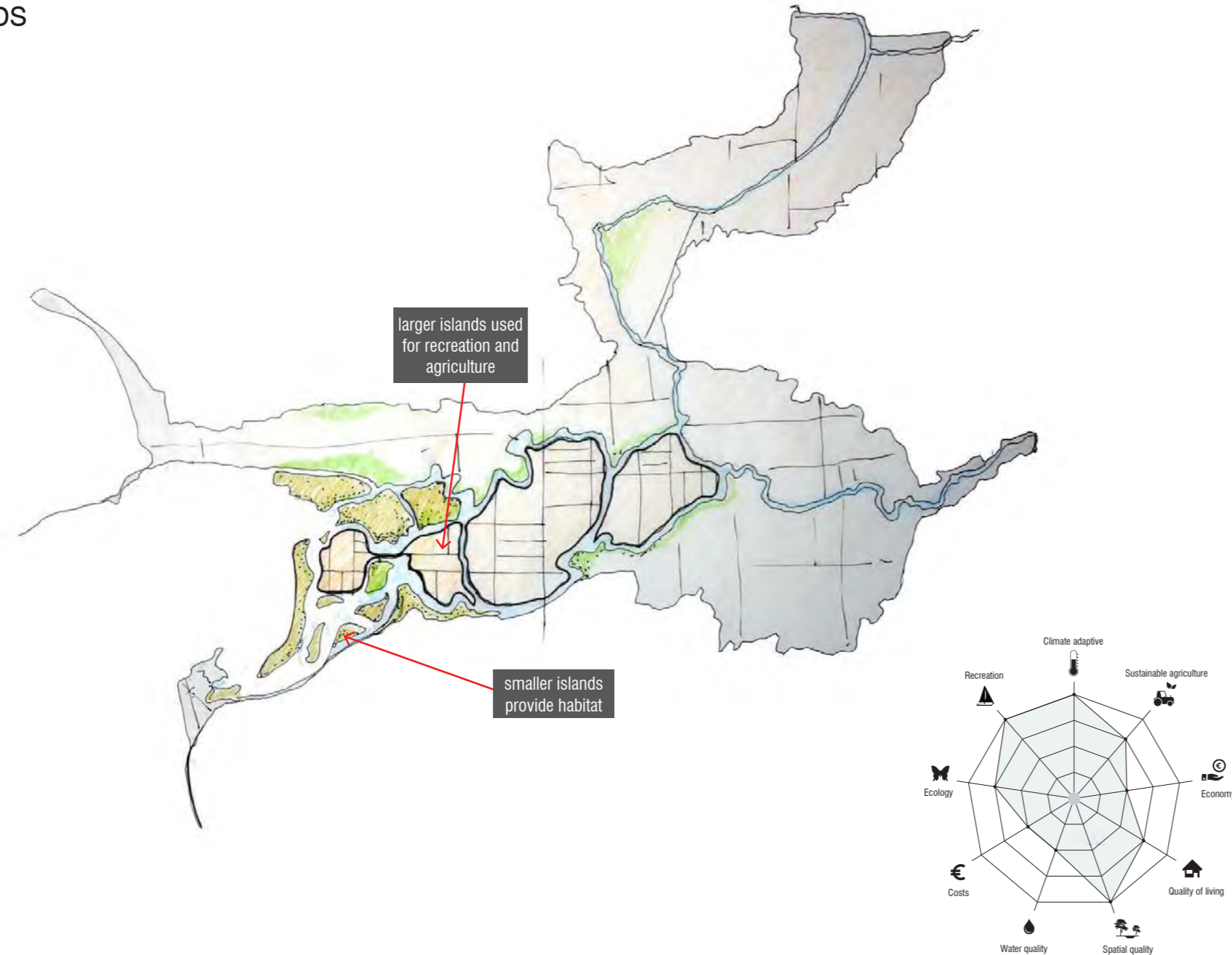
RIVER ISLANDS



PHASE 1: 2050



RIVER ISLANDS



PHASE 2: 2100

RIVER ISLANDS

River Islands is a scheme that involves accommodating flooding. Parts of the Mud Bay Dyking district are being dug out to form waterways and the leftover material is being used to raise islands in between the rivers. The smaller islands has the function as bird habitat while the bigger ones provide space for agriculture and recreation.

Phasing: This is a flexible system and allows a phased approach of creating the islands based on changing conditions. The islands may be constructed so that some flood before others.

Flood Control: There are more areas that can accommodate flooding and therefore fewer areas which require flood protection.

Recreation: The islands create a unique landscape with many new recreation opportunities.

Environment: The floodplain now has a closer resemblance to a naturalized floodplain. The diversity of spaces creates new habitat.

Infrastructure: NHC to advise on best sea dam location.

Agriculture: The inter-river area greatly reduces agricultural production.

PRECEDENT IMAGES:



River Island Natural Area restoration
image: <http://www.oregonmetro.gov/river-island-natural-area-restoration>



Managed realignment, Medmerry, Sussex, UK
image: http://s0.geograph.org.uk/geophotos/04/49/86/4498694_b2211565.jpg

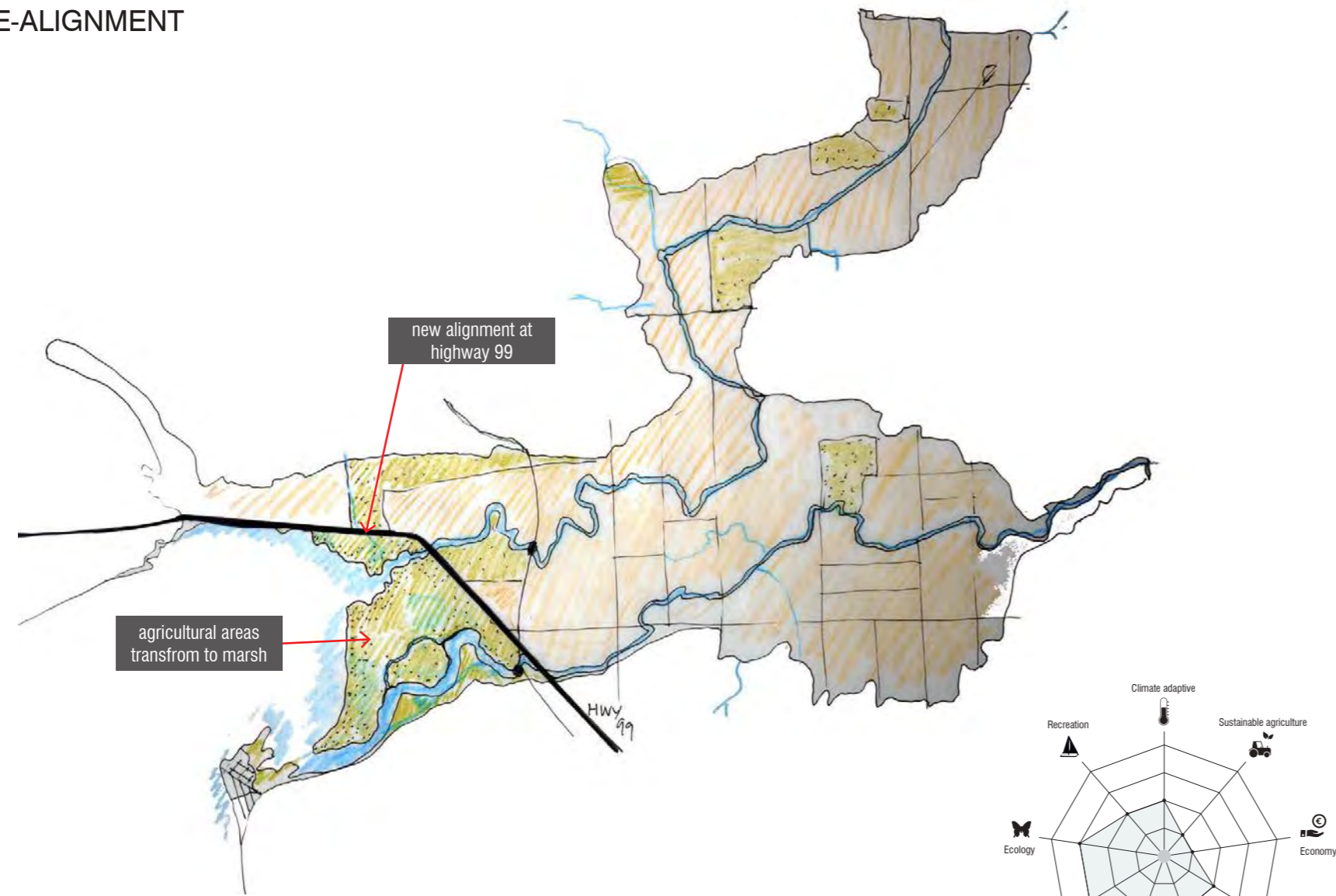


Three Island Crossing, Oregon, US
image: <http://travelogs.us/2007/Logs/Idaho%202007/66-3%20Island%20Crossing/66aa-Three%20Island%20Crossing.htm>



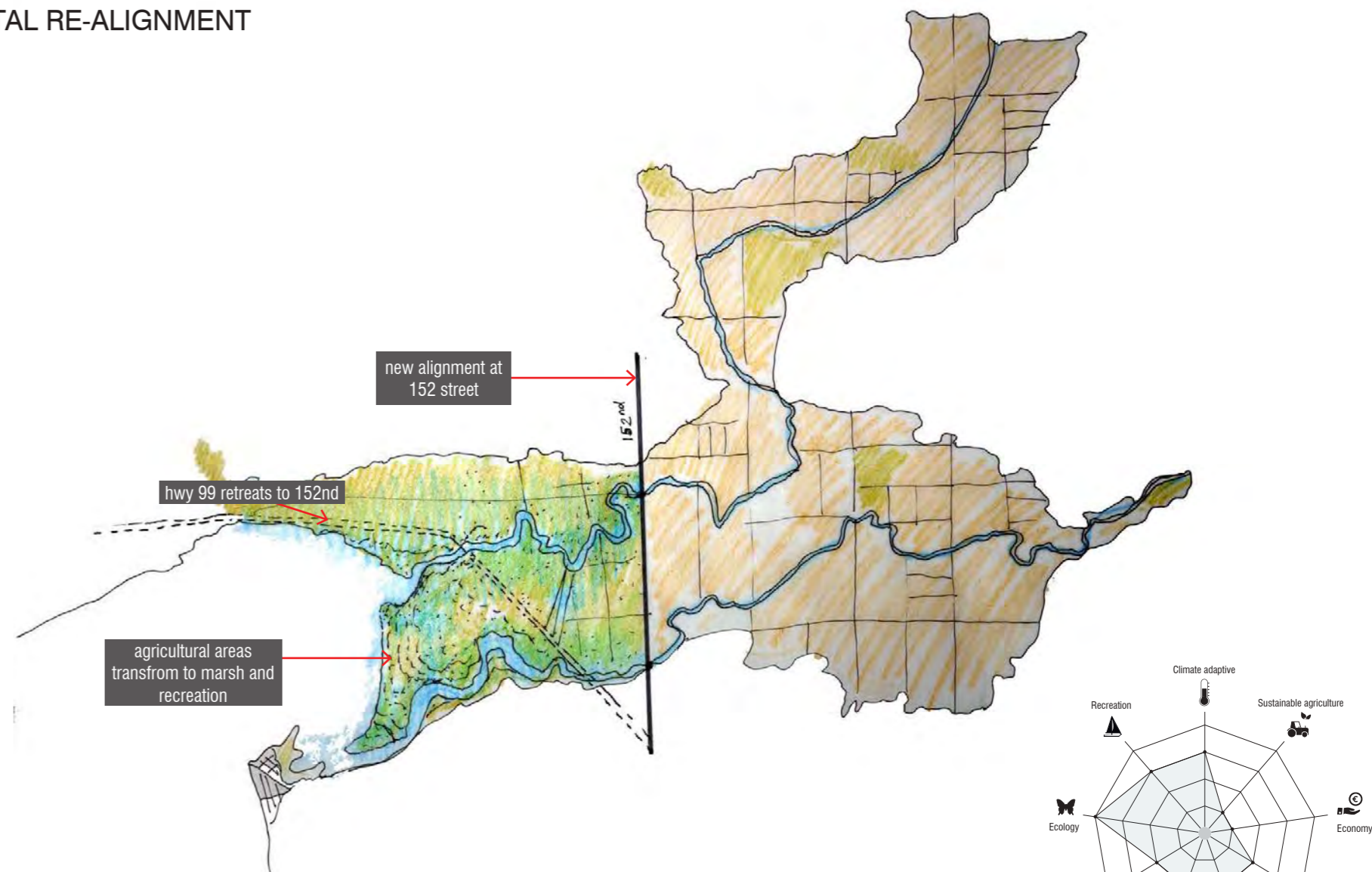
Chenhaiwei Rural Wetland, Yushan Town, China
image: <http://www.intecol-10iwc.com/EN/HelpCenter/HelpInfo.aspx?nid=77>

COASTAL RE-ALIGNMENT



OPTION A: HIGHWAY 99

COASTAL RE-ALIGNMENT



OPTION B: 152 ST

COASTAL RE-ALIGNMENT

Both coastal re-alignment schemes propose aligning the new coast with road infrastructure (highway 99 or 152nd street) which will involve having to raise the infrastructure. On the sea side of the new alignment, agriculture lands may be transformed to marsh or other habitat areas.

Phasing: The phasing of the highway being raised may involve building temporary lanes. The transformation of the old agricultural land to marsh may be managed by creating an intentional breach, or it may flood over time.

Flood Control: The new alignment provides protection for infrastructure and agriculture. The old agricultural land provides a buffer for wind and waves.

Recreation: The retreated agriculture land can be transformed into a park space.

Environment: The retreated agriculture land may provide valuable marsh land.

Infrastructure: Flood infrastructure and road infrastructure are combined.

Agriculture: Minimal to extensive agriculture retreat.

PRECEDENT IMAGES:

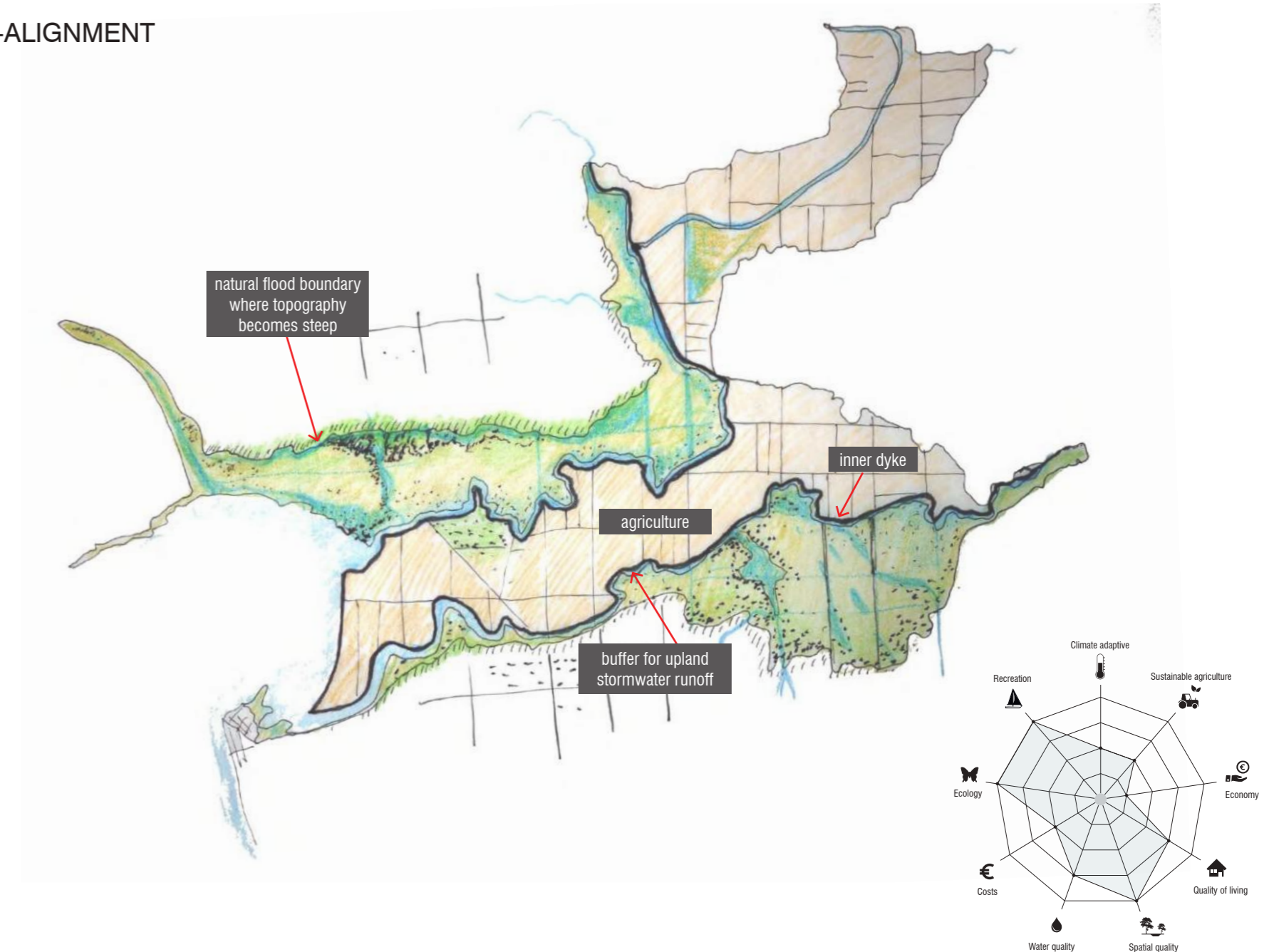


Hoogwatergeul Veesen Wapenveld, NL image: <http://www.ijsseweide.com/>



Friesland at Sea, Buro Harro, NL image: <http://buroharro.nl/fryslan-at-sea/>

EDGE RE-ALIGNMENT



EDGE RE-ALIGNMENT

This concept proposes a retreat of the floodplain on the outer edges of the floodplain. The steep topography on the edge of the floodplain acts as a natural flood barrier. This proposal will provide more flood water storage and reduce the amount of dyke upgrades needed. Additionally, the retreated landscape acts as a buffer to cleanse pollutants in upland runoff before it reaches the rivers.

Phasing: The extent of the retreat could be phased.

Flood Control: using the natural topography of the floodplain reduces the amount of dyke maintenance.

Recreation: The retreated areas could provide recreational areas, linking residents to the floodplain.

Environment: The scheme will cleanse water, thus improving water quality in the rivers. Marshes and floodplain forests are also created.

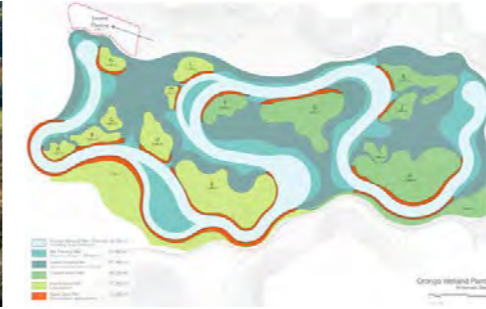
Infrastructure: NHC and further study for highway and sea dam locations.

Agriculture: is maintained in inter-river areas.

PRECEDENT IMAGES:



Floodplain forest
image: http://www.landzine.com/index.php/2017/04/the-parklands-of-floyds-fork-by-wrt/louisville-03-photo-ted-wathen_img_5621/

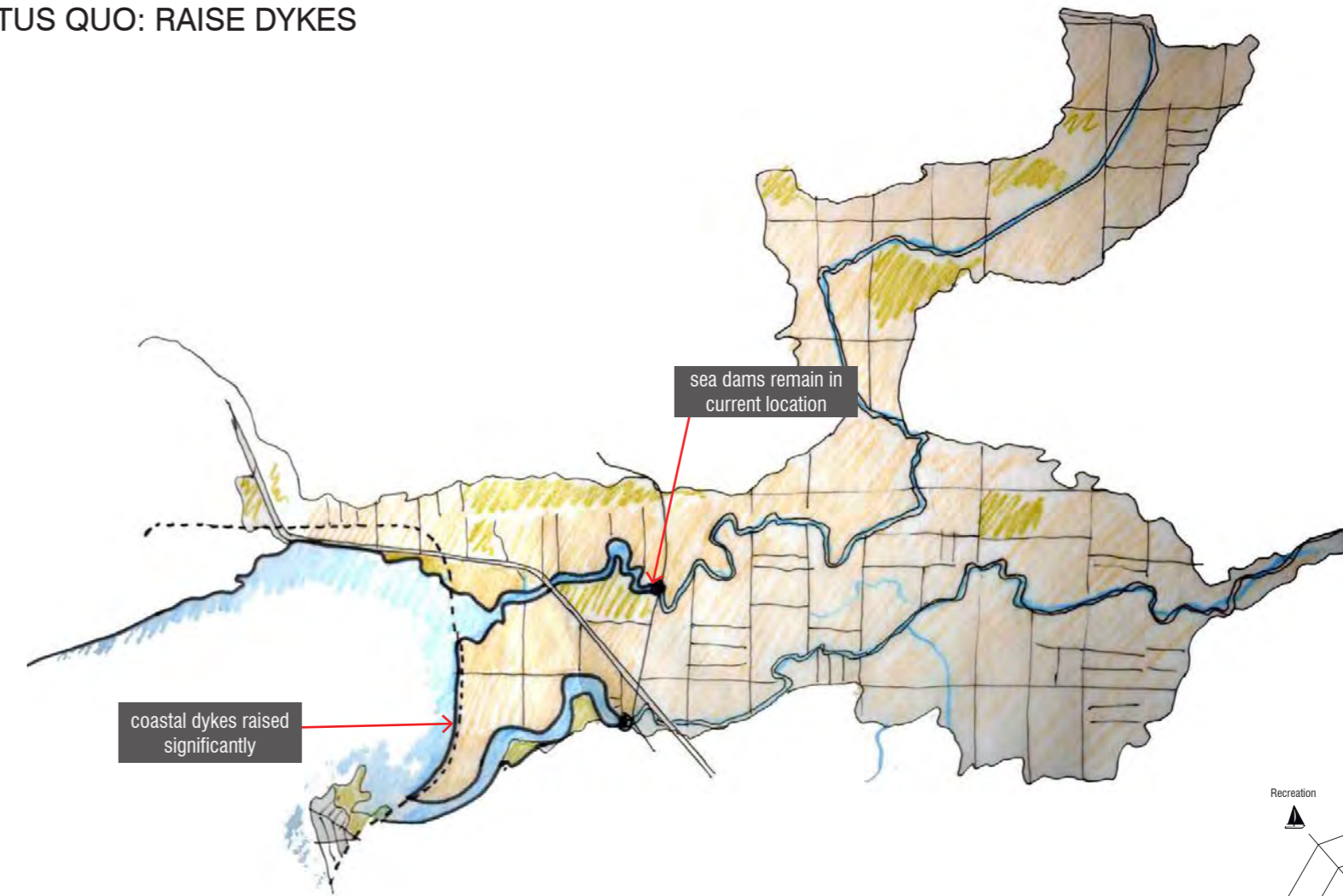


Variety of topography creates new habitat and recreation
image: <https://www.asla.org/2010awards/205.html>



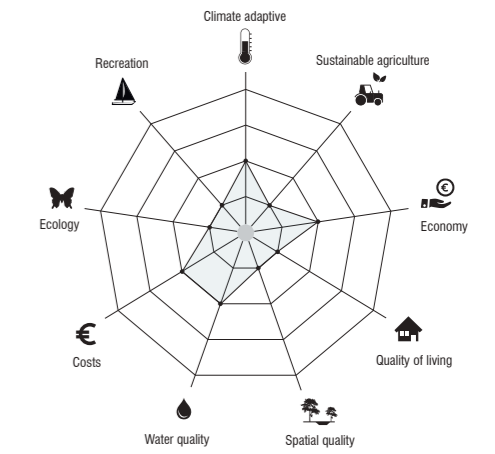
Flooding against steep topography
image: <https://www.asla.org/2010awards/205.html>

STATUS QUO: RAISE DYKES



sea dams remain in current location

coastal dykes raised significantly



STATUS QUO: RAISE DYKES

Surrey continues to raise current dykes to meet flood protection standards.

Phasing: Dykes may be raised over time.

Flood Control: Dykes need to be very high and wide to protect against storm surge.

Recreation: Raised dykes may limit (even further) access to water and recreational opportunities.

Environment: Coastal squeeze will continue to be an issue. Habitat loss from wide dyke footprint.

Infrastructure: Sea dam locations may change. Other infrastructure is protected.

Agriculture: mostly protected . Some loss of land due to wide dyke footprint.

PRECEDENT IMAGES:



News article on the high costs of dike upgrades
 image: <http://www.cbc.ca/news/canada/british-columbia/metro-vancouver-dike-upgrades-to-cost-billions-1.1220516>

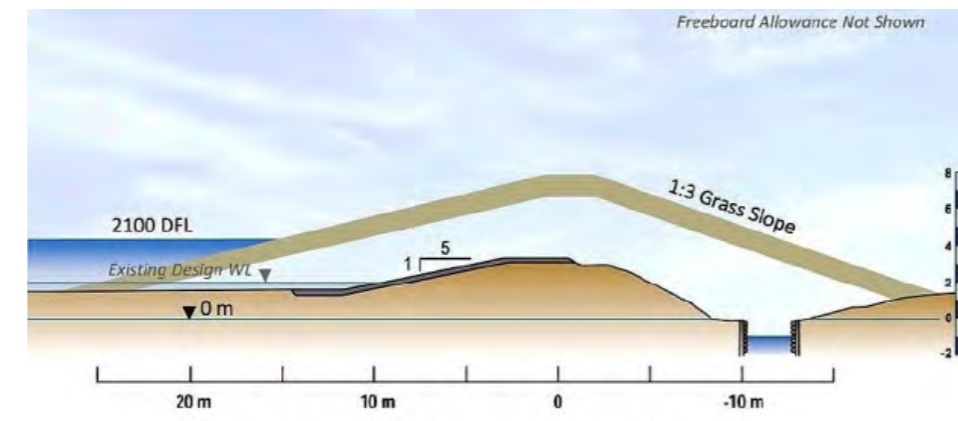
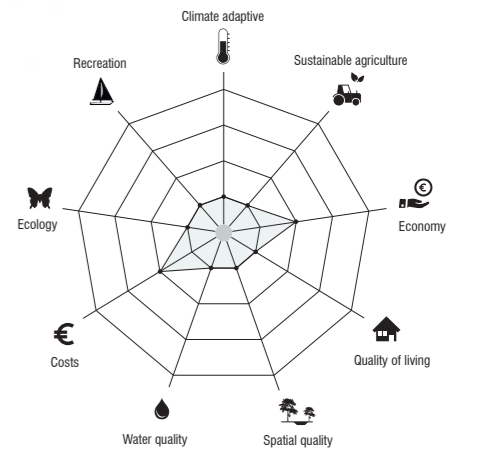
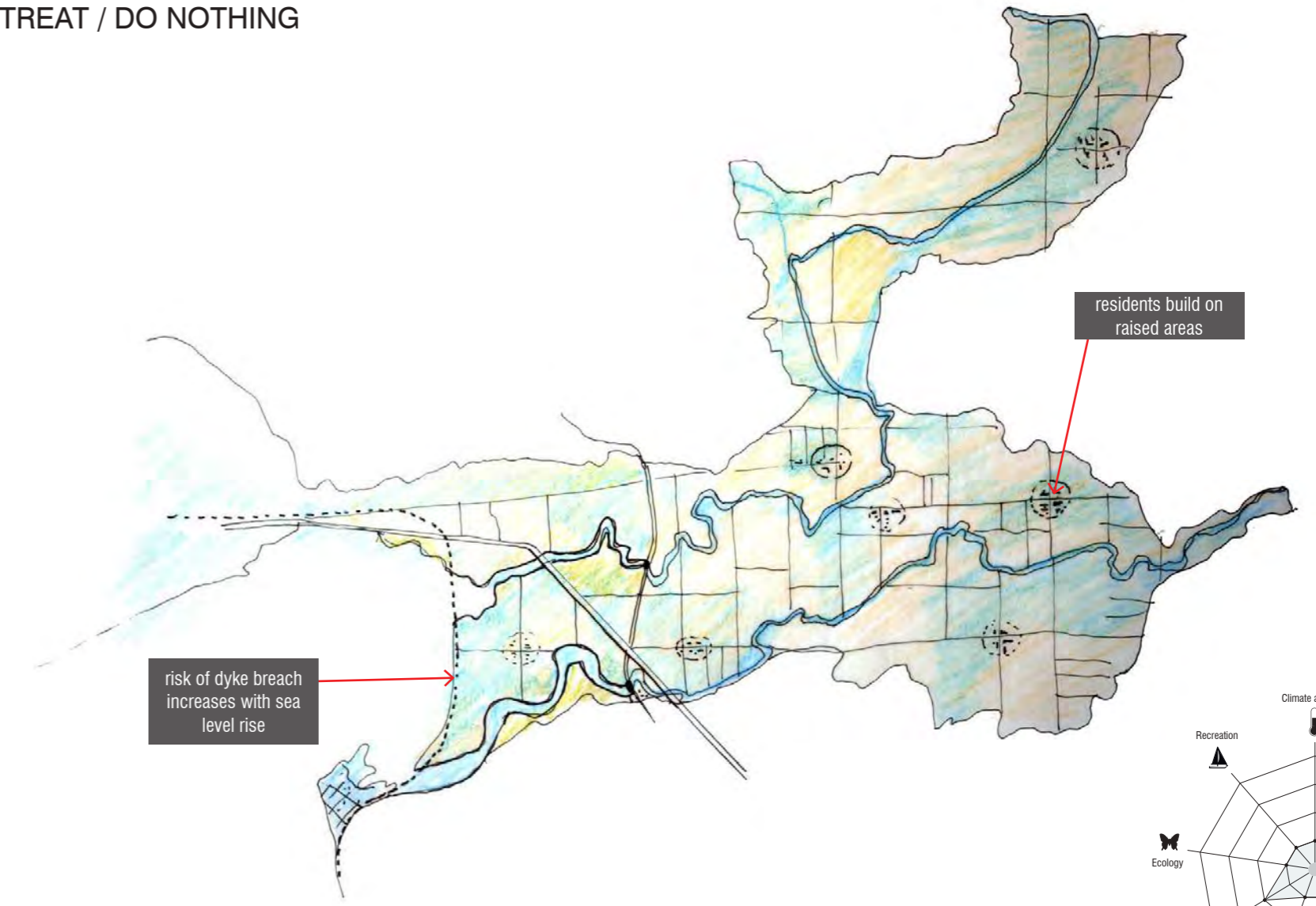


Figure 1-13 Example Sea Dike for 2100 – West Richmond
 elevations: CGD

Proposal sea dike upgrade, West Richmond
 image: <http://www.vancouversun.com/cms/binary/7673982.jpg>

RETREAT / DO NOTHING



RETREAT / DO NOTHING

In this scenario, no major flood defense changes have been made. To ensure safety, evacuation routes are established and there is more investment in temporary flood barriers. This will reduce negative impacts during minor flood events. However, a major flood event could have severe impacts on homes, land, infrastructure and safety.

Phasing: The retreat could be phased with predicted flood extents.

Flood Control: Dykes are not fixed or maintained.

Recreation: no further improvements.

Environment: no further improvements.

Infrastructure: could experience major delays and losses.

Agriculture: high risk of crop and investment loss.

PRECEDENT IMAGES:



Removeable flood barriers

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Evacuation routes

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Increased nuisance flooding

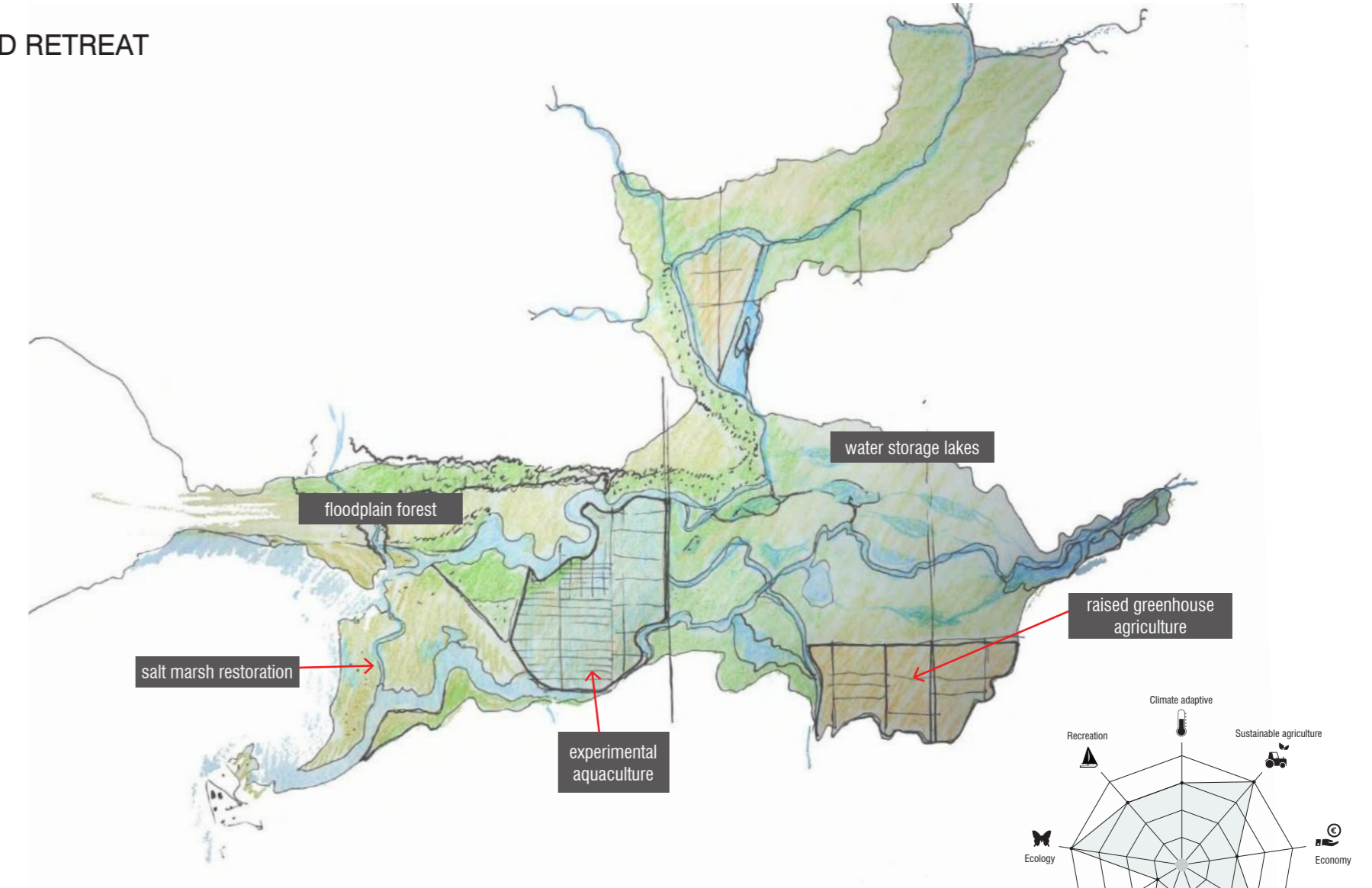
image: <http://www.businessinsider.com/flooding-is-a-growing-concern-for-us-coastal-cities-2015-7>



Major flood event, Crescent Beach will flood

image: <http://www.techtimes.com/articles/72327/20150728/study-identifies-causes-of-major-flooding-risk-for-u-s-coastal-cities.htm>

MANAGED RETREAT



MANAGED RETREAT

A managed retreat affords the opportunity to introduce new land uses into the area that are adaptive to sea level rise and that work with coastal processes rather than against.

Phasing: The retreat could be phased with predicted flood extents.

Flood Control: All land uses within the floodplain would be able to adapt to flood events.

Recreation: This retreated land could be used for various recreational purposes such as hunting, kayaking, hiking, atv, etc.

Environment: salt marsh could be restored and new habitat created for migratory and resident bird populations.

Infrastructure: needs to be raised/ flood adaptive.

Agriculture: intensive agriculture in greenhouses and experimental aquaculture.

PRECEDENT IMAGES:



Recreation
image: http://www.wenka.com/files/2113/7228/2554/Menomonee_-_dylan-group.jpg



Aquaculture
image: http://www.holbertsoysterfarm.com/uploads/1/0/8/4/10844066/4582057_orig.jpg



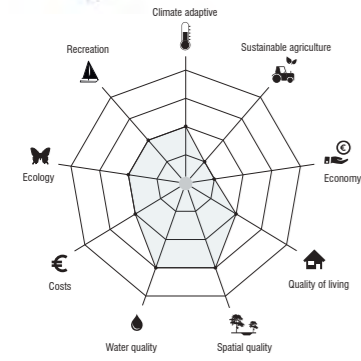
Raised greenhouse agriculture



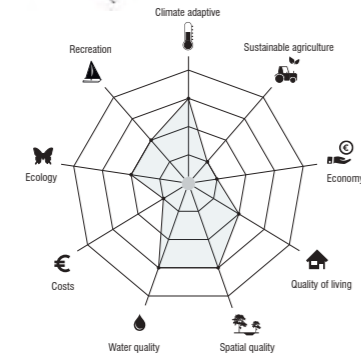
Diverse Habitat
image: Sacha Dench, WWT

EVALUATION

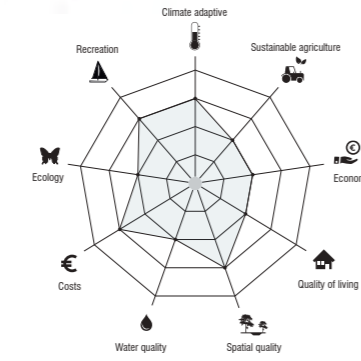
ADAPTIVE BARRIER (2050)



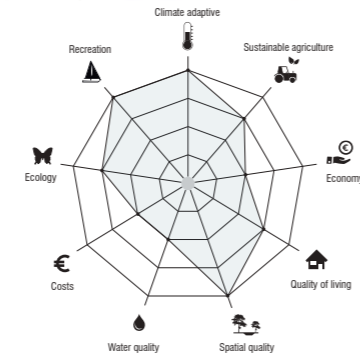
ADAPTIVE BARRIER (2100)



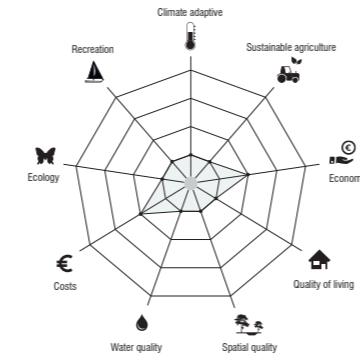
RIVER ISLANDS (2050)



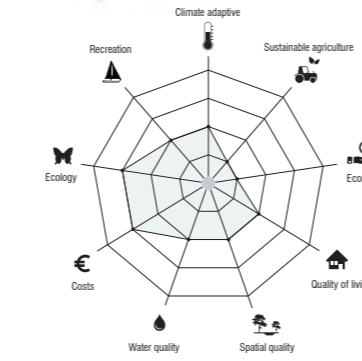
RIVER ISLANDS (2100)



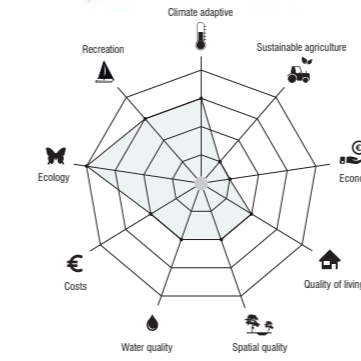
RETREAT / DO NOTHING



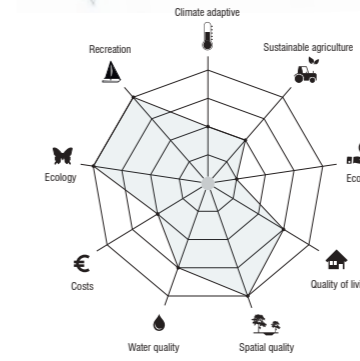
COASTAL RE-ALIGNMENT (A)



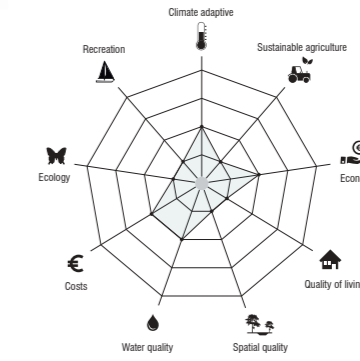
COASTAL RE-ALIGNMENT (B)



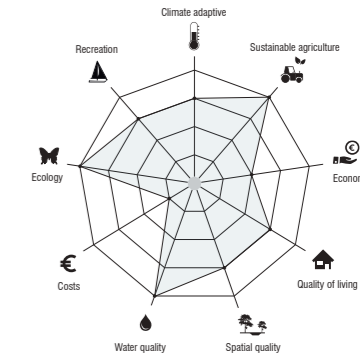
EDGE RE-ALIGNMENT



STATUS QUO: RAISE DYKES



MANAGED RETREAT





WIDENED COASTAL ZONE



FUTURE-PROOF AGRICULTURE



FRESHWATER RETENTION + SUPPLY



RECREATIVE NETWORK + NATURE DEVELOPMENT

5. VISION MUD BAY

The vision for the area of the Mud Bay is being characterised through four themes. These themes are based upon the results we concluded out of the workshop and sketch sessions we held. The four themes of the vision are: a widened coastal zone, the retention and supply of freshwater, future-proof agriculture, and recreative network in combination with nature development. The four themes of the vision are being elaborated further down below:

- Widened coastal zone

Sea level rise is going to have a significant effect on the coastal areas of the Mud Bay area. In our vision we think coastal adaptation should be applied on the area as a whole instead of primarily focussing on the dykes only. By widening the coastal zone, flood adaptations can be more resilient by combining it with other important functions such as recreation, agriculture and nature development.

- Freshwater retention + Supply

Instead of discharging the entire volume of water in the river, we intent to store water inside the floodplain. The stored water can be used again as irrigation water during periods of drought.

- Future-proof agriculture

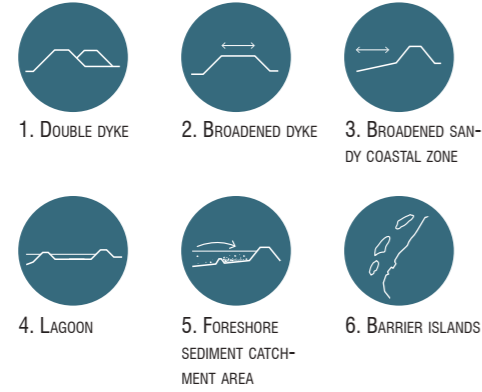
Sea level rise and changes in precipitation patterns result in an increase in salination, floods and droughts. These changes have a negative impact on the agricultural sector, crops and land can suffer an increase in potential damages in the future. Since agriculture is an important part of the economy of Surrey, it is of importance to maintain a vital agricultural sector. By providing future solutions and alternatives, the agricultural sector can be adapted in order to reduce the negative impact sea level rise and changes in precipitation patterns have on the landscape.

- Recreative network + Nature development

In the current situation, the connection between the urban areas and the floodplain is missing for recreational users. By creating a green network in combination with recreational routes, the city and the floodplain can be reconnected again. Besides creating recreational routes, the green network can also create opportunities for nature development and water storage to increase biodiversity and water safety.

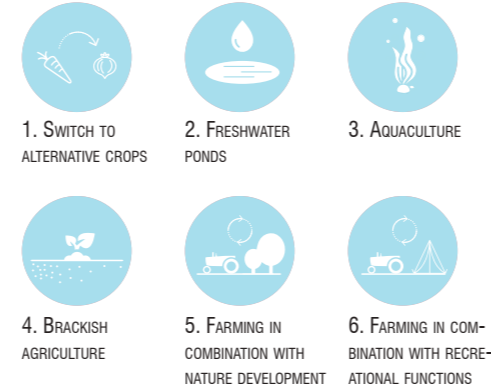
WIDENED COASTAL ZONE

Double dyke
Dyke
Broadened dyke
Dam
Broadened sandy coastal zone
Reed
Swamp
Mangrove
Dune
Dredgetube
Lagoon
Foreshore sediment catchment area
Barrier islands



FUTURE-PROOF AGRICULTURE

Farming in combination with nature development
Farming in combination with recreational functions
Aquaculture
Greenhouse
Switch to alternative crops
Low drains
Freshwater ponds
Swamp
Wet forest
Brackish agriculture
Vertical farms



FRESHWATER RETENTION + SUPPLY

Green roof
Blue roof
Green facade
Water tower
Broadened river
Waterfence
Retention garden
Flood polders
Lawn
Permeable surface
Bioswale
Waterpound
Bypass / Floodway
Fountain
Water square
Lake
Ditch
Spongepark
Lane
Natural creek areas along river
Forest
Deeper river + Higher dykes
Higher dykes
New river
Riparian buffer
Terps/ Heighten buildings



RECREATIVE NETWORK + NATURE DEVELOPMENT

Jetty
Dyke with path
Changing landuse
Recreational development
Connecting creeks and rivers
New recreational routes on land
Sustainable nature-orientated housing development Program (e.g. holiday houses, restaurants, hotels)
Recreational spots (e.g. swimming spot, bird watching hut)
New recreational routes on water
Green network of nature areas



6. MATRIX OF INTERVENTIONS

Within this chapter, an exploration is made of the different interventions that fit within the different themes of the vision for the Mud Bay. For each theme, different relevant projects have been analysed in order to set up a matrix of different interventions. Within each theme, the most suitable interventions are being highlighted. These interventions will form the base on which the spatial design strategy in the next chapter will be developed.

WIDENED COASTAL ZONE



1. DOUBLE DYKE

BY CREATING A SECOND DYKE, EITHER INLAND OR ON THE FLOODPLAIN SITE, THE WATER SAFETY OF THE AREA CAN BE IMPROVED. THE SECOND DYKE SERVES AS BACKUP IN CASE THE FIRST DYKE BREACHES OR GETS OVERTOPPED. IN THE ZONE IN BETWEEN THE DYKES, FUNCTIONS SUCH AS AGRICULTURE, ECOLOGY AND RECREATION CAN BE IMPLEMENTED.



DOUBLE DYKE: DYKE IMPROVEMENT EEMSHAVEN DELFZIJL, NL
(<https://www.waterinnovatieprijs.nl/wp-content/uploads/2016/09/Dijkverbetering-Eemshaven-Delfzijl.jpg>)



DOUBLE DYKE: OVERSLAGDIJK WADDEN DYKE, NL
([HTTP://LANDSCAPEINTERVENTIONS.NL/BROADENED-WADDEN-DYKE](http://landscapeinterventions.nl/broadened-wadden-dyke))



4. LAGOON

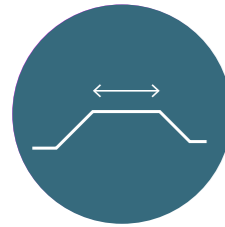
A LAGOON IS A BODY OF WATER THAT IS BEING SEPARATED FROM THE OCEAN BY BARRIER ISLANDS OR A DAM. LAGOONS CAN BE USED TO STORE WATER, BUT BESIDES WATER STORAGE THE LAGOON CAN ALSO FUNCTION AS A FLOOD PROTECTION BARRIER SINCE IT ABSORBS THE ENERGY OF WAVES COMING IN.



LAGOON: LAGOON RIA FORMOSA, PORTUGAL
(https://media.licdn.com/mpr/shrinknp_800_800/AEAAGAAAAAAd-PAAAAJDM1MWewMWYzLTl3NmYNDZmMC1hMmQ0LTA2MGZjNDY1NW1zYQ.jpg)



LAGOON: SWANSEA BAY TIDAL LAGOON, WALES
(<http://4.walesonline.co.uk/incoming/article12603424.ece/ALTERNATES/s810/Worlds-first-tidal-lagoon-power-plant.jpg>)



2. BROADENED DYKE

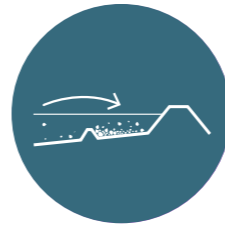
THE CURRENT DYKE STRUCTURE WILL BE REINFORCED BY BROADENING THE DYKE. THIS ADAPTATION COULD PROVIDE EXTRA SPACE FOR NEW FUNCTIONS BEING IMPLEMENTED INSIDE OR ON TOP OF THE BROADENED DYKE.



BROADENED DYKE: KATWIJK AAN ZEE, NL
([HTTP://WWW.FLOODDEFENCES.ORG/UPLOADS/5/5/2/0/55201631/4939760_ORIG.JPG](http://www.flooddefences.org/uploads/5/5/2/0/55201631/4939760_orig.jpg))



BROADENED DYKE: BROAD GREEN DOLLARD DYKE, NL
([HTTP://WWW.EE-EEMSDelta.NL/ASSETS/IMAGES/EEMS/BB_BREDE%20GroENE%20DOLLARD-DIJK_HUNZE%20en%20Aas.jpg](http://www.ee-eemdelta.nl/assets/images/eems/bb_brede%20Groene%20Dollard-Dijk_Hunze%20en%20Aas.jpg))



5. FORESHORE SEDIMENT CATCHMENT AREA

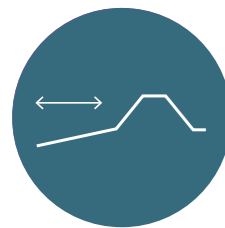
BY MAKING USE OF STRUCTURES (WOOD, CONCRETE, STONE ETC.) ALONG THE COASTLINE, SEDIMENT COMING IN DURING HIGH TIDES IS BEING DEPOSITED DURING THE LOW TIDES, THIS PROCESS SLOWLY FORMS NEW LAND IN BETWEEN THE CREATED STRUCTURES.



FORESHORE SEDIMENT CATCHMENT AREA: KWELDERS WITH CATCHMENT GRONINGEN, NL
(<http://www.ee-eemdelta.nl/assets/pdf/dossiers/natuur-en-landschap/Magazine%20Waterschap%20December%202015.pdf>)



FORESHORE SEDIMENT CATCHMENT AREA: SEDIMENT CATCHMENT COAST GERMANY
(<http://footage.framepool.com/shotimg/qj/968500624-fascine-groynes-coastal-protection-wave-breaker.jpg>)



3. BROADENED SANDY COASTAL ZONE

A LARGER COASTAL SAND AREA IS BEING CREATED THROUGH THE DEPOSIT OF SEDIMENT ALONG THE COASTLINE. BESIDES ADDITIONAL FUNCTIONS SUCH AS RECREATION AND NATURE DEVELOPMENT, THE COASTAL SAND AREA ALSO FUNCTIONS AS FLOOD PROTECTION. BY FORMING A LARGER BARRIER BETWEEN THE OCEAN AND THE LAND, IT ABSORBS THE ENERGY OF WAVES RESULTING IN AN INCREASE IN FLOOD SAFETY.



BROADENED SANDY COASTAL ZONE: BROADENING BEACH CALLANTSOOG, NL
([WWW.CALLANTSOOGSTRAND.NL/NEUWS/HONDSBOOSCHE.JPG](http://www.callantsoogstrand.nl/nieuws/hondsboosche.jpg))



BROADENED SANDY COASTAL ZONE: SAND-ENGINE FOR COASTAL PROTECTION, UK
([HTTPS://PHYS.ORG/NEWS/2015-10-SAND-ENGINE-COASTAL-EROSION.HTML](https://phys.org/news/2015-10-sand-engine-coastal-erosion.html))



6. BARRIER ISLANDS

BARRIER ISLANDS ARE SEDIMENT STRUCTURES LOCATED IN FRONT OF A COASTLINE. BARRIER ISLANDS CAN HAVE SEVERAL USES FOR RECREATION AND NATURE. BARRIER ISLANDS CAN ALSO FUNCTION AS FLOOD PROTECTION, SINCE THE ISLAND ABSORBS THE ENERGY OF WAVES COMING IN FROM THE OCEAN. REDUCING THE AMOUNT OF ENERGY A WAVE HAS ALSO REDUCES THE IMPACT IT HAS ON THE COASTLINE, THUS INCREASING FLOOD SAFETY.



BARRIER ISLANDS: Blue Dunes, West 8, US
([HTTP://WWW.WEST8.NL/PROJECTS/RESILIENCE_STRATEGIES_SUSTAINABILITY/BLUE_DUNES_THE_FUTURE_OF_COASTAL_PROTECTION/](http://www.west8.nl/projects/resilience_strategies_sustainability/blue_dunes_the_future_of_coastal_protection/))



BARRIER ISLANDS: Louisiana Barrier Island, US
(<http://www.habitat.noaa.gov/about/habitat/barrierislands.html>)

FUTURE-PROOF AGRICULTURE



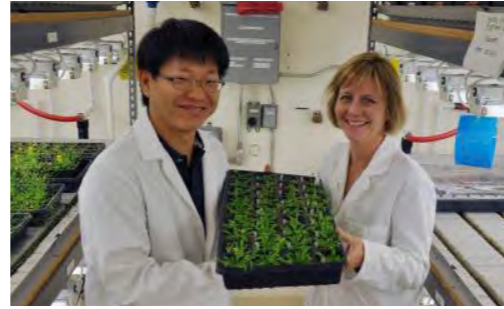
1. SWITCH TO ALTERNATIVE CROPS

AN INCREASE OF FLOODS IN THE FUTURE OF AGRICULTURAL LANDS, COULD RESULT IN LIMITATIONS TO THE PRODUCTION OF CERTAIN CROPS. BY SWITCHING TO ALTERNATIVE CROPS SUCH AS CROPS THAT HAVE A HIGHLY TOLERANCY TOWARDS FLOODING OR BY SWITCHING TO GREEN HOUSES THAT CAN WITHSTAND FLOODING, AGRICULTURAL LANDS CAN REMAIN PRODUCTIVE IN THE FUTURE EVEN THOUGH FLOOD RISK INCREASES.

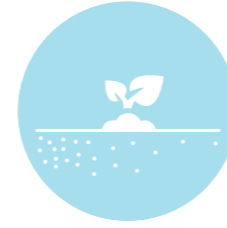
EXAMPLE PROJECTS



SWITCH TO ALTERNATIVE CROPS: FLOATING FARM, ROTTERDAM, NL
[HTTP://WWW.DUURZAAMBEDRIJFSLEVEN.NL/LANDBOUW/5679/DRUVENDE-LANDBOUW-VOOR-MEER-VOEDEL](http://www.duurzaambedrijfsleven.nl/landbouw/5679/druvende-landbouw-voor-meer-voedsel)



SWITCH TO ALTERNATIVE CROPS: FLOOD TOLERANT CROPS
[HTTPS://PHYS.ORG/NEWS/2011-10-BREAKTHROUGH-PRODUCTION-FLOOD-TOLERANT-CROPS.HTML](https://phys.org/news/2011-10-breakthrough-production-flood-tolerant-crops.html)



4. BRACKISH AGRICULTURE

THE PREDICTED SEA LEVEL RISE IN COMBINATION WITH SALT WATER SEEPAGE HAVE A NEGATIVE INFLUENCE ON THE AVAILABILITY OF FRESHWATER FOR AGRICULTURE. THE INTRUSION OF SALTWATER ON AGRICULTURAL LANDS COULD DO SINCERE DAMAGE TO THE CROPS, THIS COULD EVEN INCREASE IN THE FUTURE. BY SWITCHING TO CROPS THAT ARE MORE TOLERANT TO SALT, THE AGRICULTURAL SECTOR CAN REMAIN PRODUCTIVE EVEN WHEN LANDS ARE BECOMING MORE SALINE.



BRACKISH AGRICULTURE: MARCFOODS TEST LOCATION SALINE CROPS, NL
[HTTPS://WWW.SG.UU.NL/SITES/DEFAULT/FILES/STYLES/NLINE/PUBLIC/CONTENT/TESTLOCATIE_TELXEL_RUIS-SELBERGHE.PNG?ITOK=MAMMta_0](https://www.sg.uu.nl/sites/default/files/styles/nline/public/content/testlocatie_telxel_ruis-selberghe.png?itok=MAMMta_0)



BRACKISH AGRICULTURE: KWELKWEKERIJ, NL
[HTTP://WWW.VANBERGENKOLPA.NL/NL/22_KAS_EN_LAND.HTML](http://www.vanbergenkolpa.nl/nl/22_kas_en_land.html)



2. FRESHWATER PONDS

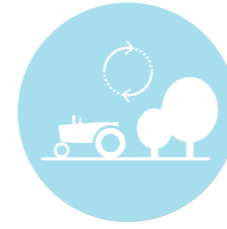
FRESHWATER PONDS CAN BE USED TO STORE WATER USED FOR IRRIGATION. IN THE FUTURE DROUGHTS ARE BECOMING MORE OF AN ISSUE. THE CREATION OF FRESHWATER PONDS CAN FORM A SOLUTION FOR THOSE PERIODS OF DROUGHT. BESIDES WATER STORAGE THE PONDS CAN ALSO BE USED FOR RECREATION AND NATURE DEVELOPMENT.



FRESHWATER PONDS: WATER RETENTION LANDSCAPE, BRASIL
[HTTP://WWW.LIVING-GAIA.ORG/FUTURE_PROJECTS.HTML](http://www.living-gaia.org/future_projects.html)



FRESHWATER PONDS: IRRIGATION WATER STORAGE, MARLBOROUGH, NEW ZEALAND
[HTTPS://TEARA.GOVT.NZ/EN/PHOTOGRAPH/19609/DAM-WATER-STORAGE](https://teara.govt.nz/en/photograph/19609/dam-water-storage)



5. FARMING IN COMBINATION WITH NATURE DEVELOPMENT

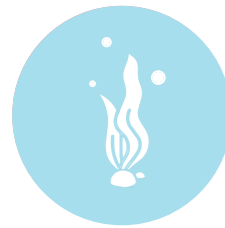
NATURE CAN PROVIDE SEVERAL ECOSYSTEM SERVICES THAT ARE BEING BENEFICIAL FOR AGRICULTURE. THE BENEFITS RANGE FROM SOIL FORMATION, NATURAL PEST CONTROL, WATER AND AIR REGULATION, AND INCREASE IN BIODIVERSITY. THE NATURE AREAS CAN ALSO PROVIDE FOR EXTRA INCOME FOR FARMERS, INCOME CAN BE GENERATED FROM ECOTOURISM OR THE HARVESTING OF NATURAL PRODUCTS SUCH AS WOOD AND FOREST FRUITS. THIS EXTRA INCOME CAN COMPENSATE THE LOSSES CREATED BY THE TRANSFORMATION OF AGRICULTURAL LANDS TOWARDS NATURE AREAS.



FARMING IN COMBINATION WITH NATURE DEVELOPMENT: NATUURDERJ KEIZERSRANDE, DIEPENVEEN, NL
[HTTP://WWW.KEIZERSRANDE.NL](http://www.keizersrande.nl)



FARMING IN COMBINATION WITH NATURE DEVELOPMENT: AGRO-ECOLOGY
[HTTP://WWW.CRA.WALLONIE.BE/FR/NOUVELLES/LAGROECOLOGIE-UNE-VOIE-DE-TRANSITION-POUR-LAGRICULTURE](http://www.cra.wallonie.be/fr/nouvelles/lagroecologie-une-voie-de-transition-pour-lagriculture)



3. AQUACULTURE

AQUACULTURE CAN BE AN ALTERNATIVE FOR AGRICULTURAL LAND THAT ARE EXPERIENCING DAMAGES REGULARLY BECAUSE OF THE CONSEQUENCES OF FLOODING. AQUACULTURE FOCUSSES ON THE FARMING OF FISH, CRUSTACEANS, MOLLUSCS, AQUATIC PLANTS, ALGUE AND OTHER AQUATIC ORGANISMS. SINCE THEY ARE BEING GROWN IN FRESH- OR SALTWATER, AQUACULTURE IS LESS PRONE TO FLOODING COMPARED TO NORMAL AGRICULTURE, FORMING AN ALTERNATIVE PRACTISE FOR FLOOD-PRONE AGRICULTURAL AREAS.



AQUACULTURE: OYSTER FARM PLEASANT BAY, US [HTTPS://STATIC1.SQUARESPACE.COM/STATIC/52540738E4D05048EA3A9D0F/53F75C00E4A0271E38CA9F85/53F75C03E4A0271E38CA9F8F/1408719875961/PLEASANT-BAY-OYSTER-FARM.JPG](https://static1.squarespace.com/static/52540738e4d05048ea3a9d0f/53f75c00e4a0271e38ca9f85/53f75c03e4a0271e38ca9f8f/1408719875961/pleasant-bay-oyster-farm.jpg)



AQUACULTURE: TYLER FISH FARM, US [HTTP://TYLERFISHFARM.COM/IMAGES/POND2.JPG](http://tylerfishfarm.com/images/pond2.jpg)



6. FARMING IN COMBINATION WITH RECREATIONAL FUNCTIONS

IN ORDER TO COMPENSATE FOR POSSIBLE LOSSES DUE TO THE CONSEQUENCES OF CLIMATE CHANGE, FARMERS COULD GAIN EXTRA INCOME BY CREATION NEW FUNCTIONS BESIDES THE PRODUCTION OF CROPS. EXAMPLES OF SIDE-FUNCTIONS ARE: BED&BREAKFAST, PETTING ZOO, CAMPING AT THE FARMER, NATURE EDUCATION, FARMER'S MARKET, SPECIALIZED PRODUCTS (E.G. CHEESE), AND RURAL RESTAURANT.



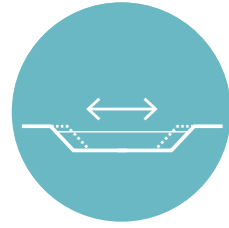
FARMING IN COMBINATION WITH RECREATIONAL FUNCTIONS: FARMER'S CAMPING 'HET VARSENERVELD' [HTTP://WWW.BUTEUN.NL/AANBOD/1465192#.WVnJg4vLUk](http://www.buteun.nl/aanbod/1465192#.WVnJg4vLUk)



FARMING IN COMBINATION WITH RECREATIONAL FUNCTIONS: SLOW FOOD MARKET AT FARM EYCKESTEIN [HTTP://DEBLINBEELD.NL/2017/06/21/EERSTE-SLOW-FOOD-MARKT-OP-BOERDERIJ-EYCKESTEIN/](http://deblinbeeld.nl/2017/06/21/eerste-slow-food-markt-op-boerderij-eyckestein/)

FRESHWATER RETENTION+SUPPLY

EXAMPLE PROJECTS



1. WIDENED RIVER

By giving the river more space to flow, the water levels of the river will be lowered. By widening the river, higher volumes of water can flow through the river without the dykes being overtopped with water.



WIDENED RIVER: ROOM FOR THE RIVER, NIJMEGEN, NL
(<http://www.landzine.com/wp-content/uploads/2017/04/Room-for-the-River-Nijmegen-0-Photo-Siebe-Swart.jpg>)



WIDENED RIVER: FLOODPLAIN EXCAVATION MEINERSWIJK, NL
(<https://www.ruimtevoorderivier.nl/project/uterwaardvergraving-meinerswijk/>)



4. FLOOD POLDERS

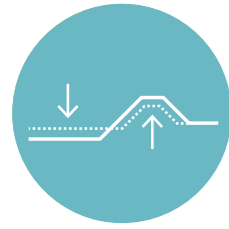
Flood polders are used as water storage to prevent rivers from flooding valuable land, and instead flood less valuable polders. During times of high water levels in the river, they flood the polders in order to lower the water levels. When a flood polder is not being used to store water it remains functional as agricultural land.



FLOOD POLDERS: HOOG BOEZEM POLDER, HAASTRECHT, NL
(<https://www.hdsr.nl/publish/pages/9155/webversie.jpg>)



FLOOD POLDERS: OVERDIEPSE POLDER, NL
(<http://www.nytimes.com/2013/02/17/arts/design/flood-control-in-the-netherlands-now-allows-sea-water-in.html>)



2. DEEPER RIVER + HIGHER DYKES

By deepening the river bed and by raising the dykes, the maximum discharge capacity of a river can be increased. Higher volumes of water which in the older situation would have resulted in a flooding can now be discharged through the river without it causing to overtop the dykes.



DEEPER RIVER + HIGHER DYKES: DYKE IMPROVEMENT STEURGAT / LAND VAN ALTENA
(<https://www.ruimtevoorderivier.nl/project/dijkverbetering-steurgat-land-van-altena/>)



DEEPER RIVER + HIGHER DYKES: DREDGE PROGRAM FRASER RIVER, CA
(<http://www.dredgingtoday.com/wp-content/uploads/2014/07/fraser-river-in-need-of-dredging.jpg>)



5. NATURAL CREEK AREAS ALONG THE RIVER

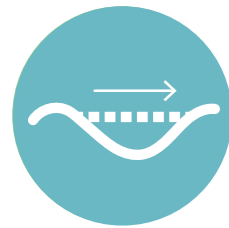
Nature areas along the river can provide habitat for birds and other species of mammals. The nature areas provide besides biodiversity, space for the river to store water in times of high river discharges. By letting the natural creek areas flood, other valuable agricultural lands can be protected.



NATURAL CREEK AREAS ALONG THE RIVER: ONLANDEN GRONINGEN, NL
(<https://www.natuurmonumenten.nl/nieuws/natuurgebieden-helpen-wateroverlast-voorkomen>)



NATURAL CREEK AREAS ALONG THE RIVER: RENATURATION OF THE RIVER AIRE, SWITZERLAND
(<http://www.landzine.com/index.php/2016/06/renaturation-of-the-river-aire-geneva/04-naturalization-river-channel-lands-cape-architecture-fabio-chironi/>)



3. BYPASS/FLOODWAY

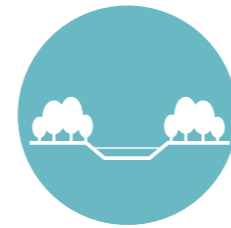
A bypass or floodway is an area of land connected to a river that can be used as a side river arm during times of high water levels. By allowing the river more space to flow, the total discharge capacity of the river is being increased, resulting in an increase in the water safety for future situations.



BYPASS/FLOODWAY: FLOOD CHANNEL VEESSEN-WAPENVELD, NL
(www.callantsoogstrand.nl/nieuws/hondsbossche.jpg)



BYPASS/FLOODWAY: RED RIVER FLOODWAY, CA
(<http://www.mhs.mb.ca/docs/sites/images/redriverfloodway31.jpg>)



6. RIPARIAN BUFFER

A riparian buffer is a zone of vegetation located near a stream of water. The surrounding vegetation protects the stream from harm being done by other land uses. The vegetation has multiple functions such as reduction of air pollution, water quality improvement and habitat for species. A riparian buffer can also function as water storage in times of high water levels.



RIPARIAN BUFFER: BEAR CREEK, IOWA, US
(<http://2030palette.org/swatches/view/riparian-buffers>)



RIPARIAN BUFFER: MEMONONEE VALLEY RESTORATION, WISCONSIN, US
(http://2030palette.org/uploads/default/crop_swatches/menomonee_valley_restoration_1.jpg)

ACCESSIBLE LANDSCAPE



1. NEW RECREATIONAL ROUTES ON LAND

NEW RECREATIONAL ROUTES CAN PROVIDE A CONNECTION BETWEEN URBAN AND RURAL AREAS. THE RECREATIONAL ROUTES CAN BE USED FOR ACTIVITIES SUCH AS: BIKING, HIKING, HORSE RIDING AND OTHER FUNCTIONS.



NEW RECREATIONAL ROUTES ON LAND: BIKE ROUTES ALONG FARMERS, NL (<http://www.meimaandrietsmaand.nl/wp-content/uploads/2017/03/17.-ZeeLand-De-Boer-op-750x350.jpg>)



NEW RECREATIONAL ROUTES ON LAND: HIKING ROUTES IN AGRICULTURAL LANDS, PEEL, NL (<http://www.ed.nl/deurme-e-0/wandelen-door-de-peel-en-kletsen-in-het-engels-tuizens-de-walk-english-a98de09c/>)



4. PROGRAM

PROGRAM CAN BE ADDED INSIDE THE AGRICULTURAL LANDS TO PROVIDE NEW STIMULUS TO VISIT THE AREA AND IT A NEW ECONOMICAL BOOST. BESIDES THE INCOME OF THE AGRICULTURAL SECTOR, THE NEWLY IMPLEMENTED PROGRAM CAN GENERATE EXTRA INCOME. EXAMPLES OF PROGRAM THAT CAN BE IMPLEMENTED AREA HOLIDAY HOUSES, RESTAURANTS, HOTELS, ETC.



PROGRAM: MEDIAMATIC ETEN, AMSTERDAM, NL (<https://www.mediamatic.net/en/page/87790/mediamatic-eten>)



PROGRAM: UIT JE EIGEN STAD, ROTTERDAM (<http://www.uitjeeigenstad.nl/>)



2. NEW RECREATIONAL ROUTES ON WATER

NEW RECREATIONAL ROUTES ON WATER CAN BE IMPLEMENTED INTO THE AGRICULTURAL LANDS. RECREATIONAL ACTIVITIES SUCH AS CANOEING, FISHING OR SMALL BOAT RECREATION CAN BE DONE ON THE NEWLY CREATED ROUTES.



NEW RECREATIONAL ROUTES ON WATER: CANOEING THROUGH THE POLDERS, KAAG & BRAASSEM, NL (<https://www.rondomkaagbraassem.nl/zieh-en-doen/routes/kaag-en-braassem-kanoroute>)



NEW RECREATIONAL ROUTES ON WATER: BOAT ROUTES THROUGH AGRICULTURAL LANDS, FRIESLAND, NL (<http://www.dobershoeve.nl/wp-content/uploads/water-klein-13.jpg>)



5. SUSTAINABLE NATURE-ORIENTATED HOUSING DEVELOPMENT

THE FOCUS OF THIS TYPE OF HOUSING DEVELOPMENT LAYS ON SUSTAINABILITY. BY CREATING CLOSED CYCLES BY RECYCLING MATERIAL AND WORKING WITH NATURAL PROCESSES, HOUSES CAN BE CREATED THAT ARE IN SYMBIOSE WITH NATURE. NATURE CAN PROVIDE SEVERAL BENEFITS FOR THE RESIDENTS, SUCH AS CLEAN AIR, CLIMATE REGULATION AND AESTHETICS.



SUSTAINABLE NATURE-ORIENTATED HOUSING DEVELOPMENT: EVA-LANXMEER, NL (<http://www.eva-lanxmeer.nl/>)



SUSTAINABLE NATURE-ORIENTATED HOUSING DEVELOPMENT: REGEN VILLAGES, ALMERE, NL (<http://www.regenvillages.com>)



3. RECREATIONAL SPOTS

IMPLEMENTING RECREATIONAL SPOTS INTO AGRICULTURAL AREAS, PROVIDES PEOPLE WITH MORE INCENTIVES TO VISIT THE AGRICULTURAL LANDS. EXAMPLES OF RECREATIONAL SPOTS ARE SWIMMING AREAS (BEACHES OR PIERS), BIRD WATCHING HUTS, SPORT ACTIVITY FIELDS AND OTHER RECREATIONAL FUNCTIONS.



RECREATIONAL SPOTS: SWIMMING BEACH SPIEGELPOLDER-PLAS, NL (<http://www.nederhorstiden-berg.nl/content/2013/07/informatie-spiegelpolderplas-bu-nederhorst-den-berg>)



RECREATIONAL SPOTS: BIRD WATCHING HUT BREEBAARTPOLDER, NL (http://www.nathalienatuurfotografie.com/uploads/5/8/2/6/5826911/2205610_orig.jpg)



6. GREEN NETWORK OF NATURE AREAS

BY CREATING A NETWORK OF CONNECTED NATURE AREAS, FRAGMENTATION CAN BE PREVENTED. THE NETWORK OF CONNECTED NATURE AREAS CAN INCREASE BIODIVERSITY AND IMPROVE THE QUALITY OF THE NATURE AREAS. FUNCTIONS AS WATER STORAGE AND RECREATION CAN ALSO BE IMPLEMENTED INTO THE GREEN NETWORK.

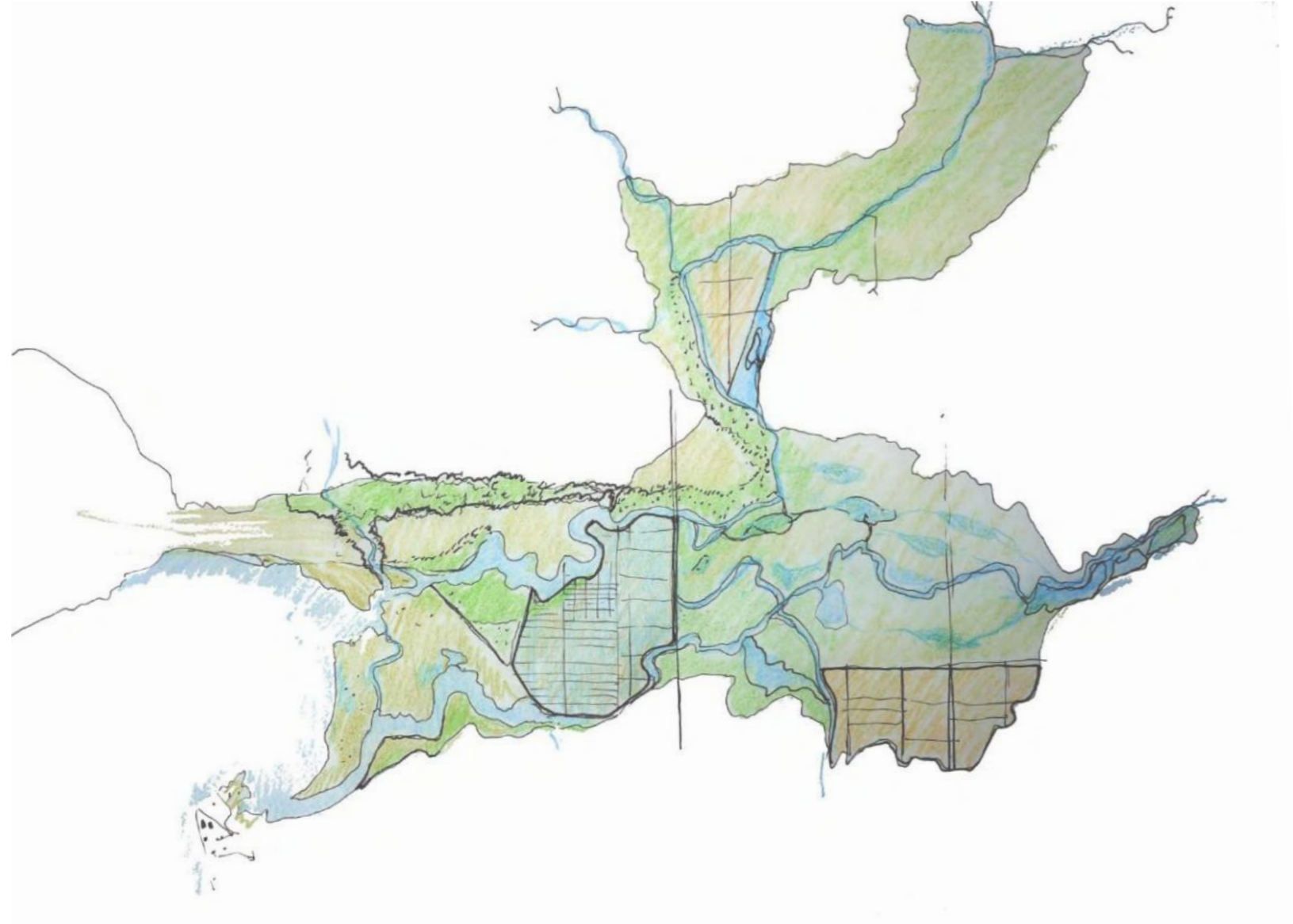


GREEN NETWORK OF NATURE AREAS: ECODUCT A50, NL (<http://www.bizarbin.com/ecoduct/>)



GREEN NETWORK OF NATURE AREAS: THE EUROPEAN GREEN BELT (<http://www.europeangreenbelt.org/ecological-network/green-infrastructure.html>)

MANAGED RETREAT

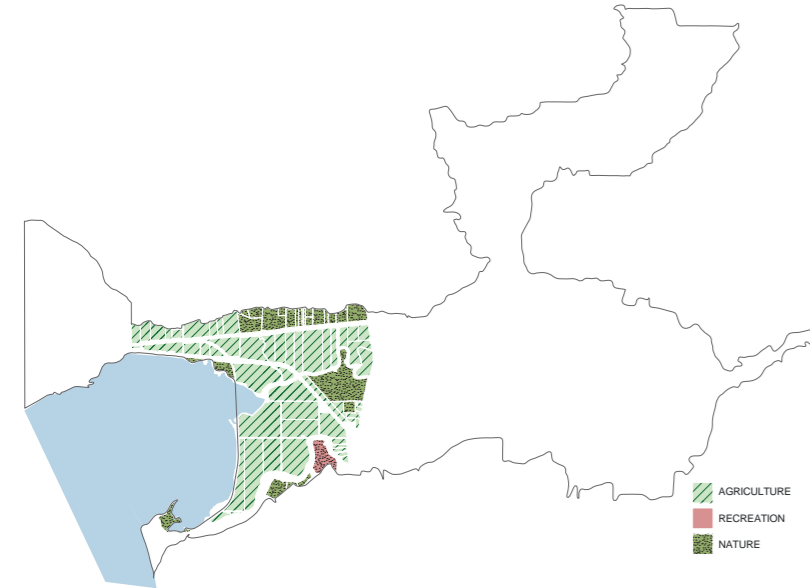


7. SPATIAL DESIGN STRATEGY

From the design models, the 'managed retreat' model was most preferred. Within this chapter a spatial design strategy is being developed for the 'managed retreat' model. The spatial design strategy is based upon four themes of the vision for the Mud Bay. The interventions found in the previous chapter will be used within the spatial design strategy.

The spatial design strategy for the Mud Bay area can be split up into two parts: One part of the strategy is concerned with the coastal area, and what effect certain interventions would have on the landscape of the Mud Bay area. And what different incentives can be created for farmers in order to cope with the effects of climate change. The second part is concerned with the riverine areas, exploring the options to give the rivers more space to flow, while giving a boost to the recreational network.

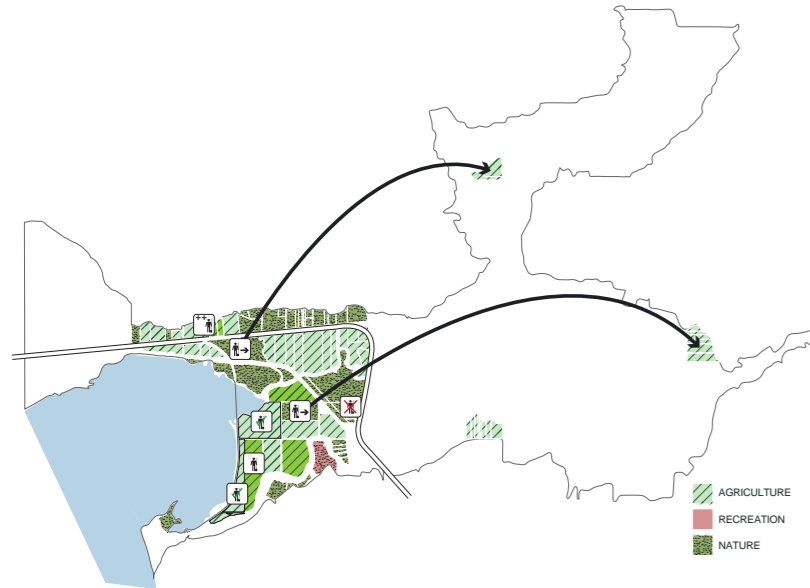
COASTAL DESIGN STRATEGY



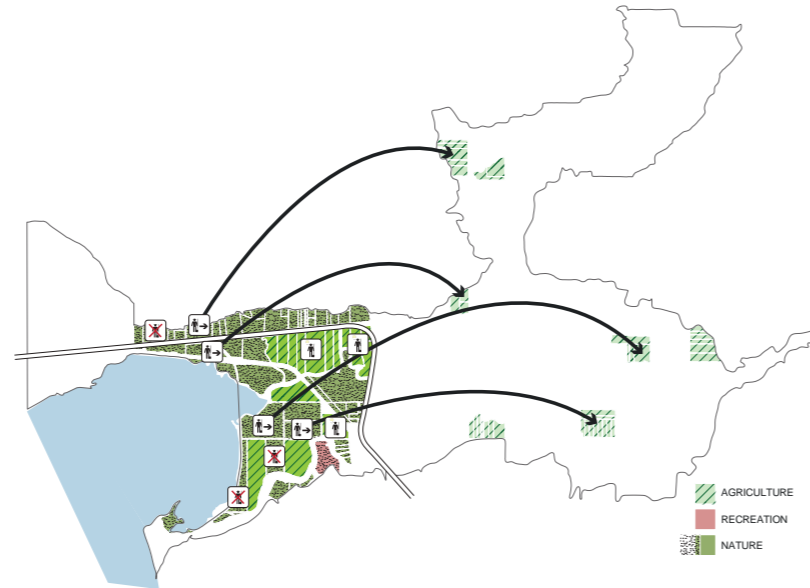
Current situation



First pioneers start adapting their farming practise to deal with the first noticeable changes of climate change. Besides adapting, some farmers chose to expand their farming activities by adding nature development, or stop with their current farm.

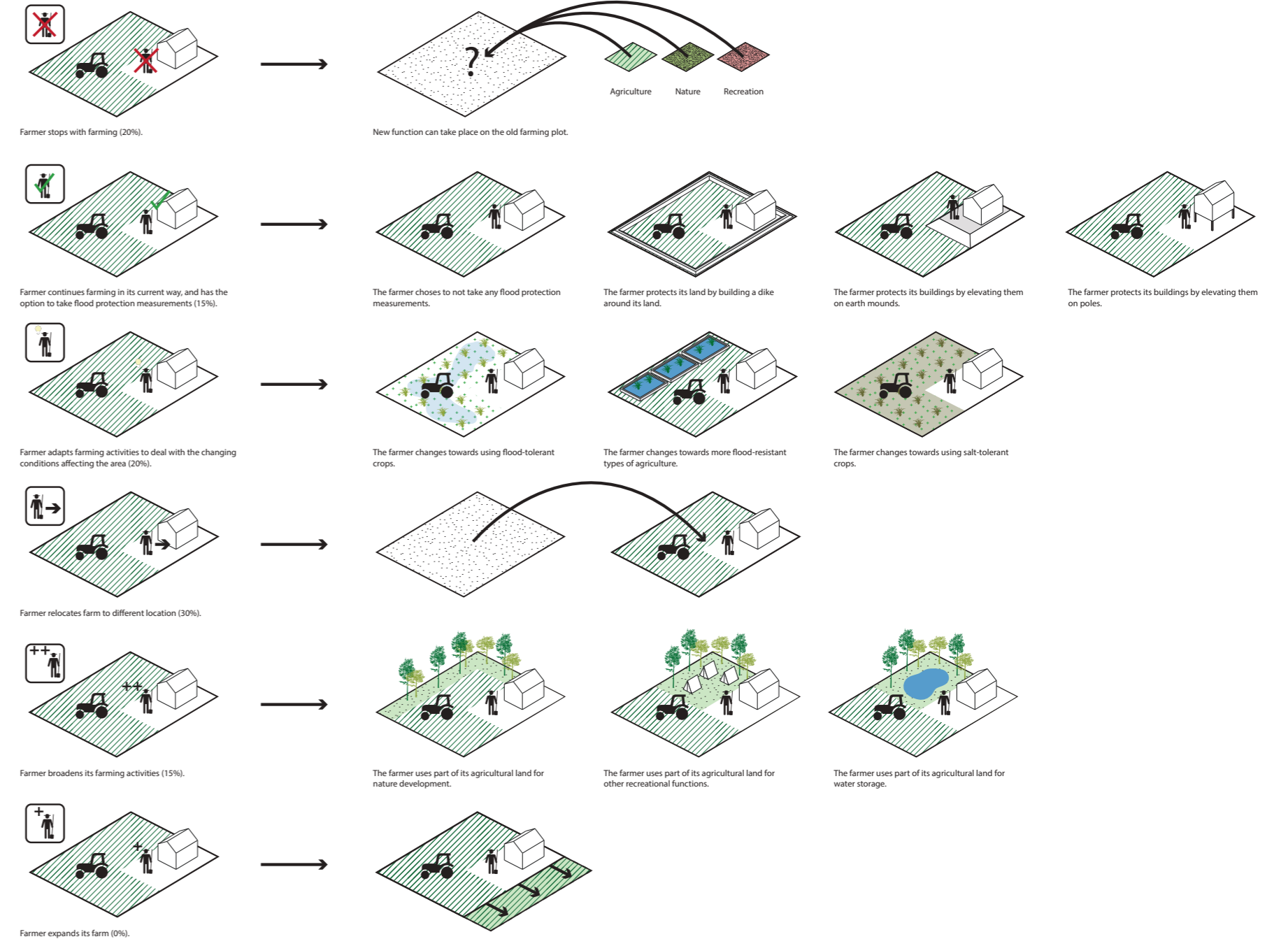


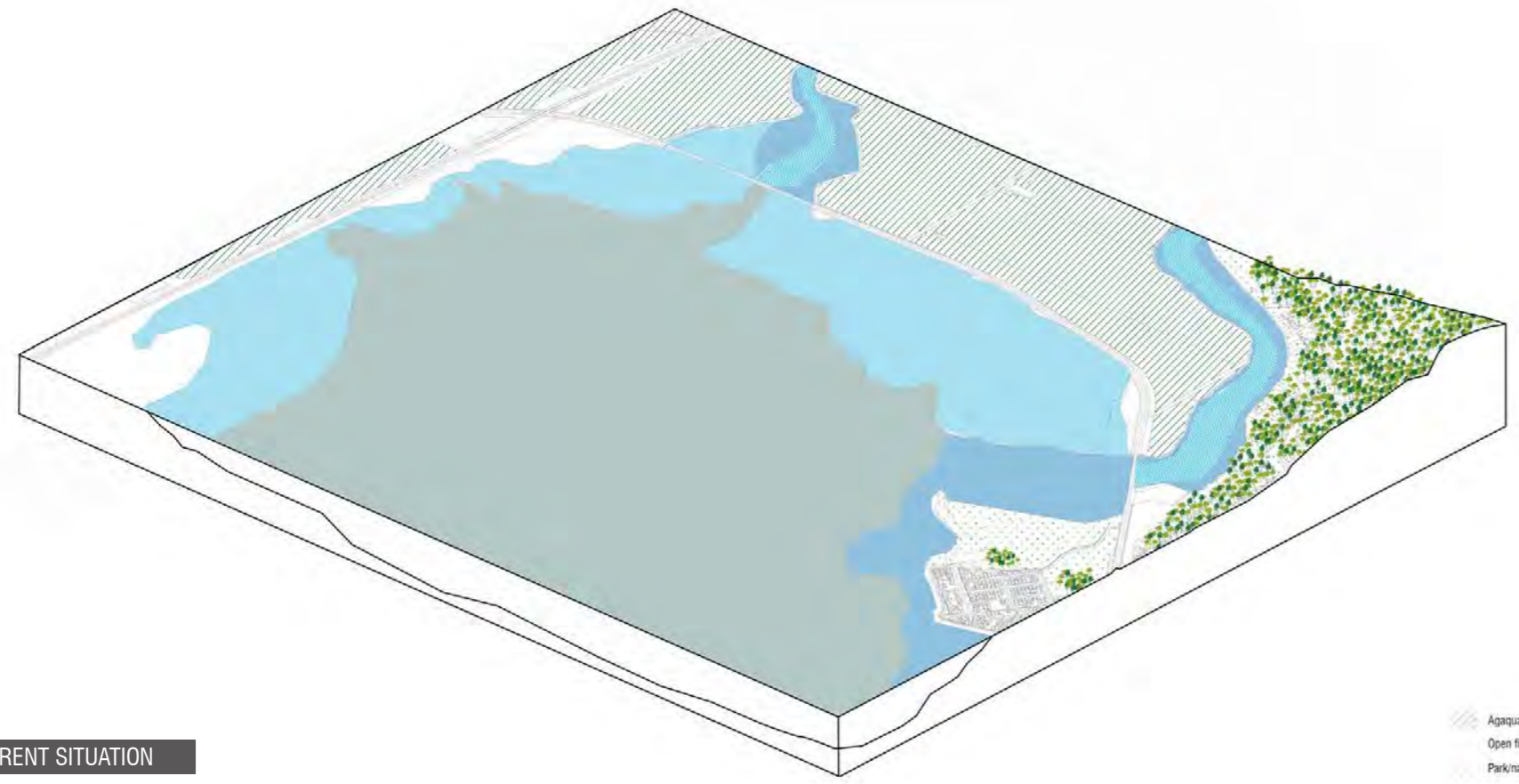
Highway 99 is being relocated towards King George Blvd, more farmers chose to adapt, change, or relocate their farming practise.



As sea level starts to rise, more farmers are relocating towards higher elevated areas in the floodplain

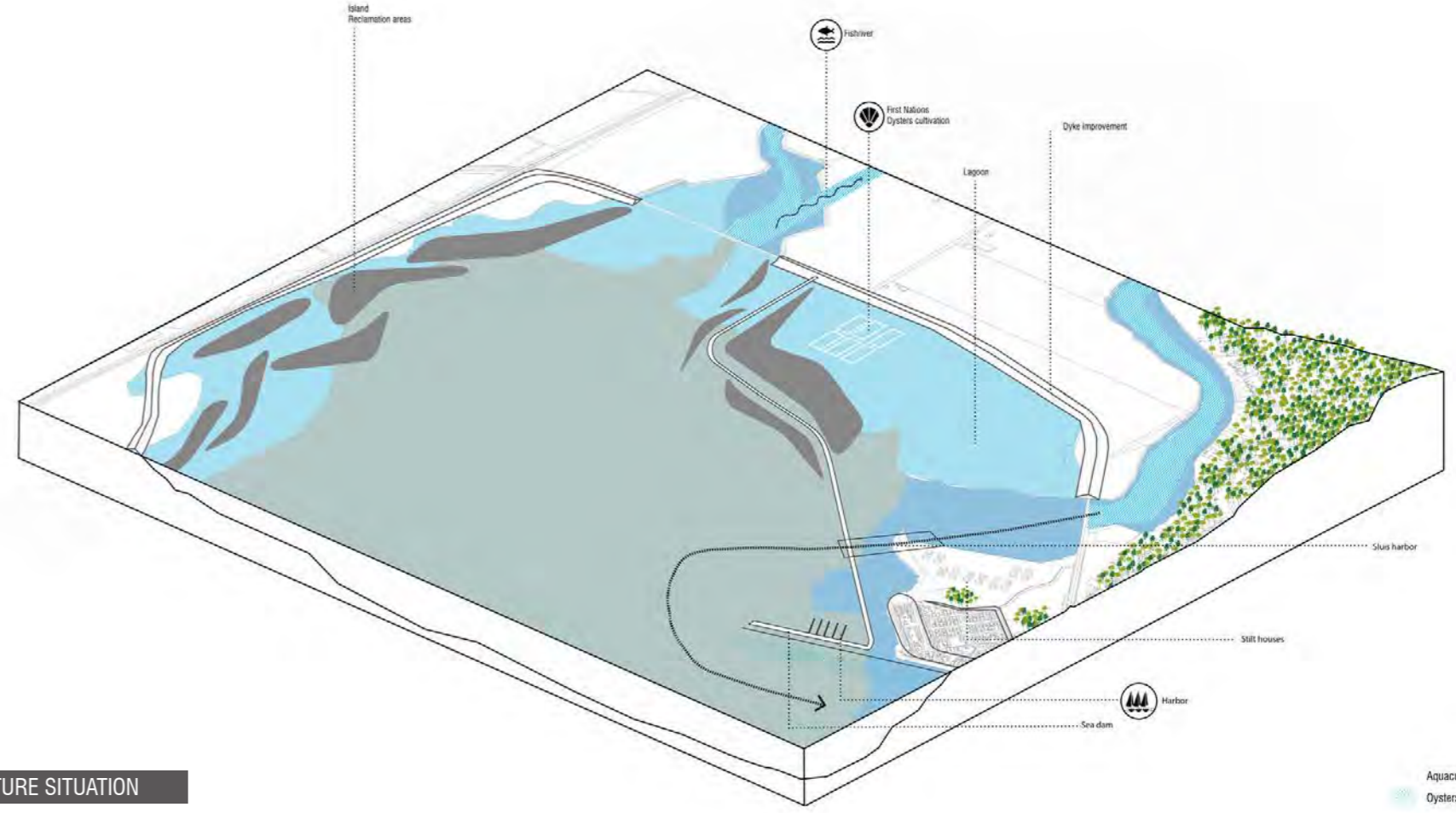
FARMER'S INCENTIVES COASTAL AREA





CURRENT SITUATION

- Aquaculture
- Open field (grass)
- Park/natural area
- Mud flat
- Freshwater river
- Estuarine Marsh

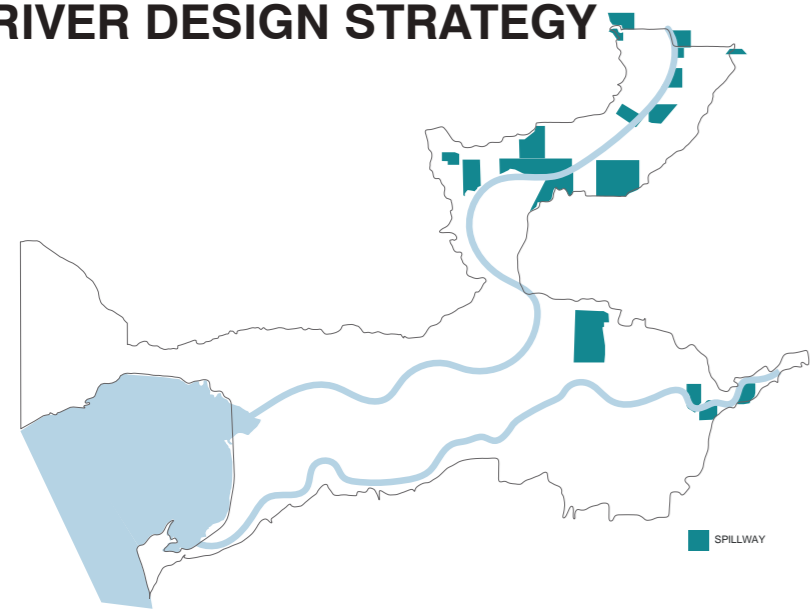


FUTURE SITUATION

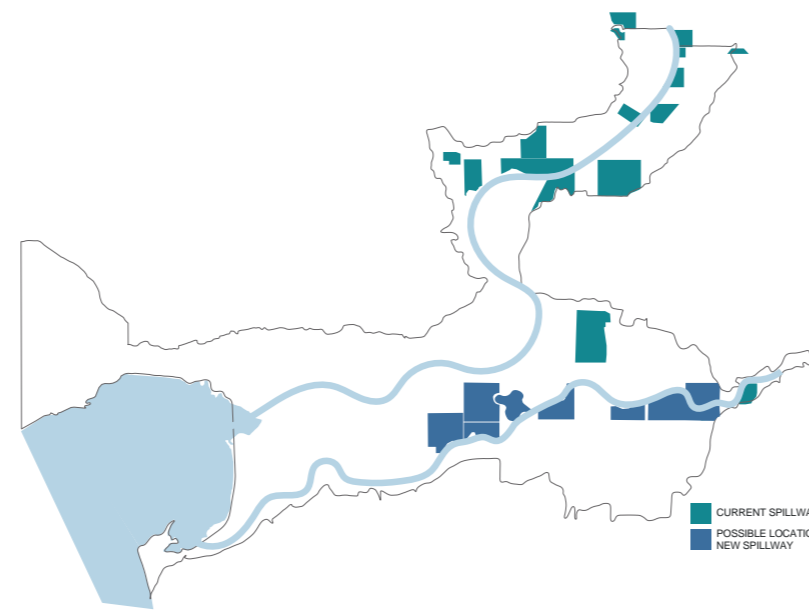
- Aquaculture
- Oysters habitat
- Mud flat
- Freshwater river
- Estuarine Marsh

A new coastal area is created through the implementation of a breakwater in front of the coastline

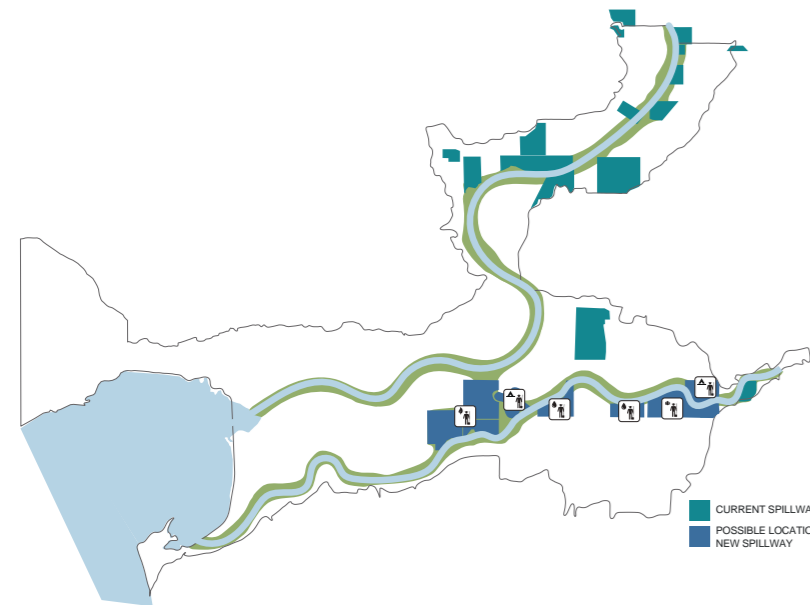
RIVER DESIGN STRATEGY



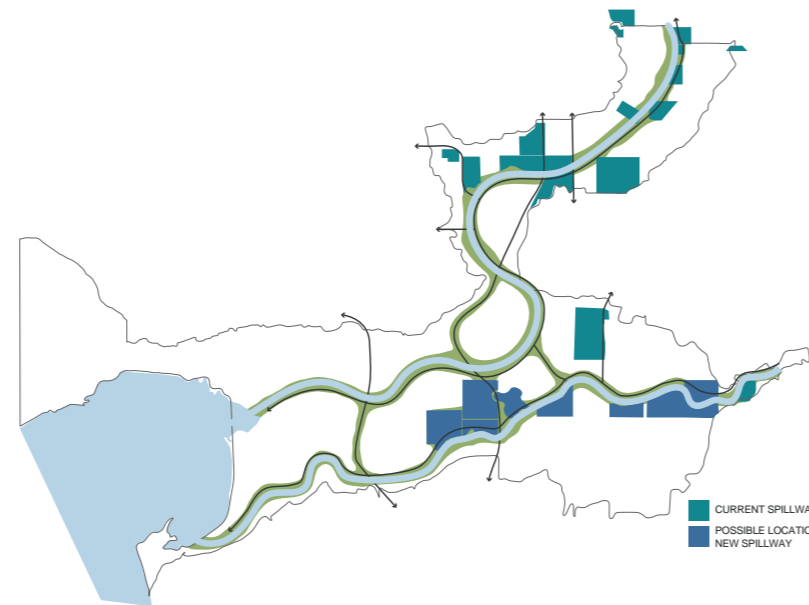
Existing situation: The spillways located in the lower elevated areas of the floodplain can be used for floodwater storage during periods of high river discharges, in order to lower water levels in the river, and thus lowering flood risk.



In order to improve flood safety, the option of expanding the system of spillways, is being explored. The areas that are found suitable for floodwater storage are the large and extra large plots located in the lower elevated areas of the floodplain.

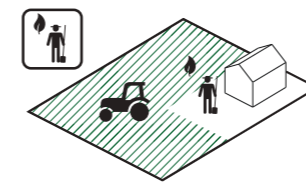


The rivers are given more space to flow by expanding the water meadows of the river. The water meadows of the river can be used to store more river water during periods of high river discharges.

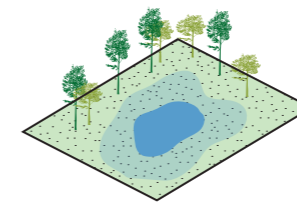


Within the final phase, new recreational routes are created, connecting the urban higher elevated areas of Surrey with the lower elevated floodplain areas. The recreational routes are integrated along the green and blue network of river- and spillway areas.

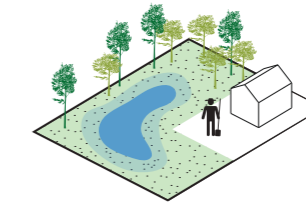
FARMER'S INCENTIVES RIVERINE AREA



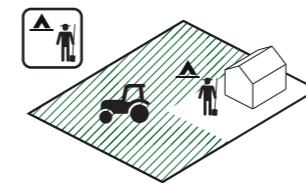
The agricultural functions of the area is being transformed to water storage in combination with nature development (15%).



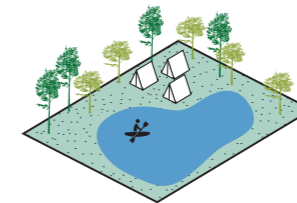
The area is completely transformed for water storage in combination with nature development



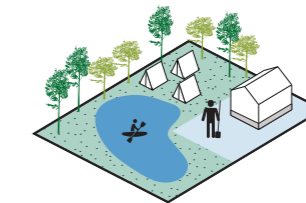
The farmer transforms its land completely for water storage in combination with nature development



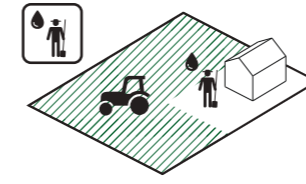
The agricultural function of the area is being transformed to water storage in combination with recreational functions (15%).



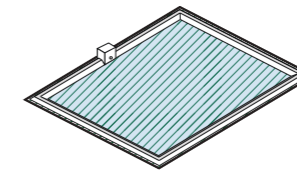
The area is completely transformed for water storage in combination with recreational functions, the farmer relocates to a different area



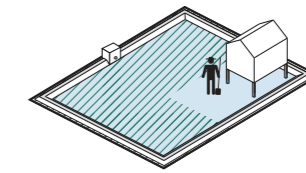
The farmer transforms its land completely for water storage in combination with recreational functions



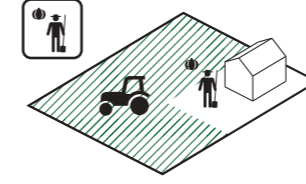
The agricultural function of the area is being transformed to water storage in combination with irrigation water supply (15%).



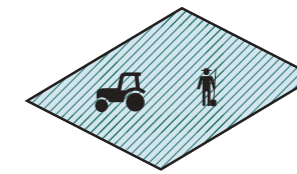
The area is completely transformed for water storage, the farmer relocates out of the water storage area



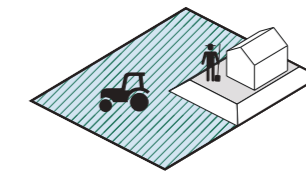
The farmer transforms its land completely for water storage, buildings are adapted to be flood-proof



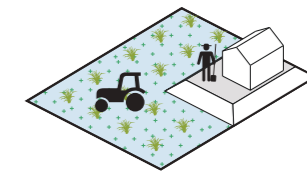
The agricultural function of the area remains (15%).



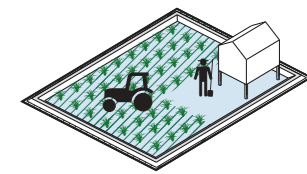
The farmer continues with its current farming practise and accepts any possible flood damages to its crops, the farmer relocates out of the water storage area



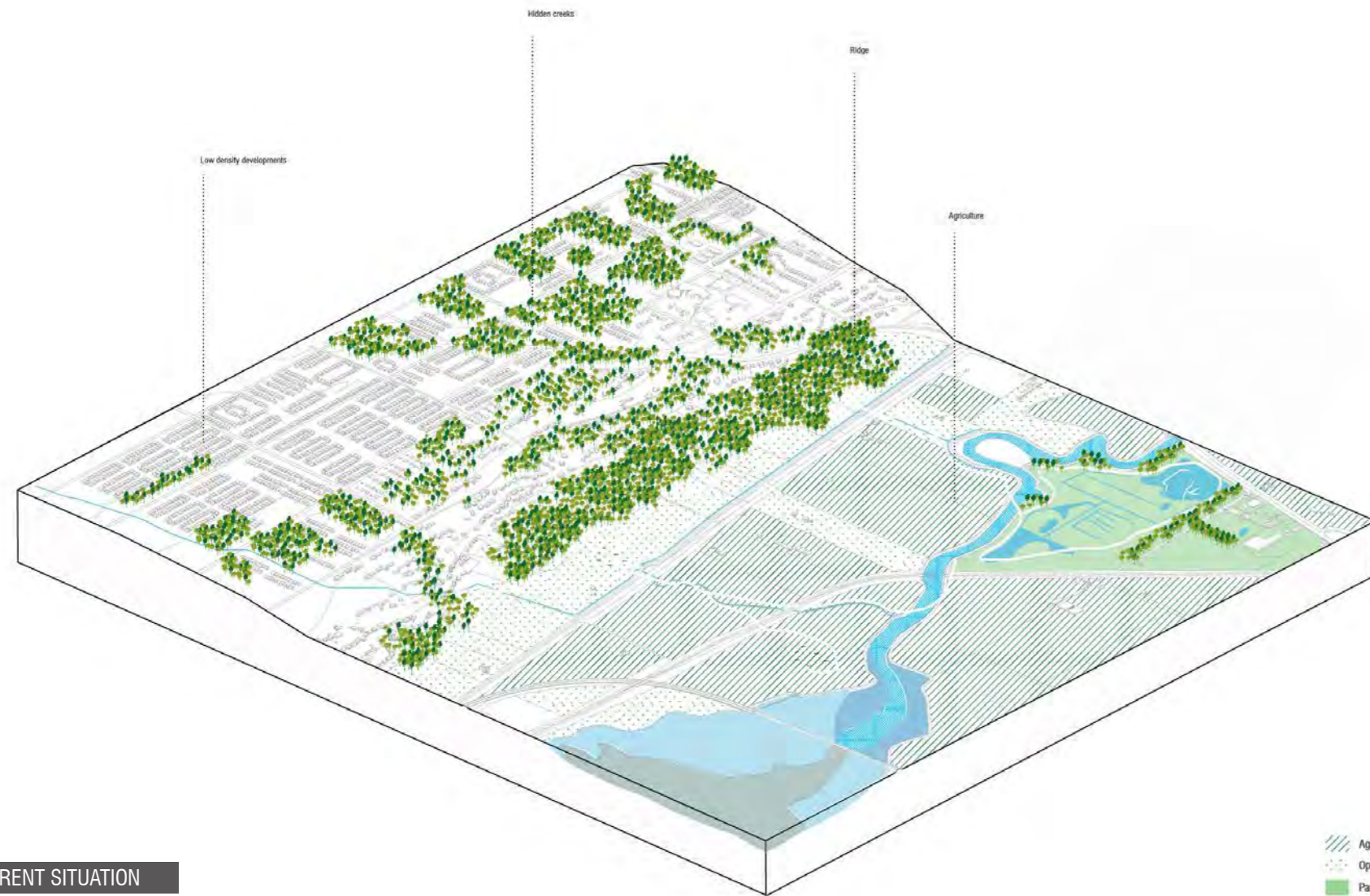
The farmer continues with its current farming practise and accepts any possible flood damages, and the farmer adapts its buildings to be flood-proof



The farmer continues with its current farming practise and changes towards using flood-tolerant crops, and adapts its buildings to be flood-proof

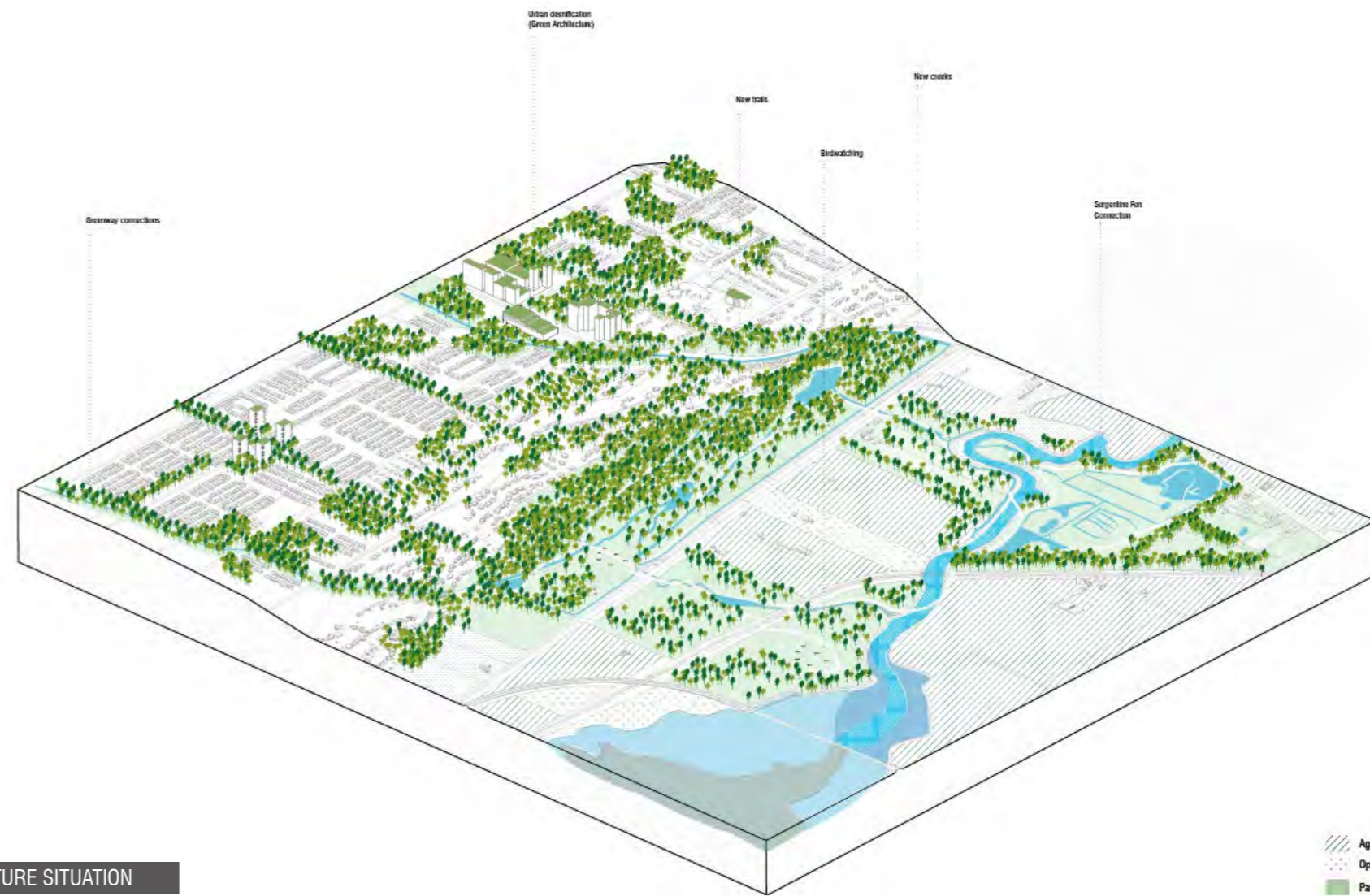


The farmer continues with its current farming practise and changes towards using flood-resistant crops, and adapts its buildings to be flood-proof



CURRENT SITUATION

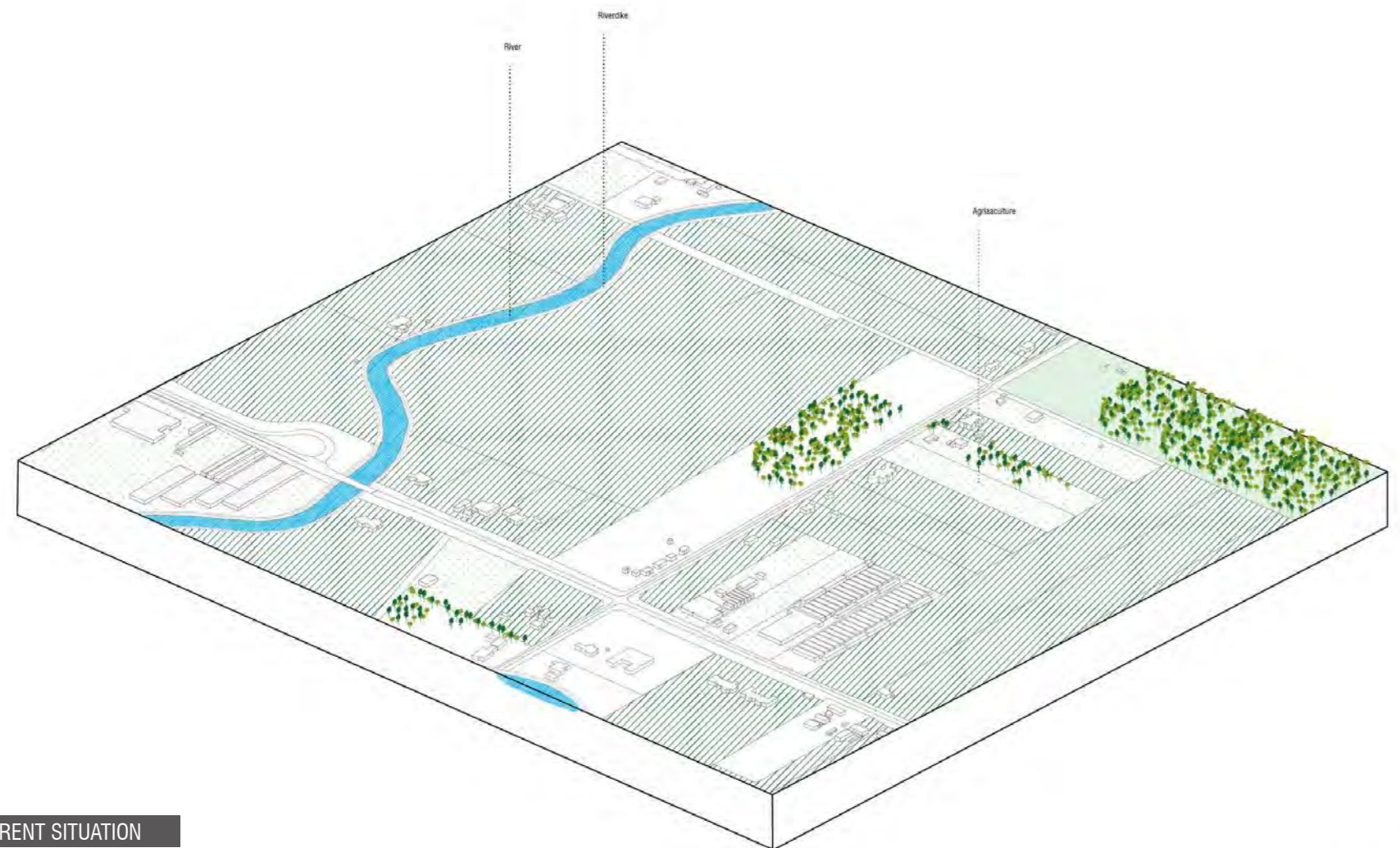
- Agriculture
- Open field (grass)
- Park/natural area
- Mud flat
- Freshwater river
- Estuarine Marsh






FUTURE SITUATION

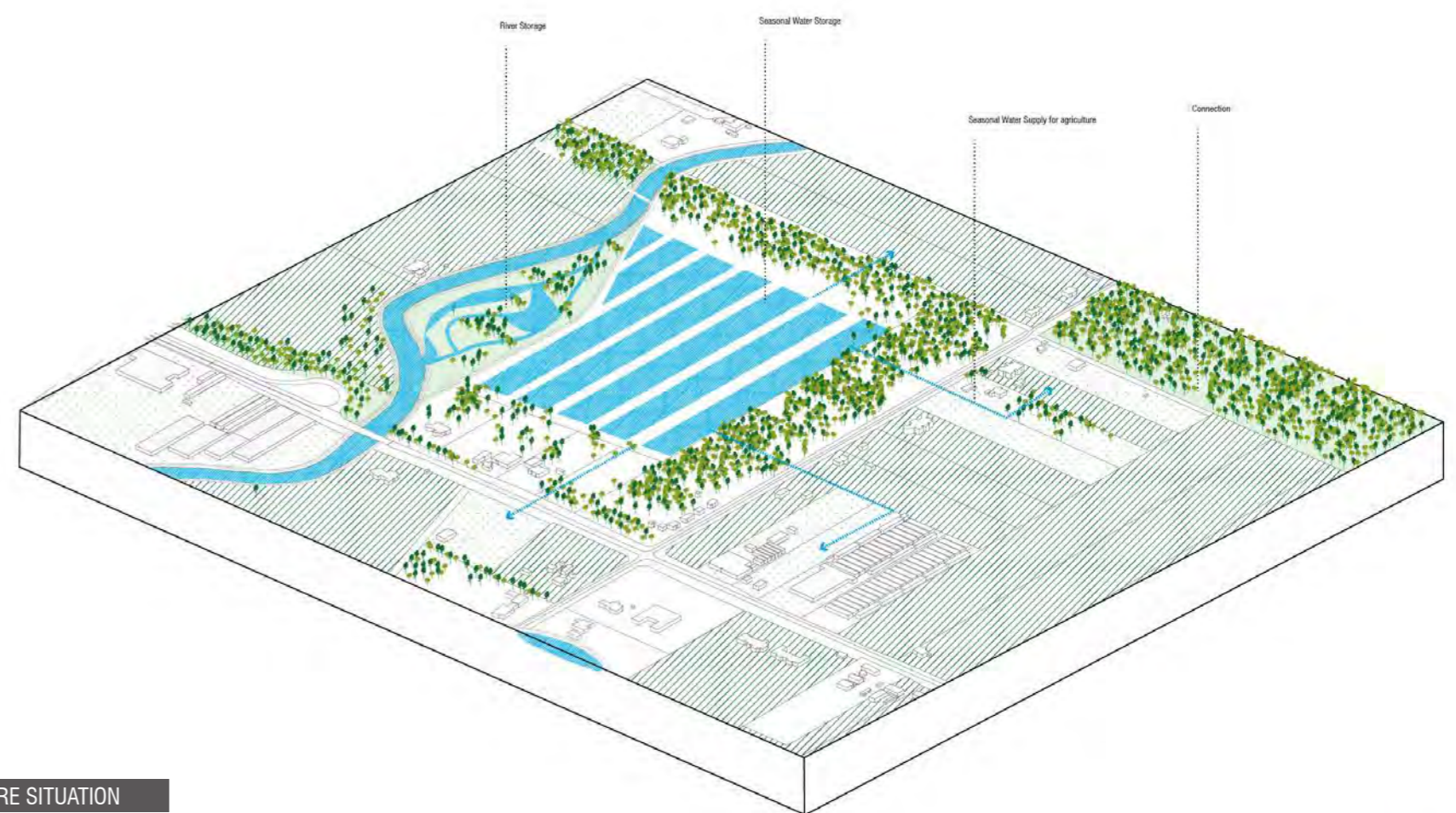
- Agriculture
- Open field (grass)
- Park/natural area
- Mud flat
- Freshwater river
- Estuarine Marsh

Within the new situation a new natural park area is created, connecting the creeks ridge with the rivers



CURRENT SITUATION

-  Agriculture
-  Open field (grass)
-  Park/natural area

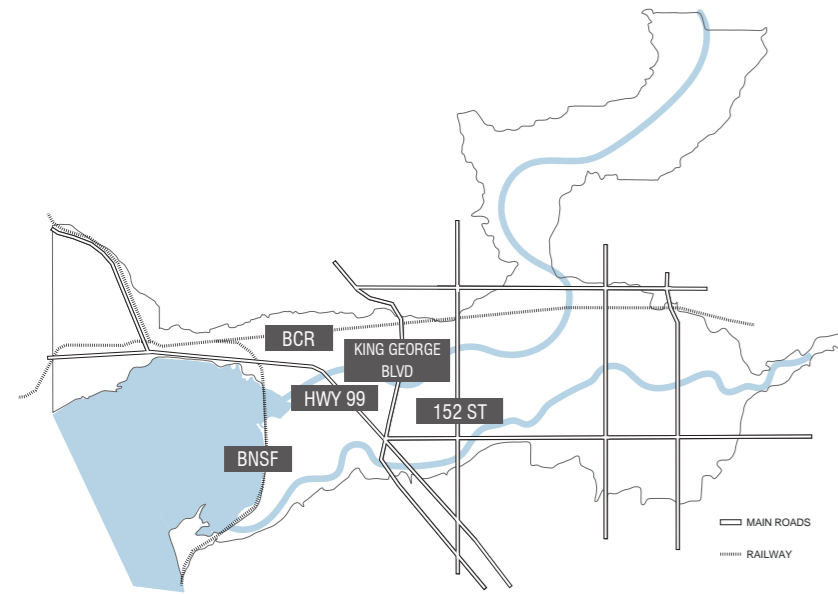


FUTURE SITUATION

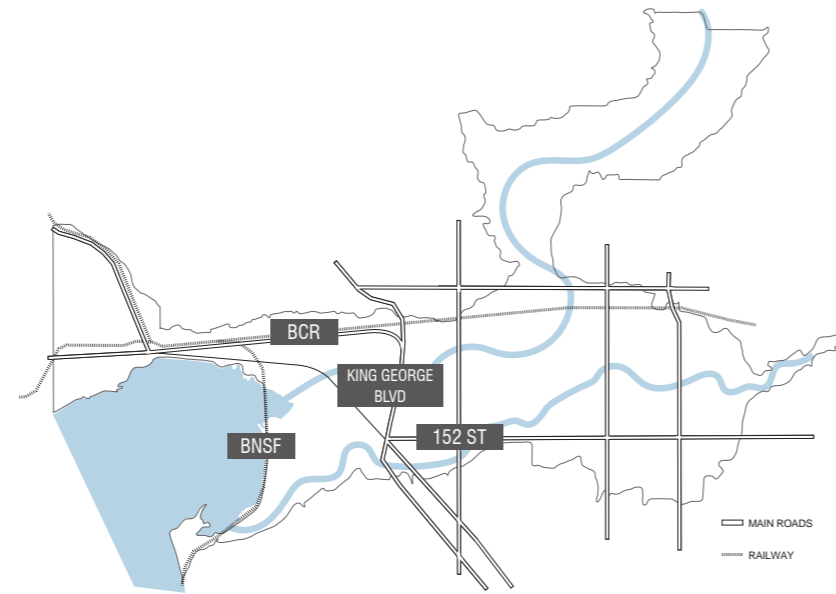
-  Agriculture
-  Open field (grass)
-  Park/natural area

Through the relocation of a dyke along the river, the river is given more space to flow, the new area results in a new connection between the river and its surrounding agricultural areas

INFRASTRUCTURE DESIGN STRATEGY

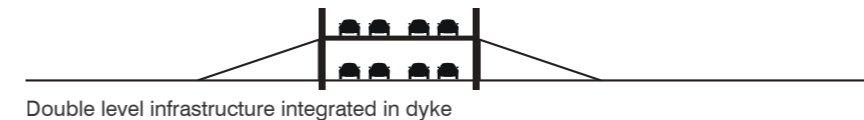
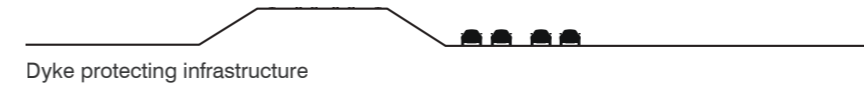


Current situation

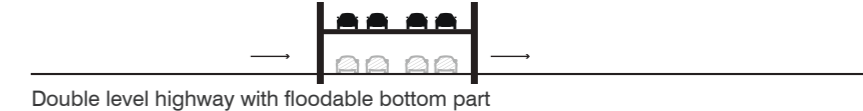
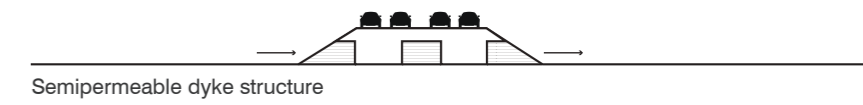


During the last phase of the design strategy, Highway 99 is being relocated along King George Boulevard. The old Highway 99 remains accessible, however over time this road can be prone to flooding. The BNSF railway remains at the same location, if needed, the railway will be adapted to be more flood-proof.

INFRASTRUCTURE THAT PROTECTS AGAINST FLOODING



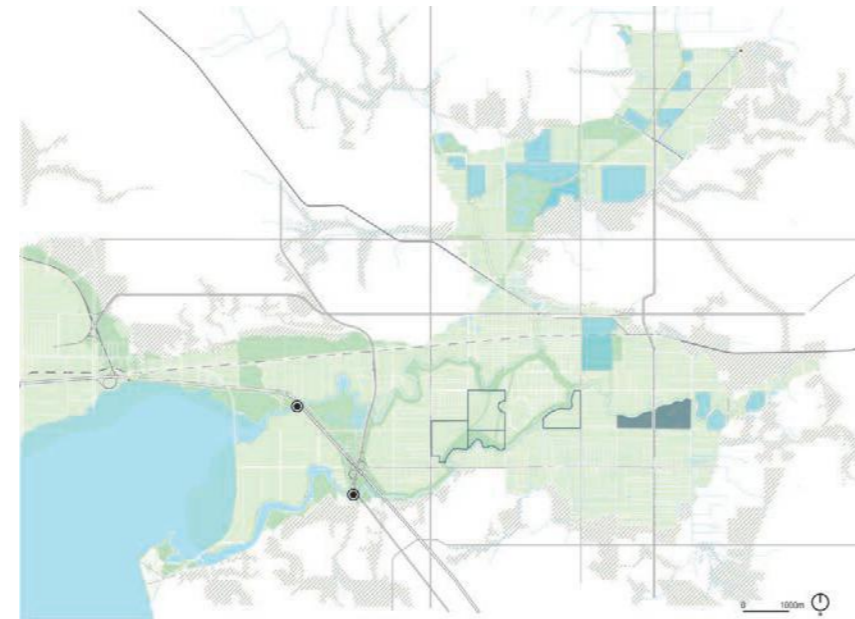
INFRASTRUCTURE THAT ACCOMMODATES FLOODING



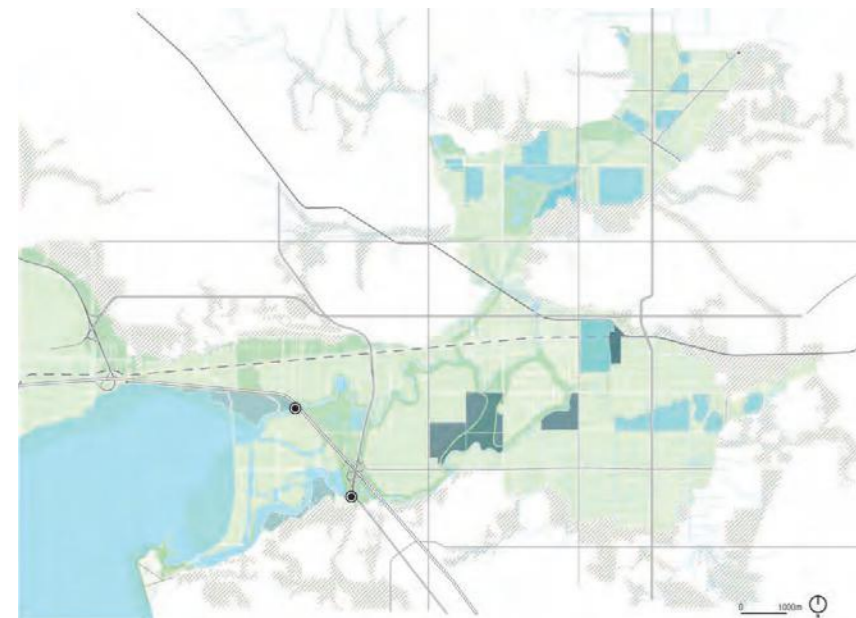
SPATIAL DESIGN STRATEGY



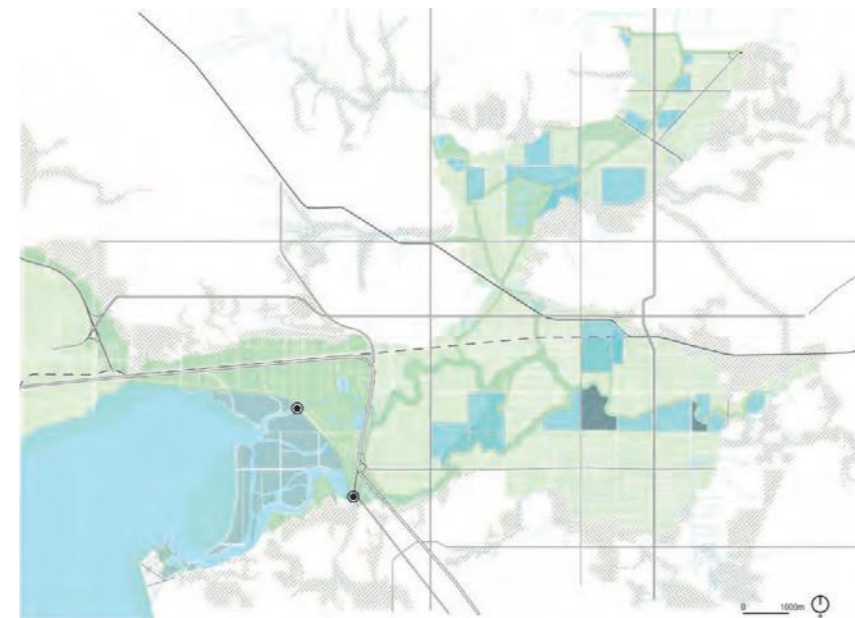
CURRENT SITUATION



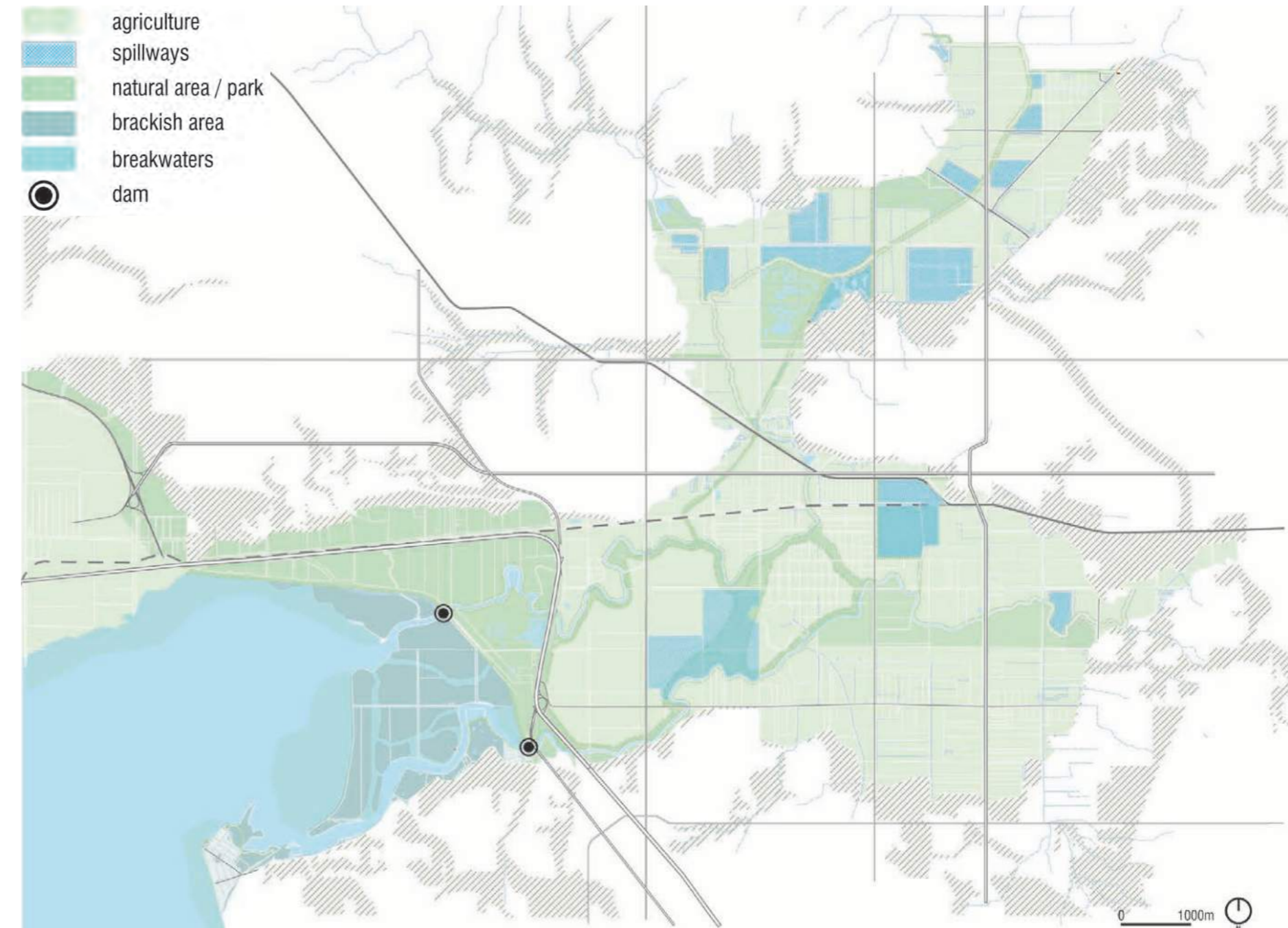
2020



2050



2075



2100

DIFFERENT STEPS IN THE DYKE GROWTH PROCESS



Current situation



Step 1: Dyke raising in combination with a green slope, a protective dam, and recreational path



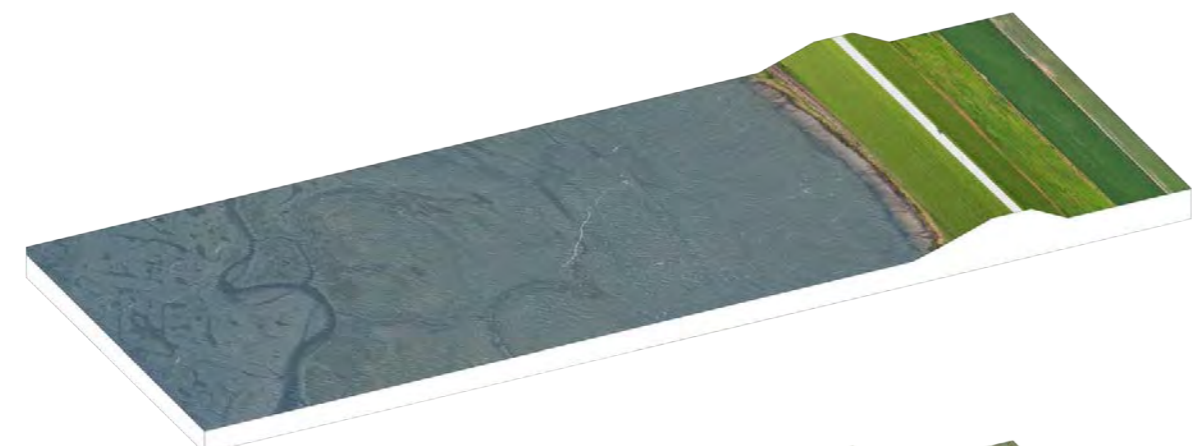
Step 2: Growth of foreland



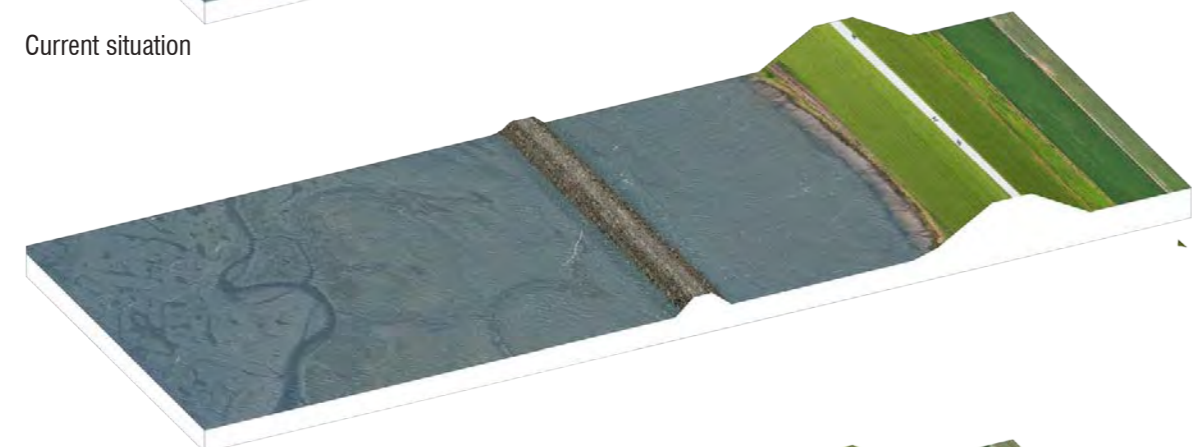
Step 3: Expand foreland and utilize recreational opportunities



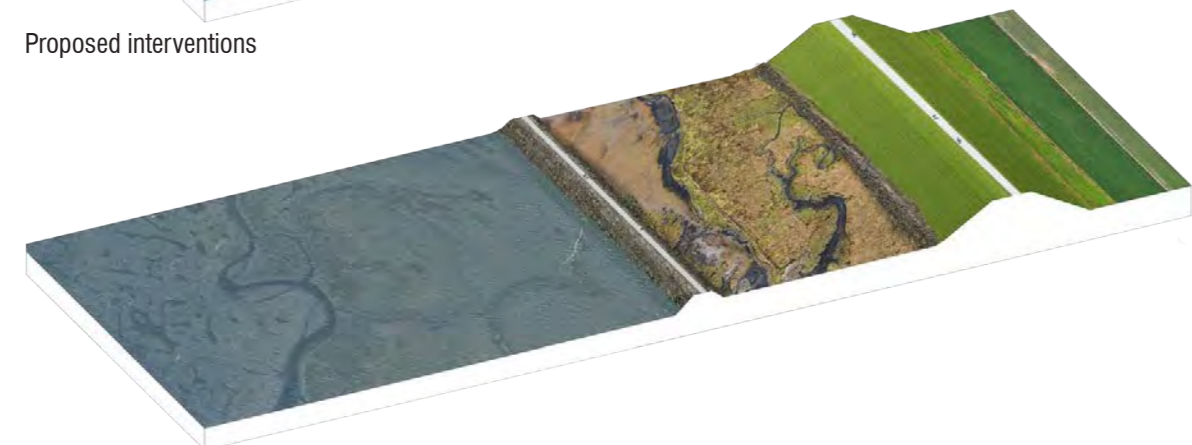
SECTION-CUTS COASTAL AREA



Current situation

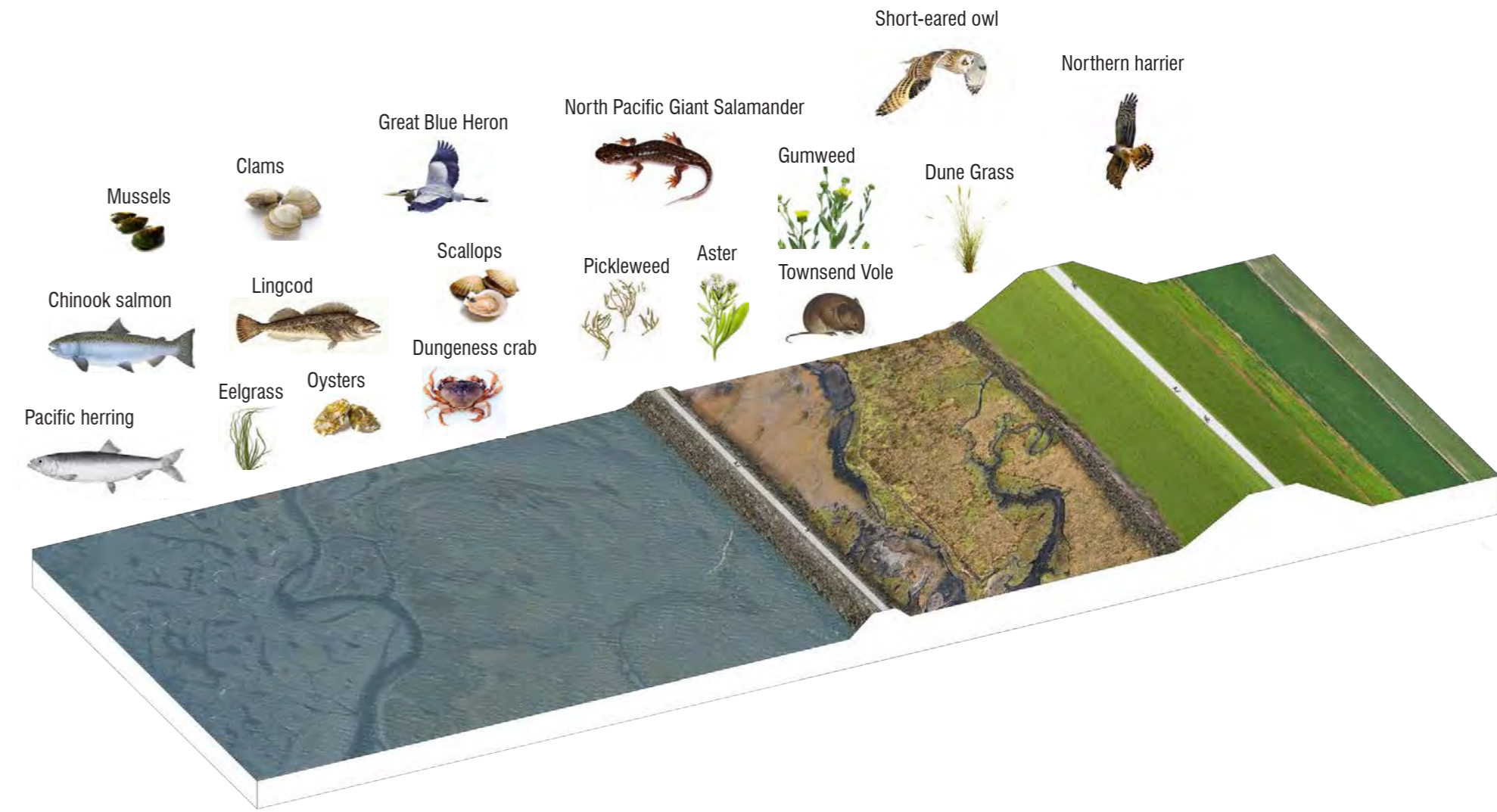


Proposed interventions



Future situation

ECOLOGICAL SECTION-CUT COASTAL AREA



DIFFERENT STEPS IN GIVING THE RIVER MORE SPACE TO FLOW



Current situation



Step 2: Development wet riverbed with cattle



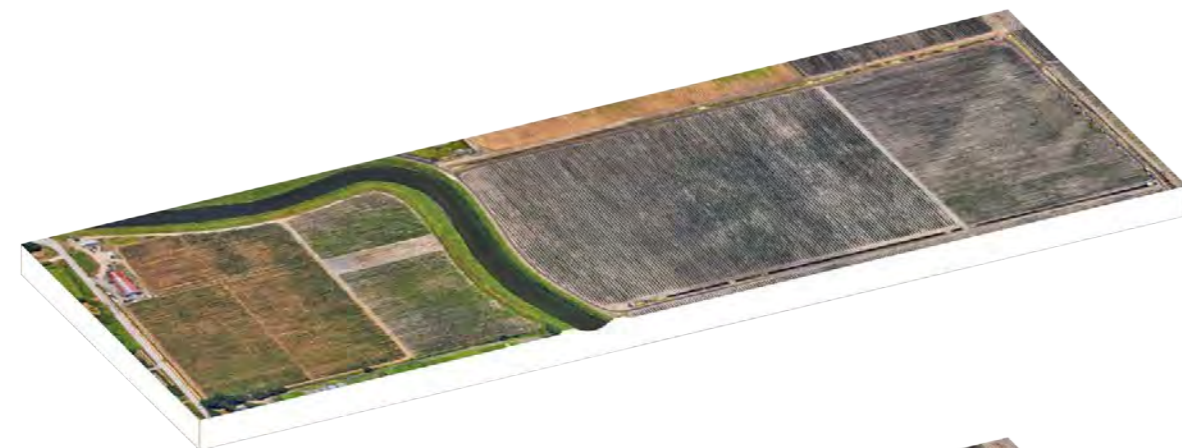
Step 1: Move dyke to widen riverbed and waterstorage



Step 3: Expanding recreational network along and across rivers



SECTION-CUTS RIVERINE AREA



Current situation

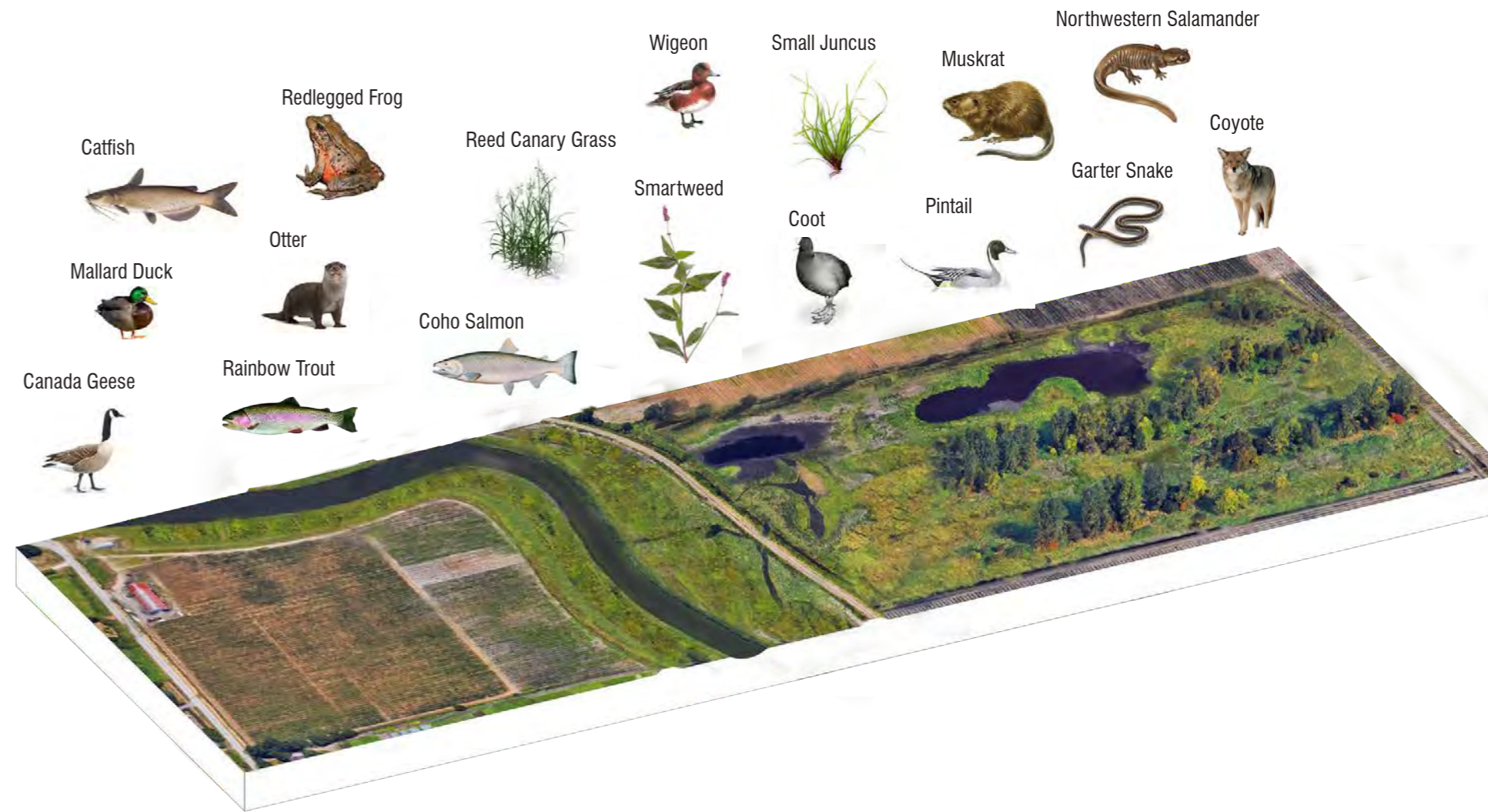


Proposed interventions



Future situation

ECOLOGICAL SECTION-CUT RIVERINE AREA



7. FOLLOW UP

MUD BAY SURREY

ATTACHMENTS

DESIGN RESEARCH
CONCEPT VERSION
JULY 2017



THE UNIVERSITY
OF BRITISH COLUMBIA

LINT
landscape interventions

MUD BAY SURREY

Date 13th July 2017

Commissioned by City of Surrey
Matt Fosler

In collaboration with University of British Columbia
Kees Lokman
Allison Tweedie

Royal HaskoningDHV
Geroge Peters
Ric Huting

Made by LINT landscape architecture
Gerwin de Vries
Alexander Herrebut
Jorne van de Water
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THE UNIVERSITY
OF BRITISH COLUMBIA



CONTENTS

1. Workshop report	8
2. Workshop results	16
3. Design models	22
4. Infrastructure study	96

ATTACHMENTS

WORKSHOP REPORT

DAY 1 - SITE VISIT

Site visit to the coastal areas of Delta and Surrey in Boundary Bay, and the agricultural lands of the Mud Bay Dyking District.
Meetup with local farmer in the area.
Kayak-tour through Nicomekl River, Boundary Bay and Crescent Beach



View of Boundary Bay from Delta



Mud flats



Boundary Bay Dike Trail



Visit to a local farm



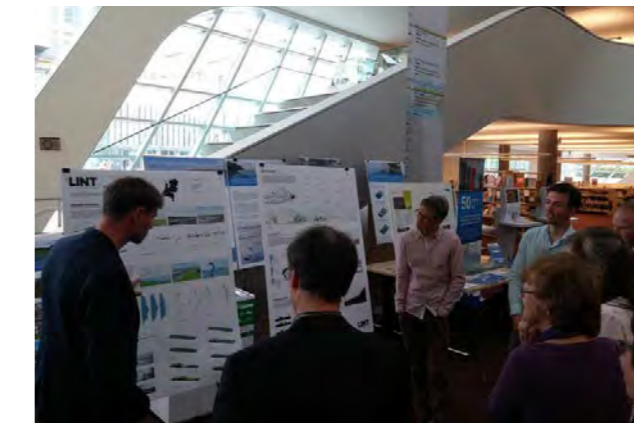
Visit to the agricultural lands of a local farmer



Kayak-tour with the team

DAY 2 - WORKSHOP PREPARATIONS

LINT and Royal HaskoningDHV gave an introduction presentation to staff members of the City of Surrey.
The rest of the day was being spent by the team on the preparation of the workshops that were held the next day.



LINT giving an introduction presentation to the city staff



Sea level rise indicator banner

DAY 3 - WORKSHOP (MORNING - AFTERNOON)

The workshop was being held on 26th of April 2017 at the Surrey's City Centre Library. For the workshop people from different fields and organisations were invited, such as the city staff, students of the University of British Columbia, local experts and other select guests. In total over thirty people participated in the workshop.

The workshop started with a presentation given by Matt Osler of the municipality of Surrey. Within the presentation, Matt Osler introduced the major issues concerning the study area and gave a general introduction for people who were not familiar with the study area. Followed by a presentation given by Kees Lokman to introduce the assignment for the workshop.

The setup of the workshop was as following;

The participants were divided in five groups of each 5 to 7 persons. Every group was given a specific theme (perspective) from which they had to look at the study area. The themes (perspectives?) that were given to the group were: 'Infrastructure', 'Retreating', 'Incentives', 'Dyking' and 'Water storage'. In order to guide the groups in their design process each group was given a set of guiding questions (see chapter 8.2).



Workshop in process



Mud flats



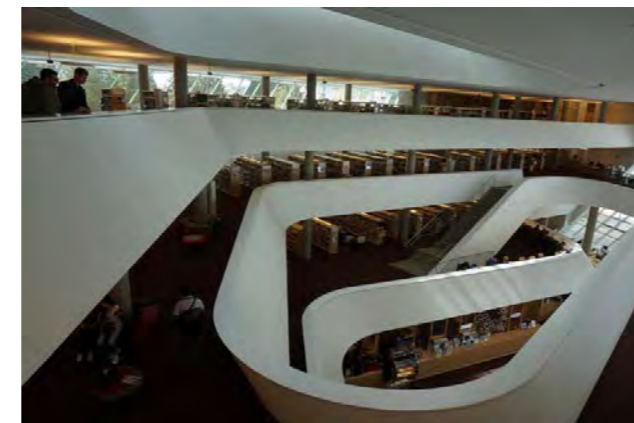
Boundary Bay Dike Trail



Introduction presentation by Matt Osler



Assignment introduction by Kees Lokman



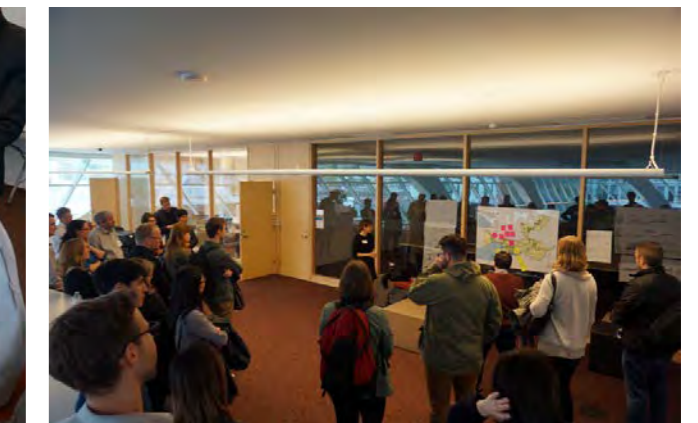
The workshop was being held in the Surrey's City Centre Library



Visit to a local farm



Visit to the agricultural lands of a local farmer



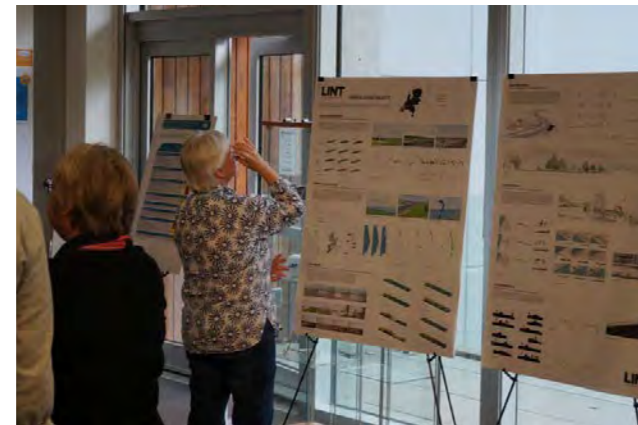
Groups presenting their results from the workshop

DAY 3 - OPEN HOUSE (EVENING)

During the evening LINT and RoyalhaskoningDHV gave presentations, at the public open house, on different flood adaptation-related projects they have worked on. The audience consisted of involved stakeholders and other people who were interested. Another topic that was being discussed was the future of the floodplain of Surrey.



Presentation for stakeholders involved in the area



Walk-around tour for people interested



There was an opportunity for the visitors to ask the team questions

DAY 4 - EXPLORING VANCOUVER REGION

On the fourth day the team of LINT and RoyalhaskoningDHV visited several projects in the region of Vancouver. The visited projects were related to coastal adaptations made to provide flood safety. In the evening the team was invited by the Dutch consulate to celebrate King's day at the house of the Dutch consulate.



Vancouver's waterfront



The Seawall



Houseboats on Granville Island



Habitat Island



Vancouver Seaplane Terminal



King's day at the Dutch consulate

DAY 5 - WORKSHOP CONCLUSIONS

During the last day of the workshop week, the team analysed the results from the workshop and summarized the main concepts generated by the participants of the workshop. The team summarized the main ideas into four concept sketches. In the afternoon the results from the workshop were being presented to the city staff, followed by a discussion afterwards.



The Blue ALR



Mud Bay Dike



The Zipper



Mud Bay Expansion

WORKSHOP RESULTS

GROUP 1: INFRASTRUCTURE

This group focuses on the various types of infrastructure within the study area, including rail, highway, sewage lines, transmission lines, water mains and sea-dams.

- What is the most critical infrastructure and how will future flooding impact them?
- Which infrastructures are currently combined?
- What infrastructure can be flood-tolerant?
- How can infrastructure be relocated and combined with flood control?
- How do you address phasing (2020, 2040, 2070 and 2100)?

Concept 1

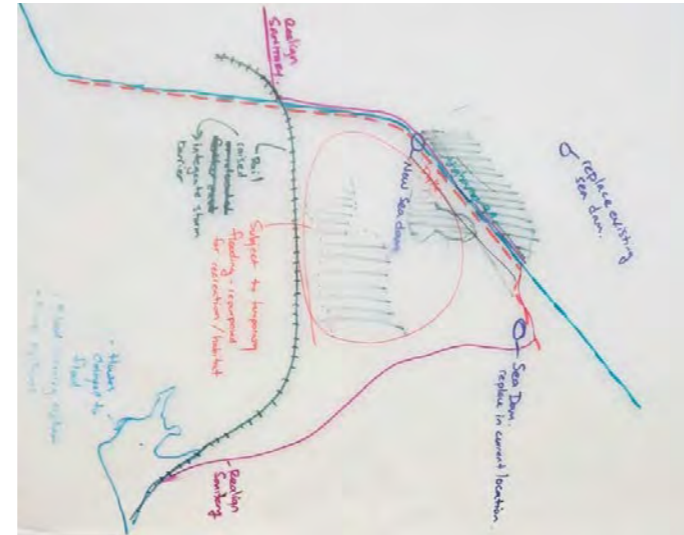
- Future Highway 99 raised to function as dyke
- Remove critical infrastructure from Mud Bay Dyking District and realign along Highway 99
- Remove the current Serpentine Sea Dam and reintegrate the Sea Dam in the new dyke structure of Highway 99
- Raise BNSF railway and integrate with storm barrier
- Mud Bay Dyking District can be used for temporary flooding, repurposed for recreation/habitat
- Crescent beach :
 - o Adapt houses to withstand flooding
 - o Create flood warning system
 - o Pump systems

Concept 2

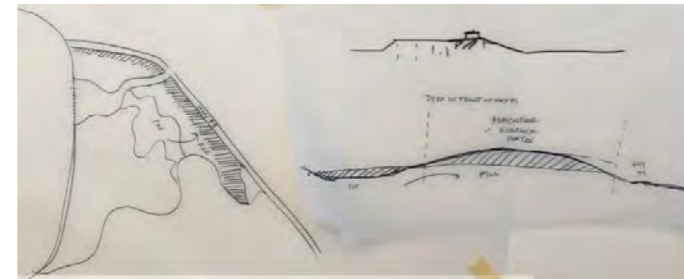
- Dyke in front of Highway 99
- Agricultural or ecological functions on new created dyke
- Excavate soil from Mud Bay Dyking District to provide for the needed soil to create the new dyke.

Concept 3

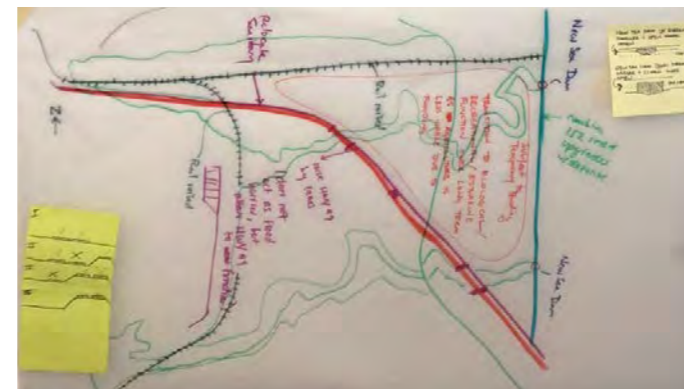
- Combine 152 St upgrades with flood defenses
- Relocate Sea Dams to 152 St
- Raise Highway 99 (does not act as flood barrier, but allows Highway 99 to maintain its function when the surrounding land floods)
- BNSF railway is being raised to cope with sea level rise
- In the future Mud Bay Dyking District and the Interriver Area will be subject to flooding. Transition to ecological/ recreation/ estuarine functions over long term as agriculture is less valuable due to flooding.



Infrastructure Concept 1



Infrastructure Concept 2



Infrastructure Concept 3

GROUP 2: DYKING

This group focuses on the dykes (both coastal and riverine), and their contextual conditions within the study area.

- Think about the different dyke locations as well as the consequences of current and future storm surges and water levels (coastal and river).
- What are the different dyke typologies in the study area?
- What are potential adaptation strategies (hard/soft) for these dykes?
- How can other functions be linked to the dyke?
- What are the co-benefits of these strategies?
- How do you address phasing (2020, 2040, 2070 and 2100)?

Coastal Super Dike

- Barrier Island
- Intertidal section
- Natural trail and infrastructure rail
- Terrace farming

Super Dike Highway

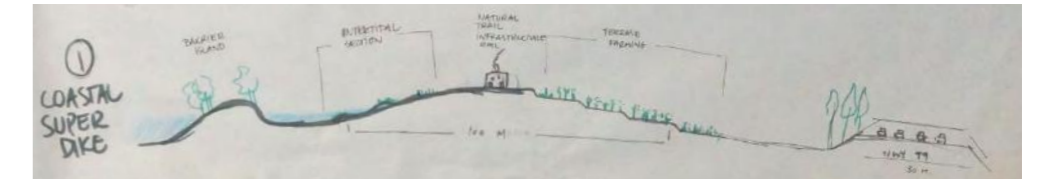
- Current dyke
- Flooded agriculture zone
- Super Dyke Highway
 - o Highway on top of super dyke
 - o Highway next to super dyke

Mud Bay Dyke

- Infrastructure dyke
 - o Train
 - o Windmill
 - o Development
 - o Recreation
- Intertidal zone
- Existing dyke
- Agriculture

2020 Superdike

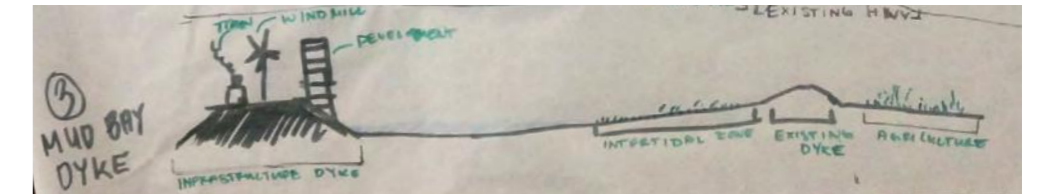
- Green corridor
- Housing
- Highway
- Agriculture phasing



Dyking Concept 'Coastal Super Dike'



Dyking Concept 'Super Dike Highway'



Dyking Concept 'Mud Bay Dyke'



Dyking Concept '2020 Superdike'

GROUP 3: RETREATING

This group explores the possibility of retreating the most vulnerable land uses in the floodplain.

Which areas are most vulnerable and why?

Can any of these land uses be relocated? And if so, which areas would be most suitable for relocation? What indicators should be used to evaluate relocation? What types of land uses can be (re)introduced?

Can you think of any co-benefits between vulnerable and floodable land uses?

How do you address phasing (2020, 2040, 2070 and 2100)?

What incentives can you think of to stimulate relocation?

Concept 1

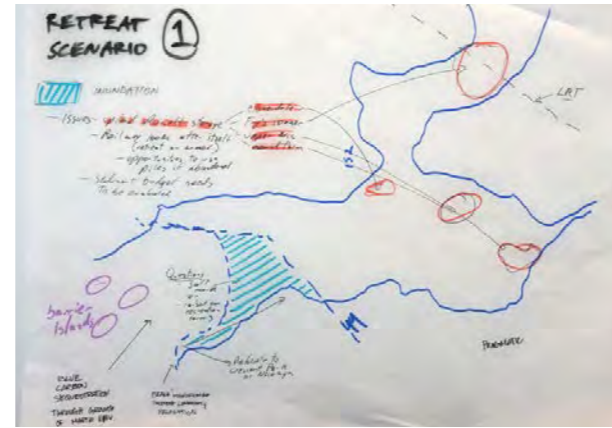
- Relocate Crescent beach to Crescent Park or Nicowynd
- Beach migration through community relocation
- Barrier islands
- Railway looks after itself
- Blue Carbon Sequestration through growth of marsh
- Mud Bay Dyking District
 - o Salt marsh
 - o Raised for recreation, farming

Concept 2

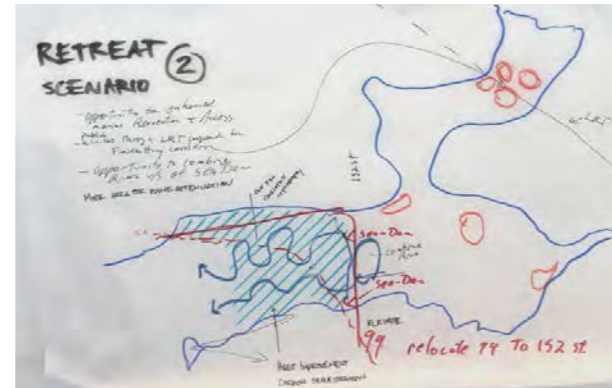
- Opportunities for enhanced marine recreation + access public
- Access through Light Rail Transit (LRT) purposed for Fraser Highway
- Opportunity to combine rivers v/s of Sea Dam
- More area for wave attenuation
- Elevate 152 St and relocate Highway 99 towards it
- Mud Bay Dyking District used for:
 - o Wave attenuation
 - o Habitat improvement
 - o Carbon Sequestration

Concept 3

- Tidal agriculture
- Regional water quality improvement
- Intensive agriculture/ Greenhouse/ Hydroponic



Retreating Concept 1



Retreating Concept 2



Retreating Concept 3

GROUP 4: INCENTIVES

This group is concerned with creating spatial strategies and policy-oriented principles to create co-benefits between different stakeholders and land uses. For example, port expansion will require habitat compensation; the study site might be able to accommodate this.

Who are the main stakeholder groups in the area? Where are they located?

What cultural, environmental or economic opportunities are there in the area?

What types of incentives could you develop to promote a transition to more flood-resilient land uses?

Which flood-adaptable land uses could benefit multiple stakeholders and uses?

Concept Protection

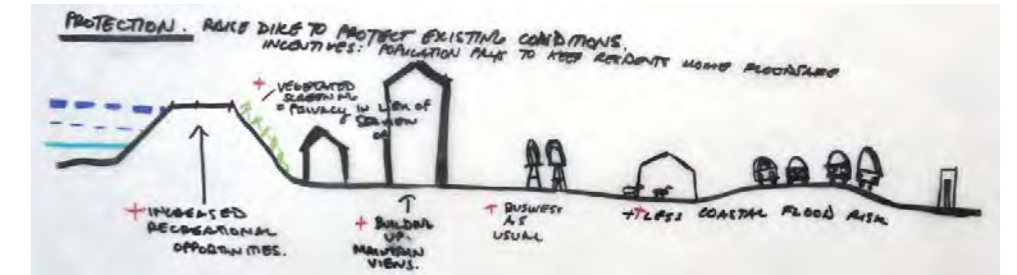
- Raise dike to protect existing conditions
- Recreational opportunities on raised dike
- Swap land use of farmland to public use

Concept Adaptation

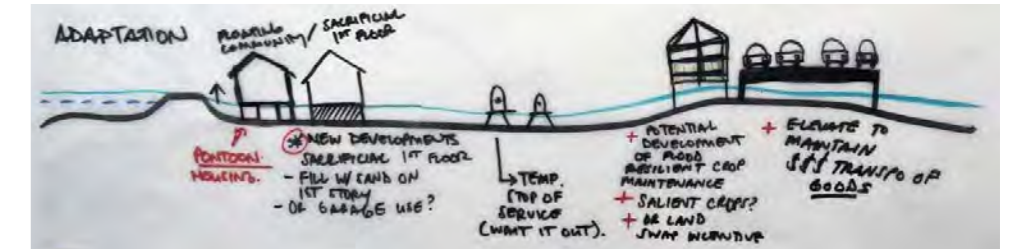
- New developments have a more flood resilient 1st floor
- Agriculture switches to more flood resilient crops
- Elevate highway to maintain transit of goods

Concept Retreat

- BNSF is relocated to maintain service
- Environmental and recreational opportunities
- Highway 99 is elevated and could form new dike infrastructure
- Farmers given incentive (ultimatum) to leave salient/ poor soil areas and relocate them further inland



Incentives Concept Protection



Incentives Concept Adaptation



Incentives Concept Retreat

GROUP 5: WATER STORAGE

This group focus more on the relationships between upstream and downstream (temporary) water storage. Think about the difference between salt and fresh water, as well as between fresh water storage for irrigation and temporary water storage for flooding.

Which areas are most vulnerable to flooding (coastal and riverine) currently and in the future? And during which month or season?

Which areas are most vulnerable to drought (currently and in the future)?

Where within the flood plain could you store fresh water for irrigation during periods of drought? And how can co-benefits be created?

Where within the flood plain could you (temporarily) store water to relieve flooding? And how can co-benefits be created?

How do you address phasing (2020, 2040, 2070 and 2100)?

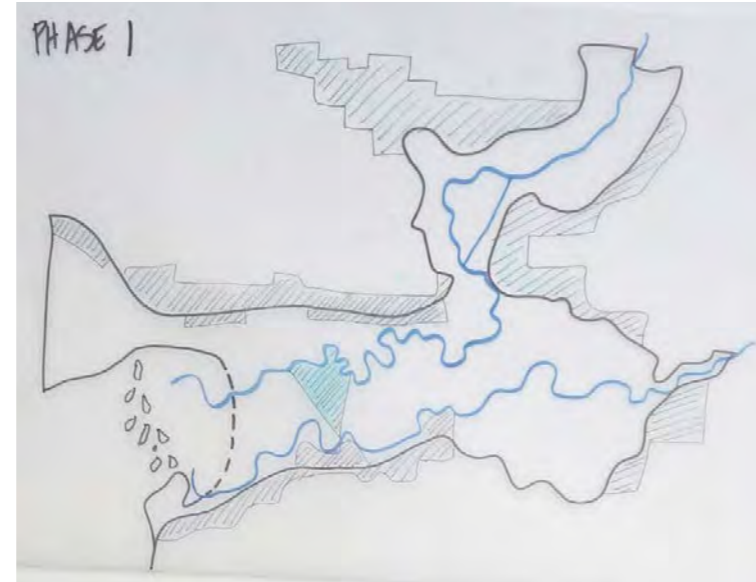
What incentives could you provide to stimulate flood storage?

Phase 1

- The creation of barrier/ habitat islands in front of the coast
- Due to the tides, sediment is being brought in the system, allowing the barrier islands to slowly grow over time
- Creation of a water retention zone in the Interriver Area
- On the edges of the floodplain, several water detention measurements are created along the slopes

Phase 2

- The Mud Bay Dyking District is being developed into a natural area which can be inundated during times of high water levels
- A dyke is created along Highway 99
- Extra water retention areas are created in the area
- The green water detention zones on the edges exist out of a combination of several elements, including:
 - o Green roofs
 - o Rain gardens
 - o Bioswales
 - o Tree planting
 - o Re-wilding
 - o Water detention parks (water detained within these parks can be re-used for irrigation)



Retreating Concept 1

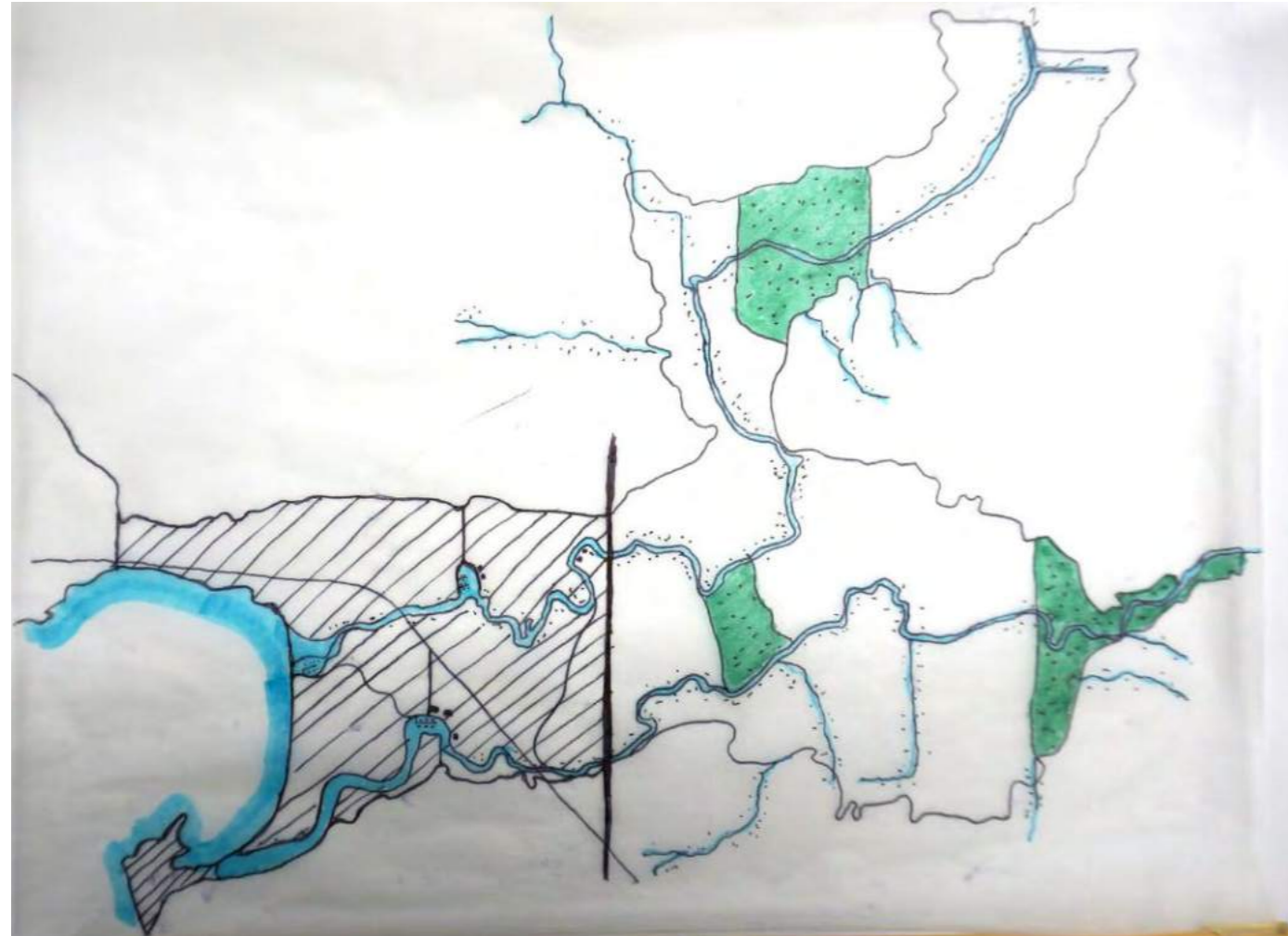


Retreating Concept 2

DESIGN MODELS

THE BLUE ALR

The relocation of agricultural functions from the Mud Bay Dyking District makes space for the exploration of new functions in the area. The main dike and the sea dams are being relocated to 152 St. This results in the area left of the main dike being more prone to flooding in the future, but by the making the landscape more adaptive to flooding, water can be accommodated inside of the floodplain in a controlled way. This provides opportunities for new functions such as recreation, nature development or water adaptive housing development.



PRECEDENTS IMAGES:



Special No. 9 House, New Orleans, Louisiana, US
 image: John Williams Architects



Noordwaard, NL
 image: <https://www.deingenieur.nl/artikel/noordwaard-wordt-doorstroompolder>



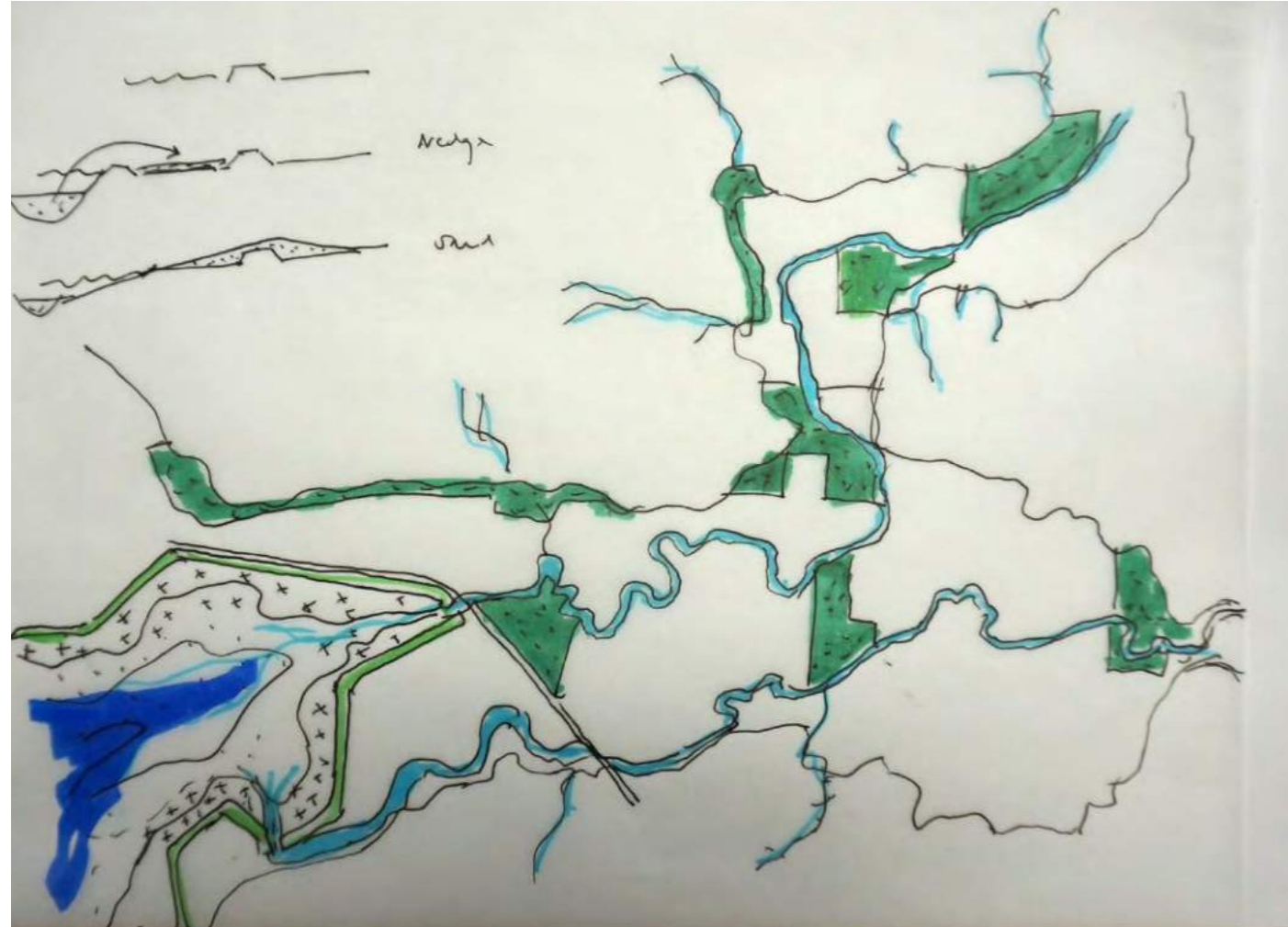
Blauwestad, Groningen, NL
 image: <http://www.waterkavelsleuwerik.nl/het-plan>



Polder keizersguldenwaard, Werkendam, NL
 image: <http://www.aerophotostock.com/media/9ce542fc-cc33-47e2-be21-983d73da3788-huize-keizersguldenwaard-polder-keizersguldenwaard-werkendam?>

MUD BAY DIKE

Water safety, ecology and recreational use is improved by using the existing qualities and context of the area. The eroding coastline and tidal wetlands in Mud bay are improved by a soft sloping dike consisting out of sediments which is able to resist storm surge and waves and adding new habitat in front. The dike is able to gradually grow in time to anticipate on sea level rise. Catchment of sediment is an essential aspect by using a “kleivang” or kwelderwerken or oyster reefs.



PRECEDENTS IMAGES:



Marker Wadden, NL image: <http://nos.nl/artikel/2134152-een-nieuw-stukje-nederland-de-marker-wadden-zijn-open.html>



Oyster reef Oosterschelde, NL image: https://www.deltaexpertise.nl/wiki/index.php/Uitvoeren_onderzoek_naar_zandhonger_Oosterschelde_i.h.k.v._MIRT



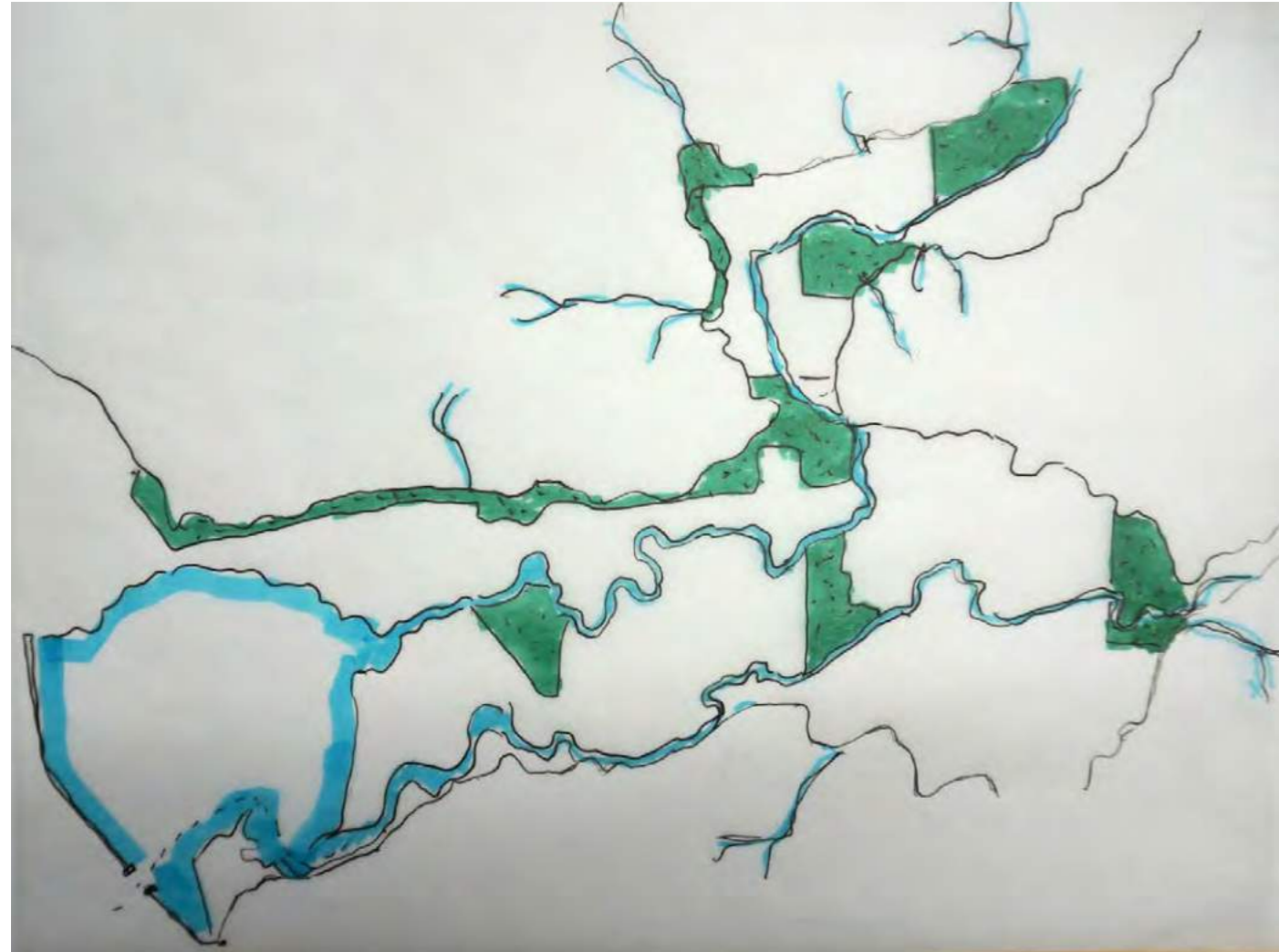
Groene Dollarddijk, NL image: <http://www.binnenlandsbestuur.nl/ruimte-en-milieu/achtergrond/achtergrond/slappe-pap-als-waterwal.9550015.lynxk>



Kwelders with clay catchment Groningen, NL image: <http://www.ee-emsdelta.nl/nieuws/nieuws/veel-enthousiaste-reacties-op-de-brede-groene-dijk>

THE ZIPPER

The creation of a dam between Surrey and Delta. In a normal situation the dam is open to let out the freshwater coming from the 2 rivers ending in the Mud Bay. During high water levels the dam can be closed off from the ocean, providing flood safety while also serving as a wave breaker during storm surges.



PRECEDENTS IMAGES:



Afsluitdijk, Den Oever, NL image: http://medias.photodeck.com/23b7bc1a-a320-11e3-8e21-e3cb21bb4404/77711_xgapius.jpg



Maeslantkering, Rotterdam, NL image: <https://s-media-cache-ak0.pinimg.com/236x/e8/15/07/e8150762ae3457b0ecbedfd96b0f581.jpg>



Afsluitdijk, NL image: <https://www.renovatieprofs.nl/images/article/medium/5502e1bd03746.jpg>



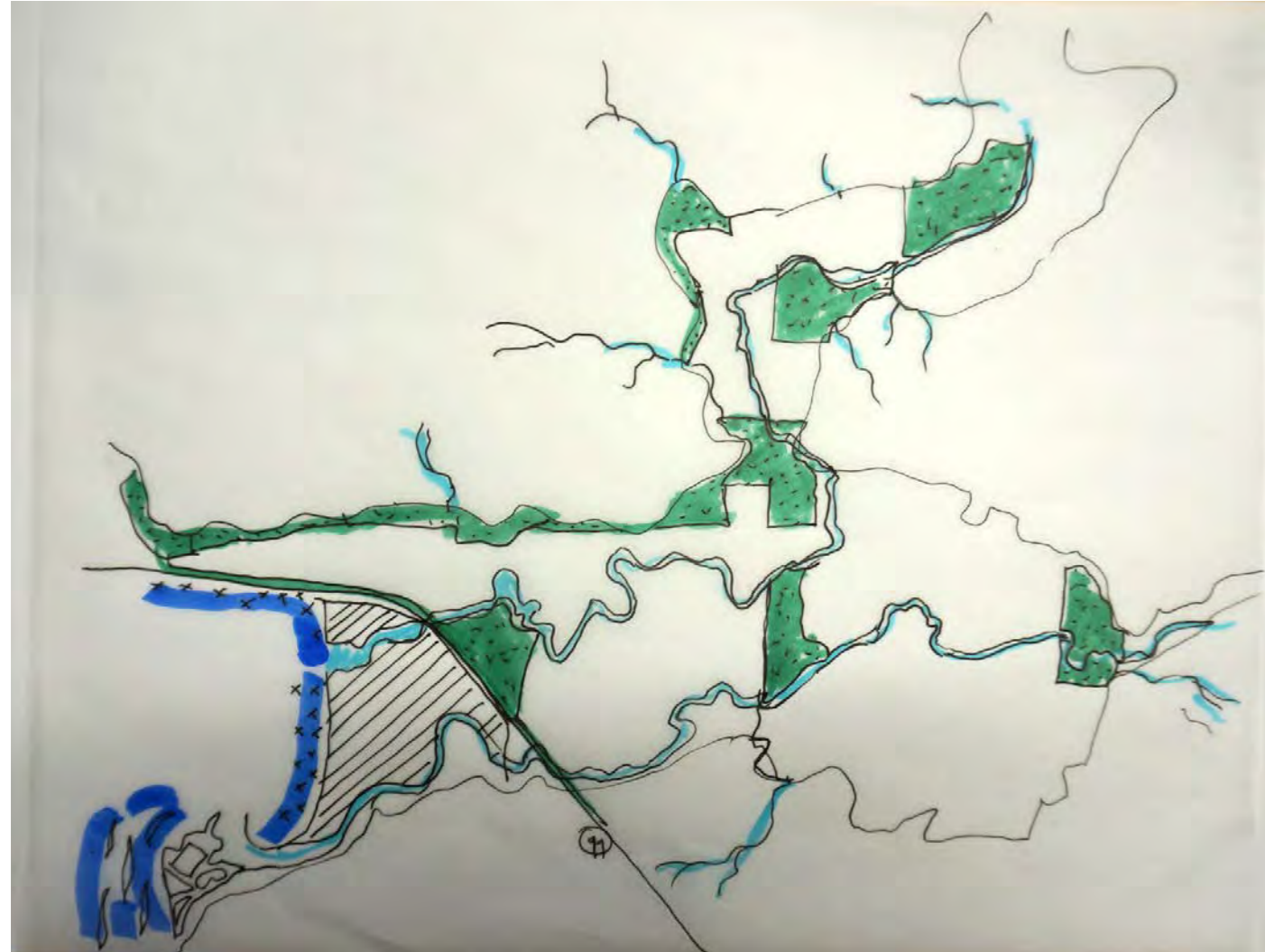
Afsluitdijk, NL image: <http://static.yurfs.net/cache/image1/03/038a0558d975eec115f22fb49ec7fa31.jpg>



Oosterscheldekering, NL image: http://app.nos.nl/evenementen/droge-voeten/img/afsl/Oosterscheldekering_in_werking_16_9_ANP-1039373.jpg

MUD BAY EXPANSION

Mud Bay will be expanded by both transforming existing farmland into wet areas and making new tidal lands in front. By doing this the dike will become less important itself and a new gradient in the landscape will emerge. This soft landscape buffers storm surge and offers a lot of opportunities for aquaculture and saline crops. New habitat will appear on and between the islands.



PRECEDENTS IMAGES:



Marcfoods test location saline crops, Texel, NL
image: <https://static.globalinnovationexchange.org/Salt%20Farm%20Texel.jpg>



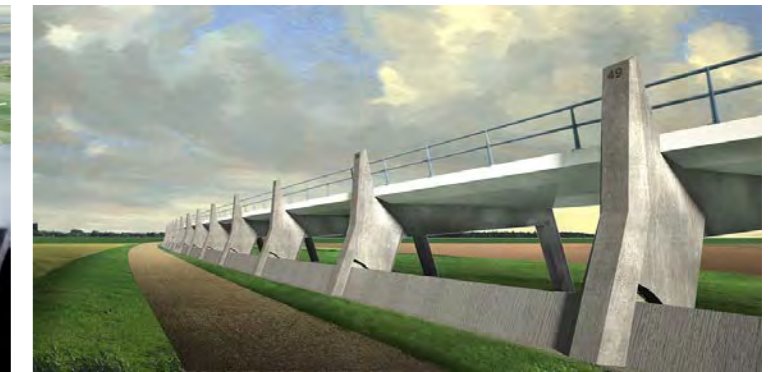
Marker Wadden, NL
image: <http://static1.persgroep.net/volkskrant/image/e3da7898-712d-4fbb-b66a-08cab8644b9f?width=664&height=374>



Zandmotor, NL
image: https://www.zuidhollandslandschap.nl/media/cache/page_wide_figure/media/areapage/image/w2-zandmotor-rijkwaterstaat-joop-van-houdt.jpg



Hoogwatergeul Veessen-Wapenveld, NL
image: <https://architectenweb.nl/media/illustrations/2014/02/5304076e-64ed-40f5-bbc9-27dd19295a5c.jpg>



Hoogwatergeul Veessen-Wapenveld, NL
image: http://www.zus.cc/_we_thumbs_/2111_2_232_HoogwatergeulKerkdijk_vanaf-fietspad.jpg

INTER-RIVER WETLANDS

Inner dikes of both rivers are lowered resulting in a wetlands area which occasionally floods during high water levels. The formation of the new wetlands can be combined with housing development, nature development and recreation.



PRECEDENTS IMAGES:



Shelby Farms Park, US image: http://www.fieldoperations.net/fileadmin/fo_uploads/projects/09_ShelbyFarms/SFP-MASTERPLAN-AERIAL.jpg



Onkaparinga River Recreation Park, Australia image: <http://www.weekendnotes.com/im/008/00/onkaparinga-river-recreation-park-wetlands-walk-bo1.jpg>



Salt swamps of Guérande, France image: http://www.france-voyage.com/visuals/photos/zoute-moerassen-guerande-7306_w300.jpg



Abbotts Hall Farm image: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcTsqaDbxj0kHk7DgbqGZg_foSrqnIVcZulVTJvk8B.JidRw_p_A



Biesbosch Dordrecht, NL image: <http://www.triple-bridge.nl/wp-content/uploads/2015/05/Foto-Biesbosch-Dordrecht-225x150.jpg>



Floating homes, China image: <http://www.designboom.com/architecture/david-chipperfield-xixi-wetland-estate-hangzhou-apartments-china-10-22-2015/>

ROOM FOR THE RIVER

New floodplains will be created along the two rivers, these floodplains provide new opportunities for new kinds of agriculture, recreational spots and routes or nature development. The floodplains can flood during times of high water levels, giving the rivers more space to flow, this controlled way of flooding results in an increase in flood safety while providing several new opportunities.



PRECEDENTS IMAGES:



Room for the River, Nijmegen, NL

image: <http://www.proraalpersberichten.nl/bericht/799/>



Room for the River, IJsseldelta, NL

image: <https://www.royalhaskoningdhv.com/nl-nl/nederland/projecten/ruimte-voor-de-rivier-ijsseldelta/3832>



High water channel Veessen - Wapenveld, NL image: <https://www.veluwekroon.nl/nieuws/399383.aspx?t=factsheet+hoogwatergeul+veessen+wapenveld>



Room for the River, IJsseldelta, NL

image: <https://www.rijkswaterstaat.nl/over-ons/nieuws/nieuwsarchief/p2016/12/ruimte-voor-de-rivier-ijsseldelta-gereed-in-2022.aspx>



Room for the River, Nijmegen, NL

image: <http://www.landezine.com/index.php/2017/04/birds-eye-view-of-hns-works>

1000 ISLANDS

Agricultural functions will be relocated from the area, the natural processes of the river and the ocean and its tides will influence the area. New islands will be formed resulting a green natural landscape with major opportunities for new types of recreation and nature development.



PRECEDENTS IMAGES:



De Vijfhoek, Deventer, NL
image: <http://www.panoramio.com/photo/53761364>



Canoeing on the Kooraste lakes, Estonia
image: <https://www.visitestonia.com/en/canoeing-on-the-kooraste-lakes-a-adventure-for-true-nature-enthusiasts>



Fishing pond, NL
image: <http://hsvlimmen.nl/wp-content/uploads/2017/04/overdie-002.jpg>



1000 Islands, Canada
image: <http://www.1000islandsphotoart.com>



Marais de Rochefort, France
image: <http://maraisderochefort.n2000.fr/marais-de-rochefort/patrimoine-naturel/milieux-naturels>

WATER STORAGE LAKES

Water from the rivers will be stored in new created lakes during the freshet. These lakes provide opportunities for recreation activities (e.g. swimming, canoe, fishing), the lakes also provide habitat for resident and migratory birds. During periods of drought the surrounding agricultural lands can benefit from the stored water by using it as irrigation water. Agriculture will retreat from the coastline forming a natural coastline.



PRECEDENTS IMAGES:



Fryslân at Sea, Buro Harro, NL
image: <http://buroharro.nl/fryslan-at-sea/>



The Restoration of Coastal Marsh Buffers, US
image: <https://www.georgiaconservancy.org/marshbuffers>



Loosdrecht, NL
image: <https://www.wijdmeren.nl/Loosdrecht>



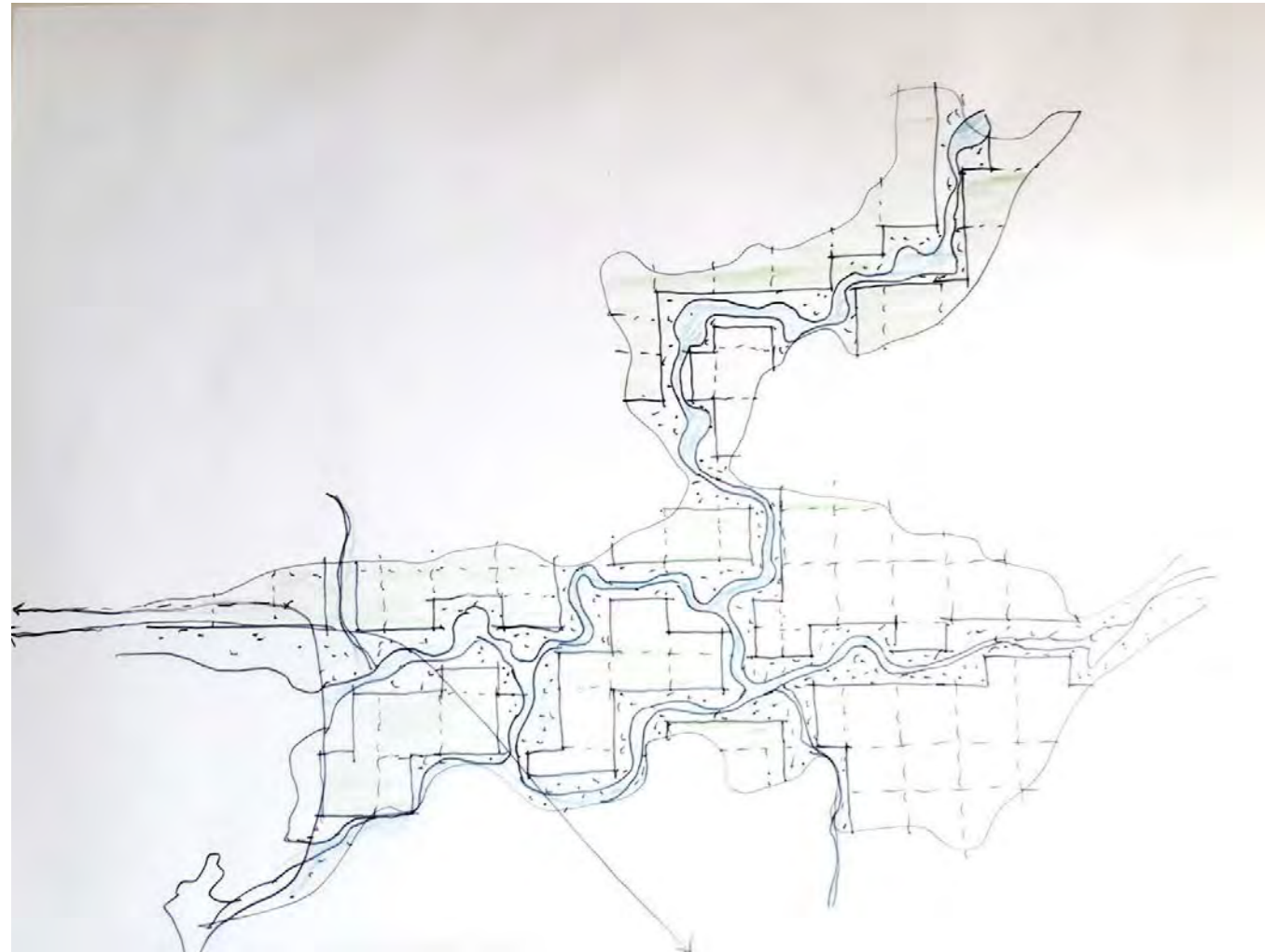
Natte Ogen, Winschoten, NL
image: <http://www.delyon.nl/no.html>



Perch Lake, US
image: <http://nwrn.eu/measure/lake-restoration>

EMBRACING THE GRID

The grid which is organizing both the urban fabric around as the floodplain itself is used as the main framework. The grid facilitates all kind of uses (flood boxes, spillways, fresh water storage). The river can meander more freely this cultural landscape. By doing this the river offers new habitat and possibilities for recreational use. The contrast between river and the landscape is enhanced and respects the cultural and natural qualities of the landscape.



PRECEDENTS IMAGES:



Volgermeerpolder, NL

image: https://www.flickr.com/photos/de_kist/11823944166



Marais salants de Guérande, France

image: <http://blog.la-biscuiterie.fr/wp-content/uploads/2013/03/marais-salant-guerande.jpg>



Algae farms

image: <https://www.oneworld.nl/food/natte-landbouw-maakt-opmars-lelystad>



Pumping station Meerpolder, NL

image: http://nootdorp.straatinfo.nl/fotos/cascade-naar-gemaal-meerpolder_731783/



Marais salants de Guérande, France

image: https://commons.wikimedia.org/wiki/File:Marais_salants_de_Gu%C3%A9rande_3_Loire-Atlantique_France.JPG

ALONG THE CREEKS

Stormwater and rainwater from the urban areas can be stored in creeks going to the floodplains. Surrounding the creeks are natural green zones with recreational routes for bikers and pedestrians. The creeks connect the growing urban areas surrounding the floodplain with the floodplain itself, forming a recreational network combined with green-blue infrastructure.



PRECEDENTS IMAGES:



Groengebied Amstelland, NL
image: http://www.natuurwegwijzer.nl/bezoekerscentrum-tops/beheersbureau-groengebied-amstelland/detail_bezoekerscentrum=1007_000000_000000_000033



Denver Bike Trails, US
image: <https://www.denver.org/things-to-do/sports-recreation/bike-trails/>



River Walk, Texas, US
image: <https://www.sacurrent.com/sanantonio/best-jogging-trail/BestOf?oid=2246498>



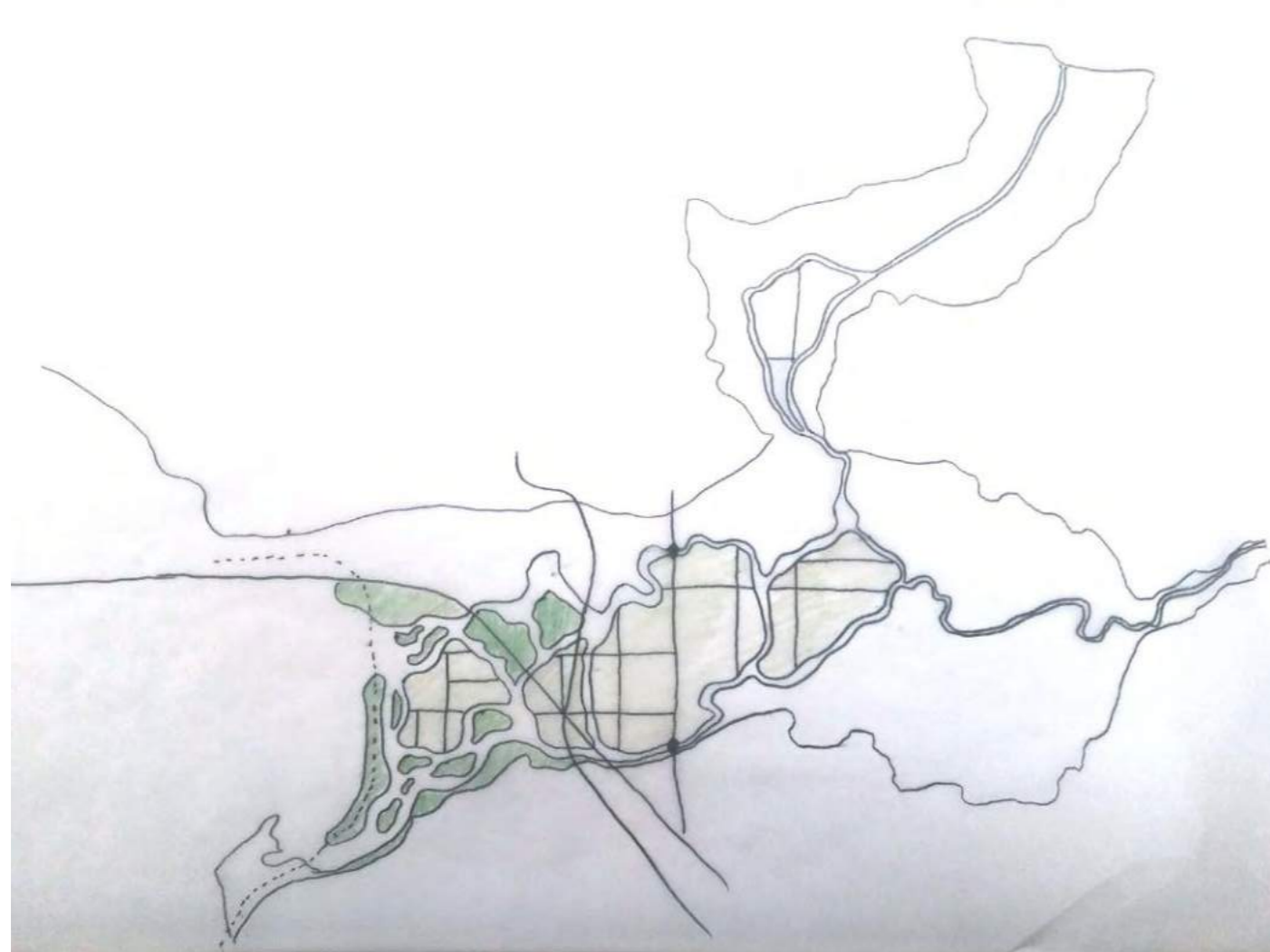
Cherry Creek Trail, Colorado, US
image: <https://corvustristis.wordpress.com/2012/04/30/morning-bike-ride/>



Biking trail, Roosendaal, NL
image: <http://www.stadsoevers.nl/nl/artikel/de-kracht-van-water/18>

RIVER ISLANDS

Parts of the Mud Bay Dyking district are being dug out to form water ways and the left over material is being used to raise islands inbetween the rivers. The smaller islands has the function as bird habitat while the bigger ones provide space for agriculture and recreation. The two sea dams are removed and replaced at 152 St.



PRECEDENTS IMAGES:



Algae farms

image: <https://www.oneworld.nl/food/natte-landbouw-maakt-opmars-lelystad>



Managed realignment, Medmerry, Sussex, UK

image: http://s0.geograph.org.uk/geophotos/04/49/86/4498694_b2211565.jpg



River Island Natural Area restoration

image: <http://www.oregonmetro.gov/river-island-natural-area-restoration>



Three Island Crossing, Oregon, US

image: <http://travellogs.us/2007/Logs/Idaho%202007/66-3%20Island%20Crossing/66aa-Three%20Island%20Crossing.htm>

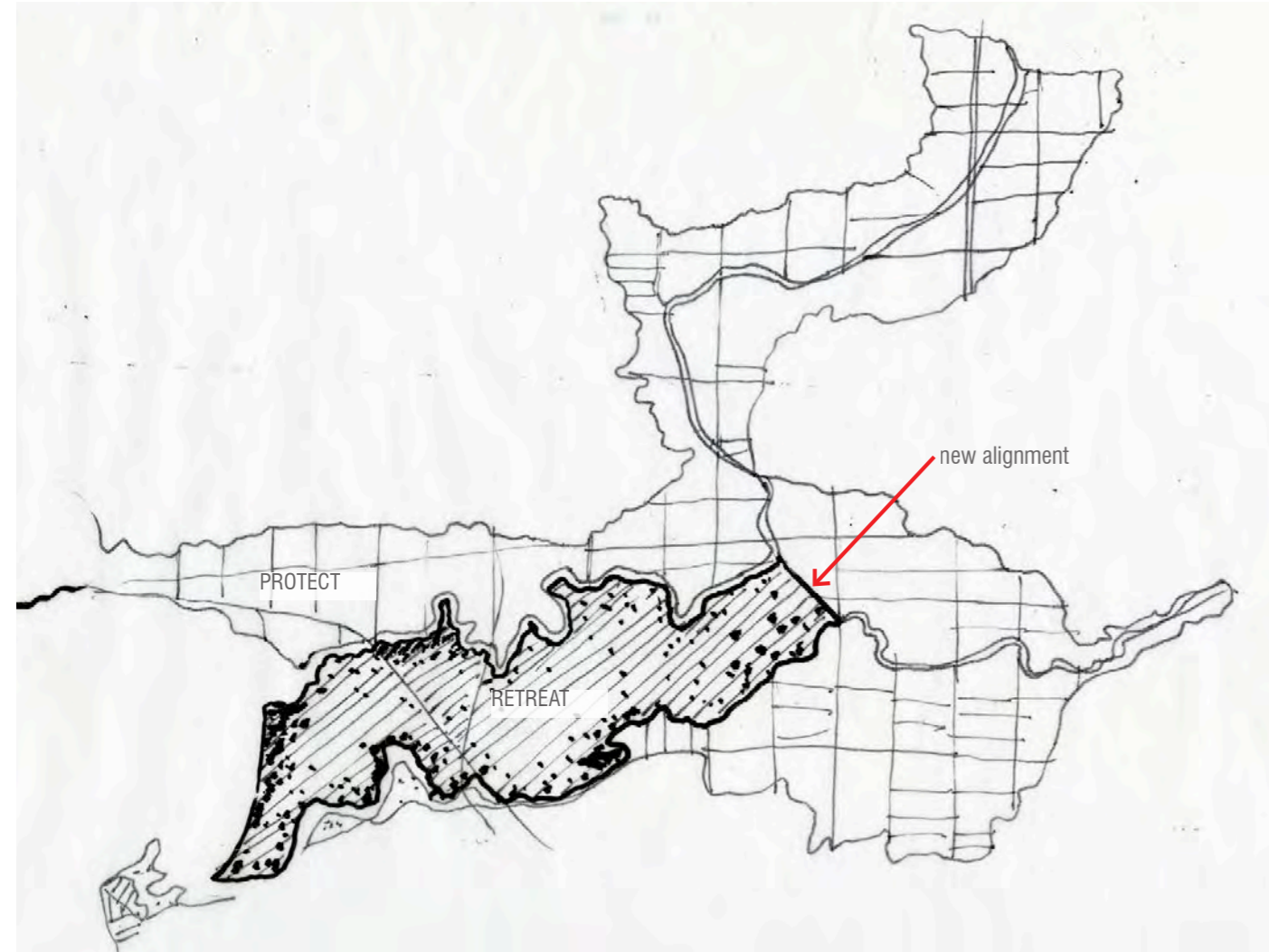


Chenhaiwei Rural Wetland, Yushan Town, China

image: <http://www.intecol-10iwc.com/EN/HelpCenter/HelpInfo.aspx?nid=77>

INTER-RIVER RETREAT

This concept proposes a retreat of current agricultural practices within the inter-river area extending until approximately 168 street where a new dyke could be built between the two rivers. Within the retreat area, new habitat types, agricultural practices and recreation areas could emerge. Ex: Floodplain forest, aquaculture, hunting lands.



PRECEDENTS IMAGES:

COASTAL REALIGNMENT, MEDMERRY, UK

“The managed realignment project at Medmerry was completed in 2013 at a cost of £28m. It is the largest open-coast scheme in Europe and is one of the most sustainable projects the Environment Agency has ever delivered.”

- Institution of Civil Engineers



Oyster Farming, Washington

image: <https://www.pmel.noaa.gov/co2/file/Oyster+Farming>



New embankment

image: <http://www.geograph.org.uk/photo/4498694>



Tourism at Abbott's Hall Farm salt marshes

image: <http://www.essexwt.org.uk/events/2016/07/02/abbotts-hall-farm-history-walks>



Medmerry cycle paths

image: <http://cycle-geography.blogspot.ca/2014/07/medmerry-cycle-paths.html>



Medmerry Coastal Realignment

image: <https://www.ice.org.uk/disciplines-and-resources/case-studies/managed-realignment-at-medmerry-sussex>

EDGE RETREAT

This concept proposes a retreat of the floodplain on the outer edges of the floodplain. The steep topography on the edge of the floodplain acts as a natural flood barrier. This proposal will provide more flood water storage and reduce the amount of dyke upgrades needed. Retreated areas can provide new habitat types, agricultural practices and recreation areas could emerge.
Ex: Floodplain forest, aquaculture, hunting lands.



PRECEDENTS IMAGES:

ORONGO STATION CONSERVATION
MASTER PLAN / NELSON BYRD WOLTZ
LANDSCAPE ARCHITECTS
NORTH ISLAND, NZ

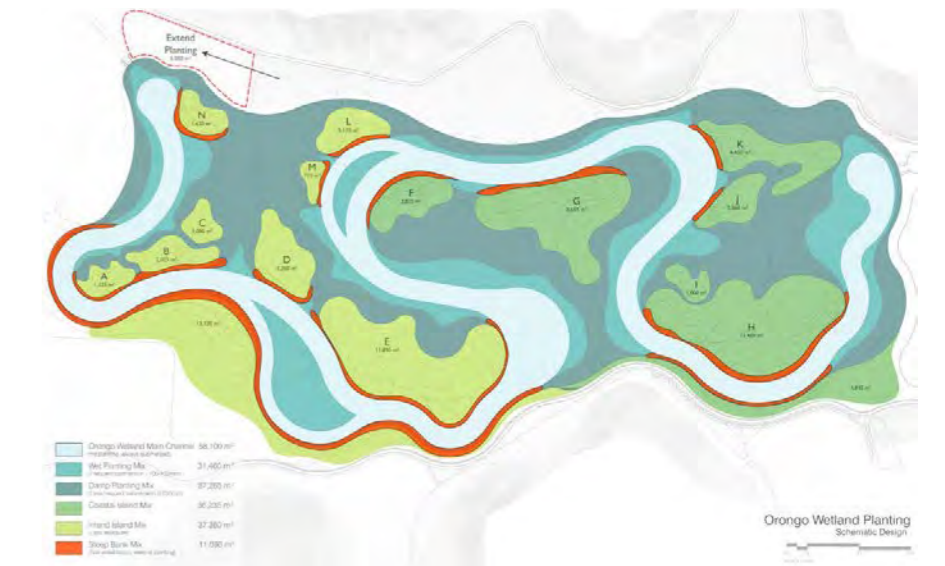
“The Orongo Station Conservation Master Plan for a 3,000-acre sheep farm in New Zealand establishes a vision for the extensive regeneration of a devastated ecology while expanding agricultural production and revealing a cultural landscape rich in history. Completed in collaboration with a team of public officials, private stakeholders and local experts, the project serves as an important model that can expand the current definitions of sustainability and landscape architecture.”
-Nelson Byrd Woltz Landscape Architecture



Flooding against steep topography
image: <https://www.asla.org/2010awards/205.html>



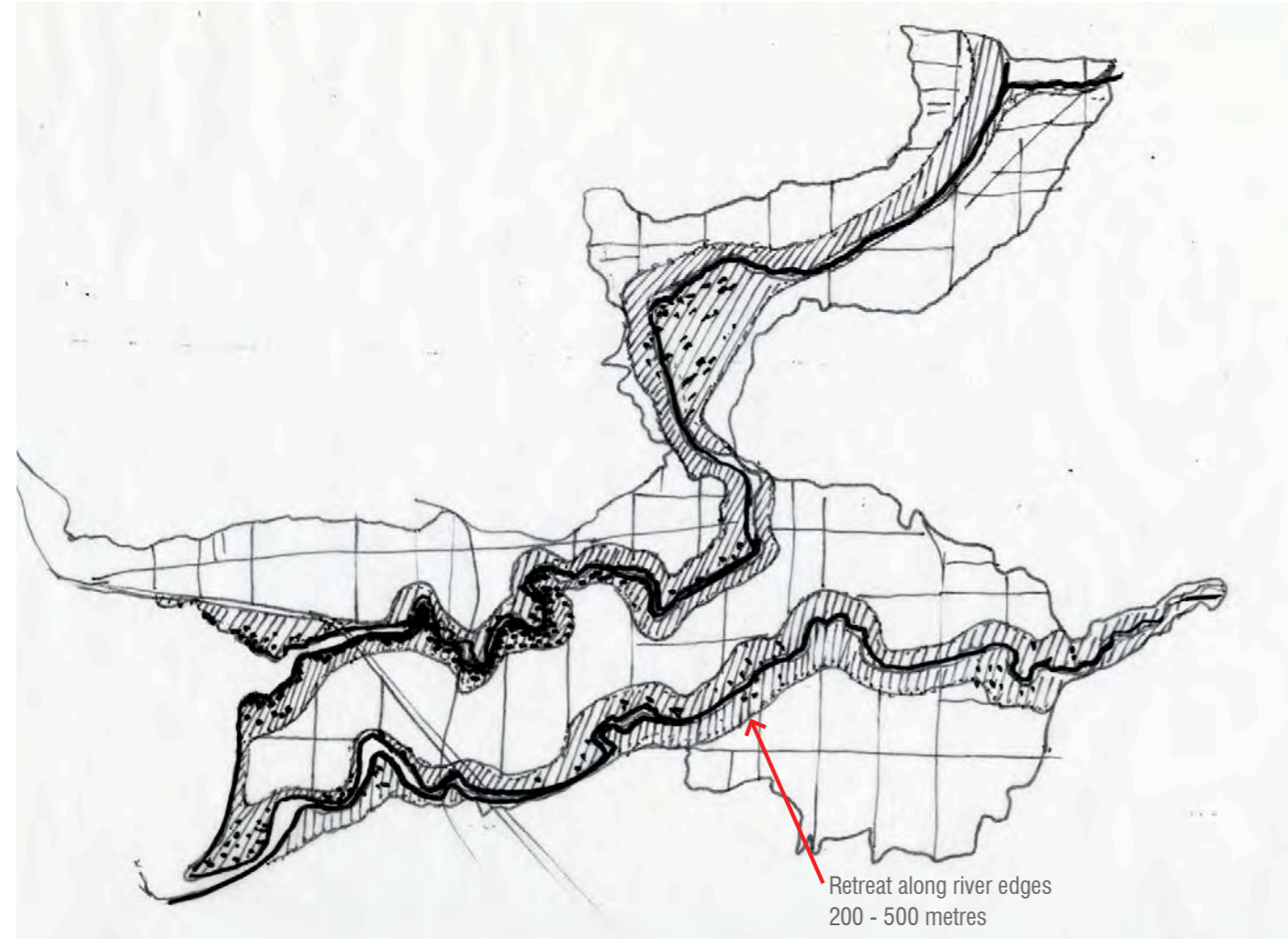
Floodplain forest
image: http://www.landezine.com/index.php/2017/04/the-parklands-of-floyds-fork-by-wrt/louisville-03-photo-ted-wathen_mg_5621/



Variety of topography creates new habitat and recreation
image: <https://www.asla.org/2010awards/205.html>

ROOM FOR THE RIVERS

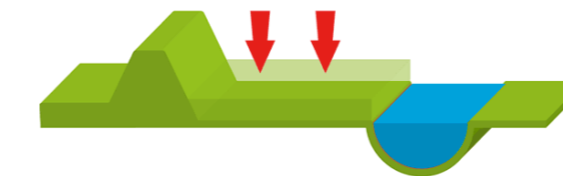
This concept proposes a widening of both the Nicomekl and Serpentine Rivers. This would require a secondary dyke, or the raising up of surrounding agriculture. The current dykes could either be breached intentionally or naturally overtop during flood events/ as sea levels rise. Widening the river provides opportunities for new types of agriculture in the flooded areas, improved riparian habitat or new types of river recreation.



PRECEDENTS IMAGES:

ROOM FOR THE RIVER, THE NETHERLANDS

One of the strategies for “Room for the River” in the Netherlands is the lowering of floodplains to make more room for the river during high flow periods. These interstitial spaces are now used for temporary agricultural practices such as grazing. They also provide recreation and habitat opportunities.



Lowering the Floodplain
image: <https://www.ruimtevoorderivier.nl/english/>



Lower level of floodplain becomes grazing area for sheep
image: <http://nliintheusa.com/room-waal-project-opens/>



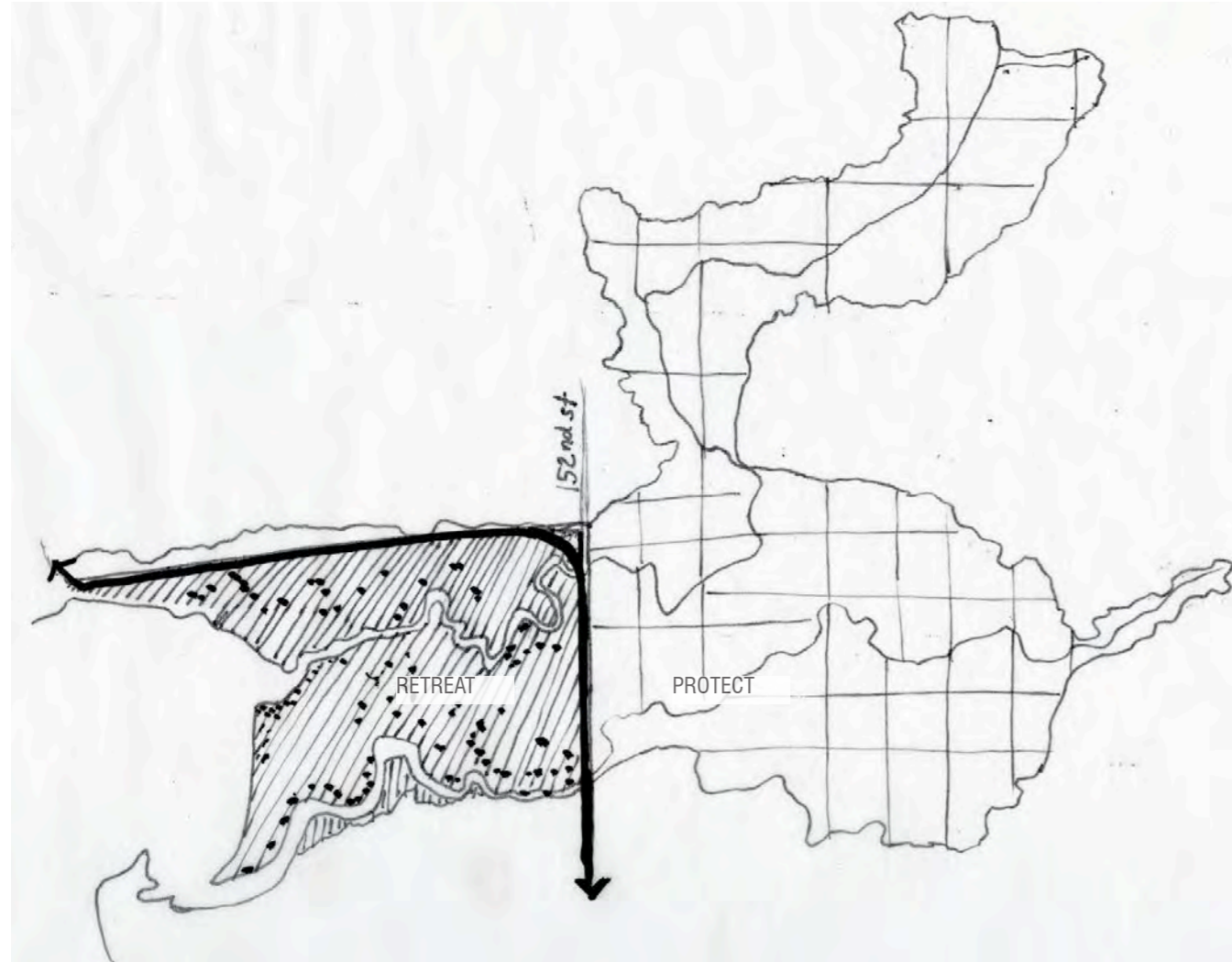
Vegetation and new landform in riparian areas
image: <http://www.landezine.com/index.php/2016/06/renaturation-of-the-river-aire-geneva/03-naturalization-river-channel-landscape-architecture-fabio-chironi/>



Riparian restoration provides new opportunity for recreation
image: <http://www.landezine.com/index.php/2012/09/bottiere-chenaille-eco-district-by-atelier-des-paysages-bruel-delmar>

LAYERED INFRASTRUCTURE

This concept proposes retreating to 152nd street or Highway 99. In these schemes, transportation infrastructure doubles as a new line of flood defense.



PRECEDENTS IMAGES:

HOOGWATERGEUL VEESEN -
WAPENVELD, ROOM FOR THE RIVER,
THE NETHERLANDS

One of the strategies for "Room for the River"
in the Netherlands...



Hoogwatergeul Veessen - Wapenveld
image: <http://www.ijsseweide.com>



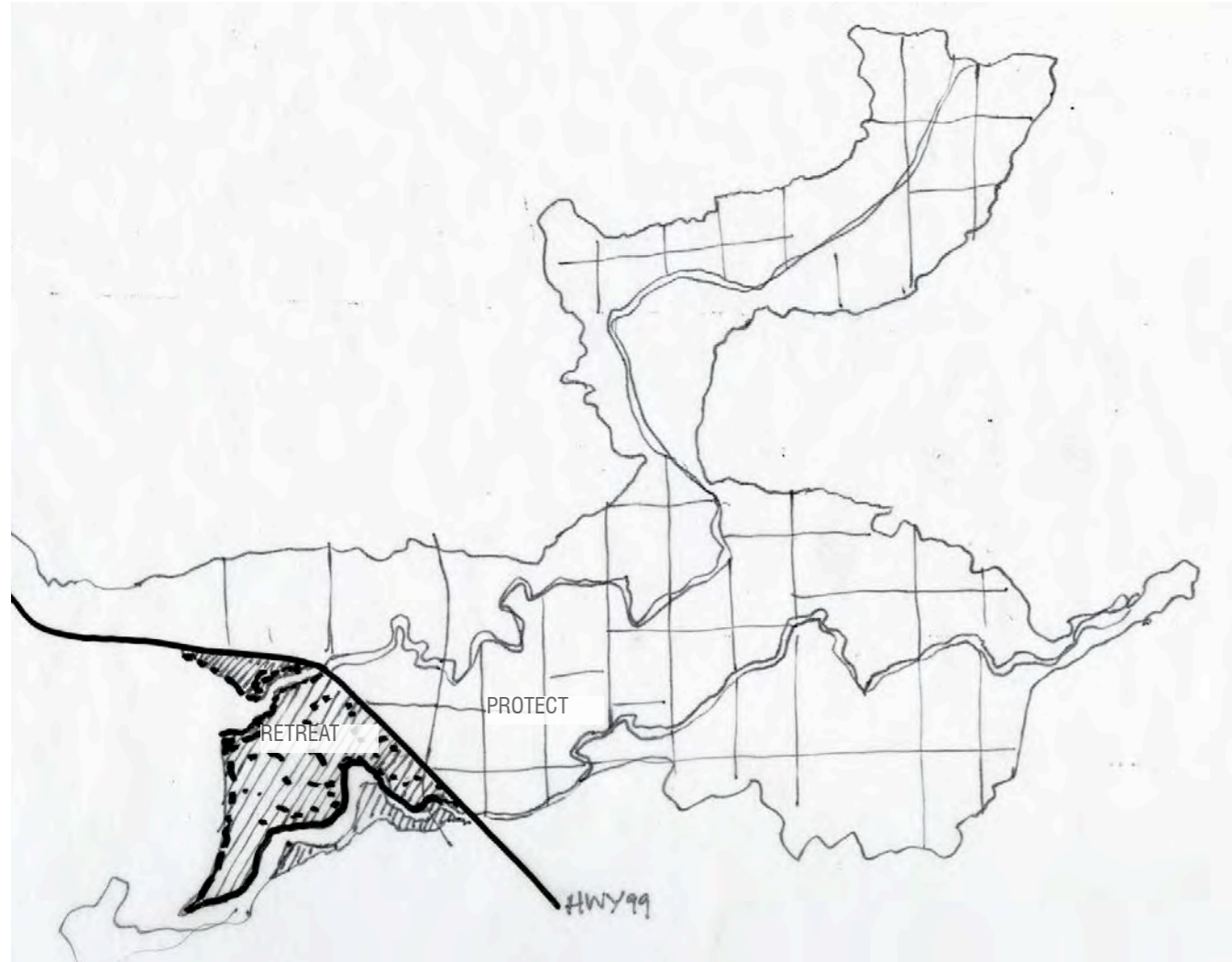
Lower bike path along highway with flood gates
image: <http://www.luttjeboer.nl/projecten/stuwen-inlaten/hoogwatergeul-veessen-wapenveld/>



Raised highway on dike
image: <http://www.landezine.com/index.php/2012/02/vienna-detzhofer-landschaftsarchitektur/landform-by-the-vienna-highway-ring-by-detzhofer-landschaftsarchitektur-05>

PARTIAL RETREAT

Within this partial retreat, the landscape can provide a storm surge buffer. In the retreat area, additional storm surge barriers can provide flood defense and also create new habitat. This area can also become a recreation area.



PRECEDENTS IMAGES:

FRYSLAN AT SEA /
BURRO HARRO, NORTHERN FRIESLAND,
THE NETHERLANDS

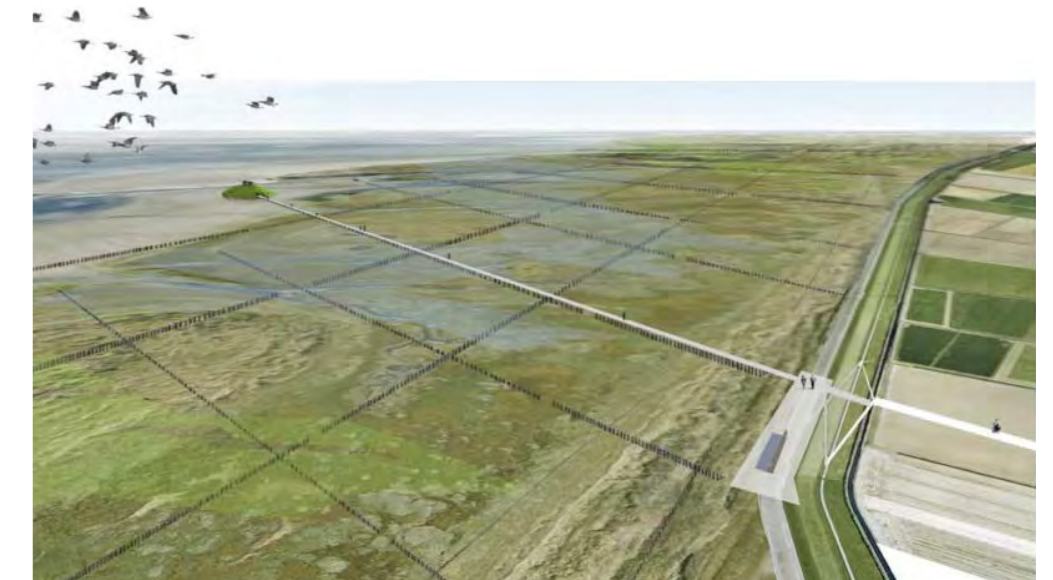
“Fryslan at Sea’ proposes to enrich this new marsh zone outside the dikes with new, accessible ‘Dobbes’ (round, elevated fresh water basins). These Dobbes can be used for camping, bird watching, swimming or sunbathing, while all these activities remain completely unnoticed for people on the other side! The Dobbes are constructed at the end of long dams that make the area accessible and stimulate the formation of the marshes.” - Burro Harro



Recreation in the flooded landscape
image: <http://buroharro.nl/fryslan-at-sea/>



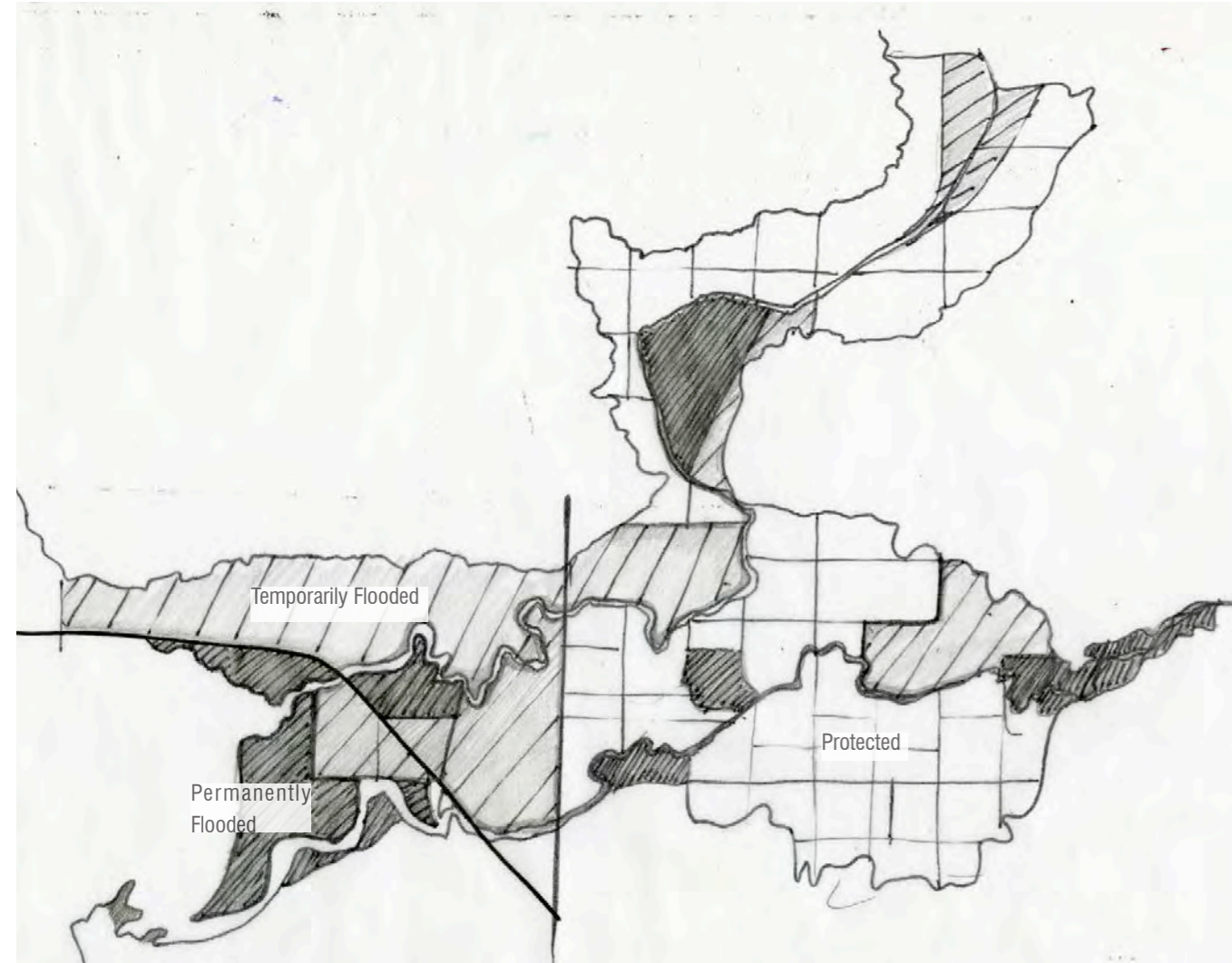
Area becomes a new destination
image: <http://buroharro.nl/fryslan-at-sea/>



“Dobbes” on the outside of the dyke stimulate marsh growth and provide storm relief
image: <http://buroharro.nl/fryslan-at-sea/>

PHASED FLOODING

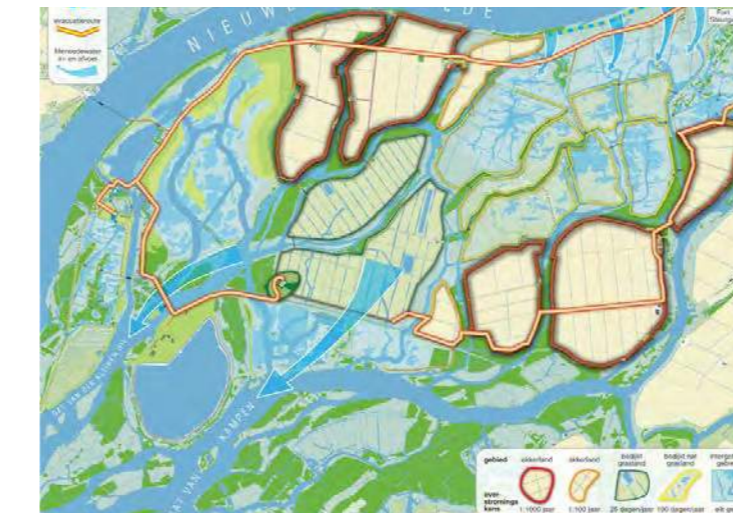
This concept uses topography or a variety of dyke heights to create a landscape that changes over time. Some areas are flooded daily with the tides, others may only be flooded during storm events, and some areas are kept protected in all flood events. This reduces the pressure on a sole dyke and creates a diverse landscape of uses and experiences.



PRECEDENT IMAGES:

DEPOLDERING NOORDWAARD, THE NETHERLANDS

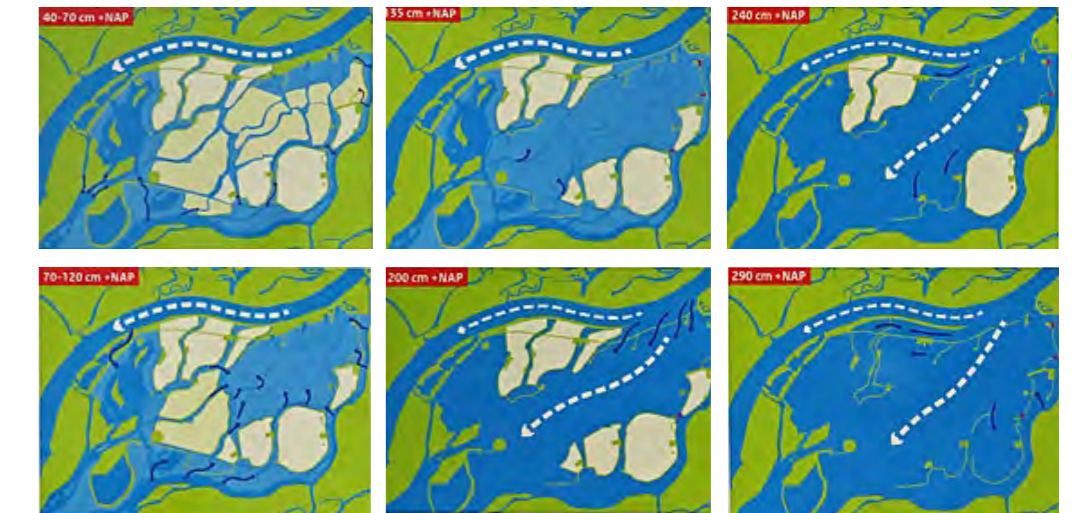
“The Noordwaard polder is one of the key areas of the National Dutch project Ruimte voor de Rivier (Room for the River). This polder is one of 39 locations holding great strategic significance for the water management of the main rivers of The Netherlands and thus for the safety of more than 4 million people. By lowering the dike of the Noordwaard polder the area will become subject to controlled inundation and function as a dedicated water detention district.”
- West 8



Depoldering Noordwaard: Phased Flooding
image: <https://www.deingenieur.nl/artikel/noordwaard-wordt-doorstroompolder>



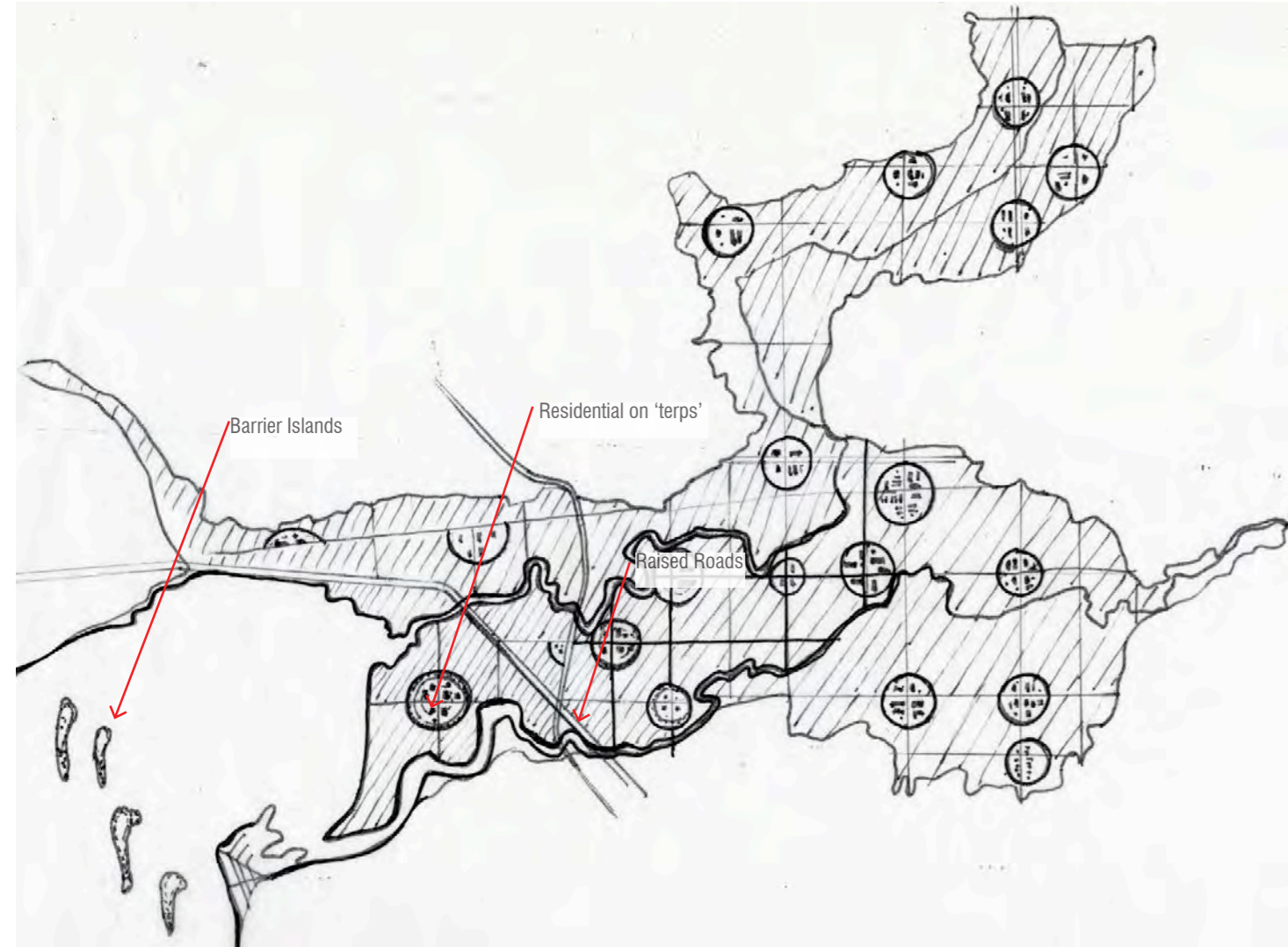
Bridges of Noordwaard, West 8
image: www.west8.nl/projects/infrastructure/noordwaard



Changes with high tide and other rising water levels
image: <https://www.dutchwatersector.com/news-events/news/15756-room-for-the-river-programme-completes-its-largest-depolderingproject.html>

RAISED GROUND

Barrier islands are constructed offshore to reduce storm surge impacts and existing coastal dykes are maintained. Homes and important amenities are located on raised 'terps'. Highway 99 and other critical transit corridors are raised over time. All other non-raised areas of the floodplain are subject to flooding during extreme events.



PRECEDENTS IMAGES:



Blue Dunes, West 8
image: <http://www.west8.nl/images/dbase/6872.jpg>



Green dikes, NL
image: <http://www.nedanders.nl/flood-defences>



Terps (raised areas for residential)
image: <http://www.psammos.nl/Image/Terpen.jpg>



Cahokla Mounds
image: <https://images.interactives.dk/bakker-NDFN1yyTFnZOPpiRJJJE0hw.jpg>



Agriculture on raised highway/ dyke
image: <http://www.directdutch.com/2014/10/dutch-up-workshop-about-dutch-dikes/>

MULTIFUNCTIONAL SPILLWAYS

The floodplain currently has a small network of spillways. These spillways are the first areas to be flooded when river water levels get too high. This scheme proposes an extended network of spillways that also serve multiple functions such as habitat creation, recreation, and seasonal agriculture.



PRECEDENTS IMAGES:



Researchers in flooded rice fields
 image: <https://ca.water.usgs.gov/news/2014/GrowingScienceInAgriculturalWetlands.html>



Menomonee River Valley Redevelopment, Wenk Landscape Architecture
 image: <http://www.wenkla.com/projects/urban-water-green-infrastructure/menomonee-river-valley-redevelopment/>



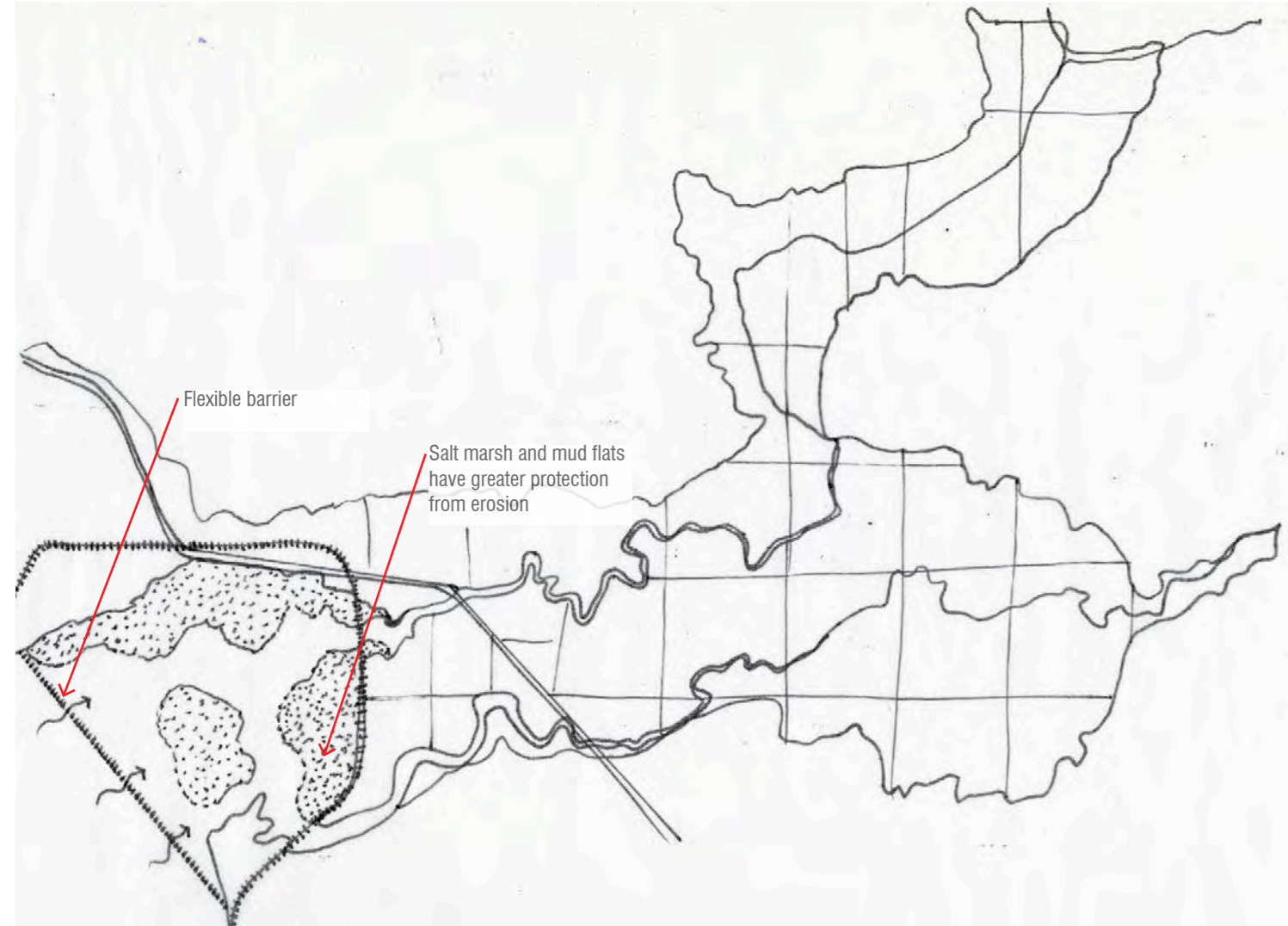
Menomonee River Valley Redevelopment, Wenk Landscape Architecture
 image: <http://www.wenkla.com/projects/urban-water-green-infrastructure/menomonee-river-valley-redevelopment/>



Menomonee River Valley Redevelopment, Wenk Landscape Architecture
 image: <http://www.wenkla.com/projects/urban-water-green-infrastructure/menomonee-river-valley-redevelopment/>

FLEXIBLE BARRIER

This scheme proposes an offshore barrier that can control water levels and break storm surges. This barrier has built in flexibility to allow better movement of water in and out of Mud Bay. As a result, the scheme has a reduced impact on the brackish ecology in Mud Bay and maintains recreation opportunities between the rivers and ocean.



PRECEDENTS IMAGES:



Oosterscheldekering

image: <http://www.amusingplanet.com/2014/04/the-netherlands-impressive-storm-surge.html>



Oosterscheldekering

image: <http://www.amusingplanet.com/2014/04/the-netherlands-impressive-storm-surge.html>

RIGID BARRIER

This barrier is coupled with the BNSF rail (or potential for other transit) and reduces saline water from entering Mud Bay. The current ecology of Mud Bay is drastically altered as a result and replaces with a predominantly freshwater ecology. A smaller opening is provided to allow fish passage and boat access to the rivers. The two sea dams are no longer necessary.



PRECEDENTS IMAGES:



Afsluitdijk, NL
(https://upload.wikimedia.org/wikipedia/commons/thumb/b/b8/Afsluitdijk_1031.jpg/1200px-Afsluitdijk_1031.jpg)



Afsluitdijk, NL
image:<https://www.rijkswaterstaat.nl/english/water-systems/protection-against-water/dykes/the-afsluitdijk-project/importance-of-the-afsluitdijk.aspx>

THE VANCOUVER BYPASS

This floodplain can be the much needed bypass for Vancouver to discharge the increasing amounts of water of the Fraser River. Very costly adaptations in the urban fabric of Vancouver can be avoided and partly invested in this area to make this a flood resistant green area and to keep it open. The increasing amount of water can supply more freshwater for farmers and transport sediments.

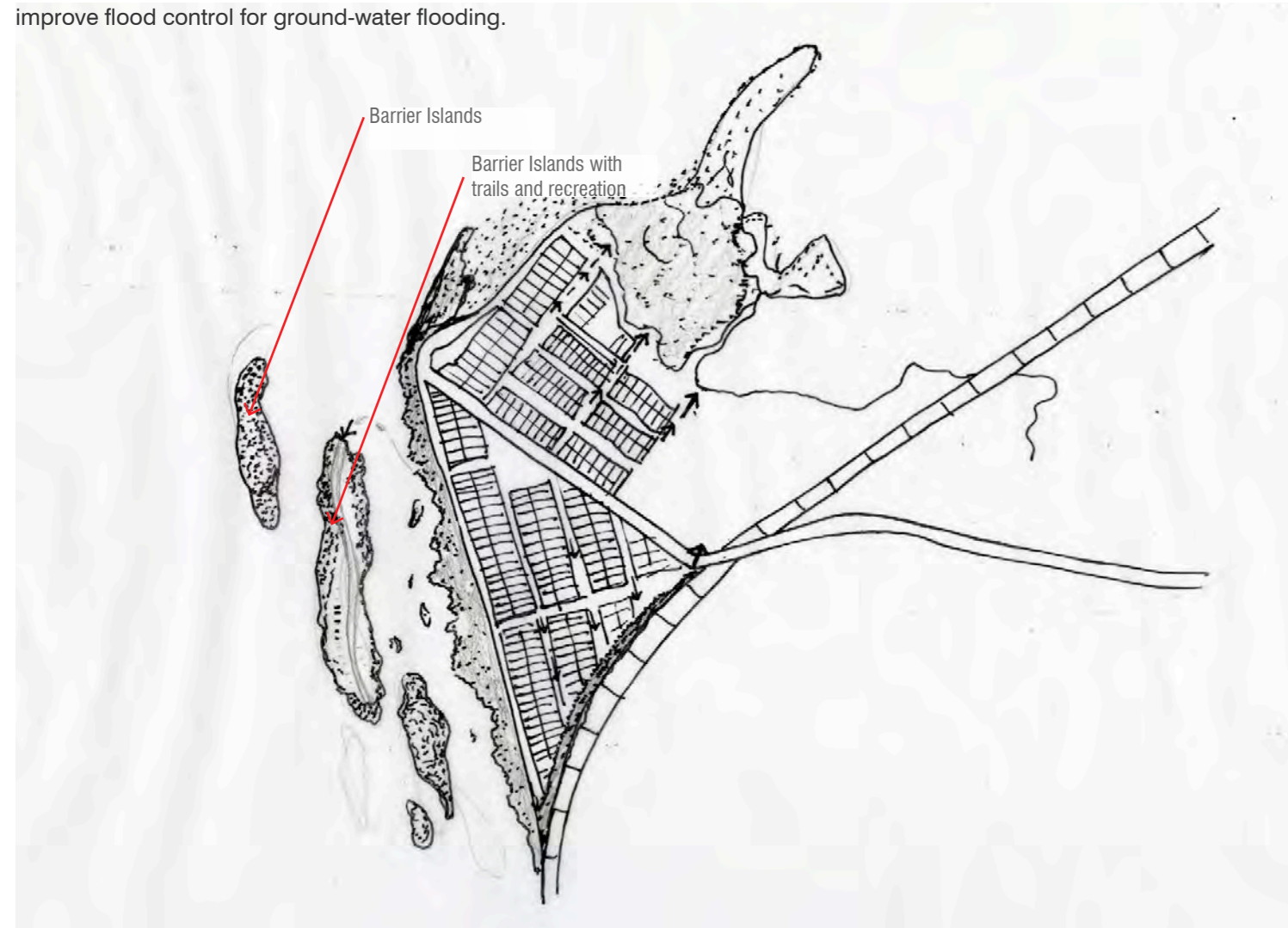


Land reclamation in coastal areas Mud Bay

Floodplain discharges Fraser River

CRESCENT BEACH BARRIER ISLANDS

Offshore barrier islands reduce storm surge impacts, making dykes and seawalls less vulnerable to overtopping and erosion. An added benefit of these islands are potential for new recreation and habitat creation. This soft approach is also very flexible and can be added to or altered over time to meet changing conditions. The community will need to continue to improve flood control for ground-water flooding.



PRECEDENTS IMAGES:



Blue Dunes, West 8

image: <http://www.west8.nl/images/dbase/6872.jpg>



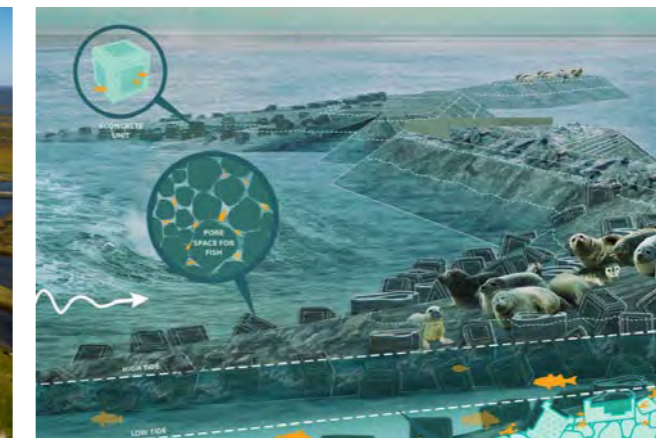
Blue Dunes, West 8

image: <https://archpaper.com/2014/04/rebuild-by-design-wxy-and-west-8s-blue-dunes-for-new-york-and-new-jersey/>



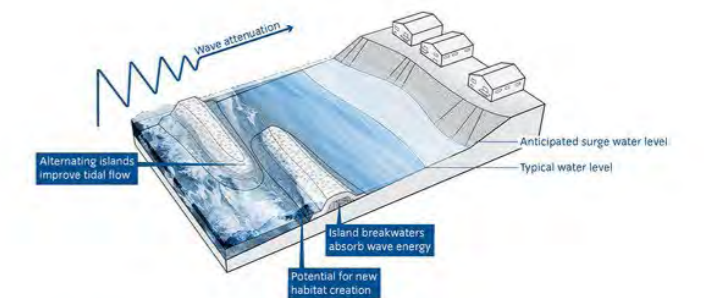
Louisiana Barrier Island

image: <http://www.habitat.noaa.gov/about/habitat/barrierislands.html>



Living Breakwaters, SCAPE

image: <http://ias.umn.edu/2015/04/17/nature/>



OFFSHORE BREAKWATERS

NYC SIRR Coastal Protection Planning, SCAPE

image: <http://2.scapestudio.com/projects/nyc-sirr-coastal-protection-planning/>

EXPANDED EDGE

This scheme proposes a partial retreat of the perimeter homes in Crescent Beach. This retreat makes room for a series of berms which protect the remainder of the community and offer new recreation and habitat opportunities. Residents now have a view of vegetated berms rather than an ocean view from ground level rooms. This living edge is flexible and can change over time.



PRECEDENTS IMAGES:



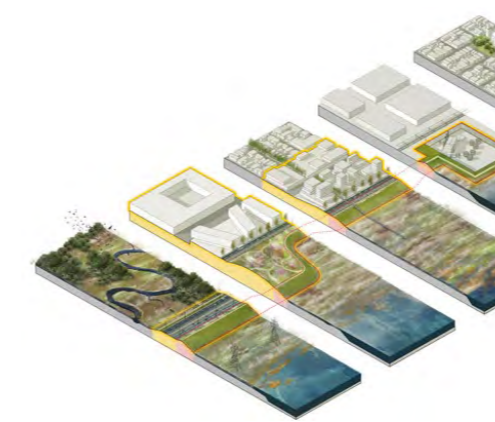
Katwijk Coastal Defense, OKRA

image: <http://www.landezine.com/index.php/2015/02/katwijk-coastal-defence-by-okra/>



Katwijk Coastal Defense, OKRA

image: <http://www.landezine.com/index.php/2015/02/katwijk-coastal-defence-by-okra/>



New Meadowlands, De Urbanisten

image: <http://www.rebuildbydesign.org/our-work/all-proposals/winning-projects/nj-meadowlands>



Rockaway East Resiliency Preserve, LOLA

image: <http://www.localofficelandscape.com/portfolio-items/rockaway-east-resiliency-preserve-proposal/>

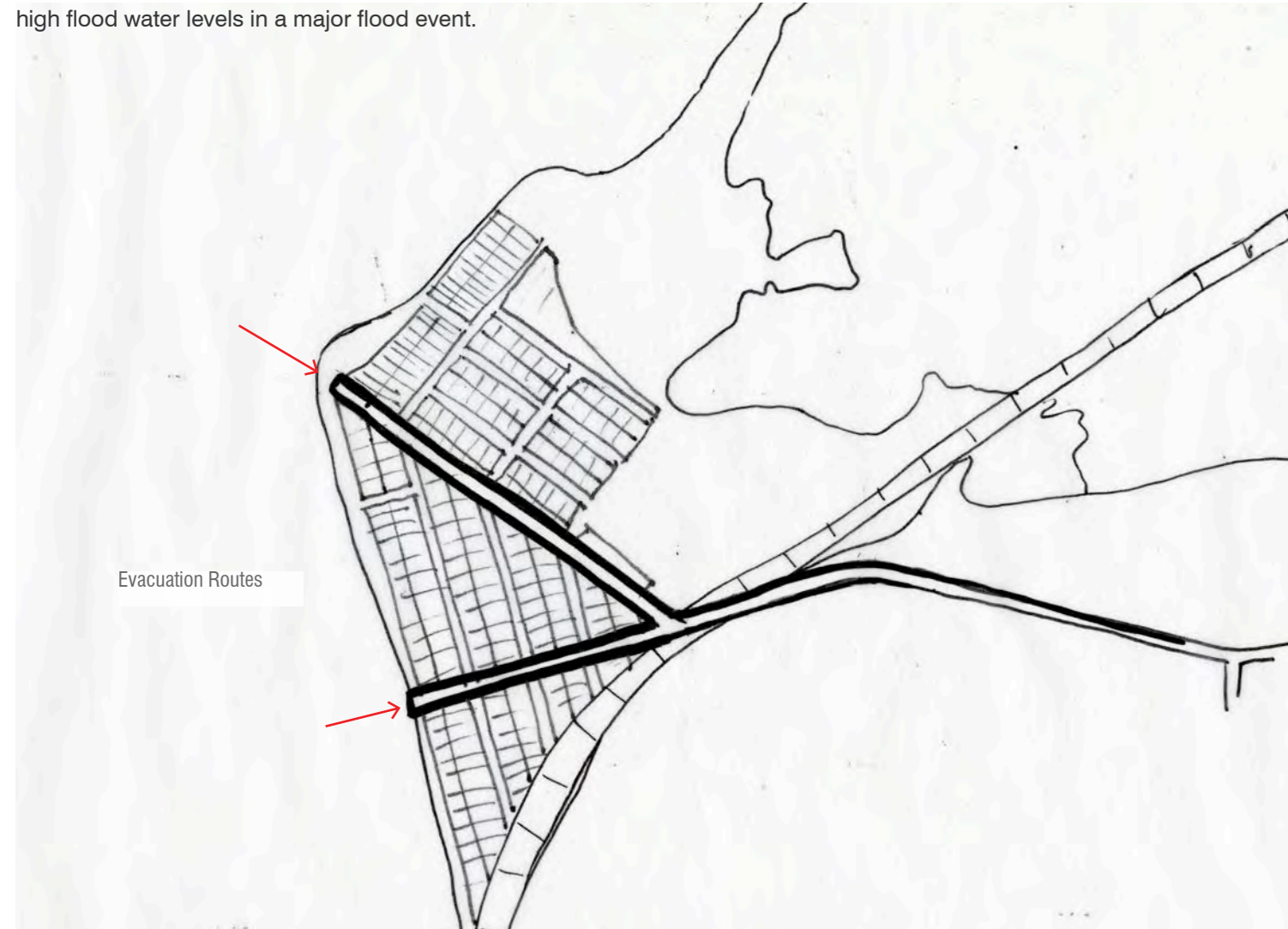


Katwijk Coastal Defense, OKRA

image: <http://www.landezine.com/index.php/2015/02/katwijk-coastal-defence-by-okra/>

SHORT TERM MEASURES / DO NOTHING

In this scenario, no major flood defense changes have been made. This is similar to a 'do nothing' approach. To ensure safety, evacuation routes are established and there is more investment in temporary flood barriers. This will reduce negative impacts during minor flood events. However, there is increased risk in this scenario as Crescent Beach will experience high flood water levels in a major flood event.



PRECEDENTS IMAGES:



Removeable flood barriers

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Evacuation routes

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Removeable barriers

image: <http://www.alamy.com/stock-photo/temporary-flood-barrier.html>



Increased nuisance flooding

image: <http://www.businessinsider.com/flooding-is-a-growing-concern-for-us-coastal-cities-2015-7>

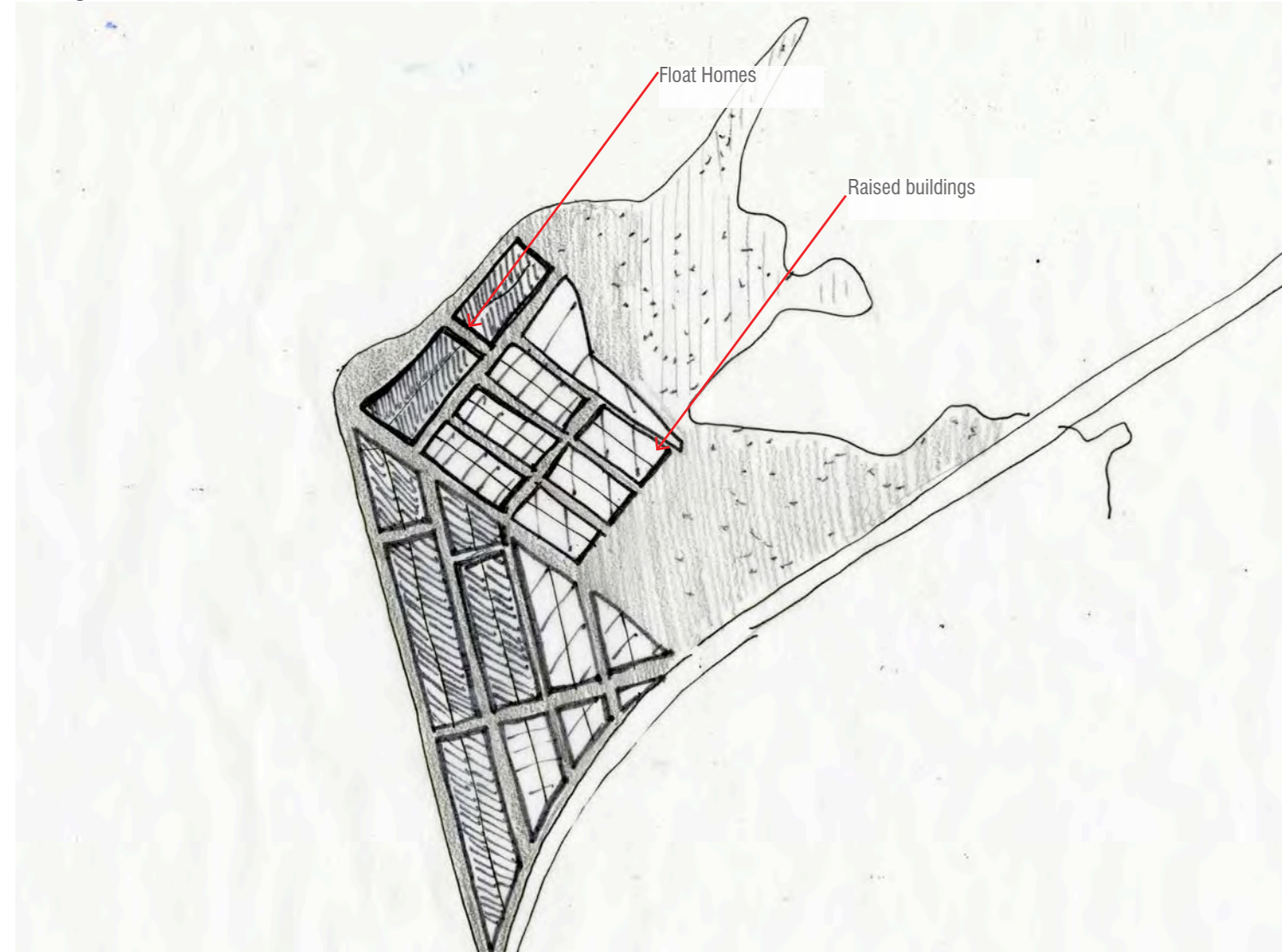


Major flood event, Crescent Beach will flood

image: <http://www.techtimes.com/articles/72327/20150728/study-identifies-causes-of-major-flooding-risk-for-u-s-coastal-cities.htm>

FLOOD TOLERANT ARCHITECTURE

Along with continuing to increase flood construction levels on homes, investments into other flood resistant building techniques are made. In the event of a major flood event, property damage is limited and residents are safe in their homes.



PRECEDENTS IMAGES:



House on stilts

image: <http://inhabitat.com/tag/flood-resistant-houses/>



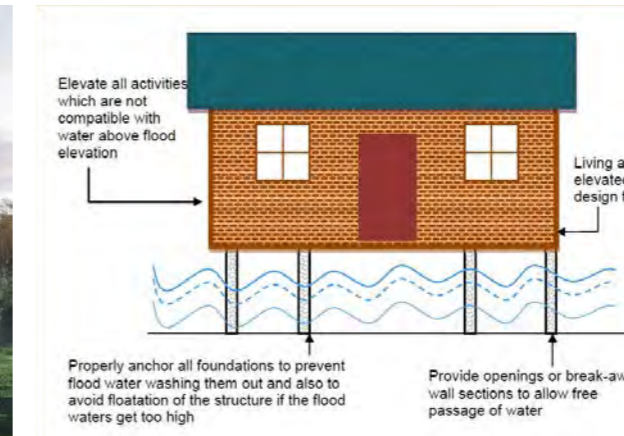
Floating Homes

image: <http://www.floathomesales.com/assets/image2.jpg>



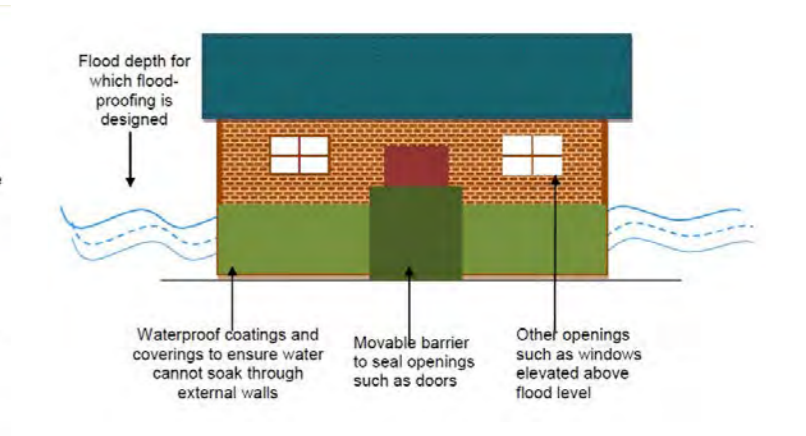
House on stilts

image: <https://www.architectsjournal.co.uk/news/john-pardey-reveals-house-on-stilts-for-flood-plain/10014178.article>



Wet Proofing techniques

image: <http://www.climatechwiki.org/content/flood-proofing>

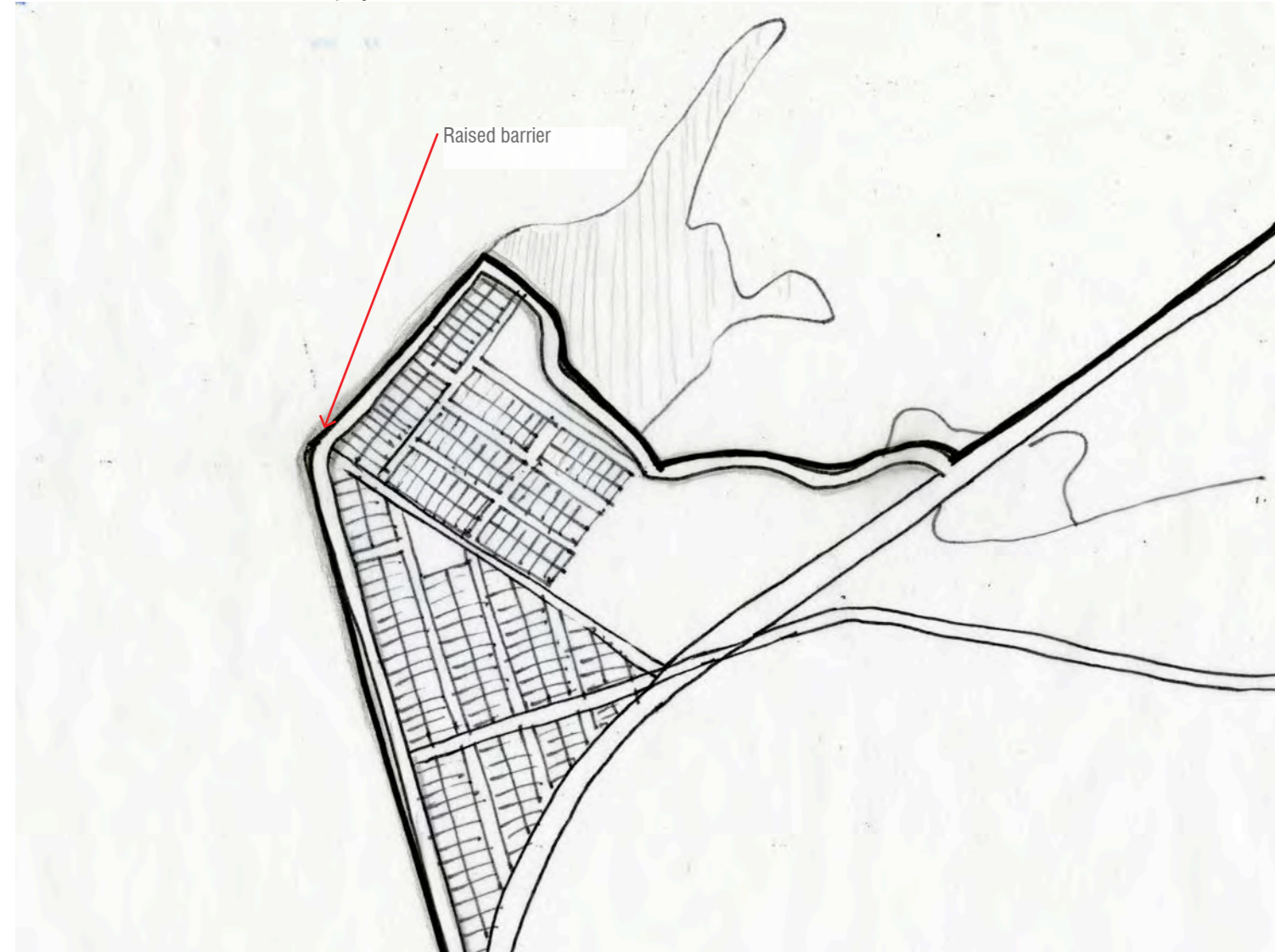


Dry Proofing techniques

image: <http://www.climatechwiki.org/content/flood-proofing>

RAISED PERIMETER

This scheme proposes building upon the existing dykes and shoreline edge. However, due to storm surge and increased sea levels, this perimeter barrier will be over 5 meters high resulting in all visual, and in some cases physical, access to the sea.



PRECEDENTS IMAGES:



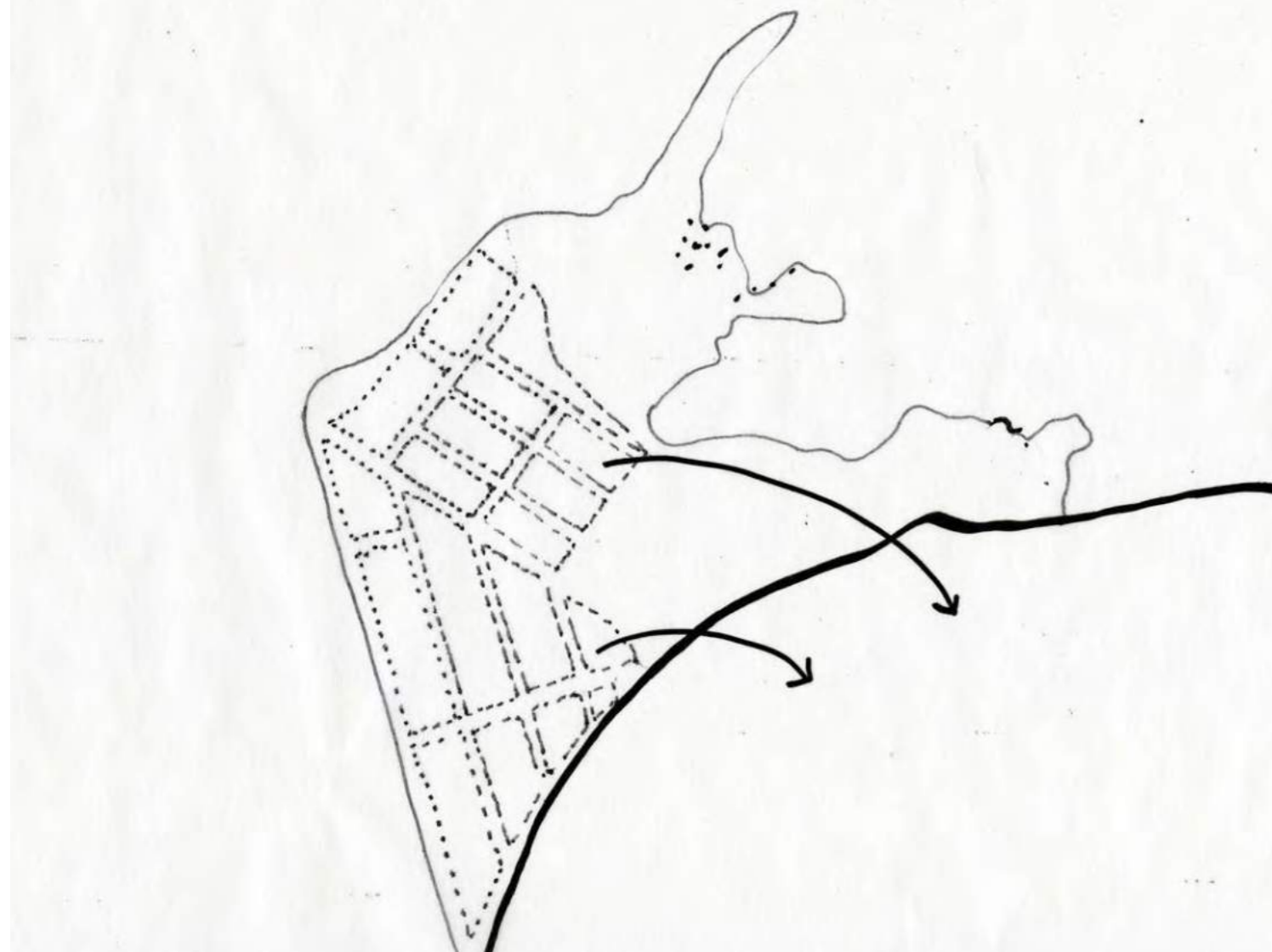
'Hold the Line', Delta RAC
image: http://delta-adaptation-bc.org/managed-retreat-2/ladner_street_htl_2100_concrete_web-2/



'Hold the Line', Delta RAC
image: http://delta-adaptation-bc.org/managed-retreat-2/ladner_street_htl_2100_concrete_web-2/

MANAGED RETREAT

Residential and commercial use of Crescent Beach is completely retreated. This scheme would involve exploring new areas for relocation and possible incentives/ buyouts to encourage residents to leave the community.



PRECEDENTS IMAGES:



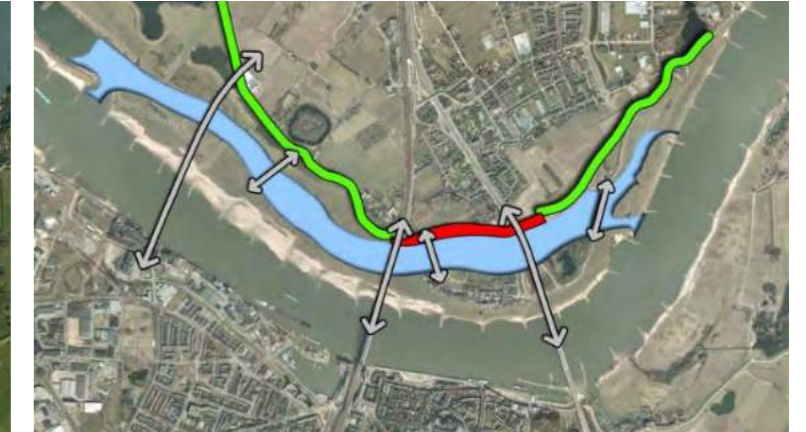
Shishmaref, Alaska where residents have voted to relocate.
images: <https://oceanactionagenda.org/story/arctic-town-climate-change/>



Historic farmhouse is moved in Lent
image: <http://citiscopes.org/story/2015/dutch-city-makes-room-its-river-and-new-identity>



Relocation of small town, Lent, for Room for the River project in Nijmegen (Before)
image: <http://citiscopes.org/story/2015/dutch-city-makes-room-its-river-and-new-identity>



Relocation of small town, Lent, for Room for the River project in Nijmegen (After)
image: http://ruimtelijkeplannen.nijmegen.nl/plannen/NL.IMRO.0268.BP21000-/NL.IMRO.0268.BP21000-OH01/1_NL.IMRO.0268.BP21000-OH01_2.1.html

SEMIAHMOO BARRIER ISLANDS

Barrier Islands constructed offshore of the Little Campbell River floodplain reduces storm surge impacts.



PRECEDENTS IMAGES:



Blue Dunes, West 8

image: http://www.west8.nl/projects/resilience_strategies_sustainability/blue_dunes_the_future_of_coastal_protection/



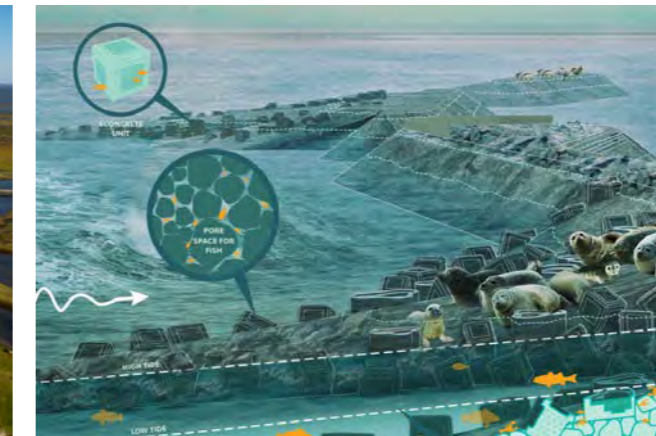
Fog Point Living Shoreline, Glenn Martin National Wildlife Refuge

image: [https://commons.wikimedia.org/wiki/File:Aerial_view_of_completed_Fog_Point_Living_Shoreline_restoration_at_Glenn_Martin_National_Wildlife_Refuge_\(27887909391\).jpg](https://commons.wikimedia.org/wiki/File:Aerial_view_of_completed_Fog_Point_Living_Shoreline_restoration_at_Glenn_Martin_National_Wildlife_Refuge_(27887909391).jpg)



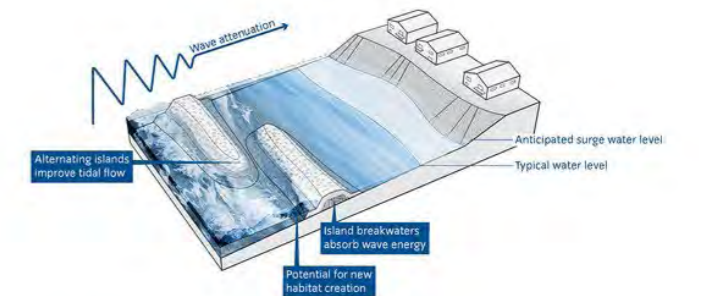
Louisiana Barrier Island

image: <http://www.habitat.noaa.gov/about/habitat/barrierislands.html>



Living Breakwaters, SCAPE

image: <http://ias.umn.edu/2015/04/17/nature/>



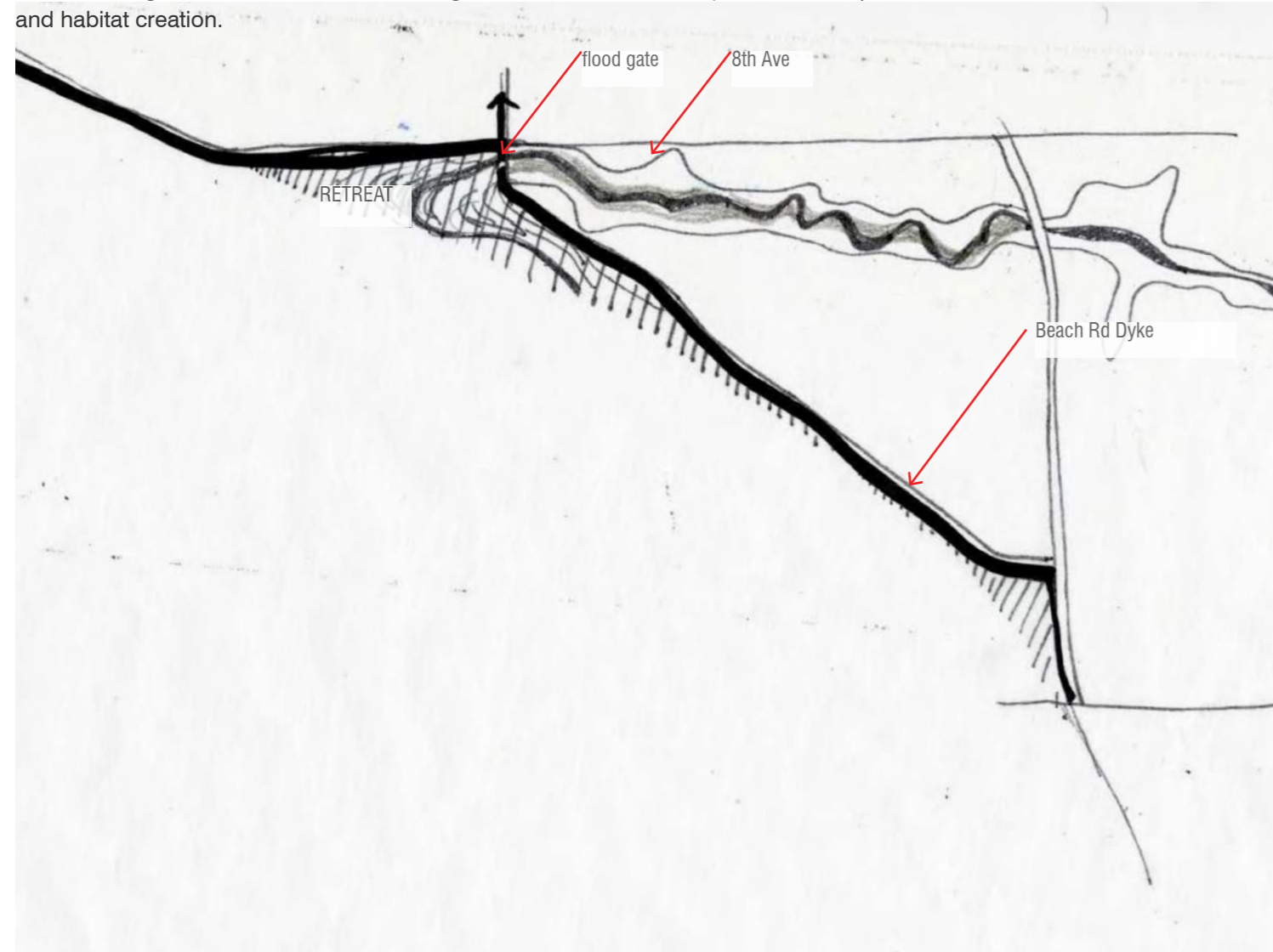
OFFSHORE BREAKWATERS

NYC SIRR Coastal Protection Planning, SCAPE

image: <http://2.scapestudio.com/projects/nyc-sirr-coastal-protection-planning/>

BEACH ROAD DYKE

This scheme proposes a partial retreat of the homes in front of Beach Road. Beach road becomes a dyke and now crosses the little Campbell river and connects to Marine Drive/ 8th Ave. A flood gate is installed at this crossing. The retreated area has potential for aquaculture and habitat creation.



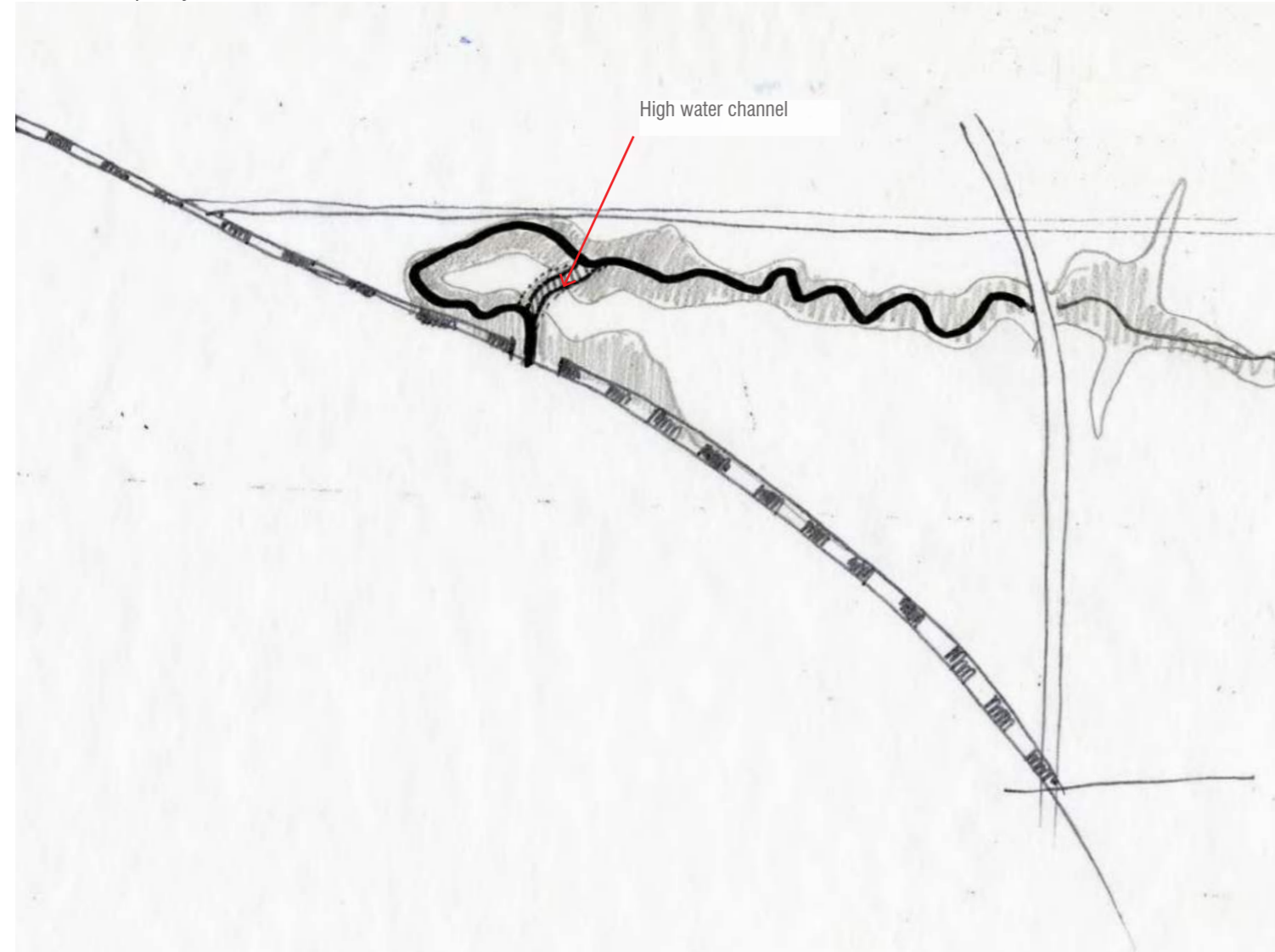
PRECEDENTS IMAGES:



Barnston Island dyke road
image: <http://thewanderingdragon.blogspot.ca/2013/04/cycling-barnston-island.html>

HIGH WATER CHANNEL

An additional channel or bioswale is created to relieve pressure where the river bottlenecks. The channel is shallow and only fills when river levels are high. This could potentially improve river water quality for salmon habitat.



PRECEDENTS IMAGES:

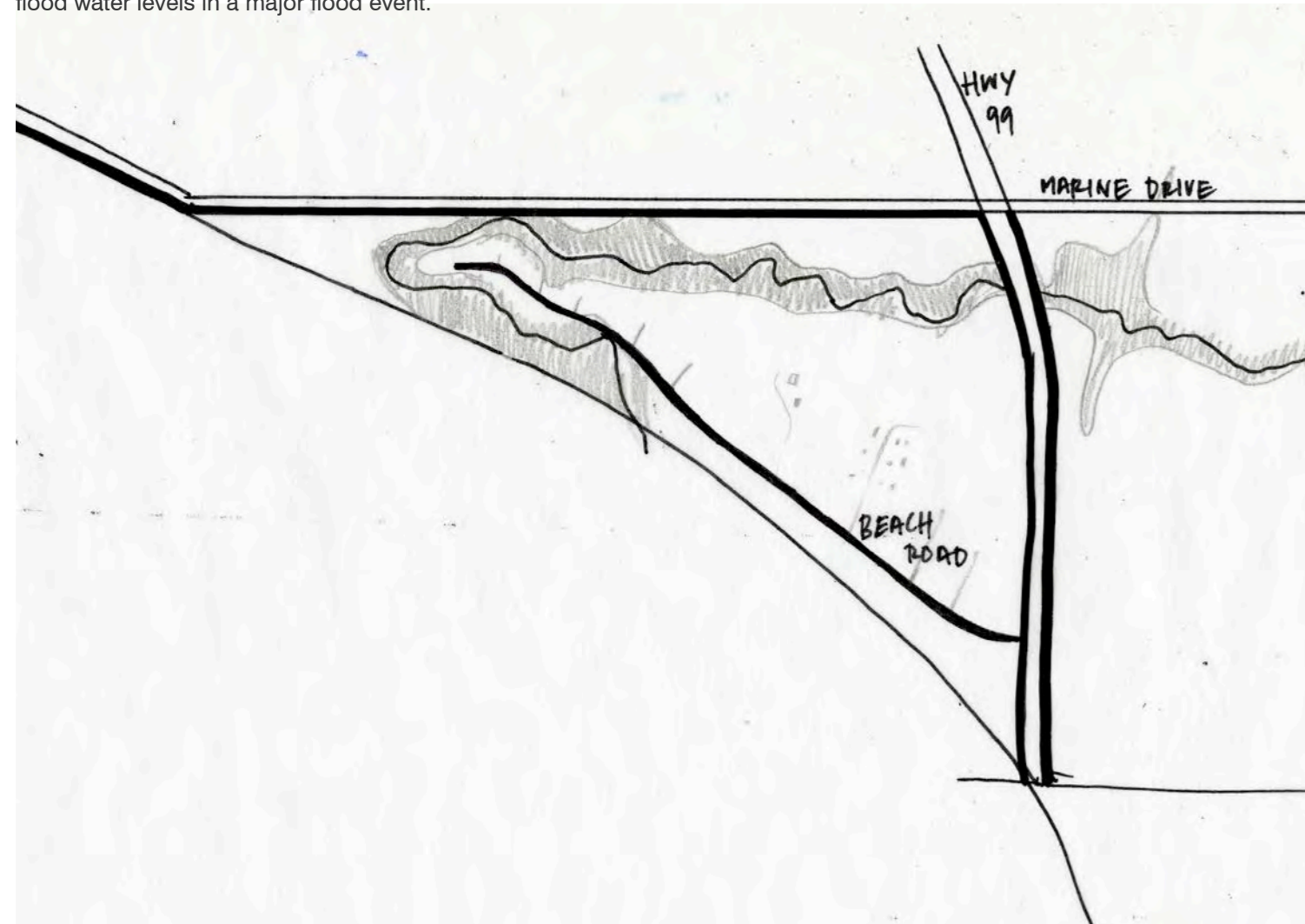


Channel flooded during peak flow.

image: <http://www.themanitoban.com/2014/09/urban-prairie-pothole-part/20428/>

SHORT TERM / DO NOTHING

In this scenario, no major flood defense changes have been made. This is similar to a 'do nothing' approach. To ensure safety, evacuation routes are established and there is more investment in temporary flood barriers. This will reduce negative impacts during minor flood events. However, there is increased risk in this scenario as the reserve will experience high flood water levels in a major flood event.



Removeable flood barriers

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Evacuation routes

image: <http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/demountable.php>



Removeable barriers

image: <http://www.alamy.com/stock-photo/temporary-flood-barrier.html>



Increased nuisance flooding

image: <http://www.businessinsider.com/flooding-is-a-growing-concern-for-us-coastal-cities-2015-7>

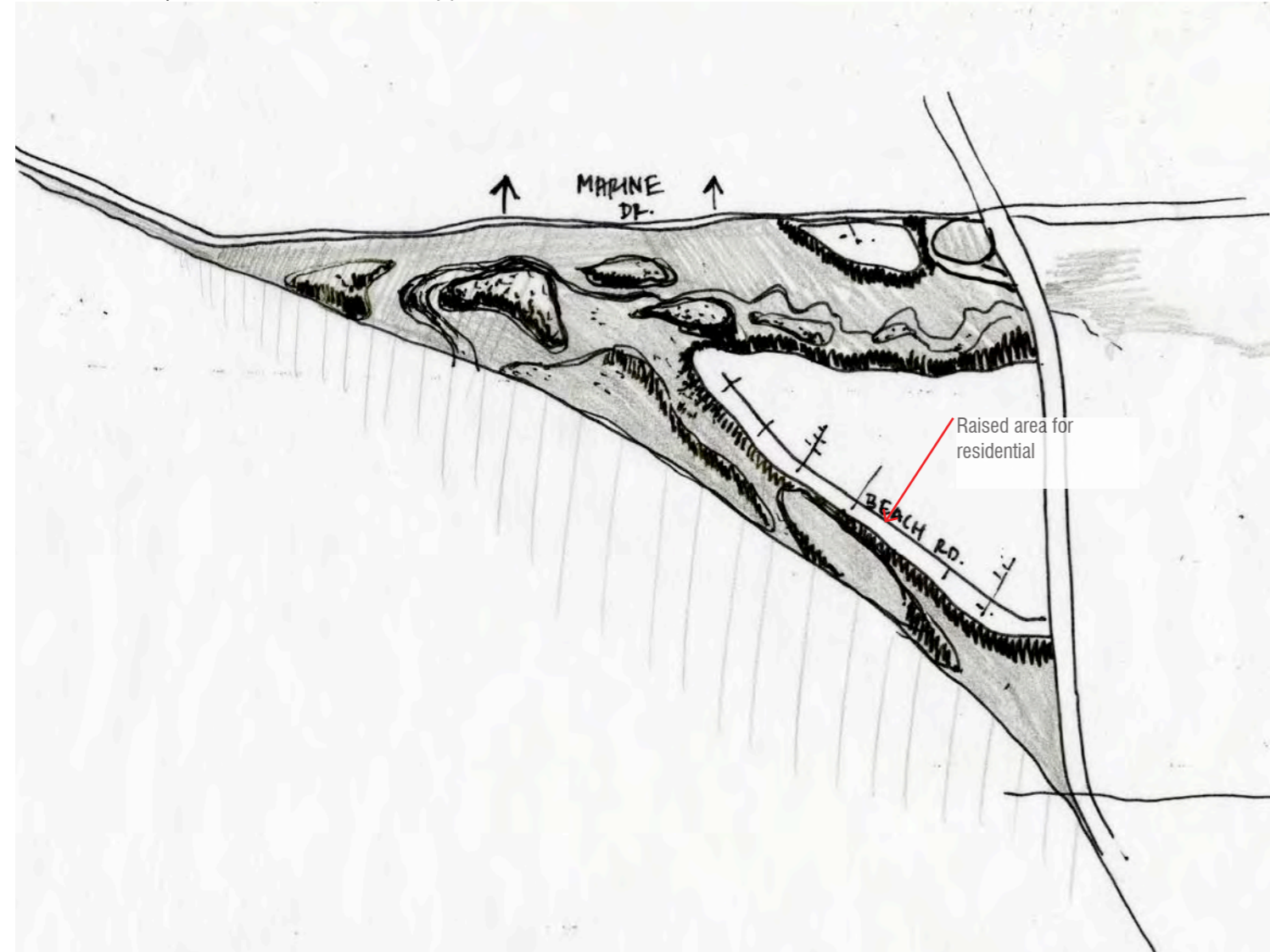


Major flood event, Crescent Beach will flood

image: <http://www.techtimes.com/articles/72327/20150728/study-identifies-causes-of-major-flooding-risk-for-u-s-coastal-cities.htm>

PHASED FLOODING

This scheme proposes retreating homes away from the lower floodplain area to higher ground along Beach Road. This reduces flood risk for residents and creates a diverse landscape with new habitat, aquaculture and recreation opportunities.



PRECEDENT IMAGES:

DEPOLDERING NOORDWAARD, THE NETHERLANDS

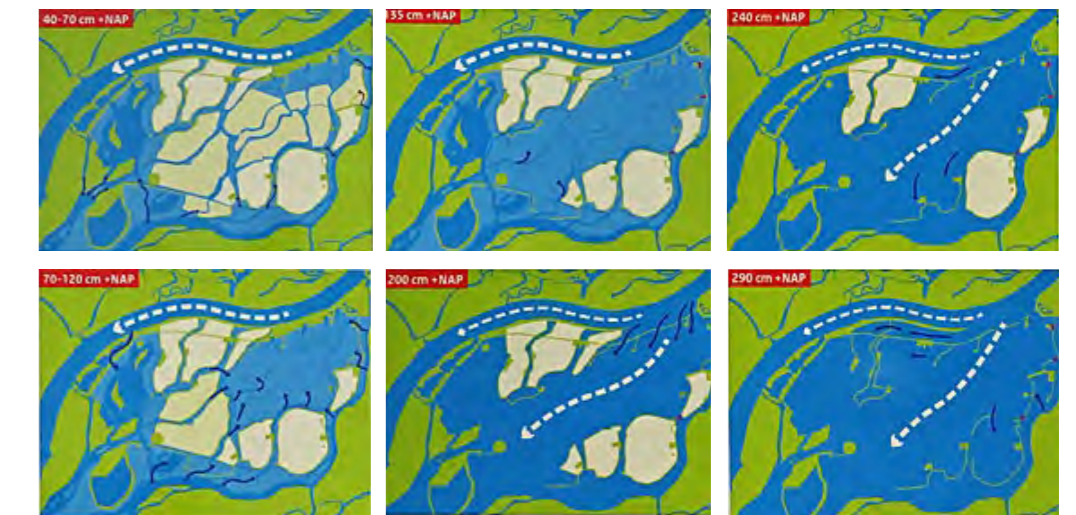
“The Noordwaard polder is one of the key areas of the National Dutch project Ruimte voor de Rivier (Room for the River). This polder is one of 39 locations holding great strategic significance for the water management of the main rivers of The Netherlands and thus for the safety of more than 4 million people. By lowering the dike of the Noordwaard polder the area will become subject to controlled inundation and function as a dedicated water detention district.”
- West 8



Depoldering Noordwaard: Phased Flooding
image: <https://www.deingenieur.nl/artikel/noordwaard-wordt-doorstroompolder>



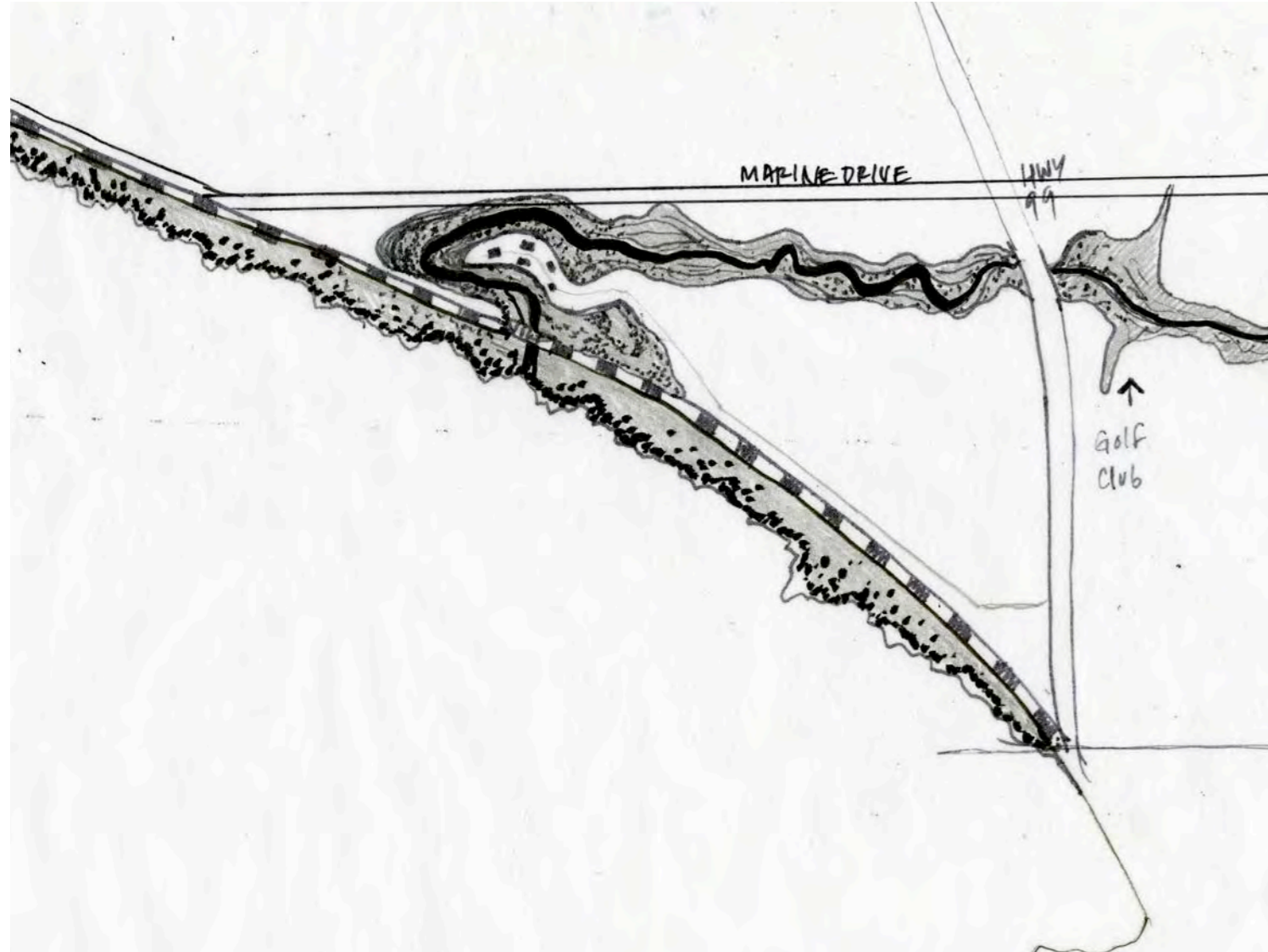
Bridges of Noordwaard, West 8
image: www.west8.nl/projects/infrastructure/noordwaard



Changes with high tide and other rising water levels
image: <https://www.dutchwatersector.com/news-events/news/15756-room-for-the-river-programme-completes-its-largest-depolderingproject.html>

ABSORPTIVE EDGES

Coastal marsh expansion and restoration as well as riparian restoration along the Little Campbell river will slow the speed of water moving through the floodplain and reduce erosion.



PRECEDENTS IMAGES:



Goldsmith Gulch before stabilization, Wenk Landscape Architecture
image: <http://www.wenkla.com/projects/parks-open-space-greenways/hutchinson-park/>



Goldsmith Gulch after stabilization and restoration, Wenk Landscape Architecture
image: <http://www.wenkla.com/projects/parks-open-space-greenways/hutchinson-park/>

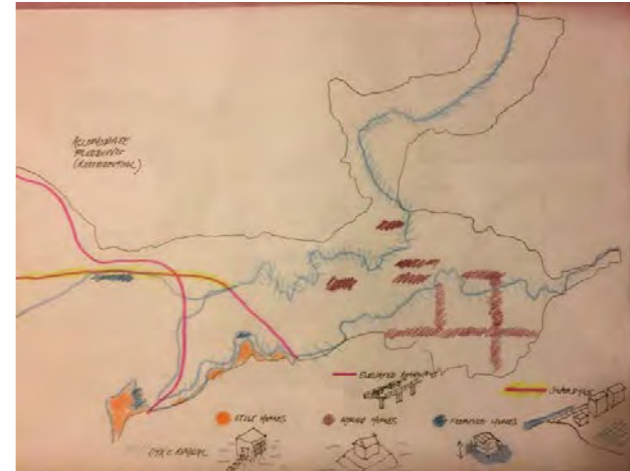
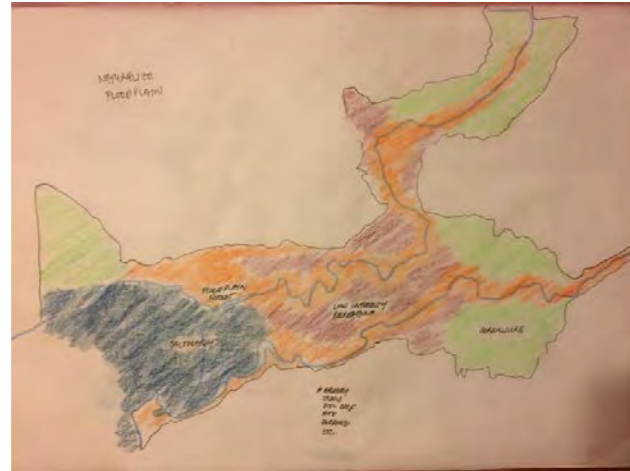
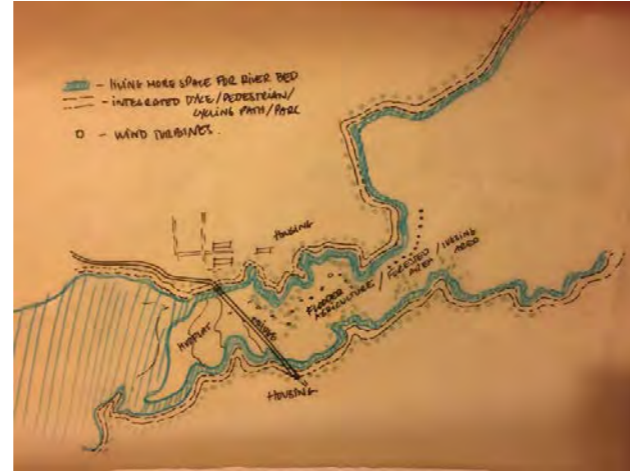
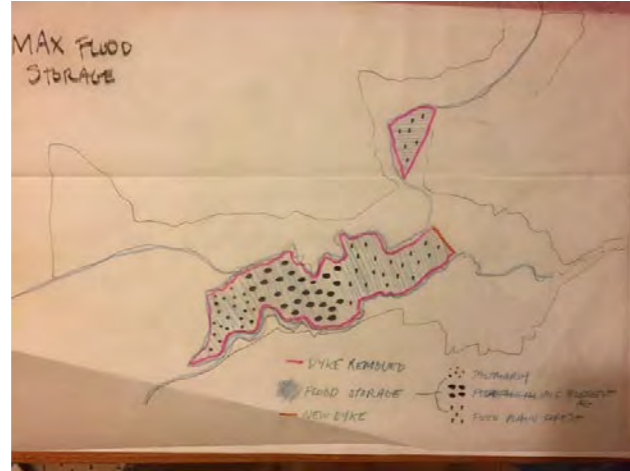
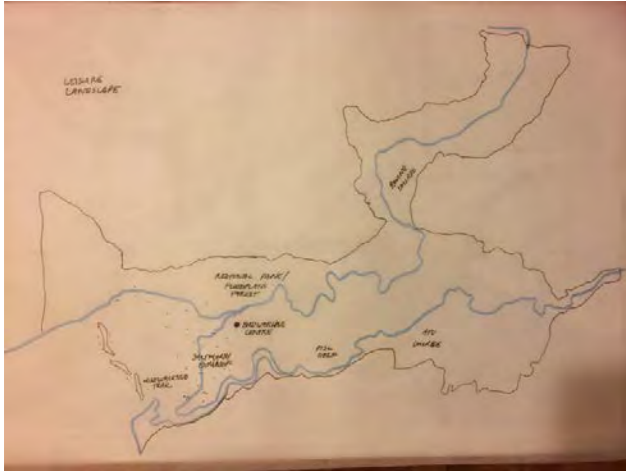


Jamaica Bay Salt Marsh restoration
image: <http://newyork.thecityatlas.org/author/jason/>

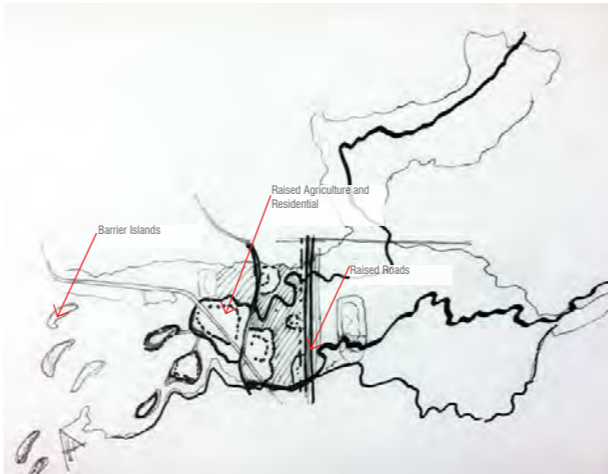
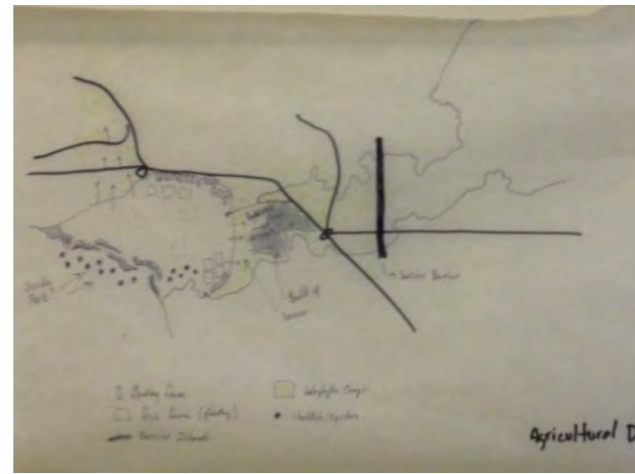
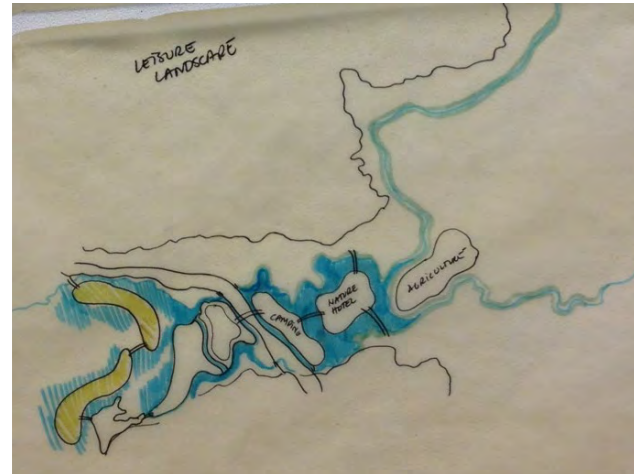


Coastal marsh restoration, community engagement
image: <http://gulfseafoodnews.com/11-w700h525/>

DESIGN CHARRETTE SKETCHES (MAY 12, UBC)



DESIGN CHARRETTE SKETCHES (MAY 12, UBC)



Land reclamation in coastal areas Mud Bay

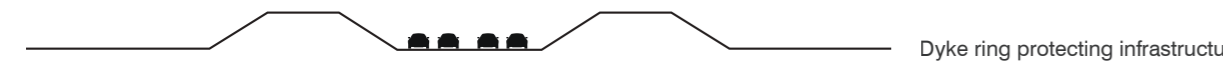
INFRASTRUCTURE PROTECTS AGAINST FLOODING



Relocate infrastructure on dyke



Dyke protecting infrastructure



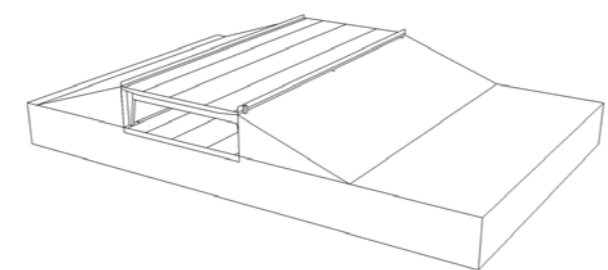
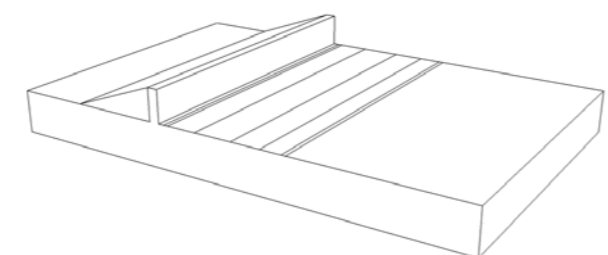
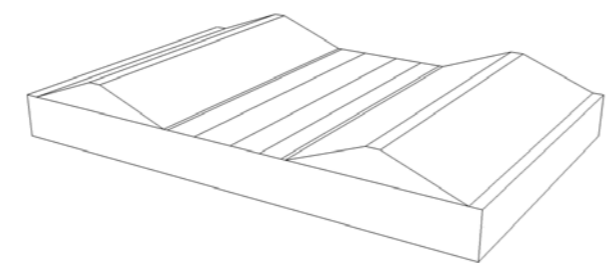
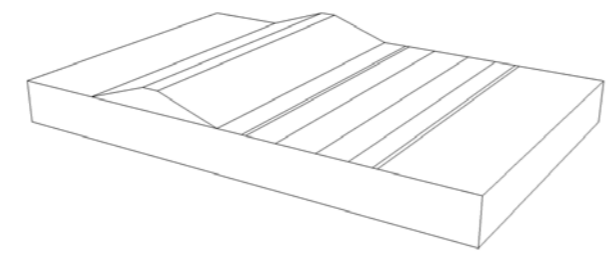
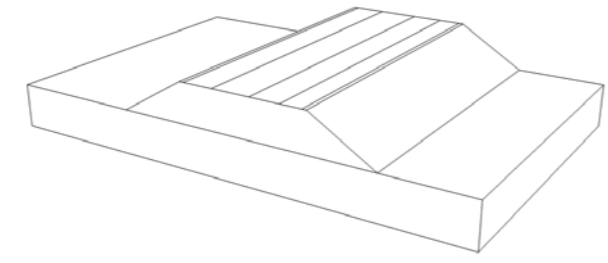
Dyke ring protecting infrastructure



Floodwall protecting infrastructure



Double level infrastructure integrated in dyke



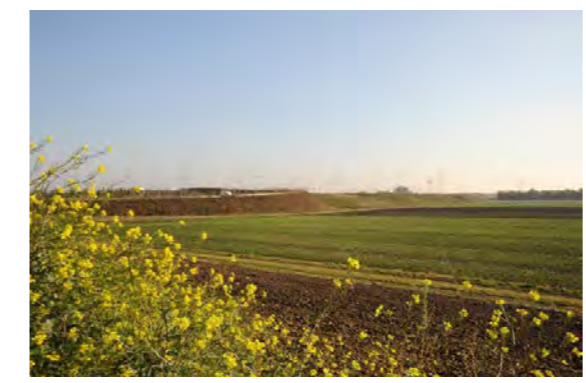
INFRASTRUCTURE PROTECTS AGAINST FLOODING



Hoogwatergeul Veessen - Wapenveld
image: <http://www.ijssewilde.com>



Elevated road
image: http://guardianlv.com/wp-content/uploads/2013/12/florida_marsh_300.jpg



Raised highway on dyke
image: <http://www.landzine.com/index.php/2012/02/vienna-detzhofer-landschaftsarchitektur/landform-by-the-vienna-highway-ring-by-detzhofer-landschaftsarchitektur-05>



Raised road structures
image: <http://refugeassociation.org/wp-content/uploads/2014/03/ding.jpg>

INFRASTRUCTURE ACCOMMODATES FLOODING



Semipermeable dyke structure



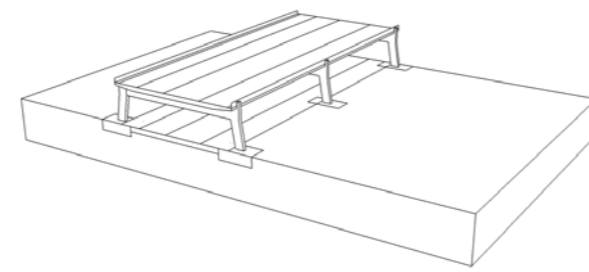
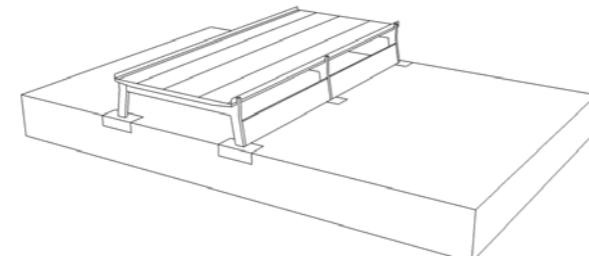
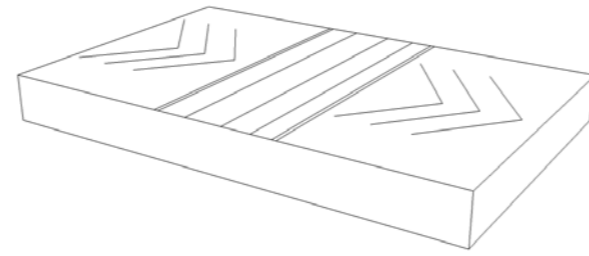
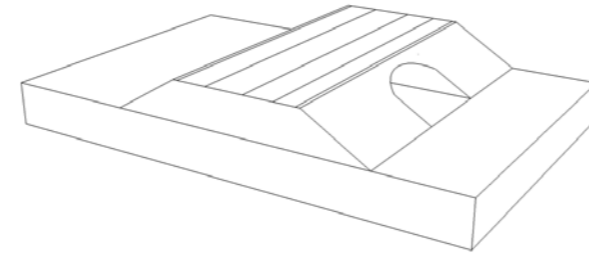
Floodable infrastructure



Elevated highway



Double level highway with floodable bottom part



INFRASTRUCTURE ACCOMMODATES FLOODING



Elevated road above floodable area
image: <http://www.luttjeboer.nl/projecten/stuwen-inlaten/hogwatergeul-veessen-wapenveld/>



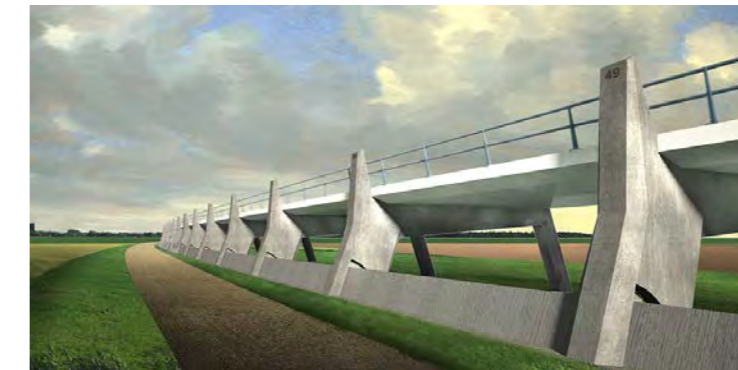
Hoogwatergeul Veessen-Wapenveld, NL
image: <https://architectenweb.nl/media/illustrations/2014/02/5304076e-64ed-40f5-bbc9-27dd19295a5c.jpg>



Elevated highway
image: http://www.rondreis.nl/media/blog/2209/2209_1000x670.jpg



Room for the River, Nijmegen, NL
image: <http://www.proraipersberichten.nl/bericht/799/>

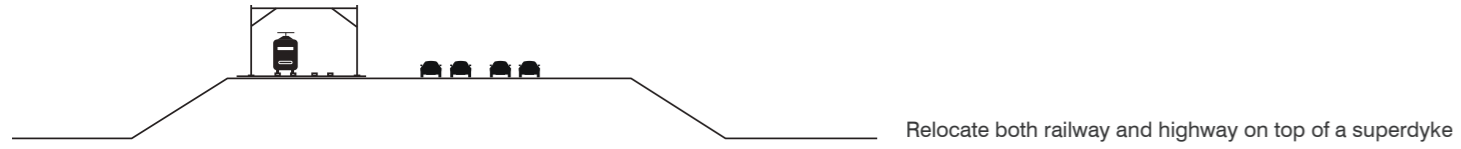


Hoogwatergeul Veessen-Wapenveld, NL
image: http://www.zus.cc/_we_thumbs_/2111_2_232_HoogwatergeulKerkdijk_vanaf-fietspad.jpg



Elevated road
image: https://images1.dallasobserver.com/imager/u/745xauto/7268713/toll_road1.jpg

COMBINED INFRASTRUCTURE



Relocate both railway and highway on top of a superdyke



Relocate railway along highway, protection by new dyke



Protection highway by new dyke, relocate railway on top of new dyke



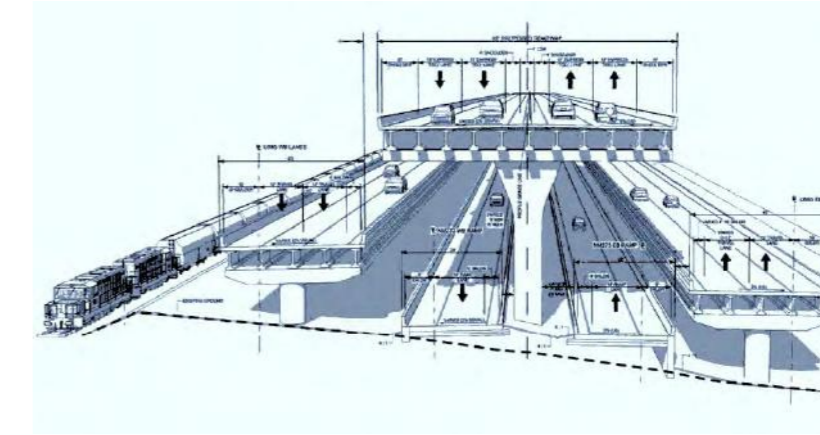
Elevated highway in combination with floodable railway

COMBINED INFRASTRUCTURE



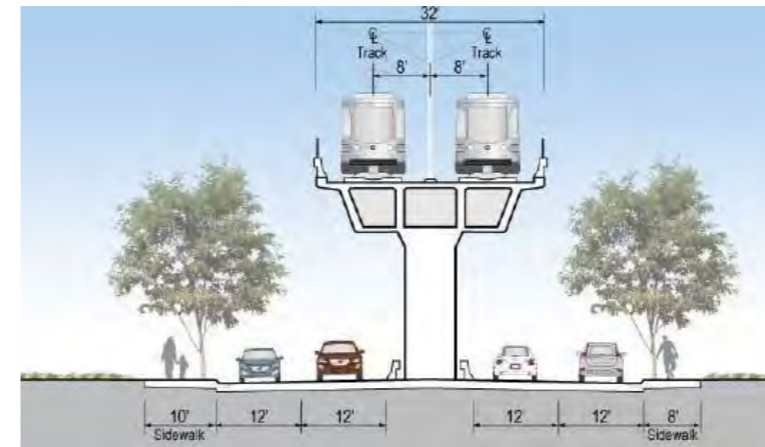
Combination train and highway

image: https://www.bart.gov/sites/default/files/images/basic_page/06_Sustainability_565x377.jpg



Combination train and highway

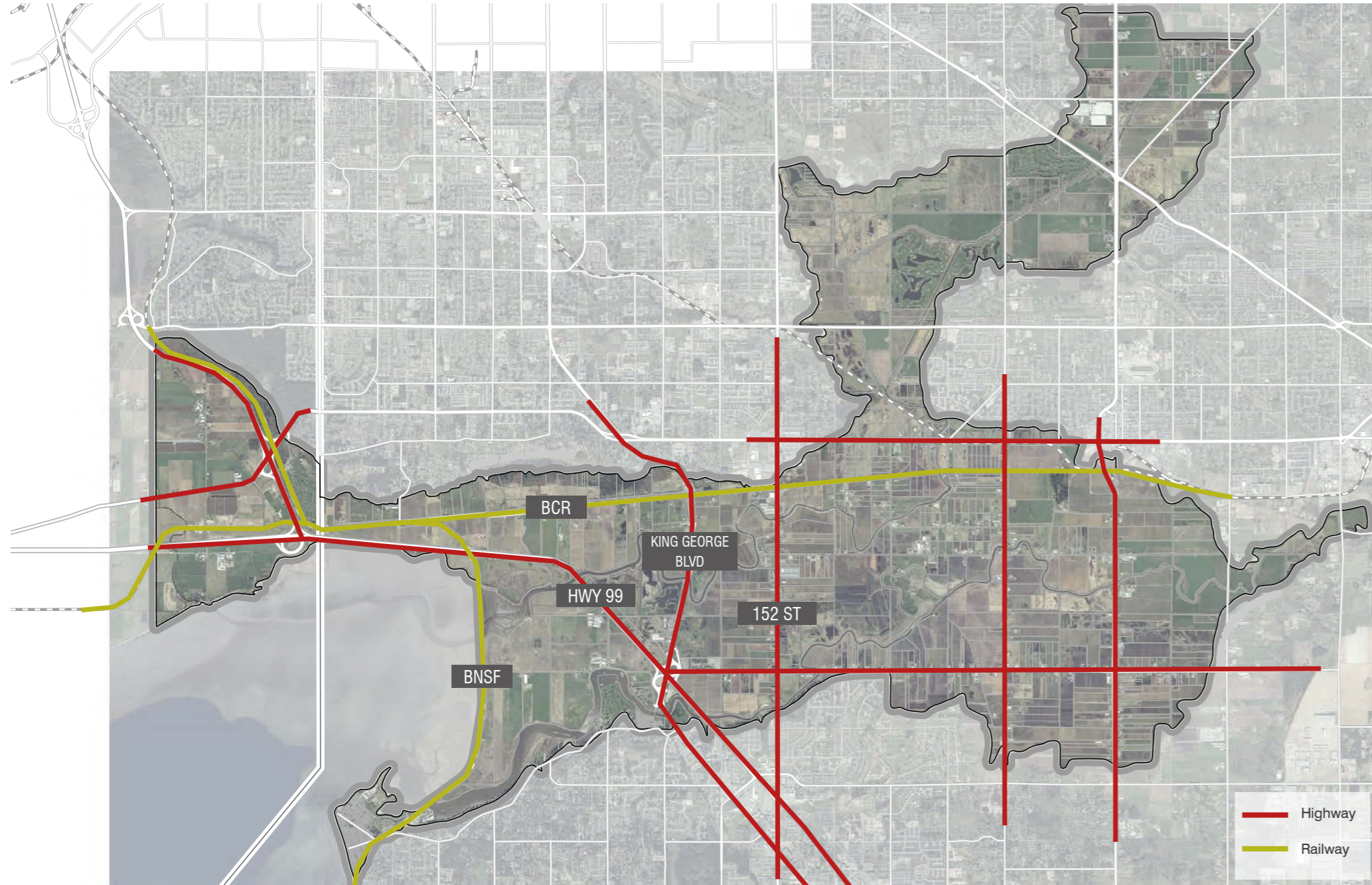
image: <http://1.bp.blogspot.com/-CCpJBq26Tho/UYht8IGTJQI/AAAAAAAAACKs/eVRX2nyeC5M/s1600/BHW+01.jpg>



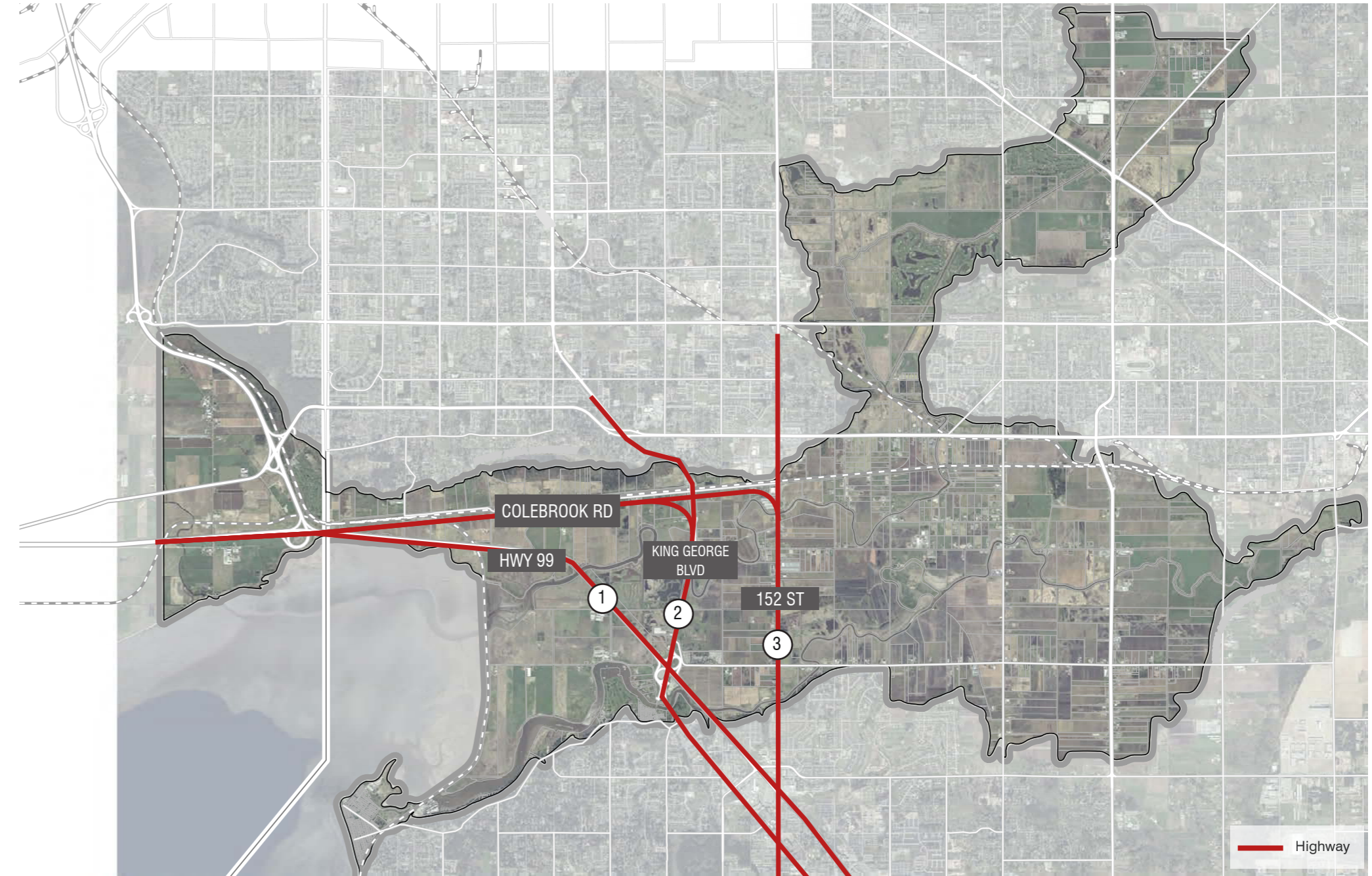
Combination train and highway

image: http://lh5.googleusercontent.com/-FMtWl6_ZhYc/UQgTAHhZB/AAAAAAAAAteg/YZpK6XgZQNW/s535/irt.JPG?gl=US

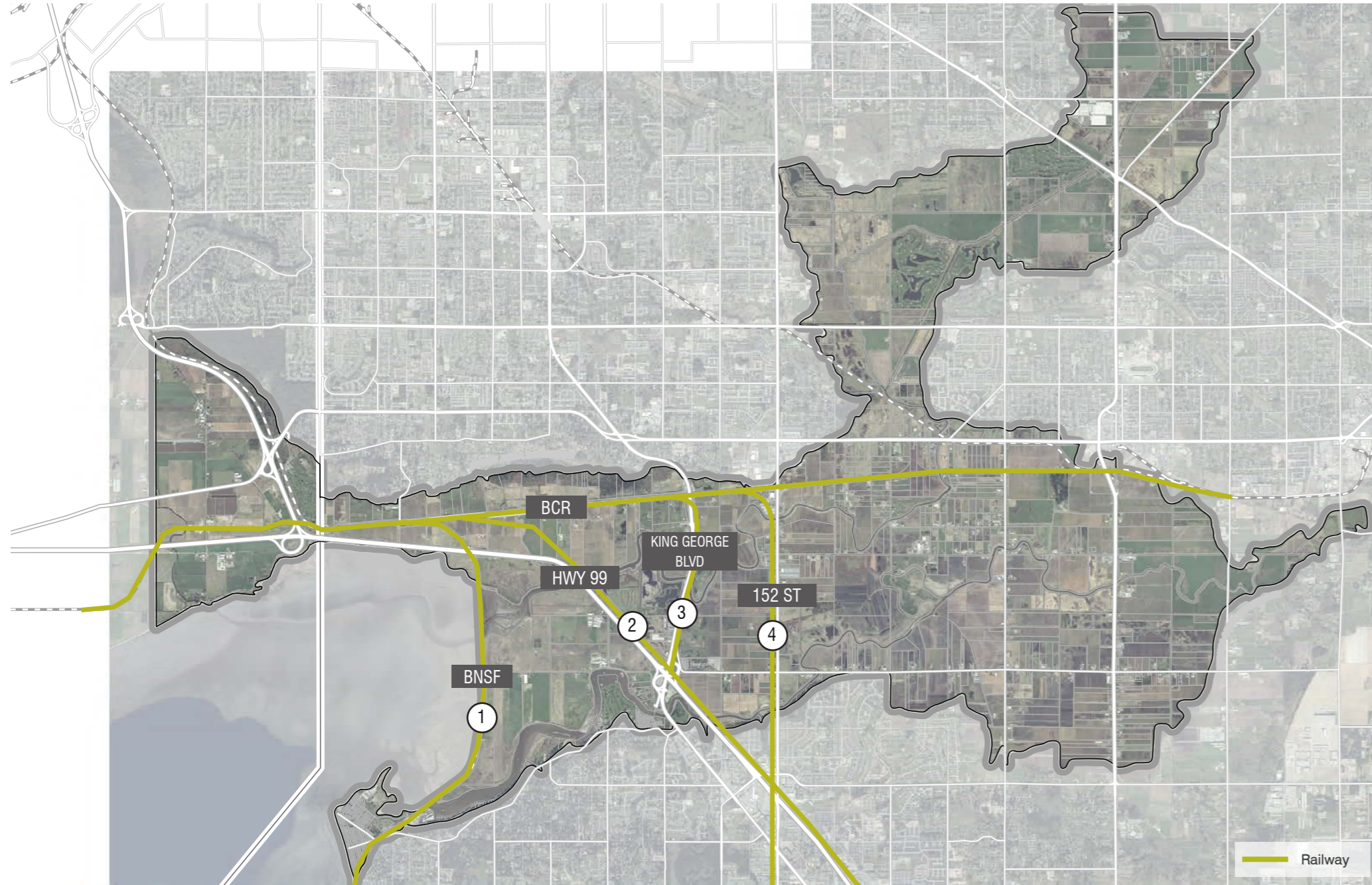
INFRASTRUCTURE CURRENT SITUATION



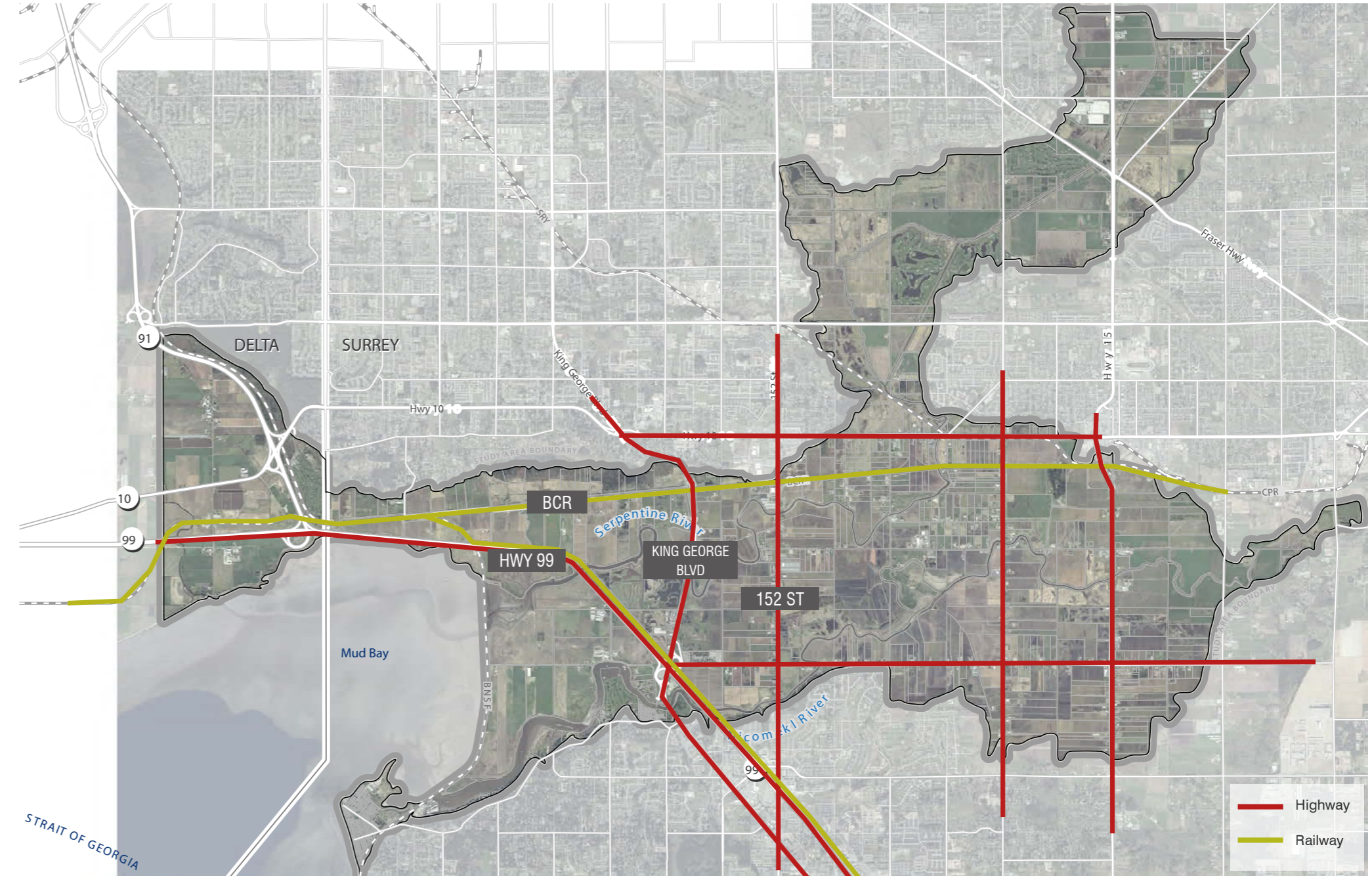
POSSIBLE INFRASTRUCTURE ROUTES CAR



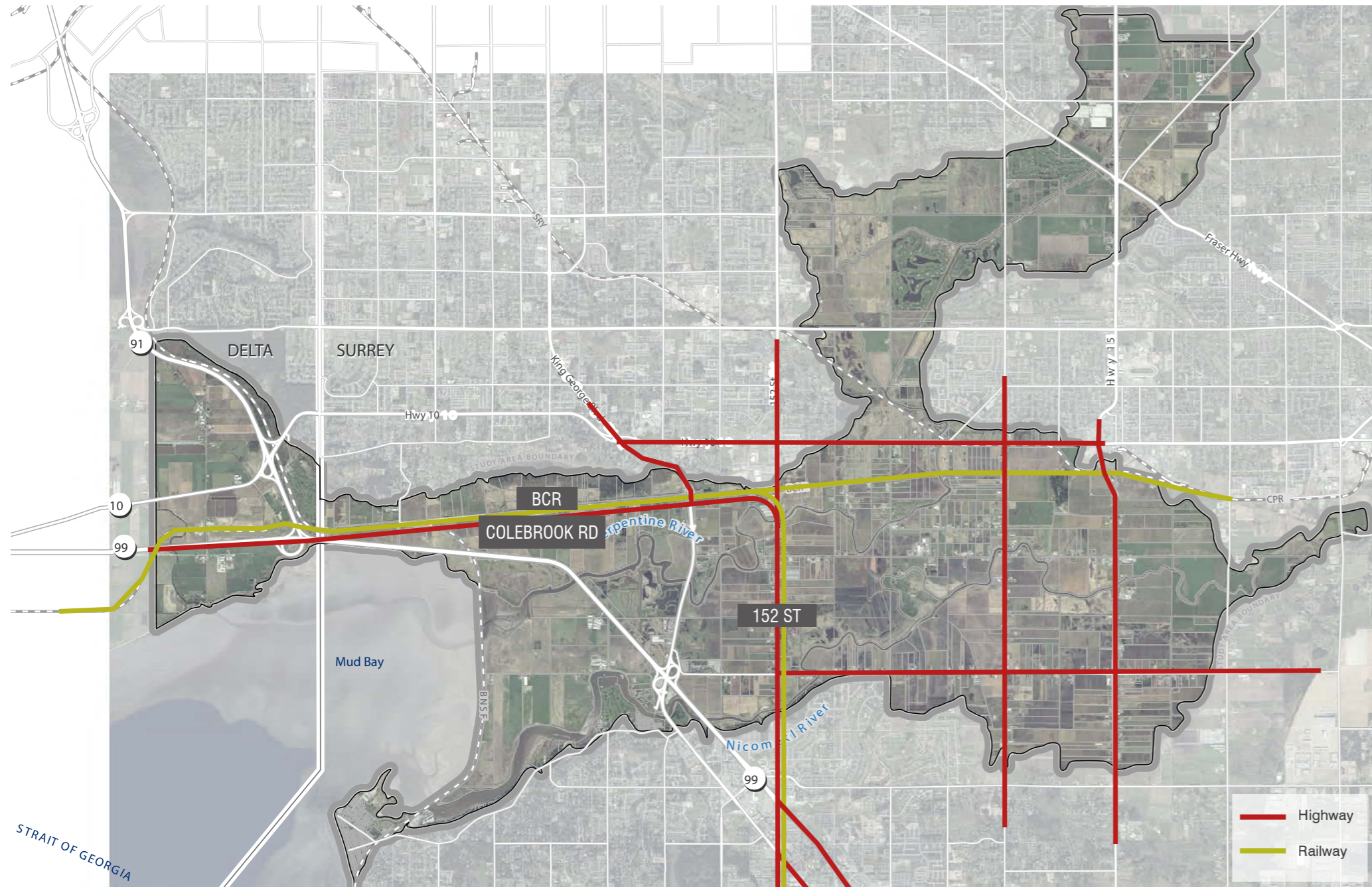
POSSIBLE INFRASTRUCTURE ROUTES TRAIN



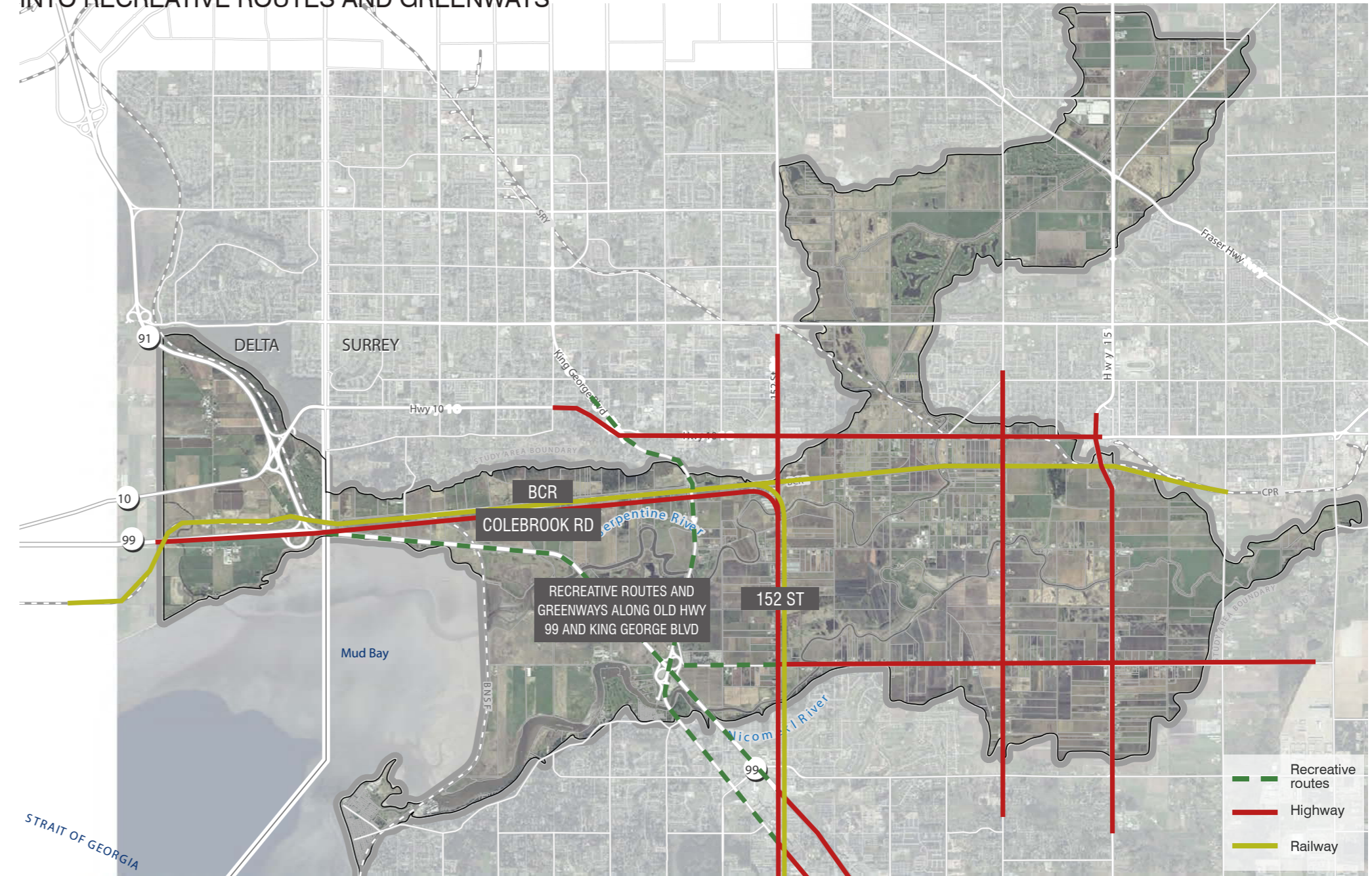
OPTION 1: COMBINATION HIGHWAY + RAILWAY AT HIGHWAY 99



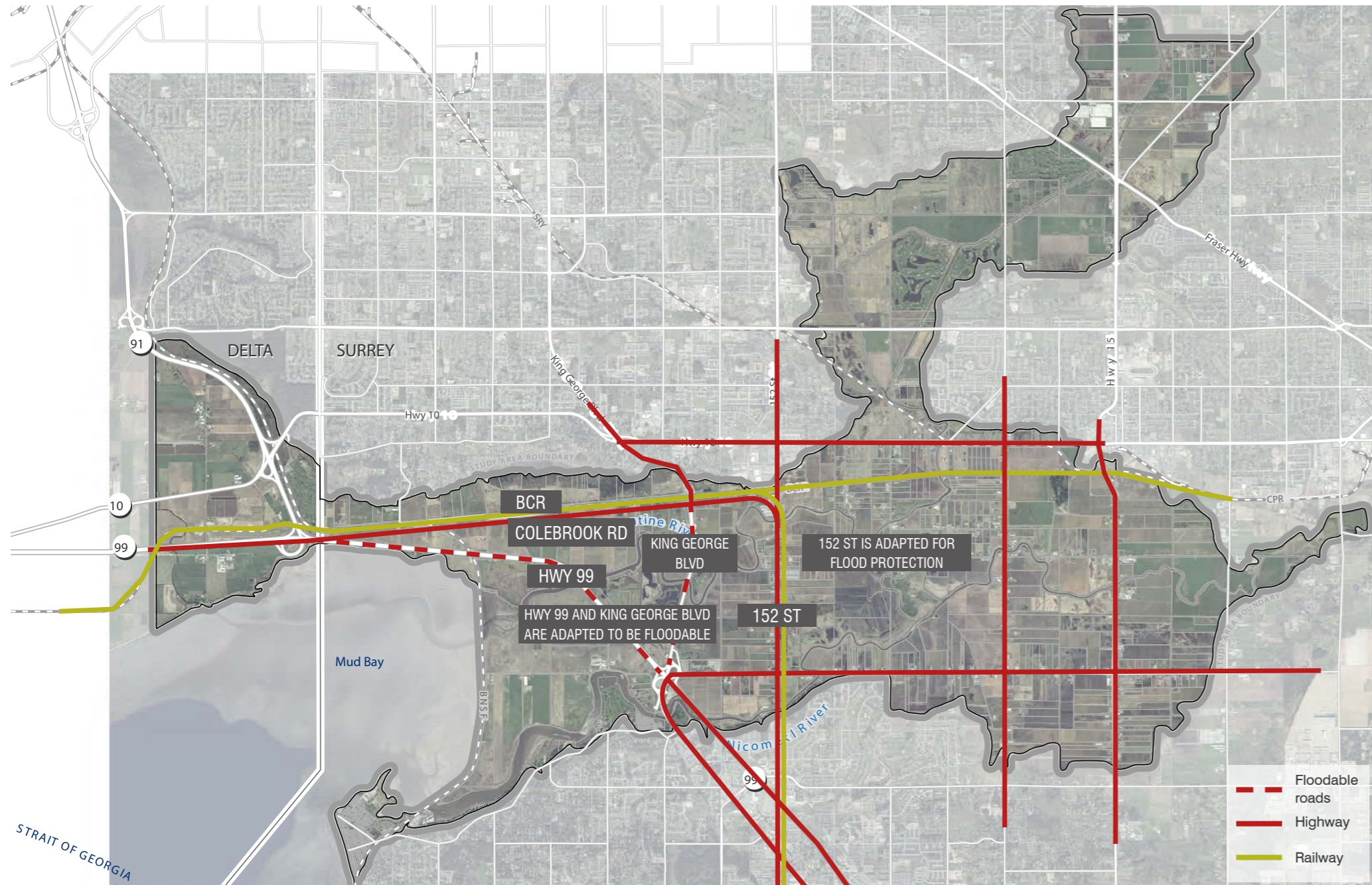
OPTION 2: COMBINATION HIGHWAY + RAILWAY AT 152 ST, REMOVAL HIGHWAY 99 AND KING GEORGE BLVD



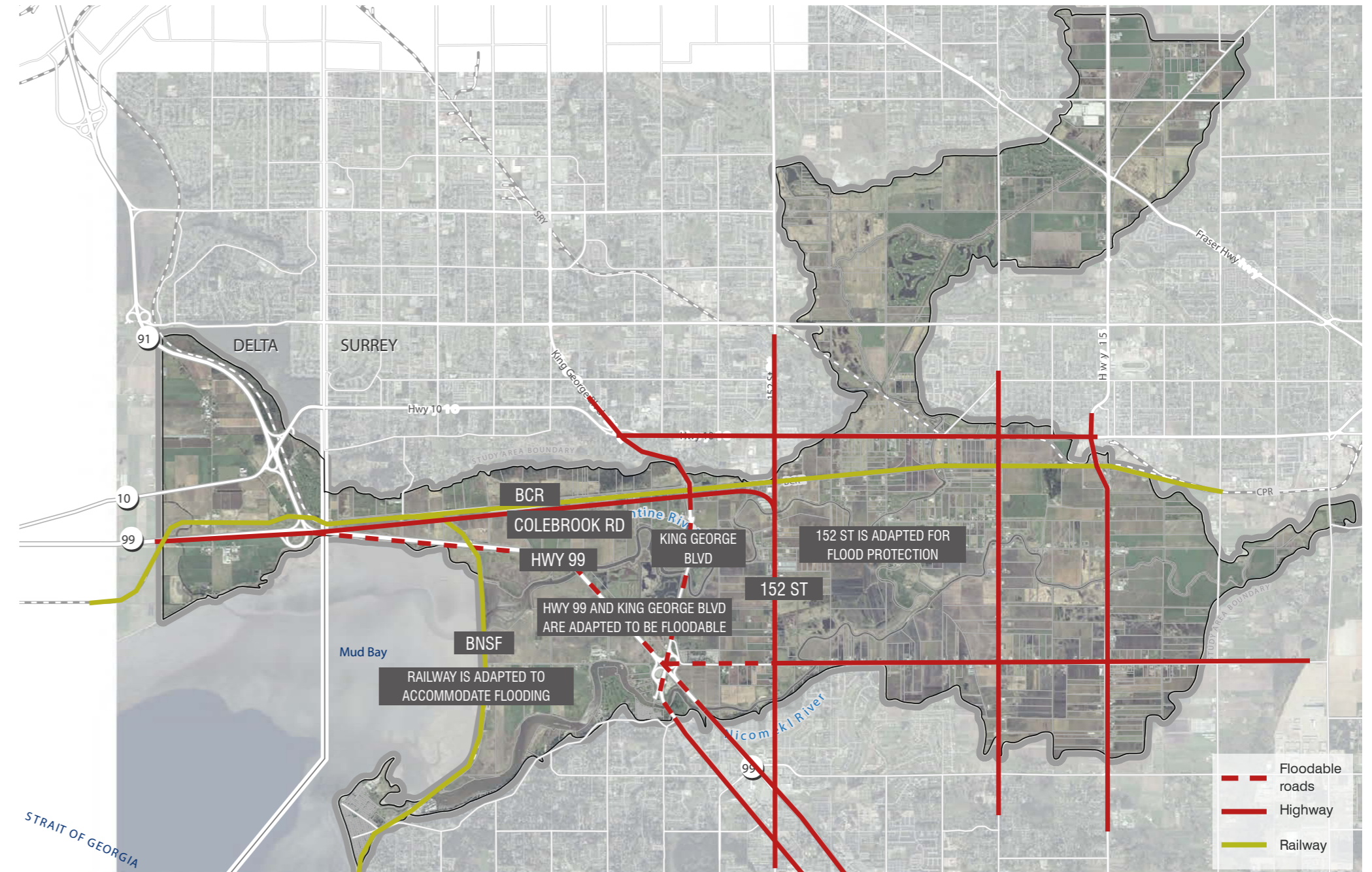
OPTION 3: COMBINATION HIGHWAY + RAILWAY AT 152 ST, HIGHWAY 99 AND KING GEORGE BLVD ARE TRANSFORMED INTO RECREATIVE ROUTES AND GREENWAYS



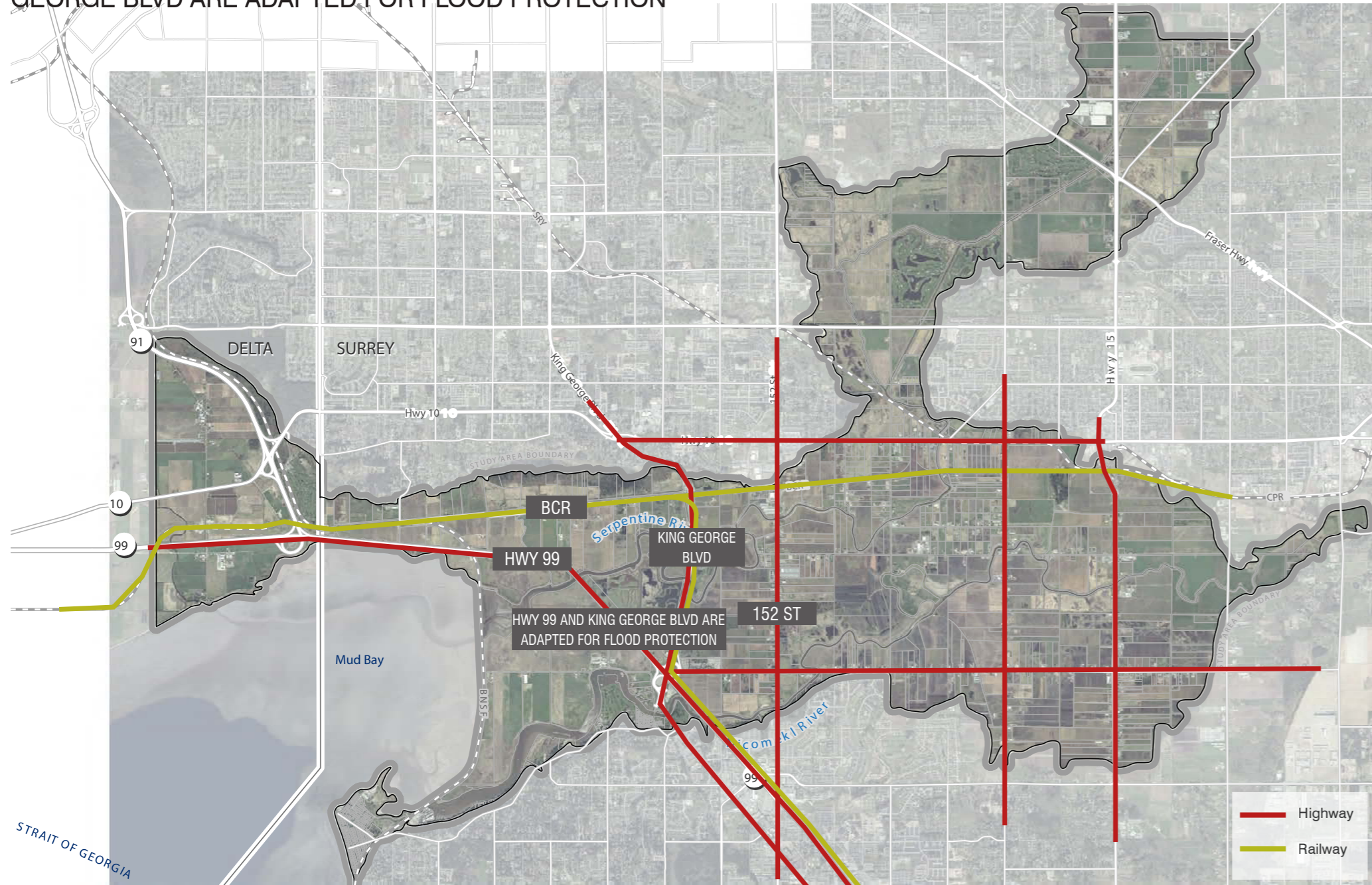
OPTION 4: COMBINATION HIGHWAY + RAILWAY AT 152 ST, HIGHWAY 99 AND KING GEORGE BLVD BECOME FLOODABLE



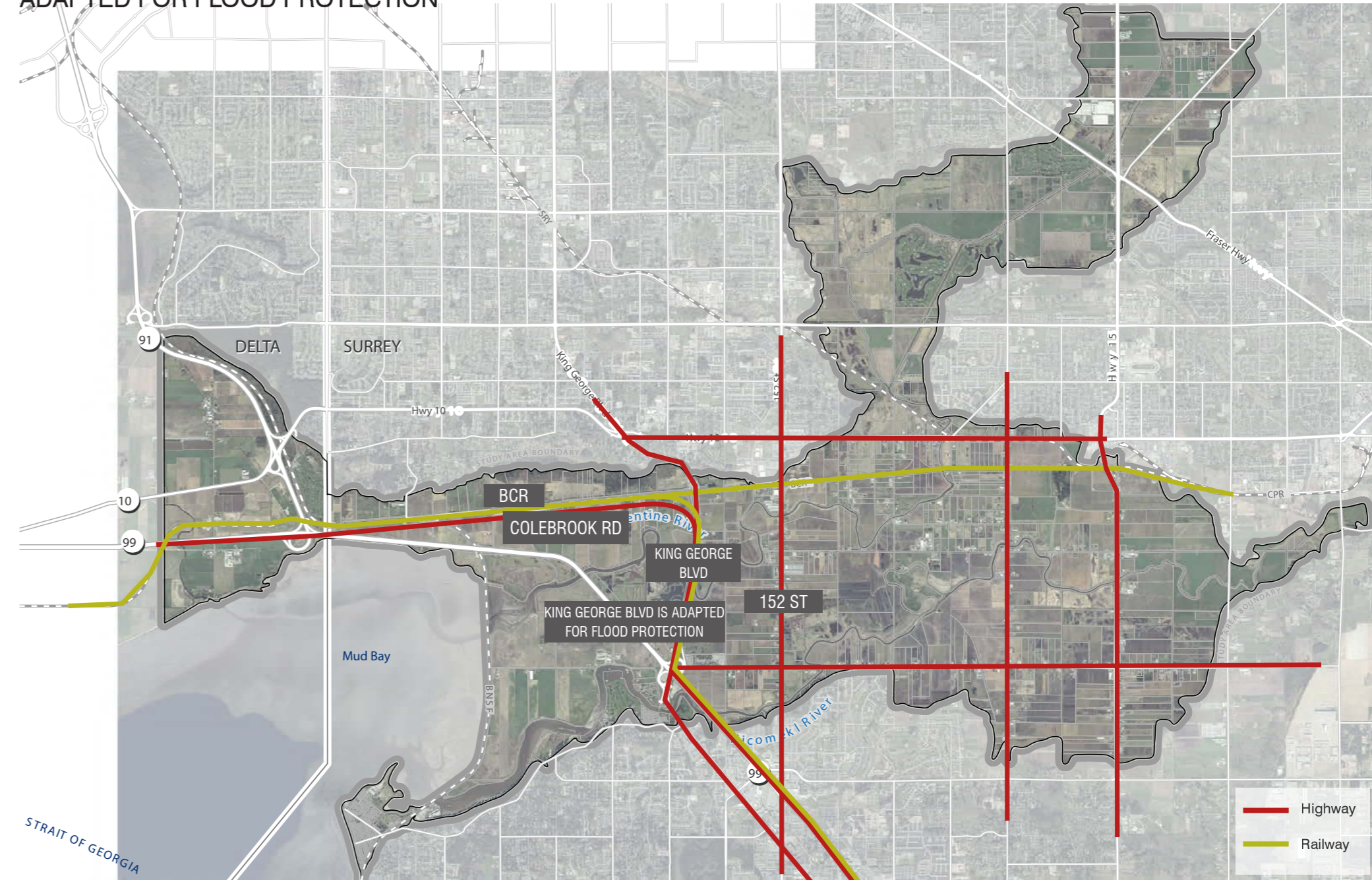
OPTION 5: ADAPT 152 ST + KING GEORGE BLVD & HIGHWAY 99 ARE FLOODABLE



OPTION 6: RELOCATE RAILWAY TO KING GEORGE BOULEVARD, HIGHWAY 99 AND KING GEORGE BLVD ARE ADAPTED FOR FLOOD PROTECTION



OPTION 7: RELOCATE RAILWAY AND HIGHWAY 99 TO KING GEORGE BOULEVARD, AND ADAPTED FOR FLOOD PROTECTION



OPTION 8: RELOCATE HIGHWAY 99 TO KING GEORGE BLVD

