River basins and deltas
Water systems and port economies in times of climate change: Rhine, Yangtze and Mississippi

PBL-TNC-CAUPD Seminar

Rotterdam, 11 – 12 October 2022

Report

Preface

This report documents the ideas and exchanges presented at the seminar *River basins and deltas Water systems and port economies in times of climate change,* held in Rotterdam and on-line on 11 and 12 October 2022. It was held precisely then and there in order to coincide with the 150th anniversary of the Nieuwe Waterweg, between Rotterdam and the North Sea.

The seminar had been envisaged as an activity of the Special Policy Study (SPS) *River Basins* of the China Council for international Collaboration on Environment and Development. Awaiting the formal start of the SPS, the seminar was held under the auspices of its lead organisations: PBL Netherlands Environment Assessment Agency, The Nature Conservancy (TNC) and the China Academy of Urban Planning and Design (CAUPD). The current report feeds the results of the seminar to the SPS, which is now formally mandated, to the seminar participants and to others who expressed interest.

New challenges in the coming decades – climate change, decarbonisation, demographic, economic and technology developments – will change the rules of the game in river basin management. Port economies and the surrounding deltas are one exiting situation where this will be on display. Very large interests are involved.

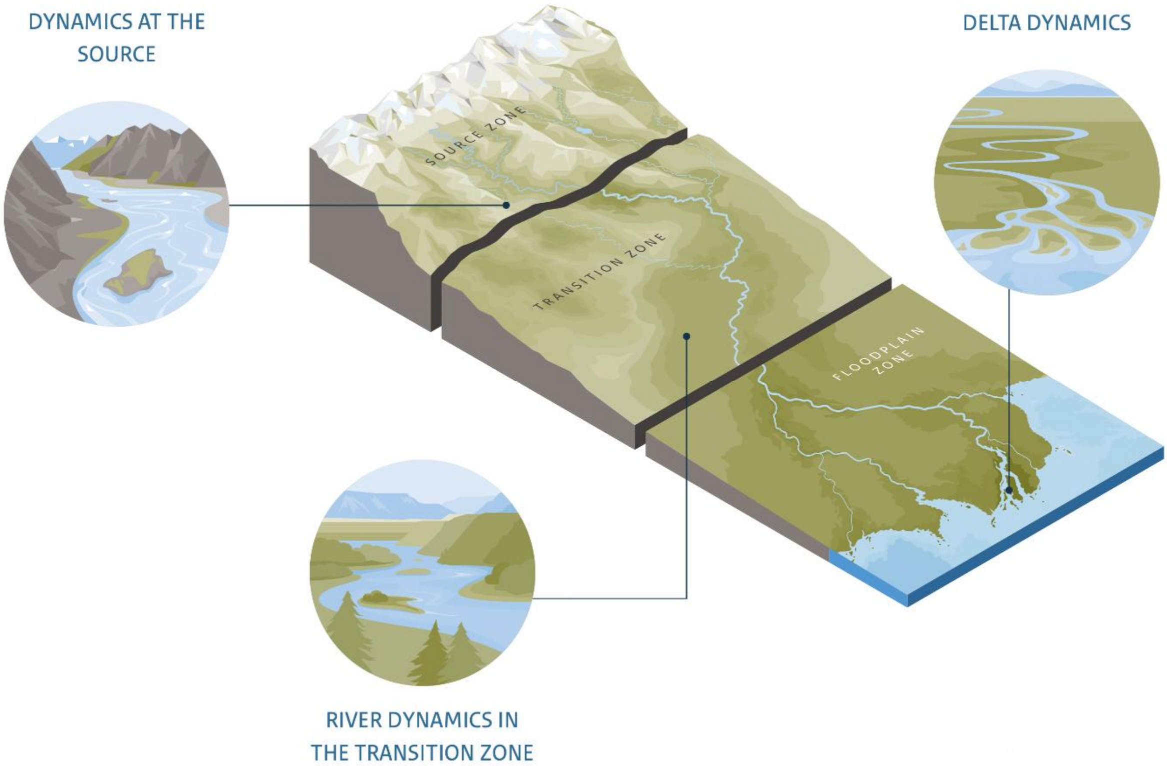
A premiss of the seminar was that in order to appreciate the scale and pervasiveness of the potential solutions to this upcoming combination challenges, one needs to study the previous ‘game change’. This previous ‘game change’ occurred typically 150 years ago, involved extensive engineering and effectively subjugated environment conditions to the requirements of the economy and expanding urbanisation. Changes in the coming decades would constitute a second game change and this time around would need to rebalance environment and economy – no longer one dominating the other.

Intellectual inputs by all participants are gratefully acknowledged, as is financial and practical support by the Netherlands’ Ministry of Infrastructure and Water Management and by PBL Netherlands Environment Assessment Agency. On-line participation was facilitated by MWee company; simultaneous translation was provided by Nancy Qin translators.

Han Meyer and Jan Bakkes (organizers)

Contents

I. Introduction and Kick-Off Document



© image from PBL River Basin & Delta Tool https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

Not just climate change

River basins and especially delta areas are currently confronted with climate change, which leads to changing conditions and to greater vulnerability to flooding, salt intrusion, but also to problems such as drought and freshwater shortages. However, it would be a mistake to look for the causes of these problems in climate change alone. In the search for effective long-term strategies, the changes in the physical conditions of river basins and delta areas, especially caused by human hands during the last century and a half, must also be considered. Although there were good reasons for these changes (economic development, urban growth and prosperity), the downside is that the resilience and dynamism of the natural system in these areas has declined sharply. The effects of climate change, such as rising sea levels and increasing peak discharges of rivers, can have a greater impact on river basins and delta areas due to this reduced resilience (PBL 2018).

The seminar that PBL, TNC and CAUPD want to organize in the autumn of 2022 is based on the observation that the transformation of river basins and delta areas during the 19th and 20th centuries can be considered a 'game-change': the game changed from a dominating role of the dynamics of natural systems to a dominating role of man-made land-use patterns, manipulating the natural systems with an overload of engineering (cf. PBL 2021). The central hypothesis, which we want to explore more carefully, is that we need a second game-change, which gives priority to restoring the dynamics and resilience of natural systems in river basins and delta areas. The working conference aims to discuss and determine whether such an approach is possible and effective. The question is what consequences such an approach has/could have for economic and urban development, and how this approach can be combined with strategies for energy transition and making our economies, cities and landscapes more sustainable.

To get a clear understanding of the current, second game-change, it is necessary to discuss also the first game-change: in order to understand the deep consequences and character of such a game change, and to learn from it.

A concrete proposal for the structure of the working conference follows in the last paragraph. First, we will discuss the backgrounds and character of the first and second 'game changers'.

The dynamics and formative power of the delta's natural system

The world of the 21st century is facing the enormous challenge of a complex combination of adaptation to climate change, of preventing an acceleration of climate change through energy transition, and of restoring biodiversity and the resilience of natural systems.

This complex combination of tasks occurs to an extreme extent in the catchment areas of the major river basins and in particular the delta areas, where the rivers flow into the sea and where the greatest economic and urban growth has taken place worldwide over the past 150 years and is still ongoing. The major rivers and especially their deltas are at the heart of the logistics process of production, transport and consumption of modern industrial societies.

It is true that this development has a long history. Nevertheless, we can say that the last century and a half, from the mid-19th to the end of the 20th century, is the period in which most river basins and delta areas experiencing a 'boost' of large-scale transformations that served to accommodate economic and urban growth. The Rhine, Yangtze and Mississippi deltas are striking examples.

These transformations not only resulted in a reclassification and functional change of the territory of the delta, but also had a strong influence on the dynamic and formative character of the delta. Deltas are the result of dynamic processes of rivers and sea, with regular and irregular changes in currents, tides, wave action, sediment transport and sedimentation, vegetation, wind, precipitation. Most deltas owe their present shape largely to the way in which these processes took place in the last 12,000 years, after the last Glacial Period. The large amounts of sediment that were brought in by rivers and the sea and subsequently became overgrown with vegetation, led to dynamic processes of land formation (Kleinhans 2010; Jarriel et al. 2021).

The dynamic nature of the natural system of deltas gave rise to three main characteristics of deltas: first, extraordinarily rich ecosystems. According to some, deltas and estuaries contain the richest ecosystems, with the most 'ecosystem services' of any ecosystem in the world (Costanza et al. 1997). Deltas include important intersections of migratory fish and migratory birds, which use deltas for foraging, spawning, and breeding.

Second, the dynamics of the delta led to the continuous formation of new (wet)land, which increasingly served as a protective buffer in the coastal landscape. It is true that these processes were erratic and in various places they also led to erosion and flooding of land. But the net result over the centuries was that the land in the delta grew with or even grew faster than the sea level rise (Seybold et al. 2007).

Third, the dynamics of water and sedimentation lead also, with some regularity, to structural changes in the course of the main river discharge and thus in the shape of the delta. The development of the Mississippi Delta shows several 'delta lobs', which are the result of changes in the course of the main river discharge since the last Glacial Period (Campanella 2006; Blum, Roberts 2012; Giosan, Freeman, 2014). These changes occur once every few hundreds or thousand years and are the result of the silting up of the estuary by sediment supply and deposits by the river itself and the sea. Now as the riverbed of the main discharge starts to silt up, it starts to act as a blockage, and the water tries to find another, easier way to the sea, especially in the case of huge peak discharges. The development of the Rhine/Meuse delta shows a similar process. The main discharge of the Rhine has moved south in several steps over the course of 12,000 years (Vos 2011).

These processes continued in most deltas until about the mid-nineteenth century, when large series of major interventions are started that radically change the hydrological system and the spatial structure of the deltas.

The first game change: From dynamic system to controlled mechanism

Two important developments during the nineteenth century are responsible for a fundamental 'game change' in the systems of river basins and delta: technology and the rise of nation-states. These two developments created the conditions for the era called 'the Anthropocene' (www.brittannica.com ; Sijmons 2014).

The technological revolution of the nineteenth century includes the invention of the steam engine and later the electric and gasoline engine, and the discovery and use of coal and later oil and gas as energy sources. The new energy sources and technical equipment created the necessity as well as the possibility of major adjustments to the water systems of deltas and rivers. The steam engine allowed for larger ship sizes; the larger ships required deeper waterways, which were made possible by steam and diesel-powered dredgers. Riverbed narrowing also took place on a large scale, resulting in deep waterways on the one hand and more available land for agriculture and urbanization on the other. The waters that mainly serve as a transport corridor are separated from the land by high dikes, where urban, agricultural and industrial development can take place. Due to intensive drainage of the swampy lowland, subsidence is occurring behind the dikes, increasing the vulnerability to possible flooding.

The new nation-states of the late 18th and 19th century created the institutional conditions for the large-scale, cross-regional interventions in the river basins, like Rijkswaterstaat (National Water Management Agency) in the Netherlands and the US Army Corps of Engineers in the USA (O'Neill 2006; Lonnquest et al., 2014; Meyer 2017).

The deltas of the Rhine, Yangtze and Mississippi all three show this development. It is true that there are many differences between the characteristics of these three deltas, but essentially the development process of each of these three deltas has the same characteristics. If you compare the maps of the three deltas from ca. 1850 with those of 2022, you will not only see a spectacular increase in urban and industrial land use, but also the consequences of large-scale river rectifications and normalisations, of new land reclamations, of countless waterworks such as new canals, dikes, dams, locks, of roads, railways, pipelines. We also see what has disappeared: many tens of square kilometres of intertidal areas: wetlands, mud flats, salt marshes, sandbanks, beaches, dunes.

What took place during this period, which began with the deployment of the first steam-powered ships, dredgers and drainage pumps, and has in fact still not ended, can be called a first fundamental game-change. With the rise of the fossil fuel based industrial society, compared to the previous centuries, a fundamental change of the game has taken place, with new players, new rules and new outcomes.

The net result is that, during the last century and a half, delta areas have been drivers of explosive economic growth and prosperity. Not only have the delta areas themselves become centers of economic growth and wealth, but this development has also been crucial for the hinterland. The Mississippi has become the main transportation corridor of the United States since the mid-19th century; 90% of what is shipped across the Mississippi and its tributaries goes to or comes from ports in the Mississippi Delta (O'Neill 2006). The Rhine basin is the economic artery of Europe, or the 'Blue banana' according to the French geographer Roger Brunet (1989). For the development of the Rhine into a Blue banana, the transformation of the Rhine delta into an efficient transhipment and distribution center played a key role (Klemann, Wubs 2013).

In China, the Yangtze Delta and the Pearl River delta are the two most densely urbanized regions of the national territory; together they are responsible for 40% of the GDP of China (www.thinkchina.sg)

However, the flip side of this development is that the delta has changed from a natural system to something resembling a mechanical system. The entire water system of the river and delta has taken the form of an industrial machine. This also creates the illusion that rivers and their deltas can be controlled and monitored like an industrial machine. The toll that must now be paid for this illusion is threefold.

Firstly, we must note that the 'mechanisation' of the delta has led to a large decline in biodiversity. In some deltas, the specific features of the delta ecosystem have largely or even almost completely disappeared. Not only did this lead to a considerable impoverishment of fauna and flora in the delta landscape itself; this also has major implications for life on Earth in a much larger context. With the disappearance of large parts of delta nature, an essential link in the food chains of countless birds, fish, shellfish and plants in our rivers, seas and oceans has disappeared (https://www.worldwildlife.org/habitats/wetlands).

Directly linked to this is the second major problem: the disappearance of a large part of the formative capacity and thus of the resilience of the natural system of the delta. Instead of processes of siltation, land accretion and soil raising, other processes have come to dominate: erosion, subsidence, ever higher water levels in the river mouths and a saltwater tongue penetrating deeper and deeper into the land. And insofar as there is still a supply of sediment, as the most important building block for land formation, it is dredged away to keep the rivers at their depth for shipping (Ericson et al. 2006; Tessler et al. 2015; Hoitink et al. 2020).

Thirdly, the attempt of optimal control and fixation of the river and delta has led to the natural process of displacement of the estuaries appears to have come to an end. We emphatically state that this process '*appears* to have come to an end', as we see that water management authorities over the past hundred years have been forced to build more and more engineering works in the river system in order to maintain the existing main drainage riverbed. In the Mississippi Delta, a series of dams, spillways and flood ways have been created around the connection between the Mississippi and Atchafalya Rivers to counteract the natural system's tendency to divert the main drainage to the Atchafalaya River. Nevertheless, it is feared that the time will come when this tendency will no longer be countered, with disastrous consequences for the city of New Orleans and the surrounding area (Barnett 2017; Day et al. 2014). In the complex network of river courses of the Rhine/Meuse delta, a series of interventions have also taken place that counteract the tendency of the Rhine and Maas rivers to discharge more and more water via the Haringvliet and force this discharge out to sea increasingly via the Nieuwe Waterweg near Rotterdam (Vellinga et al. 2014).

More than fifty years ago it became clear that maintaining this approach to the river system is harmful and unsustainable. The first large-scale protests against the loss of river and delta nature date back to the 1960s and have led to the first major adjustments in the Netherlands, such as the cancellation of the complete closure of the Oosterschelde and the construction of the Markerwaard. Not coincidentally, the report for the Club of Rome, The Limits to Growth (1972), was published during this period.

Although the main aim of these protests and changes was to prevent the disappearance of the delta nature, the need for a fundamental change in economic growth was already hinted at as a guiding principle in the development of natural landscapes (Buelens 2022). The American landscape architect Ian McHarg introduced an analysis and design method for wetland landscapes in the 1960s, in which he introduced the need to make a distinction between slow (climatic, geological, geomorphological, hydro morphological) change processes and faster, often human-initiated, change processes such as infrastructure development and urbanization (McHarg 1969). His position was that it is important to take good account of the slow processes, to offer sufficient space for this, and to adapt infrastructure and urbanization accordingly. In practice, he saw exactly the opposite happening, with disastrous results. This method was later elaborated in the Netherlands and became known as the 'layer approach', which was advocated in various government memorandums of the 1990s and 2000s (Meyer 2017).

The relevance of this layer approach became apparent from the 1990s, when the first signs of climate change emerged and it became clear that the channelled river courses did not have sufficient capacity to discharge the increasing amounts of melt and rainwater due to climate change. The Dutch *Room for the River* program (2005-2015) was the first important implementation of the layer approach. Restoration of the river ecosystem was combined with the task of increasing the discharge capacity of the rivers and restoring and strengthening the resilience of the natural system (Sijmons et al. 2017).

Also, in and around the Mississippi Delta, the first ideas for major modification of the river drainage system date back to the 1990s and gained momentum after the 2005 Hurricane Katrina disaster. The wetlands of the delta have been subject to severe erosion since the 1930s. As a result of the channelling of the Mississippi river, all the tributaries that fed sediment- and nutrient-rich freshwater into the wetlands were dammed. The wetlands form a buffer that dampens the force of hurricanes. Erosion of these wetlands is catastrophic to the survival of the city of New Orleans (Campanella 2006; Barnett 2017).

However, with the latest insights and predictions regarding climate change and sea level rise (IPCC 2022; Deltares 2018), the question is whether the changes in the Rhine/Meuse delta, Mississippi delta and Yangtze delta are sufficient. The restoration of nature and especially the restoration of the dynamics and the shaping capacity of the deltas requires a significantly more radical 'game change'.

Towards a second game change: restore the dynamics and resilience of the natural system in combination with energy transition

The need of a new ‘game change’, giving priority to nature-based solutions in delta areas, has already been addressed frequently (Costanza 1997; Temmerman, Kirwan, 2015; Day et al. 2014). However, the major task in delta areas is twofold: to restore the resilience of the natural system and provide room for its dynamics, and to shape the transition from fossil to non-fossil energy sources. This means a combination of maximum mitigation as well as adaptation.

One of the main driving forces behind these changes in deltas is the port and shipping industry. In many cases, and certainly also in the deltas of Mississippi, Rhine and Meuse and Yangtze, the transhipment, storage and processing of fossil fuels plays a central role. Port development and shipping were the basis for the radical spatial and hydrological transformation of the delta, but also for the fact that the deltas have become central hubs in an economic system based on fossil energy sources. Due to the large amount of space required and the many infrastructural systems, the port and shipping system also appears to be the most difficult to change. Because of this strategic role of ports and shipping in the delta areas, and to make the discussion more concrete, the consequences for ports and shipping will have to be explicitly discussed when discussing possible future prospects for these delta areas.

Discussions are ongoing in both the Netherlands and the Mississippi Delta about the most effective and desirable strategies for making the delta resilient to sea level rise. In the Netherlands, three approaches seem to emerge in the Sea Level Rise Knowledge Programme: (1) continue the development of the past century, with even stronger civil engineering works and on a larger scale, (2) a 'retreat' of cities and economic activity to higher grounds, and (3) more room for restoration and reinforcement of the natural system, in the expectation that this will also lead to processes that make the delta less vulnerable to sea level rise and higher peak discharges (Ligtvoet et al. 2009, 2011; Haasnoot et al. 2019).

Also, in the Mississippi Delta there seems to be a balancing of comparable alternatives, as was reflected in the design competition 'Changing Course' (http://changingcourse.us/).

The first option (reinforcement of the existing system) only seems to cause more problems in both deltas in the longer term. Maintaining an increasingly large-scale 'armour' to protect low-lying territory will encounter increasing technical, managerial and financial problems. It seems much too early for the second option ('retreat'); hopefully it doesn't have to come to that. To prevent this option, something will have to be done in the delta areas.

That is why, during the working conference, we propose to seriously examine the possibilities for a fundamental game change based on a new priority for space for the natural system.

The seminar October 11 – 12, 2022

The foregoing argument can be summarized with the following figure:

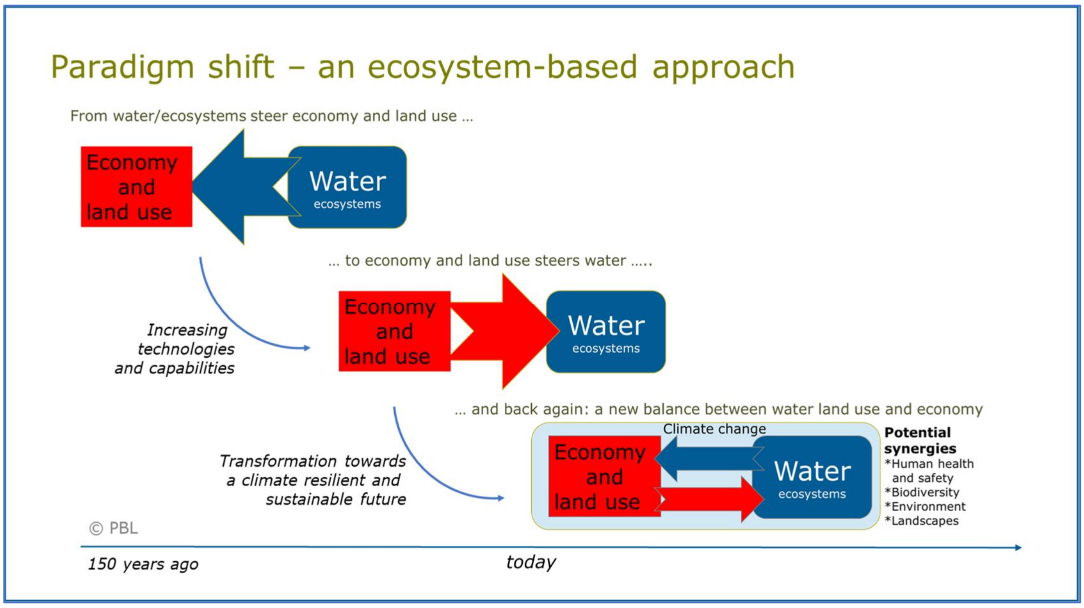


Figure 1. (Ligtvoet et al. in prep.)

The transition of the upper relationship diagram between water and economy to the middle diagram represents the first game change: from a system in which water is leading, and economic and urban development is following, to a system in which economics and urban development are dominant, resulting in adaptations of the water system. The transition from the middle relationship diagram to the bottom one reflects the current task: a new 'game change', leading to the implementation of a hybrid system in which the water system on the one hand and the economy and land use on the other hand find a new balance.

The seminar '*River basins and deltas - Water Systems and Port Economies in Times of Climate Change: Rhine, Yangtze and Mississippi'* aims to investigate to what extent the idea of the first and second game change is relevant for these three river basins and deltas, and in what sense it can give direction to a new approach for a new balance between economic and environmental development.

In particular, attention will be focused on:

a) the precise nature of the dynamics and shaping forces of the three delta regions; (b) how these dynamics and formative forces were dealt with in the period late 19th century – early 21st century, and what effects this had on the physical conditions of the delta; (c) what options are available to use 'nature-based solutions' to create space for the dynamics of the delta and to use it to restore the resilience of the natural system; (d) what possibilities there are for combining energy transition, sustainable economic development and new land use patterns with more room for delta dynamics.

These four questions will be addressed on both days by three experts on the three deltas. Subsequently, a panel of four experts in the field of water management, urban development, ecology and port economics will reflect on the potential consequences of the proposed strategies for these four fields.

References

Barnett, James F., 2017, *Beyond Control. The Mississippi River's New Channel to the Gulf of Mexico.* Jackson (MS): University of Mississippi.

Brunet, Roger, 1989, Les Villes 'Européennes'. Rapport pour la DATAR (Délégation à l'Aménagement du Territoire et à l'Action Regionale). Paris: Reclus.

Buelens, Geert, 2022, *Wat we toen al wisten. De vergeten groene geschiedenis van 1972* [What we already knew then. The forgotten green history of 1972]. Amsterdam: Querido.

Campanella, Richard, 2006, *Geographies of New Orleans. Urban fabrics before the storm.* Lafayette: Center for Louisiana studies.

Costanza, R., R. d'Arge, R. Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, et al. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature* 387: 253–260

Day, John W., G. Paul Kemp, Angelina M. Freeman, David P. Muth (editors), *Perspectives on the Restoration of the Mississippi Delta. The Once and Future Delta*, Dordrecht Heidelberg New York London: Springer

Deltares, 2018, *Mogelijke gevolgen van versnelde zeespiegelstijging voor het Deltaprogramma. Een verkenning* [Possible consequences of accellerated sea level rise for the Delta Program. An exploration]. Delft.

Ericson, Jason P., Charles J. Vörösmarty, S. Lawrence Dingman, Larry G. Ward, Michel Meybeck, 2006, 'Effective sea-level rise and deltas: Causes of change and human dimension implications'. *Global and Planetary Change* 50/1–2, 63–82

Giosan, Liviu, Angelina M. Freeman, 2014, How Deltas Work: A Brief Look at the Mississippi River Delta in a Global Context, in: John W. Day, G. Paul Kemp, Angelina M. Freeman, David P. Muth (editors), *Perspectives on the Restoration of the Mississippi Delta. The Once and Future Delta*, Dordrecht Heidelberg New York London: Springer, 29-32.

Haasnoot, Marjolijn , Ferdinand Diermanse, Jaap Kwadijk, Renske de Winter, Gundula Winter, 2019, *Strategieën voor adaptatie aan hoge en versnelde zeespiegelstijging. Een verkenning* [Strategies for adaptation to high and accelerated sea level rise. An exploration]. Delft: Deltares.

Hoitink A. J. F., J. A. Nittrouer, P. Passalacqua, J. B. Shaw, E. J. Langendoen, Y. Huismans, D. S. van Maren, 2020, Resilience of River Deltas in the Anthropocene, *Journal of Geophysical Research: Earth Surface 125/3: open access.*

IPCC, 2022, Climate change 2022: Impacts, Adaptation and Vulnerability. New York: United Nations.

Jarriel, Teresa, John Swartz, and Paola Passalacqu, 2021, Global rates and patterns of channel migration in river deltas, *Proceedings of the National Academy of Sciences* (*PNAS*) 118/46: 1-8

Kemp G. Paul, Clinton S. Willson, J. David Rogers, Karen A. Westphal, S. Ahmet Binselam, 2014, Adapting to Change in the Lowermost Mississippi River: Implications for Navigation, Flood Control and Restoration of the Delta Ecosystem, in: John W. Day, G. Paul Kemp, Angelina M. Freeman, David P. Muth (editors), *Perspectives on the Restoration of the Mississippi Delta. The Once and Future Delta*, Dordrecht Heidelberg New York London: Springer, 51-84.

Kleinhans, Maarten G., 2010, Sorting out river channel patterns, *Progress in Physical Geography* 34/3: 287–326

Klemann, Hein A.M., Ben Wubs, 2013, *River Dependence Creating a Transnational Rhine Economy 1850-2000,* Rotterdam: Erasmus University.

Ligtvoet, Willem, Joost Knoop, Bart Strengers, Arno Bouwman, 2009, *Flood protection in the Netherlands: framing long-term challenges and options for a climate-resilient delta.* The Hague: PBL.

Ligtvoet, Willem et al., 2011, *Climate adaptation in the Dutch Delta. Strategic options for a climate proof development of the Netherlands.* The Hague: PBL

Lonnquest, John, Bert Toussaint, Joe Manous Jr., Maurits Ertsen, 2014, *Two centuries of experience in water resources management. A Dutch – U.S. Retrospective.* Alexandria (VA): Institute for Water Resources, US Army Corps of Engineers, and Rijkswaterstaat, Dutch Ministry of Infrastructure and the Environment.

McHarg, Ian, 1969, *Design with Nature.* New York: Natural History Press.

Meyer, Han, 2017, *The State of the Delta. Engineering, urban development and nation building in The Netherlands.* Nijmegen: VanTilt.

PBL (2018), *The Geography of Future Water Challenges.* The Hague: PBL.

PBL (2021), *Navigating Rivers and Deltas towards a Sustainable Future.* The Hague: PBL Netherland Environmental Assessment Agency. https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

O'Neill, Karen, 2006, *Rivers by Design. State power and the origins of U.S. flood control.* Durham (NC): Duke University Press.

Seybold, Hansjörg, José S. Andrade, Jr., Hans J. Herrmann, 2007, Modeling river delta formation, *Proceedings of the National Academy of Sciences* (*PNAS*) 104/43: 16804-16809

Sijmons, Dirk, 2014, Waking up in the Anthropocene, in: Brugmans, George, Jolanda Strien, *Urban by Nature. International Architecture Biennale Rotterdam*. Rotterdam: IABR.

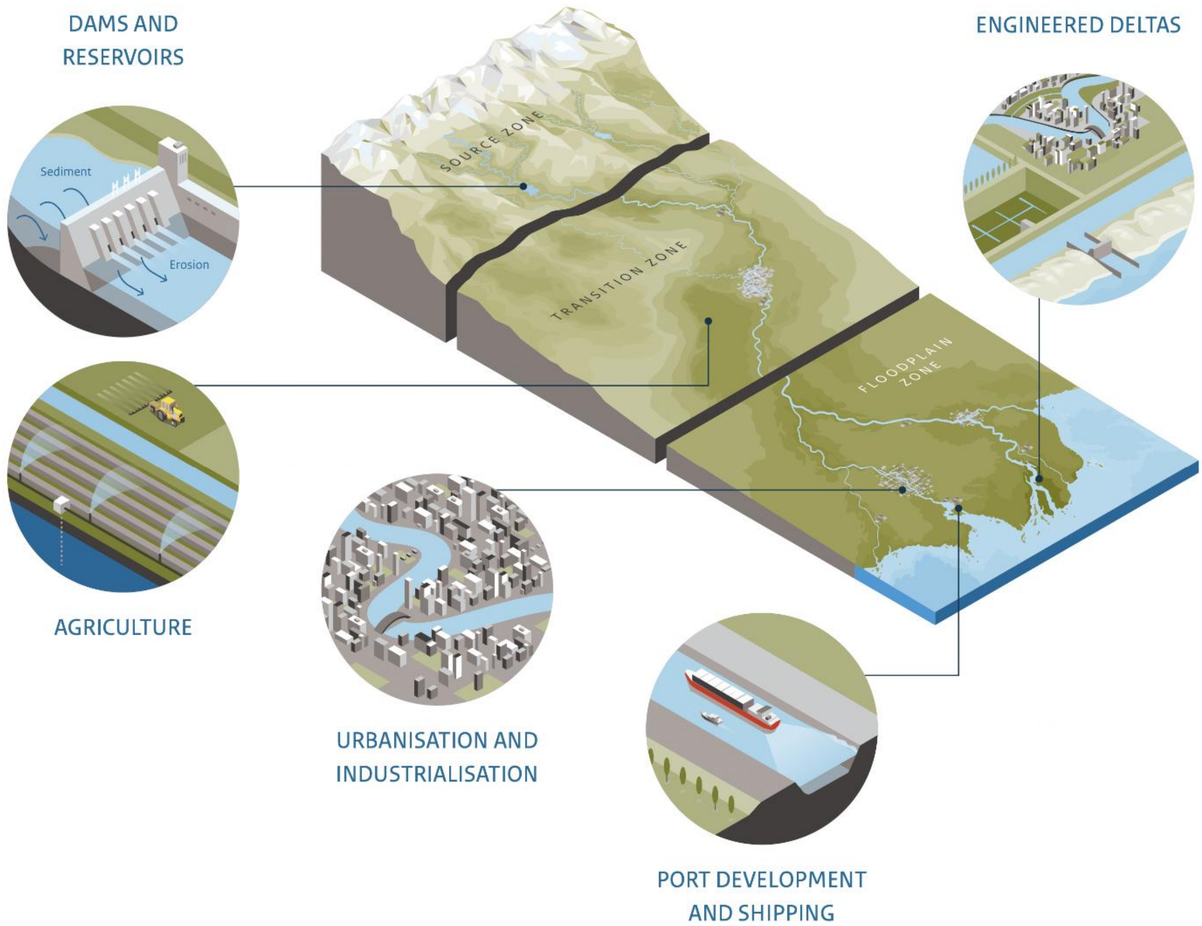
Sijmons, Dirk, Yttje Feddes, Fed Feddes, Eric Luiten, 2017, *Room for the River. Safe and attractive landscapes.* Wageningen: Blauwdruk.

Tessler Z.D., C. J. Vörösmarty, M. Grossberg, I. Gladkova, H. Aizenman, J. P. M. Syvitski, E. Foufoula-Georgiou, 2015, 'Profiling risk and sustainability in coastal deltas of the world'. *Science* 349/638 pp. 638-643

Vellinga N.E., A.J.F. Hoitink, M. van der Vegt, W. Zhangc, P. Hoekstra, 2014, Human impacts on tides overwhelm the effect of sea level rise on extreme water levels in the Rhine–Meuse delta. *Coastal Engineering* 90: 40–50

Vos, Peter, 2011, *Atlas van Nederland in het Holoceen* [Atlas of the Netherlands in the Holocene], Amsterdam: Prometheus.

II. Minutes of the seminar



© image from PBL River Basin & Delta Tool https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

DAY 1

The first 'game change'

The creation or our current rivers basins and deltas, starting with the large-scale interventions in the water systems from the 19th century until the current state-of-affairs. What did the first game change look like, and to what consequences did it lead? Delta development before the mid-19th century and after. Consequences for current problems, exacerbated by climate change/accelerated sea level rise.

PBL director *Hans Mommaas* welcomes the participants and outlines background and purpose of the seminar. In particular, attention will be focused on:

- the precise nature of the dynamics and shaping forces of the three delta regions;
- how these dynamics and formative forces were dealt with in the period late 19th century – early 21st century, and what effects this had on the physical conditions of the delta;
- what options are available to use 'nature-based solutions' to create space for the dynamics of the delta and to use it to restore the resilience of the natural system;
- what possibilities there are for combining energy transition, sustainable economic development and new land use patterns with more room for delta dynamics.

By way of overall introduction, *Willem Ligtvoet (*PBL principal investigator, international waters programme), explains the need of another game change in the relation between economic development and water systems. Deltas find themselves in a critical state, and this will worsen in the next decades due to plans for 3700 new dams in rivers worldwide, ongoing urbanization, sand mining and other human actions, delivering profit at the short term but increasing problems at the long term. Over and above this comes climate change, for example bringing sea level rise to deltas that are already at risk of shrinking because insufficient sediment is supplied. All over the world, a more sustainable approach of delta regions will result in costs at the short term, but larger benefits at the long term.

The statement of Ligtvoet is illustrated and underlined by the three next speakers:

Jaap Kwadijk (NL, Deltares) argues that a fundamental transition in Dutch water management started in the 1990s, after two extreme high-water events in the Dutch river area. The program 'Room for the River[1]' (2005 – 2015) and the Delta program (started in 2009) aim to create more room for water and 'working together with water'. This contrasts with the essentially reactive policies of the decades and centuries before. Implementation of this new approach is possible thanks to: (1) a modest but steady budget of 1 billion euro per year); (2) a law, namely the *Delta Act*; (3) a programme with a long time horizon, namely the *Delta Program*; (4) institutional anchoring at Minister-level, by way of the *Delta Commissioner*.

However, Kwadijk emphasized that the discussions on climate change and uncertainty concerning sea level rise stimulate the rise of the idea that The Netherlands are not safe anymore for long term economic investments and these perceptions are an economic reality in their own right. In retrospect, decades of high-profile engineering are now looked upon with a mixture of pride (because of effectiveness) and spite (because of the path dependency created). The current question is how to find a new balance between necessary short-term interventions and investments, and a new general belief in long term benefits and sustainability. One reason for 'pride' with the current tools is to have set up a system of periodic review of the Delta Program.

Li YuanYuan (PRC, General Institute of Water Resources and Hydropower Planning and Design, vice-president; National Committee of International Water Resources Association, president) shows the importance of a solid analysis and comprehensive approach of (1) water dynamics, (2) socio-economic dynamics and (3) ecological-environmental dynamics. These three types of dynamics are highly dependent of their own driving forces, but they also influence each other. It is important to understand the gigantic scale of these forces as well as their mutual influences. Li argues that it is necessary to develop a new general approach, implemented by new major measures.

The new general approach should be based on a solid relation between different scales of action: the scale of the river basin (creating a sustainable water-sediment balance), the delta scale (creating natural buffer areas for peak discharges as well as for fresh water storage during droughts), and the city scale (compact urban and industrial development). *New major measures* should be: guaranteed

---

[1] A central Program Bureau was appointed by the State. This Program Bureau developed scenarios concerning future expectations of peak discharges. These scenarios lead to the goal to increase the capacity of the whole system to a discharge of 16.000 m3/sec (instead of the existing capacity of 12.000 m3/sec). Furthermore, the Program Bureau ordered that this goal should be combined with the goal to improve the ecological and spatial quality of the river bed areas substantially. Subsequently, 39 project locations, functioning until then as critical bottlenecks during peak discharges, were appointed to implement these goals in concrete projects. For each project location special project groups were appointed, with local stakeholders, representatives of local interest groups, local politicians, together with hydraulic experts, spatial planners and landscape architects. A special 'quality team', composed of different disciplinary experts, kept an eye on the implementation of the general conditions of the Program Bureau. In this way a workable balance was created between central, general goals and decentral, local involvement. See for more information: Sijmons, Dirk, Yttje Feddes, Fed Feddes, Eric Luiten, 2017, *Room for the River. Safe and attractive landscapes.* Wageningen: Blauwdruk.

fresh water supply by creating key reservoirs; flood control by changing flow diversion ratio in the delta; and measures concerning ecological-environmental protection and improvement.

Justin Ehrenwerth (USA, The Water Institute of the Gulf) shows the importance of the repair of a sustainable water-sediment balance for the Mississippi delta. Due to narrowing and diking the Mississippi river, sediments don't arrive anymore in the delta wetlands but disappear in the sea, next to the mouth of the river. The result is a dramatic shrinkage of the wetlands during the last century and the loss of their function as a buffer to protect New Orleans against the violence of hurricanes.

The new *Louisiana Coastal Masterplan* provides a repair of a series of distributaries in the delta by breakthroughs in the Mississippi dikes, which will lead to in a renewed sediment and freshwater supply in the delta area itself, resulting in a recovery of the wetlands. Important features of the masterplan are (i) consistent engagement of stakeholders, including major enterprises in the area; (ii) 'structured assessment' of developments and options, as basis for everyone's engagement; (iii) periodic review of the plan.

Panel discussion

TU Qiyu (PRC, Shanghai Academy of Social Sciences) emphasizes the need and possibility to combine ecological, economic and spatial ambitions, by referring to the central position of the Shanghai water reservoir in the new Shanghai Metropolitan Masterplan. The lake is an important central feature for fresh water supply as well as for spatial quality and recreation. Also other elements of the main green ecological corridors can play these multifunctional roles. Interestingly, once the city of Shanghai had declared its intention to give this central waterbody an important role in its plan, all adjacent municipalities understood it was in their interest to join the planning process.

Bart Kuipers (NL, Erasmus University Rotterdam) emphasizes that the Chinese and Dutch deltas are strongly interconnected with each other by trade flows. However, the question is if this strong relationship will sustain in the future. Kuipers argues that a process of 'deglobalization' has started, putting more emphasis on coherence of national and continental economies and trade flows than on global interconnectedness. While current trade flows in the port of Rotterdam show a dominance of import flows, Kuipers predicts a dominance of export of local industrial products in the next decades. This transition makes it possible to reconsider the land use in the port in relation to necessary environmental and water related interventions.

Arnoud Molenaar (NL, City of Rotterdam) is concerned about the lack of directives of central authorities. Currently, spatial planning is at the mercy of 'bottom-up' initiatives, while a water system needs a comprehensive, system-wide approach, especially when it is necessary to combine this with other important societal questions, like energy transition and urban development. He argues that the national authorities should take their responsibilities and take the lead in an integrated water management and spatial planning program.

Anne Loes Nillesen (NL, DeFacto Urbanists) addresses the complexity of such a comprehensive planning: Everything is different everywhere. For example, the Dutch water system is not one entity, but a complex, hardly understandable composition of many different polder units, each with a different groundwater level and with its own water patterns and problems, and in the same time all these polders are very dependent from each other. The system of urban patterns shows a similar complexity. This makes it very difficult and also dangerous to rely too much on a top-down approach, especially with initiatives on a grand scale

Nicole Silk (USA, TNC) reminds not to forget the social implications of interventions in urbanized deltas. The applicable slogan is: 'not about us without us'. Water related disasters, like floods and droughts, have disproportional impacts for indigenous, black and poor people. Interventions to restore water systems and wetlands should enhance ecosystems and communities.

Hans Mommaas closes the day by summarizing four themes which played a main role in the discussion, reflecting the need to rebalance of economy and environment in river basins worldwide

- Attention to the relations between different scales: from local to global;
- We need systemic approaches, based upon understanding the 'behavior' of systems;
- We need integrated and holistic approaches, deliberation based on broader narratives instead of a separation among different disciplinary 'silos';
- We need solid governance models, based on central coordination and direction but leaving space to creative elaboration at a local scale.

Taken together, this means that our considerable and growing knowledge base must be used to support an array of coalitions at various scale levels and places in a timely, transparent and trustworthy manner. That is an intimidating assignment. It underlines that it is useful to look at and learn from concrete cases, as we are doing during this seminar.

DAY 2

The second 'game change'

Approaches to river basin resilience. rebalancing river basin economies and the natural system while both are changing and uncertainties are large. Options and limitations of nature-based solutions. Possibilities to link adaptation to climate change, energy transition and new land use patterns.

Welcome by Li Xiaojiang (PRC, China Academy of Urban Planning and Design, former president). In his opening speech, Professor Li emphasizes the need of regional collaboration in delta regions, with the Pearl River delta as a clear example. From the 1990s to 2010, uncontrolled growth in the PRD has led to ecosystem degradation and disappearance of natural resources and coastlines. Since the 2010s, regional collaboration has resulted in the appointment of a series of nature conservation areas.

Lv Xiaobei (PRC, China Academy of Urban Planning and Design, Deputy Director of the Shenzhen Branch) presented an account of developments in regional collaboration, focusing on the case of the Pearl River Delta. The delta, as so often, features important and fast-growing economic activity, population increase and urbanisation (especially towards the coast) as well as land reclamation. At the same time, the delta houses important nature reserves and is a node on bird migration routes. Environment pressures range from pollution and steadily increasing water temperature to habitat destruction. One key development is growing and successful public opposition to initiatives that would have caused further nature loss.

Encouraged by the national government, regional collaboration is being explored between the governments of Guangdong province, Macao and Hongkong (nearby across the water). Collaboration faces the usual challenges such as differences in standards, approaches to land reclamation and accountability mechanisms. Key ideas include setting up a regional coordination mechanism in environmental impact assessments for the construction of large infrastructure such as ports; and integrating the nature reserves of the delta to form a linked regional conservation initiative.

Marjolein Haasnoot (NL, Deltares) is a principal investigator of Deltares, involved in the Dutch Delta program in order to formulate a proper strategy for enhancing the sustainability of the Dutch delta. She emphasizes the need of *combining adaptation* (to already unavoidable future sea level rise) with *mitigation* (by reduction of greenhouse emissions in order to prevent further climate change). This means that we should look for possibilities to link adaptation measures to measures for energy transition and new land use patterns. Climate, ecosystems and human society are coupled systems: this a key to climate-resilient development. Several projects of the last decades show already that adaptation measures can include substantial improvement of the urban landscape: Nature offers significant untapped potential!

Currently, Deltares and the Delta program are exploring four different possible long-term perspectives for the Netherlands in relation to sea level rise: (1) the delta as an open system (with a lot of room for rivers and estuaries); (2) the delta as a closed system (with a closed coastline); (3) a seaward approach (a new artificial coastline in front of the current one) and (4) retreat (moving people and economic activities to higher grounds). Exploring the long-term solution space of each of these perspectives helps: *adaptation pathways* can break adaptation into manageable steps and illuminate lock-in and low-regret investments. Key to is to (i) consider multiple scenarios, including for developments that your government does not control; employ a variety of tools, from story-telling to quantitative modelling and engineering; consider history.

BAO Qifan (PRC, Shanghai International Port, former Vice President) reminds of the seven-century history of Shanghai and highlights the expansion of its port infrastructure since the mid-1990s. The agglomeration now measures 3 km^2. Bao Qifan highlights the land reclamations in the Shanghai region of the last decades. He argues that this land reclamation policy can be considered a 'building with nature' approach, making use of the massive sediment deposits along the shoreline by tidal currents of the sea. During the past ten years, Shanghai International port has expanded to deeper waters. It will continue to do so, with planned new footholds on two far-out promontories, with 22 m depth.

Liu Kunyi (PRC, China Academy of Urban Planning and Design, Deputy Chief Planner of the Shanghai Branch) explains how the Yangtze delta deals with an increased flood risk, as a result of intensification of industrial and urban development in flood prone zones and a degradation of the delta ecosystem, leading to a decrease of the capacity of the natural system to resist typhoon storm surges. Especially the growth of many domestic and industrial ports has contributed to this development. A flood would be catastrophically, because of the presence of a large number of chemical industries along the shorelines. Spatial reorganization of shorelines and ecological restoration of natural shorelines is a central goal: repair of the ecosystem should be combined with creating new public spaces and flood defense along the shorelines.

Derek Hoeferlin (USA, Washington University St. Louis / Derek Hoeferlin Design) emphasizes the coherence and interdependency of city scale, delta scale and river basin scale by explaining the way of exploiting the Mississippi river basin during the last 150 years and how it influenced the state of the delta and the city of New Orleans. The current state of the river basin can't be changed just like that: the area of the Mississippi river basin is the production area of 40% of the world's food supply. River regulation projects, dams, levees, land reclamations, they all serve the purpose of using the river basin as much as possible for food production and using the river itself for transporting this food. This development had a severe impact on the delta, as also showed by Justin Ehrenwerth at day 1. Hoeferlin argues that it is not enough to focus only on the delta itself. Despite the enormous scale and the complexity of the river basin, Hoeferlin shows that it is possible to define a set of different categories of subareas and sub-basins, which creates the possibility to define manageable projects, leading to a restoration of the natural resilience of the river system.

<u>Panel discussion</u>

Carline Borest (NL, Rotterdam Port Authority) argues that we should be aware of the societal importance of ports. For instance, the port like Rotterdam is an essential gateway for the supply of goods and energy for more than 350 million people in Europe. Changing the port system needs very serious considerations. Fundamental change needs time, and can only be organized in a series of steps. We can't control this change completely; we are dependent from many external forces, like Covid, war in Ukraine, cybersecurity, criminality, etcetera. The policy of the Rotterdam Port is based on four pillars: (1) optimizing efficiency and infrastructure; (2) a new energy system; (3) a new raw material and fuel system; (4) sustainable transport. Together it should lead to 55% CO_2 reduction in 2030 and CO_2-neutral in 2050.

Bart Kuipers (NL, Erasmus University Rotterdam) agrees with Borest that change of port areas needs time, but we should be aware that there *will* be change in the next years. The Port Authority Rotterdam itself published a policy document with four possible scenarios; two of them include a decrease of the trade flow through the port of Rotterdam. So, we should be prepared seriously for this scenario, and look carefully to the investments in and around port regions: they are signals which can clarify which scenario will become reality.

Bas Roels (NL, World Wildlife Fund) is a bit disappointed by the presentations. He pleads for more radical transformations in the deltas. Most of the presentations are rather positive, but still not radical enough. We don't have time anymore; changes are too little and too slow. 'Adaptation' has become a poisoned word; it has lost its original meaning and is used too often for too small changes. Moreover, he misses the people: Where are the people in the presentations?

TU Qiyu (PRC, Shanghai Academy of Social Sciences) agrees with Roels. A delta is water: people can enjoy water! This aspect is underexposed in the lectures. More emphasis on water as an attractive public amenity will contribute to a broad public support of radical changes in water systems.

Moreover, port cities represent a specific form of social capital [term introduced by the report drafters – JB]. They are more than transportation hubs. Port cities offer valuable, long-lived social and economic networks whose default orientation is way beyond the city – worldwide, for the examples the seminar is discussing. This value should get more attention in any analysis of rivers and deltas.

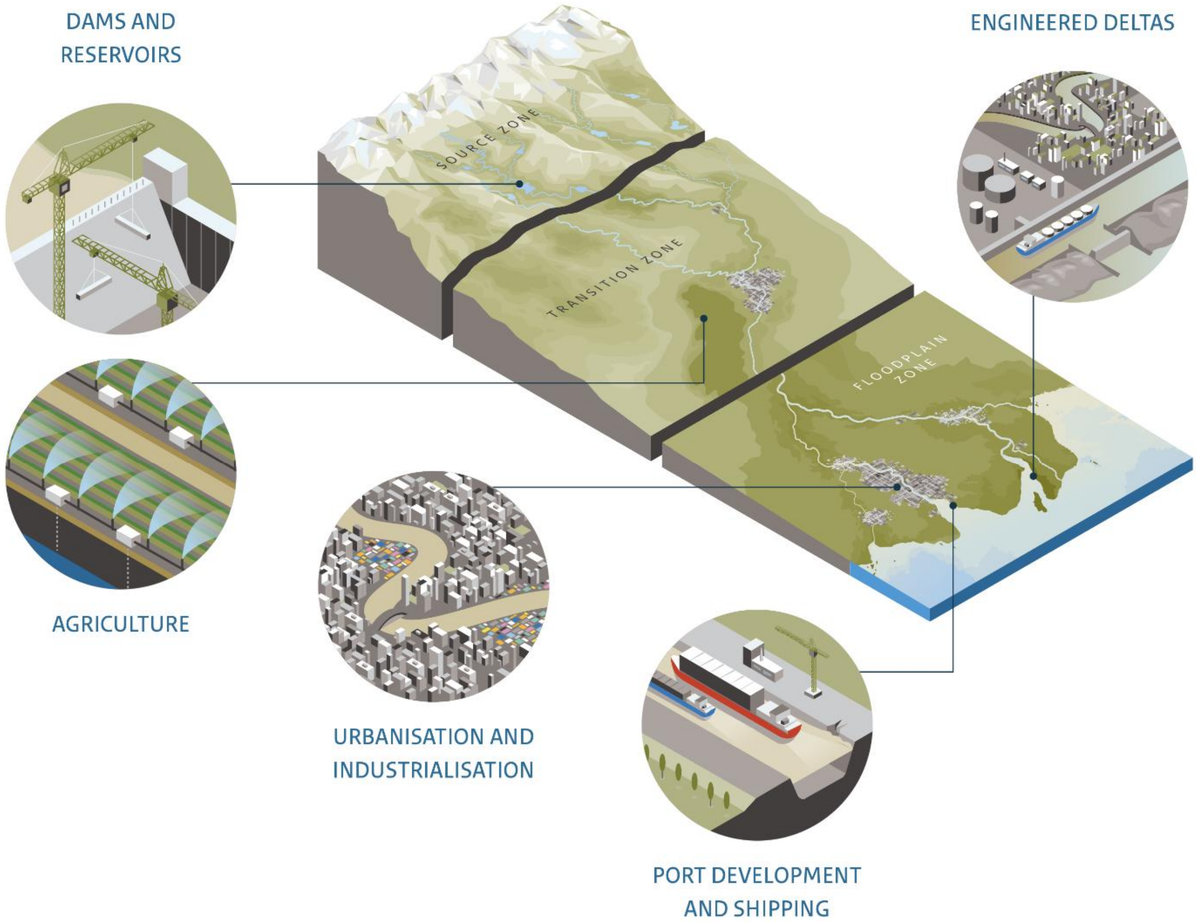
On the matter of globalisation or de-globalisation and its effect on port city economies, Professor Tu observed that of the top ten global ports by volume, seven are on China's East seaboard. This alone suggests that a key avenue forward is perhaps not increased expansion, but specialisation and upgrading.

Anne Loes Nillesen (NL, DeFacto Urbanists) refers to the presentation by Marjolein Haasnoot, talking about the need to explore the long-term solution space of different perspectives of the Dutch delta. She emphasizes the importance of 'research by design': exploring the long-term solution space is not only a matter of scientific calculations, but should be a process of interaction among creative design, scientific research and innovative engineering. The 'radical transformations', suggested by Bas Roels, only can be realized with this type of interdisciplinary collaboration.

Han Meyer gratefully refers to the call by Bas Roels for creativity and innovation. He closes the discussion by thanking all speakers and panel members.

III. Common issues

Some elements figured in multiple presentations, panel reflections and discussions. They can be grouped as follows.



© image from PBL River Basin & Delta Tool https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

Game Change

After one and a half century dominance of economy on natural water systems, the general conclusion is that this dominance has led to irresponsible distortion of natural systems and cannot be continued. Creating a new balance between on the one hand economic driven land use and on the other hand the dynamics of natural water systems should get absolute priority. This means a radical revision of the dominating approach and use of river basins and deltas. Building with Nature should lead to a restoration and improvement of biodiversity, and to a 'working together' with the dynamics and forces of natural processes of water systems, including currents, waves, erosion, sediment transport, siltation, etcetera.

An example of the start of the start of this game change is the new policy in the Mississippi delta, aiming to create a series of cuts in the dikes alongside the river, in order to provide the wetlands of the delta with sediments and fresh water of the river. This will turn the processes of erosion into enforcement and extension of the wetlands. Restoration of these wetlands, which function as a buffer to decrease the violence of hurricanes, is essential to maintain New Orleans. In recent history, dike construction alongside the river was meant to improve the conditions for navigation and agriculture. In the next future, dike construction will also be meant to improve the conditions for ecological restoration.

Another example is the experiment with 'double dikes' in The Netherlands. Letting seawater in the strips of land between the dikes will result in a natural elevation of the land by sediment deposits. Recent Chinese examples include the emphasis on green and blue infrastructure in urban development, and the cleaning up and renaturing of shorelines of the Yangtze.

Perception

It should not be taken for granted that things will stay as they are. Specifically, Li Yuanyuan sketched an array of powerful changes with lasting impetus, including forces in the physical domain, demography and spatial organisation, and measures in relation to safety and security.

After Views notably differ on the kind of ports required in the next decades. Will there be ongoing globalisation and bulk trade? Will there be de-globalisation and more emphasis on goods with high added value? Will there be no equivalent of current flows of fossil energy carriers, or, alternatively, even larger volumes, consisting of sea-borne hydrogen? All current scenarios of container goods for the Port of Rotterdam indicate some degree of shrinkage in volume; arguments regarding Shanghai differed: ongoing growth versus upgrading and specialization only. Either would perhaps offer opportunities for synergy in addressing various challenges in the basin as a whole, but in different ways.

Stories of all three ports (in fact, regional groups of ports) depicted important spatial vectors: new harbour facilities at new locations and further out to sea (Shanghai, at least in one of the views presented); hydrogen-production further out to sea and high-value import/export based further inland (Rotterdam, at least in some of the views presented.

Perceptions by market parties, including perceptions of climate risk and impending mitigation efforts, can force the hand of local governments. Two speakers from the NL pointed to this phenomenon. Arnoud Molenaar, of the city of Rotterdam, alluded to the considerable in-house analytical capacities that enable investors and large enterprises to set their own course, if it takes the government too long to reach consensus.

Scale

Many speakers supported the notion that the scale and pervasiveness of past and current changes illustrates the scale and pervasiveness of upcoming changes and the necessary responses.

A number of examples illustrated the insight that the ongoing and required changes play at a different scale than conventional strategic planning. The planning of the Great Shanghai Metropolitan Area placed strong emphasis on blue and green infrastructure. This, in turn, made local governments around Tai Hu Lake join the planning process of their own accord, as they understood the benefits of being involved. Current comprehensive planning for the Mississippi started at the lower reaches and then, logically, extended towards its middle reaches. Traditional river management in The Netherlands, although working with international river commissions, essentially behaved as if rivers begun where they entered this small country, for the last segment of the river's journey towards the sea.

Aside from spatial and temporal dimensions, the scale of invested capital is significant and was often referred to during the seminar. Obviously, the scale of past investments points to the longevity of traditional business interests. In turn, this makes it necessary that the powers representing past and future investments engage in current discussions around the future of river deltas such as the three deltas highlighted at the seminar. Interestingly, large enterprises did engage in, and sign up to, Louisiana's Coastal master Plan. In contrast, similar power players in the Rotterdam/Rhine delta seem underrepresented in the public discourse, while at the same time, no doubt, much corporate research is going on.

Involvement and empowerment

Pleas were tabled to involve power players and affected groups and interests beyond the incumbent. Principles were mentioned. For example, one such principle is "not about me without me". A related plea is for creativity to give future generations of people and businesses a voice.

Marjolijn Haasnoot underlined work of IPCC Working Group II, reminding the seminar that the traditional distinction between climate system, human system and ecosystems will no longer hold in view of the challenges for the next decades. Interestingly, through biophysical logic and systems thinking, this arrives at similar perspectives as 'ecological civilisation'.

Examples of institutional mechanisms were mentioned, although not discussed in great detail. Interestingly, 'Structured Decision Making' served well in the Mississippi delta. Strategic Environment Assessment would be the equivalent in The Netherlands and in China, but was not portrayed – probably because it requires a policy initiative for a start. Hans Mommaas, current DG of PBL and key note speaker at the seminar, will soon chair the Netherlands Commission for Environment Assessment.

Large investors seem, so far, almost invisible in discussions about redesigning Rhine delta and rethinking the role of the port of Rotterdam. In contrast, large enterprises are part of The Louisiana Coastal Master Plan.

The people

Several speakers asked 'where are the people'? A real and radical game change of economy and water system only can be reached when it will get broad public support. This, in turn, is only possible if authorities, scientists, designers and engineers can show what the new, attractive aspect will be of the 'new game'. It should lead to an environment in which water plays a main role as an issue of pleasure and joy. Li Xiaojiang referred to successful protests of the public to an extension of Shenzhen Bay cruise ship sea tour route, because of serious concerns on the consequences for the ecosystem and the quality of the landscape. Bas Roels referred to comparable public protests against plans for dike-enhancement in the Dutch river area in the 1980s. The latter was the start of a new way of thinking on the balance of safety against flooding, economic goals and quality of life, resulting in the 'Room for the River' program.

The role of the central lake in Greater Shanghai is a good illustration, explained by Tu Qiyu. The lake is important for water storage and fresh water supply in the region, but also for recreation and leisure.

This makes it necessary to develop a new story, a new *narrative* on the role of water and water systems in the urbanized world.

Long term vision as a beacon

The importance of a solid, government-sponsored vision for the long term was underlined by many. Jaap Kwadijk, for example, praised as a reason for pride to have a nationally accepted long-term expectation combined with a mechanism of review every few years. He described it as a key achievement in the development to finally move beyond policies that were in essence reactive.

On how to deal with the inherent uncertainties of the future, within the envelope of expectations, four key insights emerged.

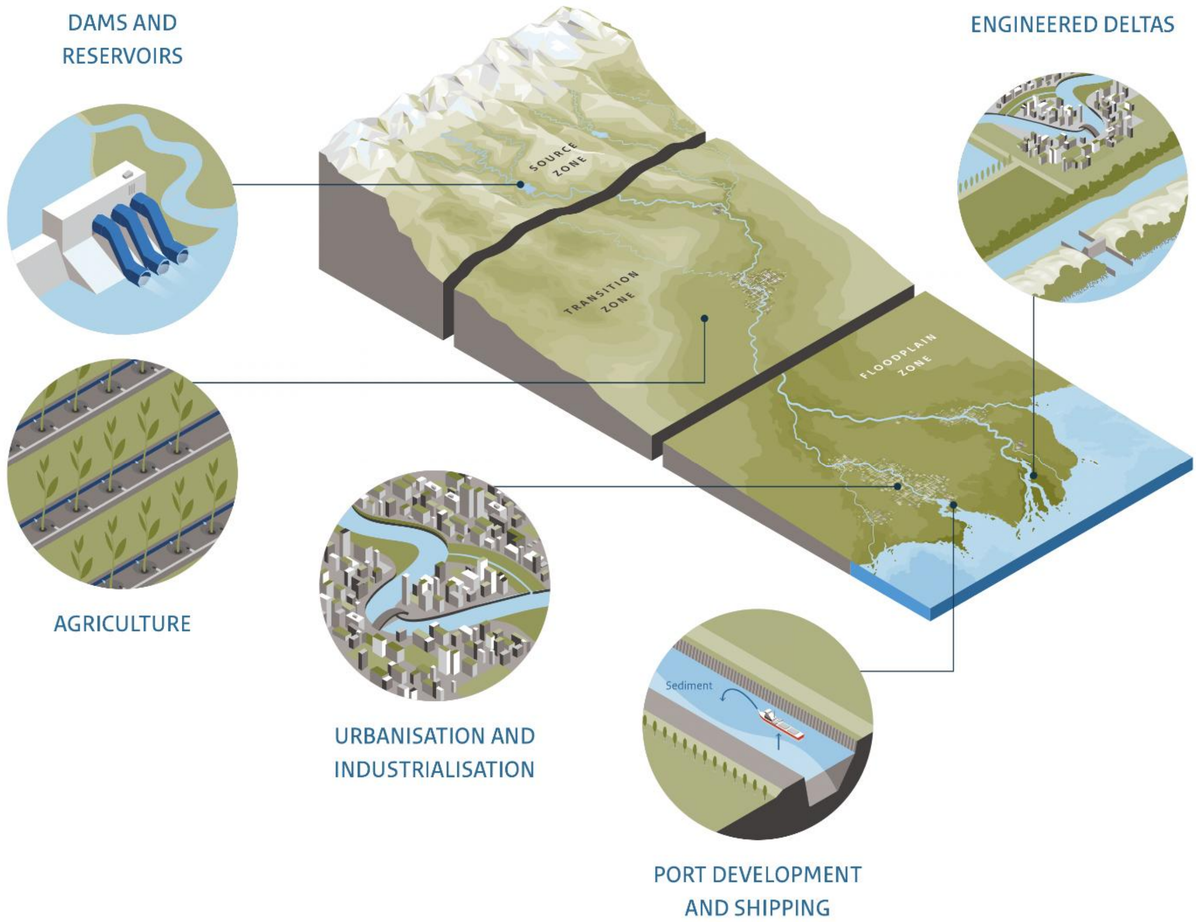
> It was argued, but not generally supported, that in view of the large uncertainties starting with small interventions is a wise strategy.
>
> Nature based solutions were often mentioned, typically as one category within a large toolbox. Looking back to the past 150 years, it is obvious that the technologies of hard engineering required decades of experience in order to mature. That much time is not available in addressing climate change and the implications of decarbonisation. Therefore, it is important to (i) moderate expectations and (ii) speed up learning from any NbS applications as much as possible.
>
> In exploring future strategies vis-a-vis climate change in delta areas, it is key to antecipate a range of scenarios – not just a most likely scenario or an accepted baseline. This requires considerable homework and critical analysis. But it can be done and informs periodic decision making, in view of 'branch points' --- orderly switching from one strategy to another, if necessary. Marjolijn Haasnoot presented an example for the Rhine-Meuse-Scheldt delta.
>
> In order to be able to define a proper strategy, based upon the possibilities of the scenarios, design explorations are necessary. Derek Hoeferlin (USA) and Anne Loes Nillesen (NL) showed that these explorations, using the creative power of experienced designers, can reveal unexpected possibilities and lead to new discoveries of the potential qualities of the river- and delta territories. It leads to an awareness that the 'game change' of economy and water system not only is necessary to avoid catastrophes, but also can lead to new perspectives of attractive and desirable environments.

Remarkable interest

On a general note, the level of interest in this topic proved remarkable --- for this seminar as well as for preceding and subsequent conferences on 'redesigning the delta'. From individual reactions, the impression of the organizers is that comprehensive view and almost-timely call for creativity have a broad appeal.

IV. Recommendations

The host organisations of the seminar, PBL, TNC and CAUPD, jointly lead the Special Policy Study River Basins of the China Council for International Collaboration on Environment and Development[2]. After scoping in 2020-2021, the Special Policy Study is now programmed for a five year period (2022-2026). It will analyse interesting cases and periodically it will formulate policy recommendations. In this context of policy recommendations, the following insights are pertinent.



© image from PBL River Basin & Delta Tool https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

1. Rebalancing is necessary between the requirements for human activities ('economy', for short) and the constraints posed by the natural system. Until one or two centuries ago, the natural system – river dynamics, for example – dictated the possibilities for human settlements and economic development. Then, in most situations typically 150 years ago, hard engineering successfully turned this around and harnessed rivers and wetlands, subjugating natural systems to the requirements of 'the economy'. In the next decades, multiple simultaneous developments will challenge this paradigm.

   Instead, creativity from many disciplines will be needed in order to rebalance these mega-systems, so that river systems and economic systems mutually support each other rather

[2] https://cciced.eco/

than one side constraining and dominating the other. Mobilizing this creativity should be supported with material resources, government guidance as well as the thinking power of all interested parties.

2. Understanding systems is at the basis of wise management of socio-environment systems, such as river basins. This calls for systematic analysis of deep drivers, such as physical changes, demographic and economic changes, environmental impacts and response strategies. Frameworks for this have been tabled at the seminar and are worthwhile following up by regional think tanks and cooperation bodies.

3. Wise and effective governance and management of river basins requires a government-backed authoritative policy. For international basins, the same applies, but in international term. This authoritative policy can be a combination of
   A. Scenario building: scientific explorations of possible futures, based upon plausible, or maximum plausible, change in climate indicators as well as possible developments in economy, demography, transport and urbanization, and identification of key biodiversity assets. Scientific institutions should have the key role in defining these scenarios.
   B. Defining a strategy. After public and political deliberation on the possible consequences of the scenarios, the overarching authority of the river basin territory should define a desirable and feasible strategy, based on the knowledge of the scenario studies and desirable developments of society and the natural system.
   C. Integral approach. Strategies concerning water safety and fresh water supply should be combined and integrated with strategies concerning energy transition, sustainable spatial planning and improvement of the ecosystem.
   D. Defining and implementing projects. A strategy can only be implemented by defining a series of concrete projects in the river basin and delta, which can be considered keys for reaching the goals of the defined strategy.
   E. Involvement of the public. Regional and local authorities, stakeholders and representatives of residents should be able to contribute to the exact definition and implementation of the projects.

   Scenario building, strategy-definition, integrated approach, defining projects and involvement of the public should be interconnected, leading to a continuous process of evaluation and adjustment of scientific knowledge, political goals and practical instruments. The Dutch 'Room for the River' program (2005-2015) can be considered an example.

4. Mechanisms exist to engage stakeholders and parties affected. For example, Structured Decision Making and Strategic Environment Assessment. What are interesting experiences, in view of the important and profound changes on the horizon?

5. Contrasting views exist on the type of international ports required in the future. Given the dominant position of the ports in the basins considered by the seminar (New Orleans, Rotterdam and Shanghai), it seems important to have discussion about the desired and probable development in the open. Based on the seminar discussions, the following observations can be made
   - each the developments discussed, for each port, means very distinct spatial developments – East, West, towards promontories, etcetera;

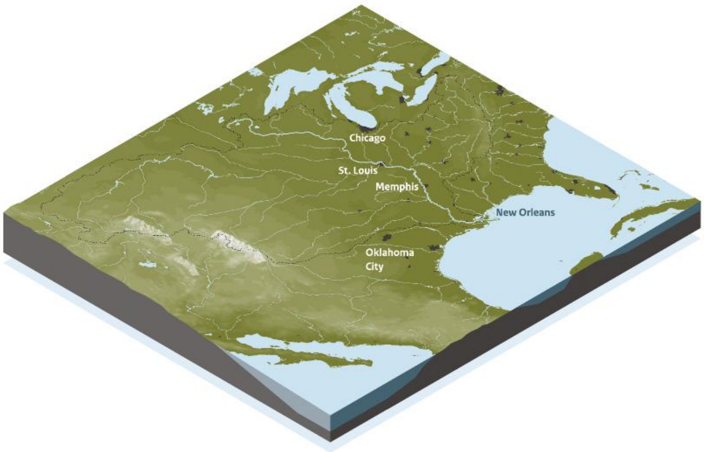
- a number of interventions responded to the advent of regional overcapacity and suggested a potential for upgrading and or specialisation – implying possibilities for redesigning the delta;
- miraculously absent from public discourse around the future of mega ports, at least in some regions, are the power players with large investments at stake.

One suggestion for the SPS is to stage a CCICED round table on this, mapping these potential developments, possibly jointly with the WEF.

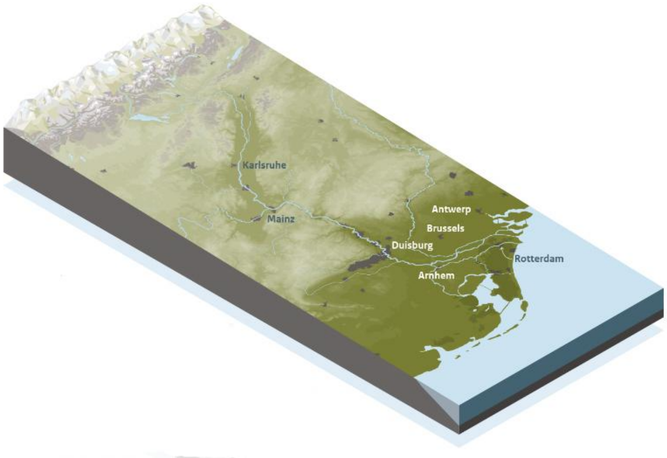
6. A key observation from IPCC WG II needs to be echoed by the SPS: the climate system, nature and the human living environment should be considered as one system – not three separate systems. Therefore, policies and governance should be coordinated, if not integrated.

7. Thus, a new general approach is advocated – most extensively, by Li Yuanyuan -- acknowledging and quantifying critical elements such as sediment flows, flows of fossil energy carriers, and climate change. Importantly, such a new general approach works at three levels of scale simultaneously: the basin scale, the delta scale and the city scale.

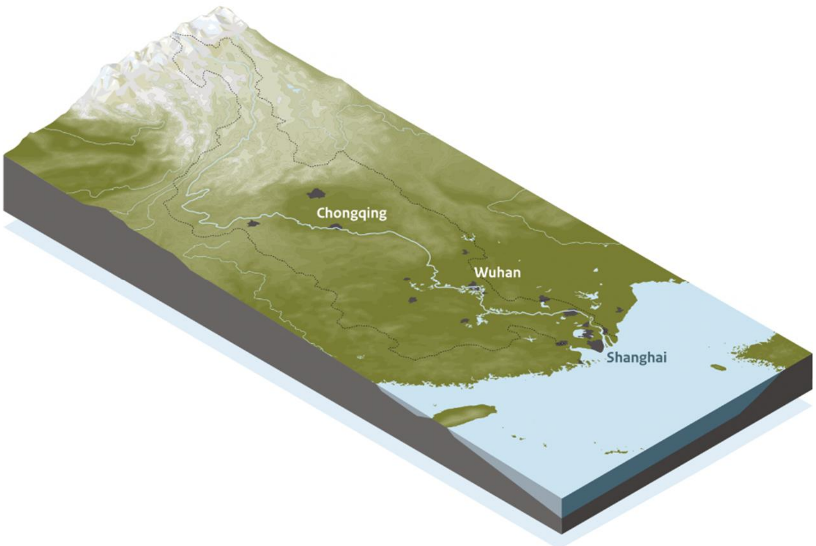
V. Programme and presentations



Mississippi



Rhine



Yangtze

Seminar programme

Day 1: afternoon of 11 October 2022, Central European Summer Time

The first 'game change'.

What did the first game change look like, and to what consequences did it lead? Delta development before the mid-19th century and after. Consequences for current problems, exacerbated by climate change/accelerated sea level rise.

14:00 CEST
Hans Mommaas (PBL, director-general) -- Welcome and kick-off (15 mins)

14:15 CEST
Introductions:
Willem Ligtvoet (PBL) - worldwide quantified overview (15 mins)

Jaap Kwadijk (Deltares) -- Rhine-Meuse delta (15 mins)

LI YuanYuan # (General Institute of Water Resources and Hydropower Planning and Design, vice-president; National Committee of International Water Resources Association, president) -- Yangtze delta (15 mins)

Justin Ehrenwerth # (Water Institute of the Gulf, CEO) -- Mississippi delta (15 mins)

15:15 – 15:30 PAUSE

15.30 CEST
Panel:
Anne Loes Nillesen (Defacto, founder), with a focus on spatial implications (5-10 mins)

TU Qiyu # (Shanghai Academy of Social Sciences), with a focus on social and spatial implications (5-10 mins)

Arnoud Molenaar (City of Rotterdam, Chief Resilience Officer), with a focus on urban resilience (5-10 mins)

Bart Kuipers (Erasmus Centre for Urban, Port and Transport Economics), with a focus on port economy implications (5 – 10 mins)

Nicole Silk # (TNC, Global Director for Freshwater Outcomes), with a focus on environmental and social implications (5-10 mins)

16:15 CEST
Discussion Moderated by Hans Mommaas

17:00 CEST closure; refreshments

Day 2: afternoon of 12 October 2022, Central European Summer Time

The second game change

Approaches to river basin resilience. rebalancing river basin economies and the natural system while both are changing and uncertainties are large. Options and limitations of nature based solutions. Possibilities to link adaptation to climate change, energy transition and new land use patterns.

14:00 CEST
LI Xiaojiang # (China Academy of Urban Planning and Design, former president) -- Welcome and kick-off (5 mins)

14:05 CEST
Introductions:
LV Xiaobei (CAUPD) – developments in regional collaboration (15 mins)

Marjolein Haasnoot (Deltares) -- Rhine-Meuse delta (15 mins)

BAO Qifan # (Shanghai International Port, former Vice President) -- Yangtze delta (15 mins)

LIU Kunyi (CAUPD) – sustainable use of Yangtze river banks (10 mins)

Derek Hoeferlin (Washington University in St Louis) -- Mississippi delta (15 mins)

15:15 – 15:30 PAUSE

15.30 CEST
Panel:
Anne Loes Nillesen, with a focus on spatial implications (5 mins)

TU Qiyu #, with a focus on social and spatial implications (5 mins)

Bas Roels (WWF Netherlands) with a focus on natural environment aspects (5-10 mins)

Bart Kuipers, with a focus on port economy implications (5 mins)

Carline Borest (Port of Rotterdam) with a focus on port development strategy (5-10 mins)

16:15 CEST
Discussion, conclusions
Moderator: Han Meyer

16:45 CEST
Concluding remarks
Han Meyer

17:00 CEST closure; refreshments

On-line

Hans Mommaas

PBL Netherlands Environmental Assessment Agency

The Future of River Basins and Delta’s

PBL-CAUPD-TCN 11/12 October 2022

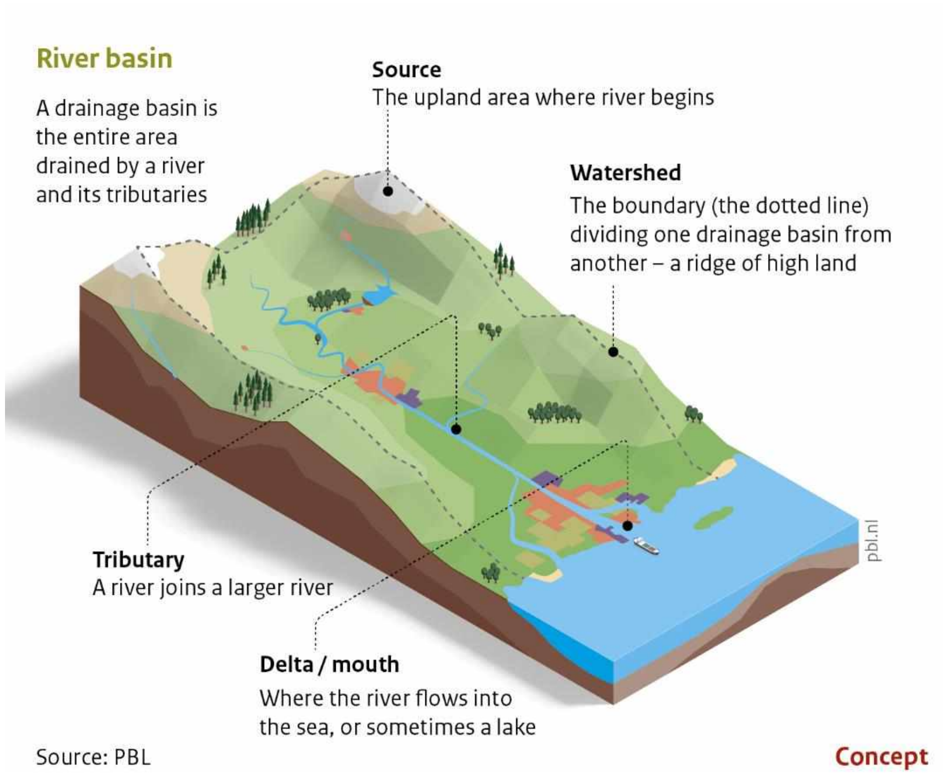
Hans Mommaas PBL

Introduction

River basins and deltas play a central role in the circulation of water on the planet and in the atmosphere and in the creation of conditions for biodiversity.

In that sense: 'healthy' river basins and deltas are essentially for **keeping the planet healthy**.

At the same time, river basins and deltas play a central role in **economic development**: as transport corridors, as zones of agricultural, industrial and urban growth.



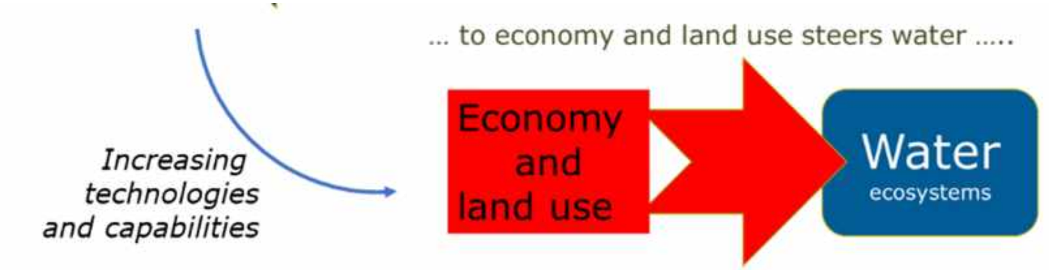
Both aspects of river basins and deltas - a key role in the environmental well-being of the planet, and a key role in economic development - are pre-eminently applicable to the river basins and deltas of **Rhine, Yangtze and Mississippi**.

These river basins are **quite different in size** (Rhine river basin 0.18 million km2, Yangtze 1.8 million km2, Mississippi 2.9 million km2) as well regarding population (Rhine river basin 49 million, Yangtze 480 million people, Mississippi 70 million).

But the common characteristic is that **all three play a key role in the drainage of their continents as well as in economic development**. All three rivers are central **transport corridors** and their deltas are the territories of the **largest port complexes** of the world.

Until the nineteenth century, we can say that the **environmental characteristics** of water systems **created the conditions for economic and urban development**: water- and ecosystems steered the economy and land-use.

But, especially **from the industrial revolution** of the nineteenth century, new technologies and state power created the conditions that **economic and urban development** increasingly **steered the water- and ecosystems of rivers basins and deltas**.



This has resulted in **substantial problems** for keeping the river basins and deltas in healthy conditions, **in two respects**:

First, industrial and economic development resulted in **essential changes of the physical characteristics of rivers basins and deltas**. Pollution, dike construction and river-narrowing, damming, land reclamations, dredging, has led to a dramatic loss of biodiversity, to rising water levels and increasing flood risks, to salt intrusion and growing problems for fresh water supply.

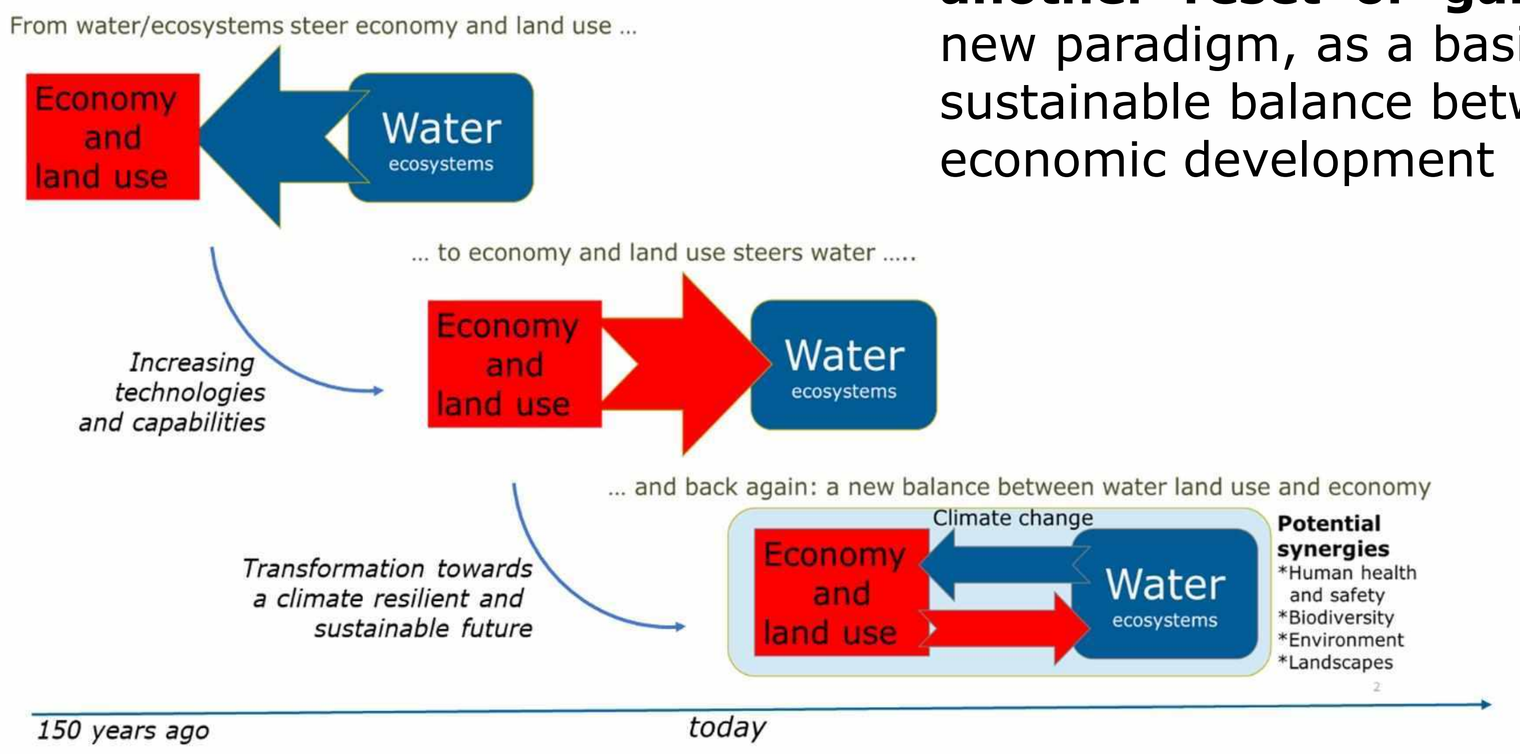
Second, the land- and water use for transport, port development, industrial development, urbanization, has resulted in the fact that river basins and deltas have become **main corridors of the fossil economy**.

Climate change, resulting in rising see level, increasing peak discharges of rivers and more intense rainstorms, has **strengthened these problems and will strengthen them more in the next future**.

Facing the **necessity** of **radical reduction of greenhouse emissions**, in order to avoid a too extreme climate change, an **economic transition in river basins and deltas** will be crucial

Both respects mean that river basins and deltas are confronted with the **challenge to combine two goals**: **adaptation**, in order to be able to deal with changes in the environment and climate which already take place, and **mitigation**, in order to avoid that climate change is going to get completely out of hand.

If we consider the industrial revolution of the nineteenth century and the following era as a first ‘reset’ or ‘game change’, leading to the paradigm of ‘economy and land use steer water- and ecosystems’, we have conclude that **we need another ‘reset’ or ‘game change’,** leading to a new paradigm, as a basic condition for a new and sustainable balance between environmental and economic development

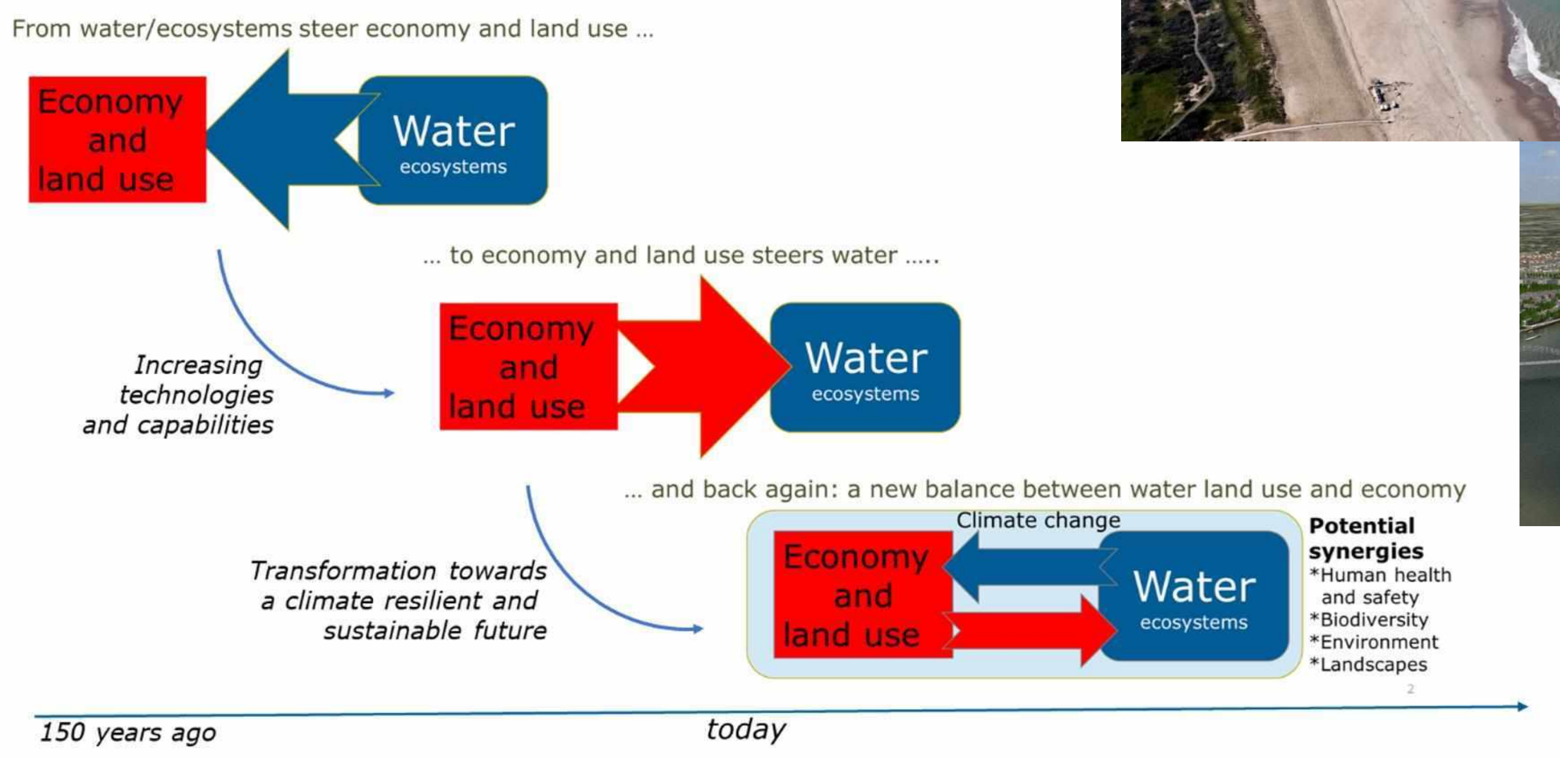


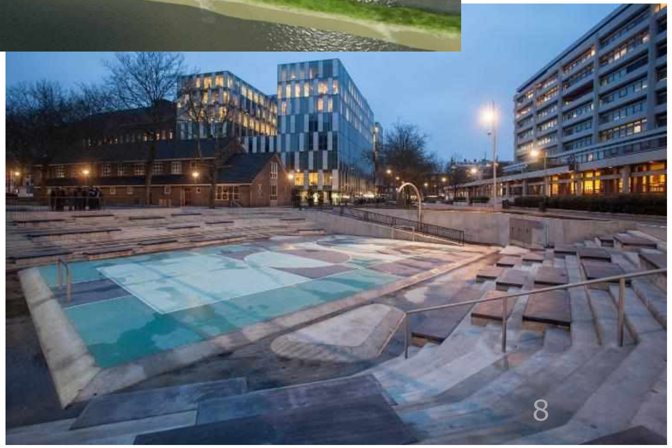
The seminar aims to investigate to what extent the idea of **the first and second game change** is relevant for these three river basins and deltas, and in what sense it **can give direction to a new approach** for a new balance between economic and environmental development.

In particular, attention will be focused on:

a) the **precise nature of the dynamics** and shaping forces of the three delta regions;
b) how these dynamics and formative forces were dealt with in the period late 19th century – early 21st century, and what **effects this had on the physical conditions** of the delta;
c) what **options** are available to use **'nature-based solutions'** to create space for the dynamics of the delta and to use it to restore the resilience of the natural system;
d) what **possibilities** there are for **combining energy transition, sustainable economic development and new land use patterns with more room for delta dynamics.**

..building with nature..





Willem Ligtvoet

PBL Netherlands Environmental Assessment Agency

River deltas – living at the edge

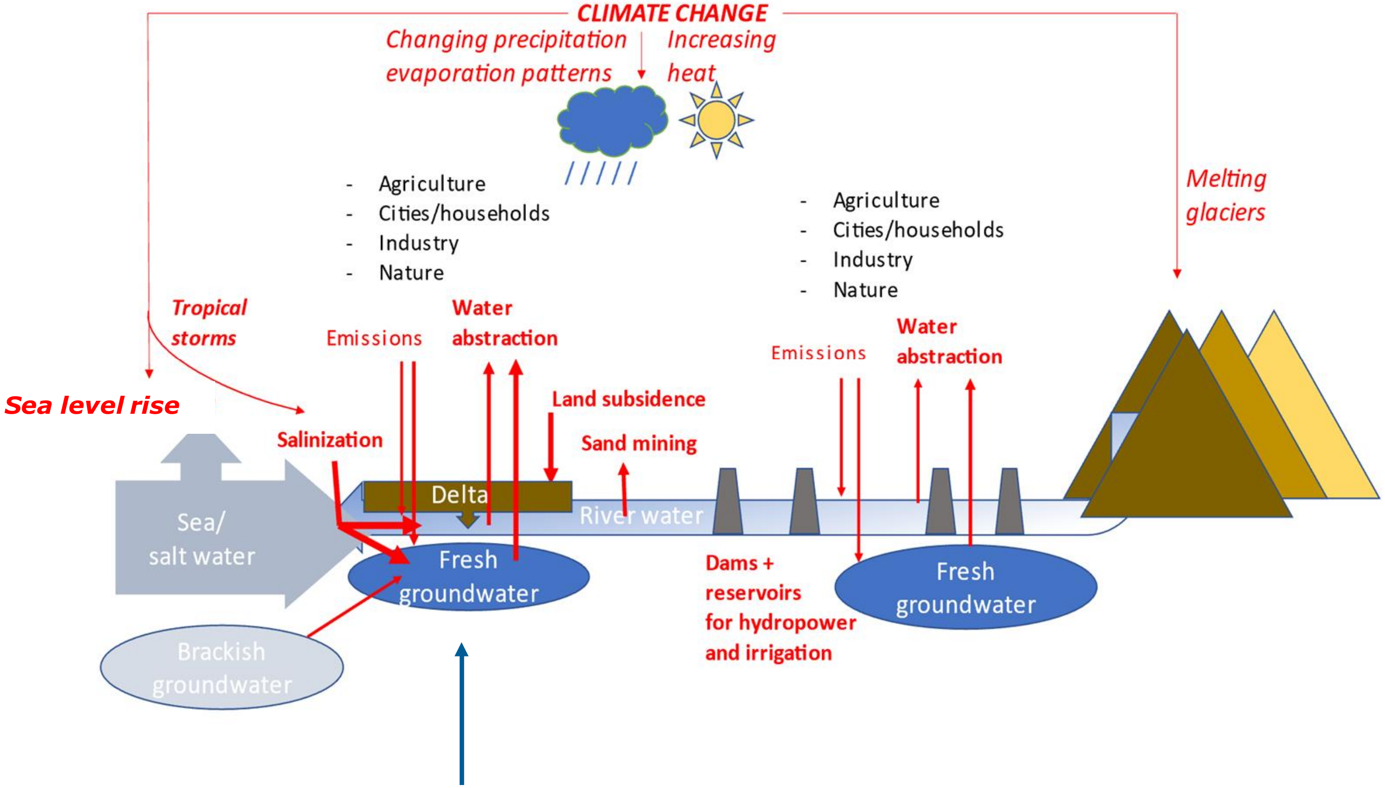
Towards ‘systemic’ strategies to bend the trend

Willem Ligtvoet, PBL Netherlands Environmental Assessment Agency

Deltas are under high pressure …

- Melting glaciers
- Changing water flows
- Sea level rise
- Weather extremes (storms, floods, droughts)
- Upstream dams
- Upstream water use
- Sediment mining
- Urbanization and infrastructure
- Land subsidence and salinization
- Water pollution

PBL Netherlands Environmental Assessment Agency



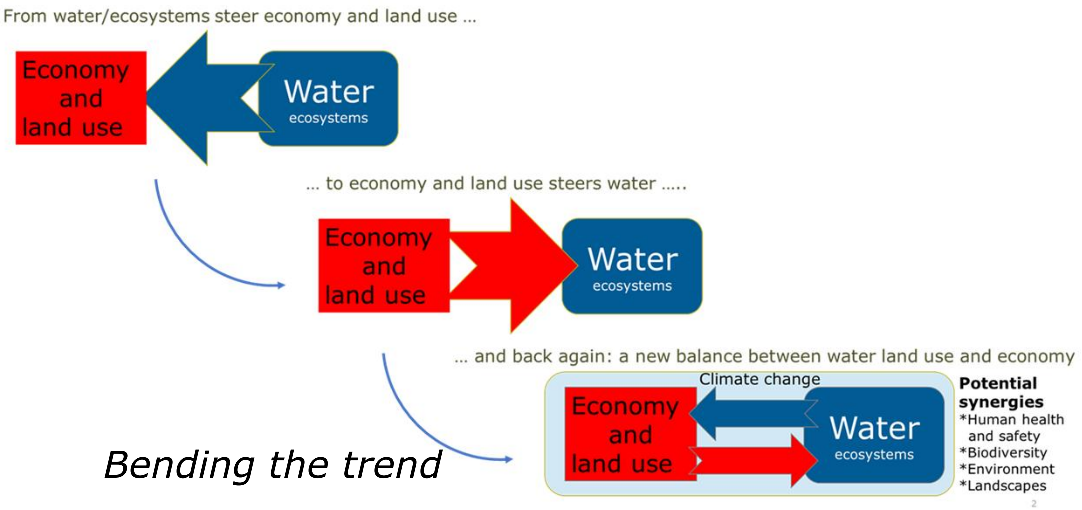
Living at the edge

Globally ca. 700 mln people

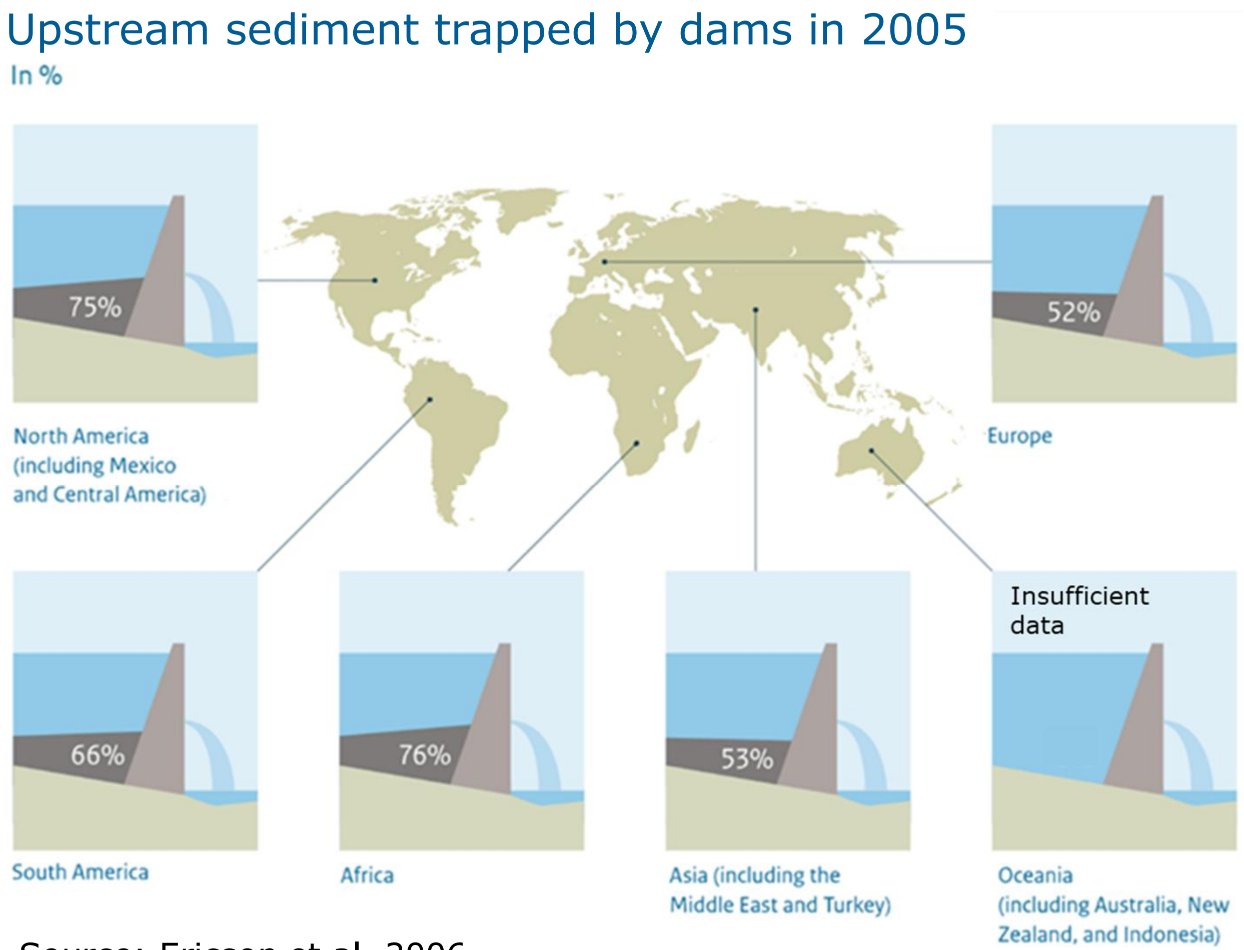
PBL Netherlands Environmental
Assessment Agency

Focus: critical processes

- **Sediment dynamics**
  * land use change and erosion ó
    dam construction trapping sediments
  * sand mining
- **Land subsidence and sea level rise**
  * groundwater withdrawal
  * sediment accretion measures
- **Protection of deltas and coasts**
  * improving protection/reducing adaptation
    deficit
  * applying nature-based solutions
- **Bending the trend**
  * towards a systemic approach
  * re-balancing water, land use and economy
    ó climate change



Sediments are trapped by dams …



Source: Ericson et al. 2006

With regional differences in resulting sediment flow:

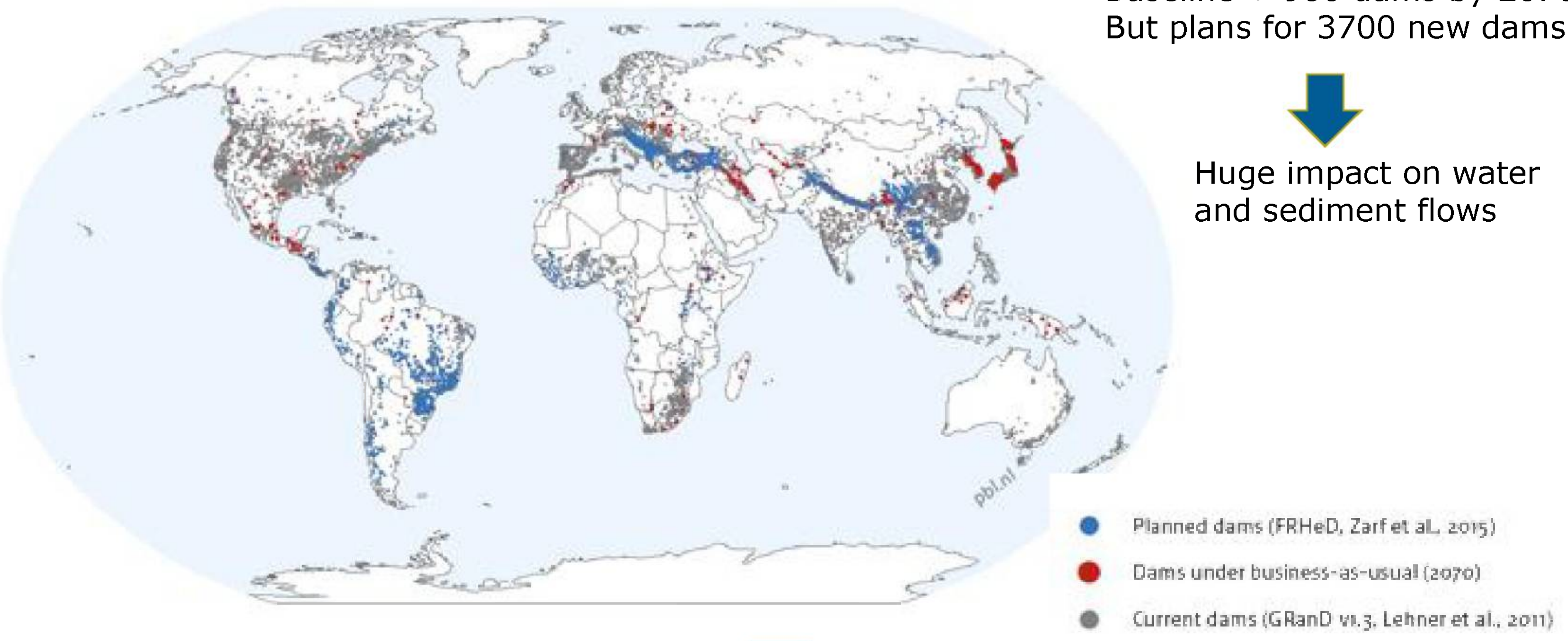
- Ø Northern hemisphere sediment starvation (trapping > erosion)
- Ø Southern hemisphere sediment flows still large. (erosion > trapping)

Source: Zarfl and Dunn 2022

PBL Netherlands Environmental Assessment Agency

… and numerous new dams will be built

Location of dams

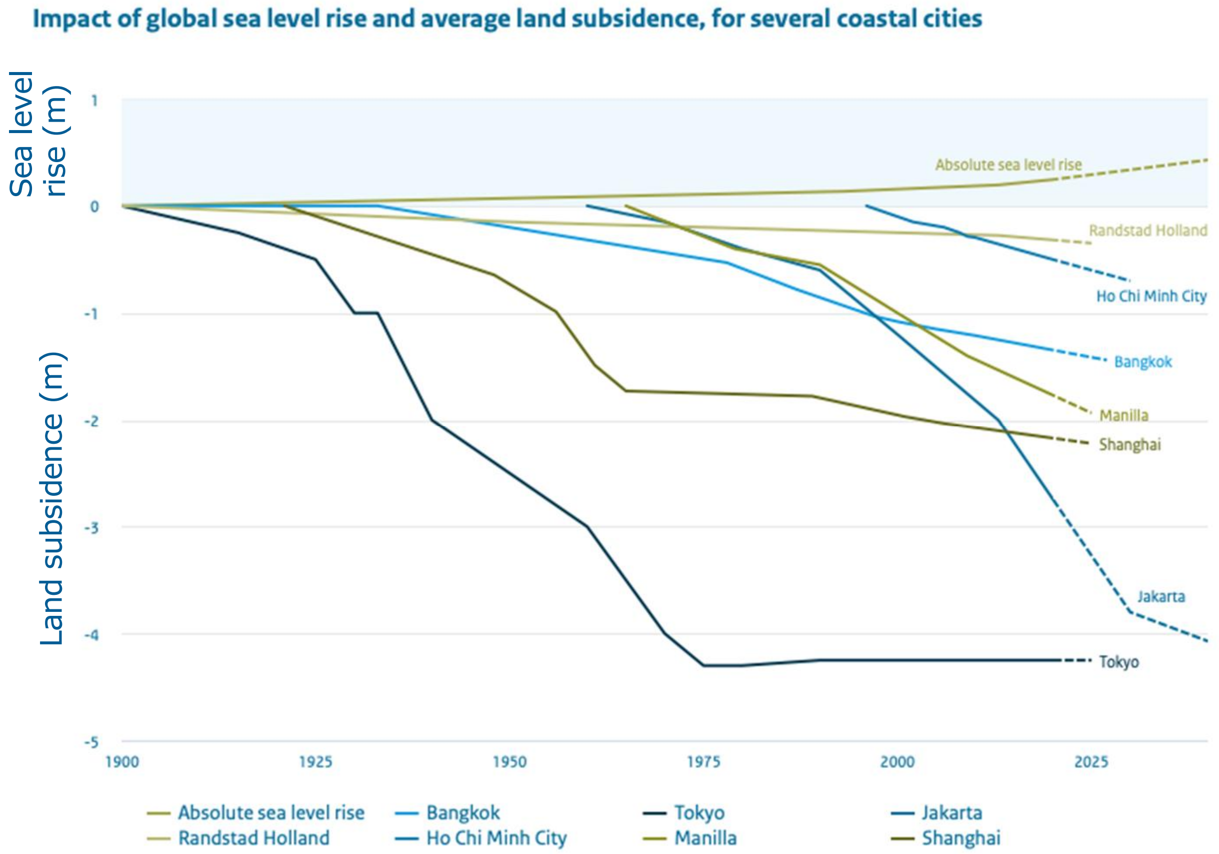


Baseline + 980 dams by 2070
But plans for 3700 new dams

Huge impact on water and sediment flows

PBL Netherlands Environmental Assessment Agency

Deltas are subsiding …



Main cause

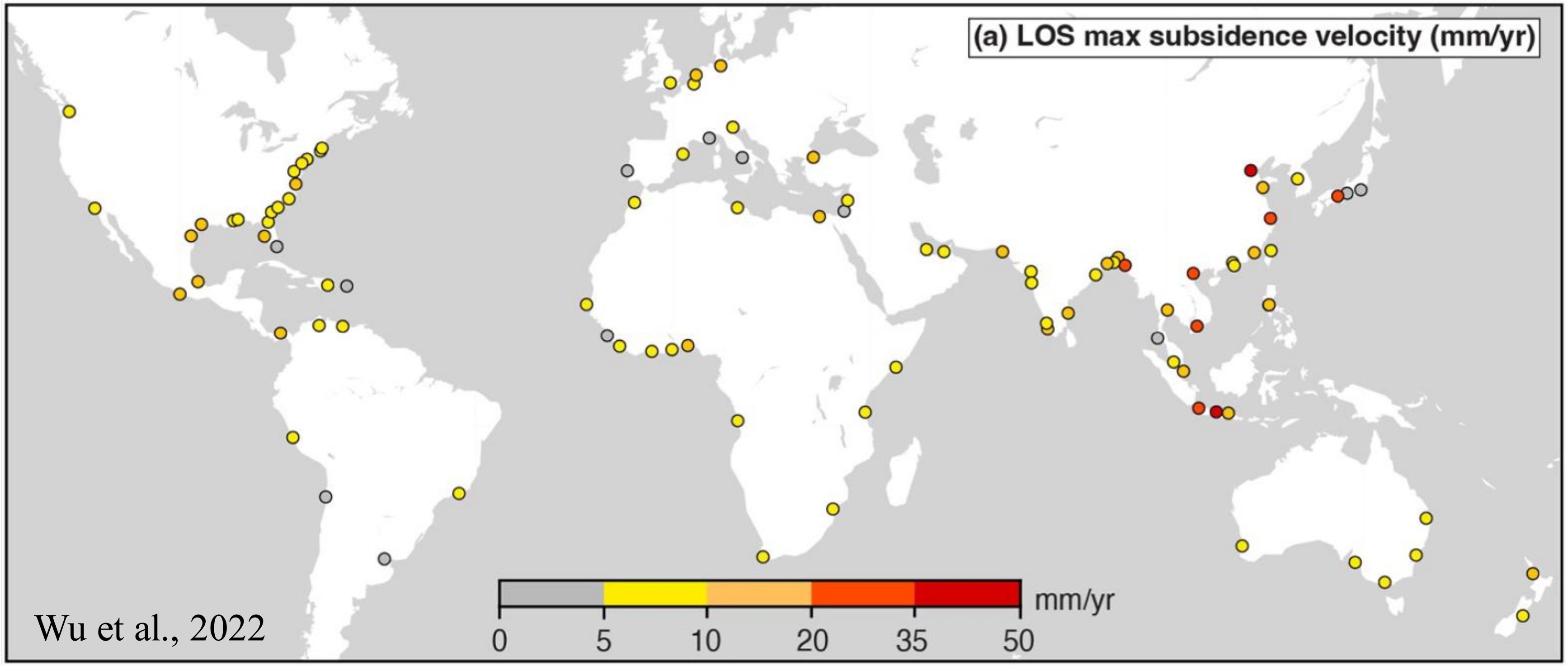
groundwater

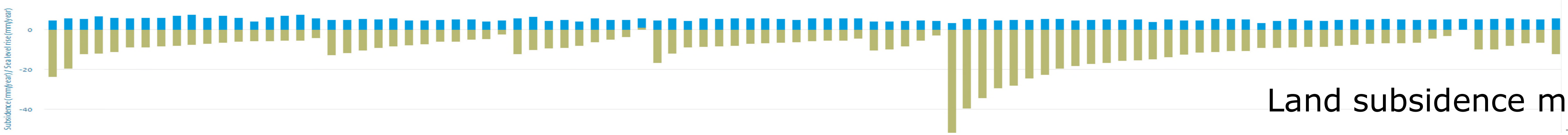
withdrawal

Source PBL/River Basin Delta Tool based on various publications

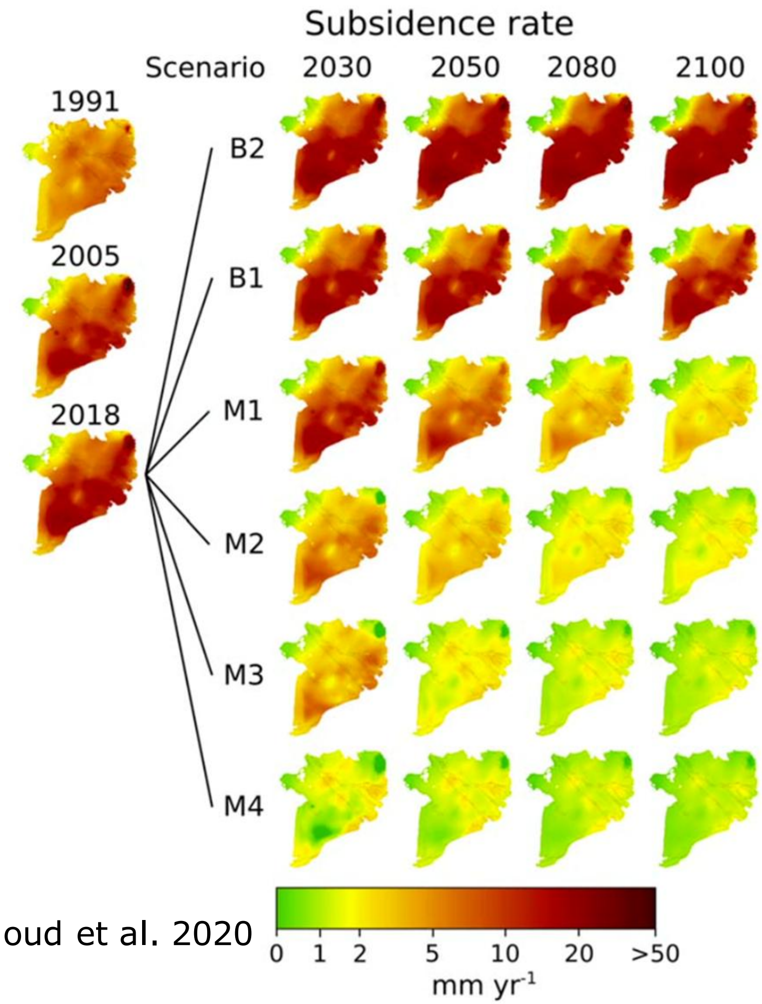
PBL Netherlands Environmental
Assessment Agency

… with land subsidence > sea level rise





Reducing land subsidence: example Mekong



Source:
Minderhoud et al. 2020

Groundwater withdrawal scenarios:

B2 +4%/yr gw withdrawal

B1 +2%/yr gw withdrawal

M1: 2019 -1.5%; 2020 -0.5%; after 2020 stable

M2: 2018–2028: -5%/yr; after 2028 stable

M3: 2018–2033: - 5%/yr; after 2033 stable

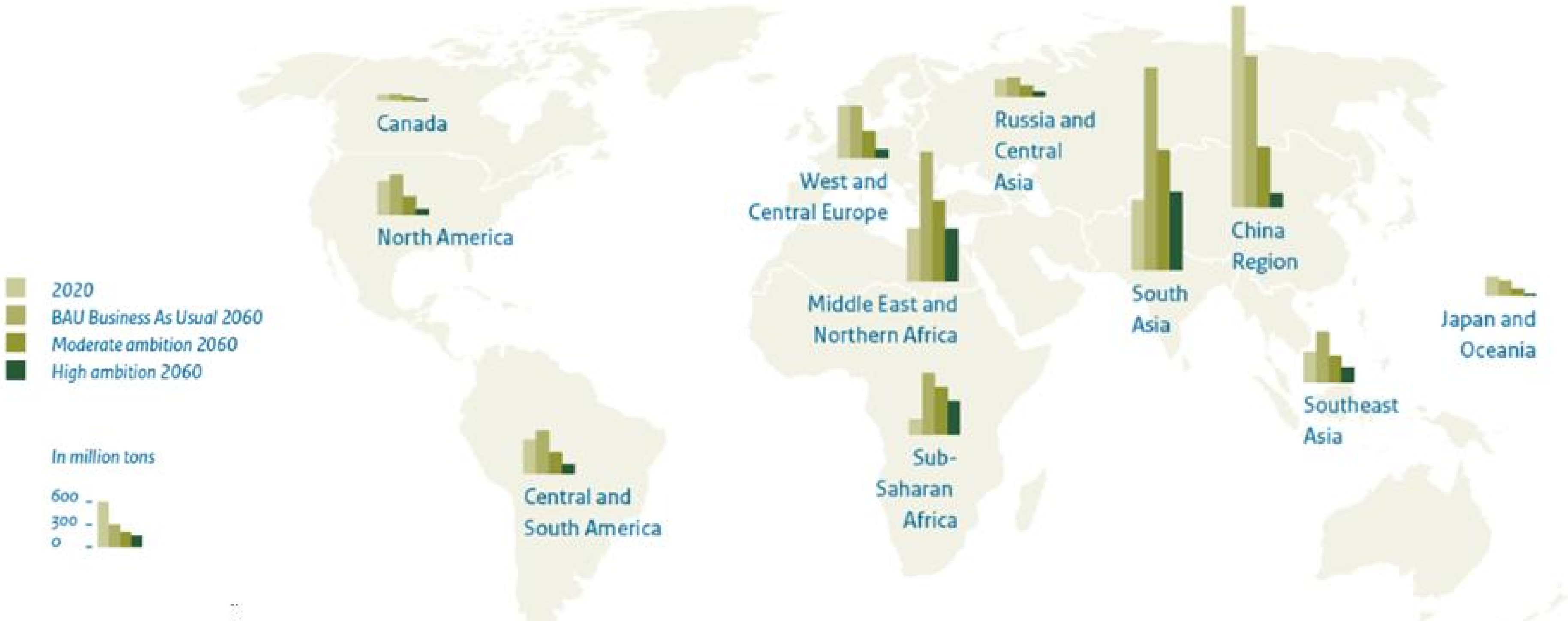
M4: complete stop after 2018

Structural adaptation of water use:

- Increasing water use efficiency
- Treated river water
- Desalinated brackish ground water
- Desalinated sea water
- Offshore fresh groundwater

PBL Netherlands Environmental Assessment Agency

Sand use projected to increase by 45% globally => increasing pressure on sand mining

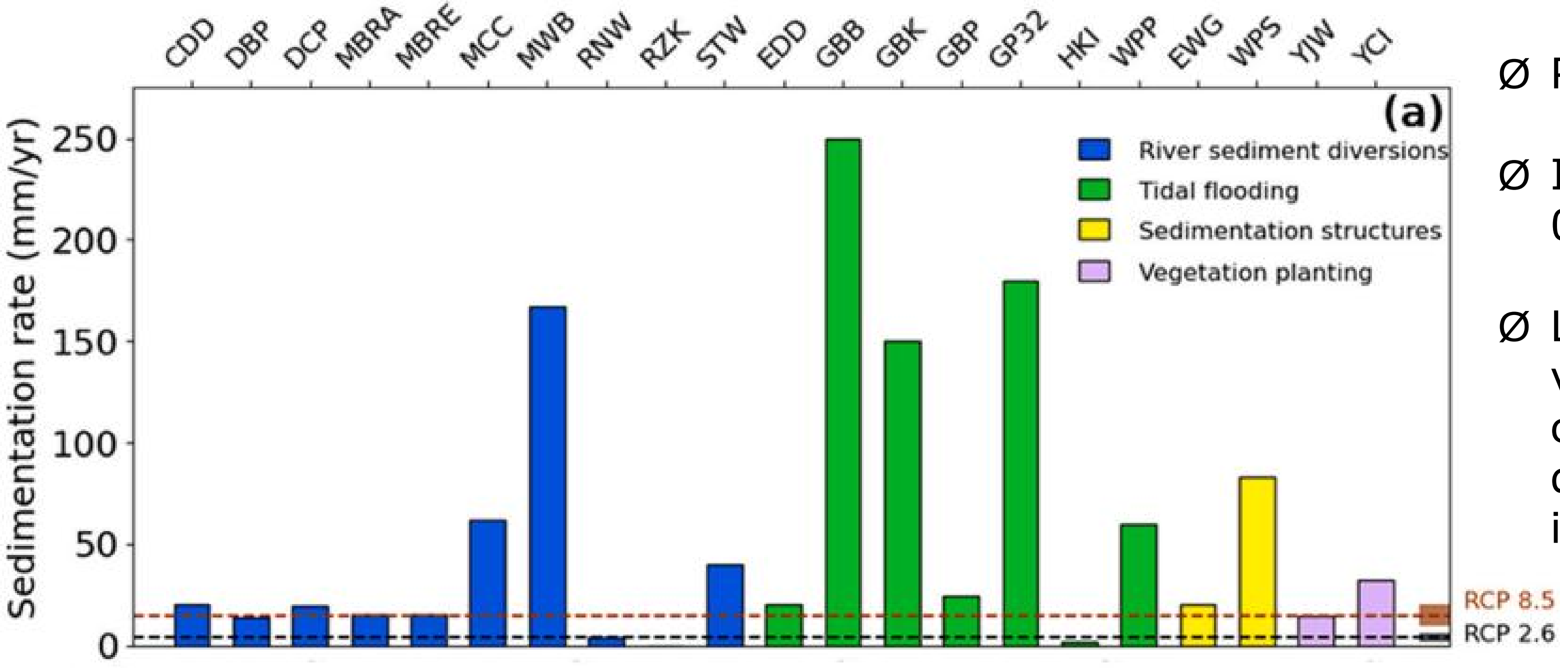


Source: Zhong et al. (2022)

Sand use in concrete and glass, representing 1/3-1/2 of the global sand use

PBL Netherlands Environmental Assessment Agency

Urban development and infrastructure hamper sediment enhancing strategies



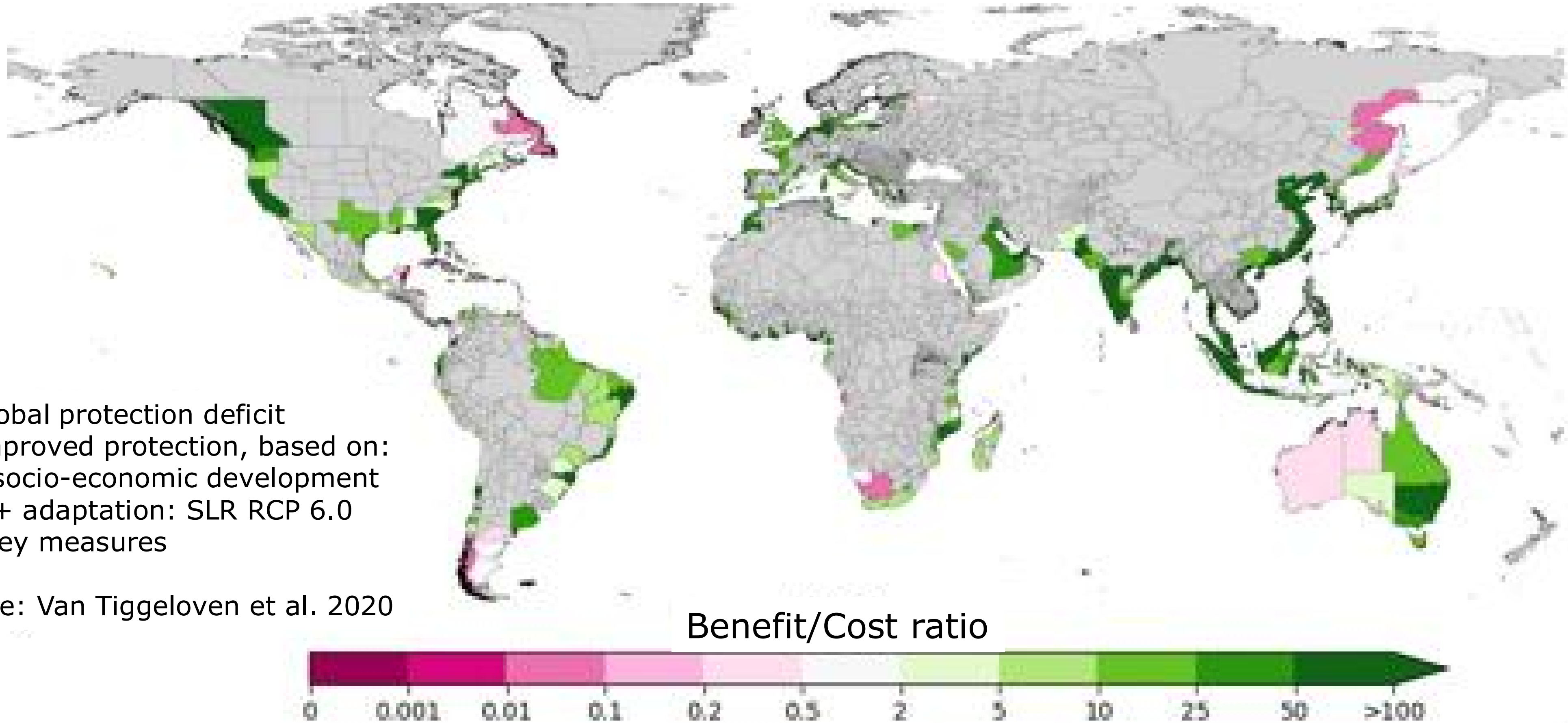
Observed sedimentation rates in 19 projects aimed to enhance (restore) the accretion of deltas. Source: Cox et al. 2022.

- Ø Promising rates, but
- Ø Implementation on ca. 0,1% of the total delta area
- Ø Large scale implementation very difficult due to compartmentation of deltas by urbanization and infrastructure

PBL Netherlands Environmental Assessment Agency

Improving protection of deltas & coasts pays off

Benefit/Cost Ratio of improving flood protection in many countries positive



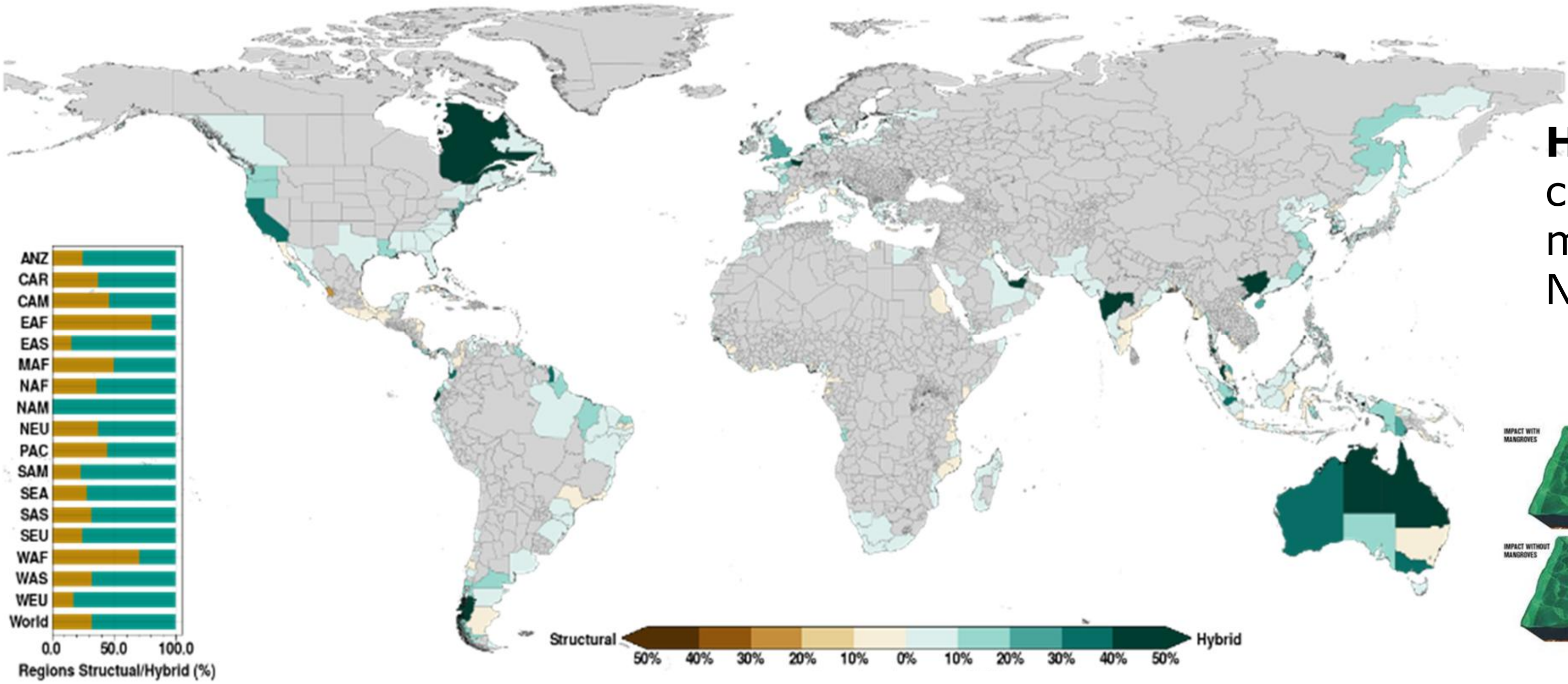
- Global protection deficit
- Improved protection, based on:
  * socio-economic development
  * + adaptation: SLR RCP 6.0
- Grey measures

Source: Van Tiggeloven et al. 2020

PBL Netherlands Environmental Assessment Agency

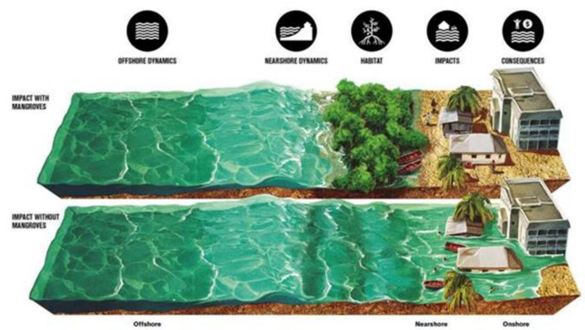
Combining grey and Nature Based Solutions

Benefit/Cost Ratio of combining grey/NBS measures in many countries positive

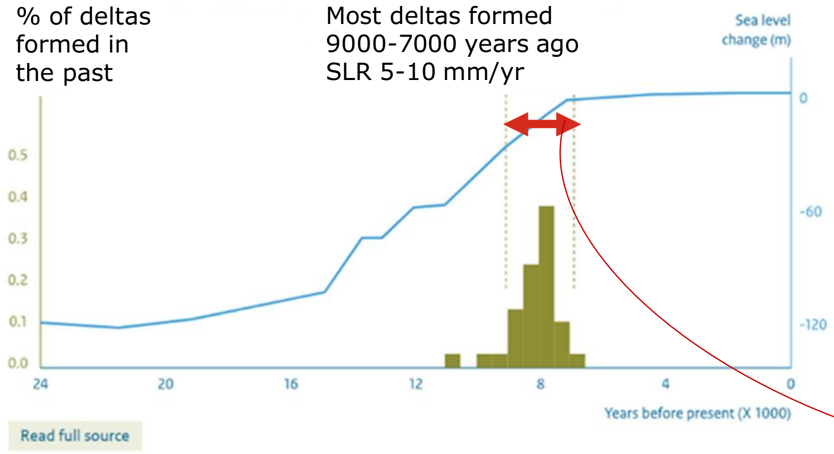


Benefit/Cost ratio

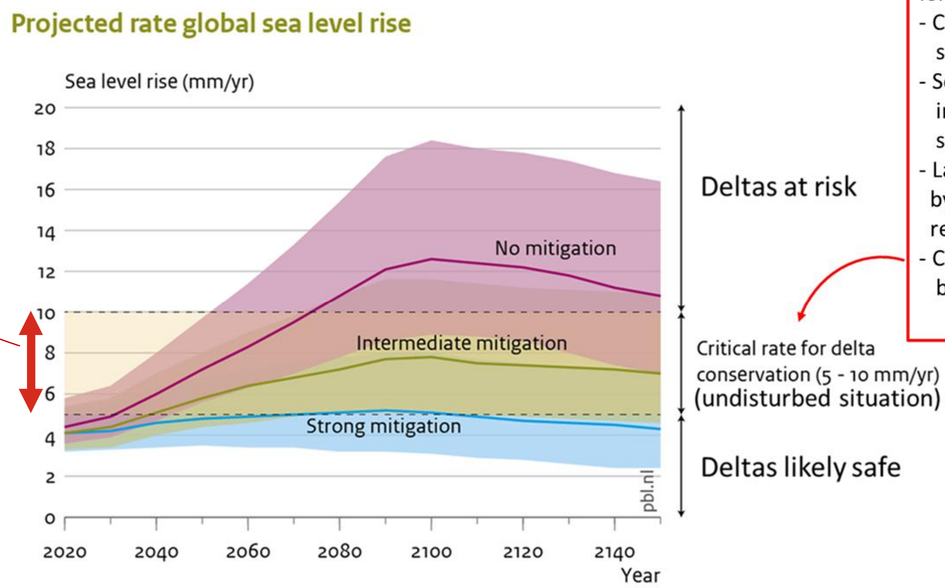
High ambition pathway:
combining protection levels moderate ambition + Nature Based Solutions



Historic context of sea level rise and deltas:
what if the past is representative for the future?



Geological research revealed that most deltas in the world have formed when the rate of sea level rise slowed down to 5-10 mm/year. Source Tuner et al. 2017.



Source: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool

Today many deltas are more sensitive for sea level rise due to:
- Constructed dams upstream, reducing sediment flows
- Sediment mining for urban and infrastructure development, reducing sediment flows
- Land subsidence and salinization, caused by groundwater abstraction and reclamation
- Compartmentation due to levees, dikes, built-up area and infrastructure

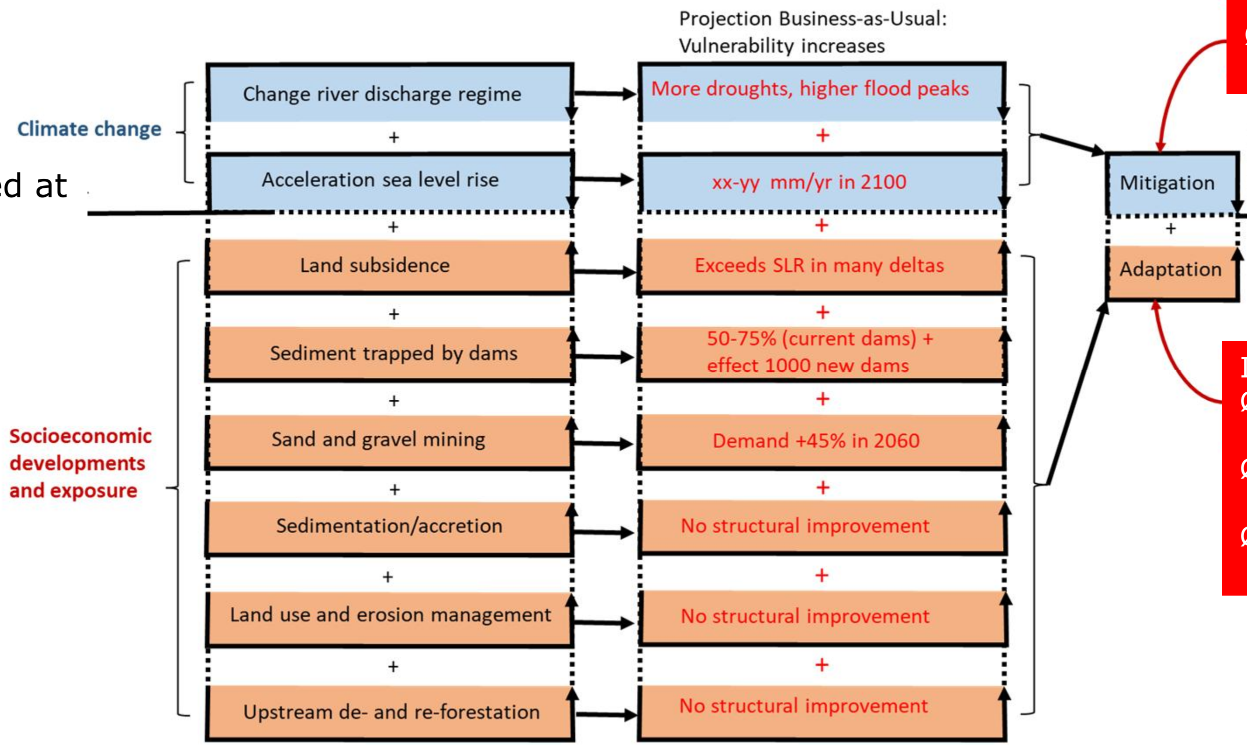
Draft

PBL Netherlands Environmental Assessment Agency

Today: all signs for deltas are on red

Diagnosis: overview of future trends of critical drivers for deltas

PAST:
Deltas formed at 5-10 mm/yr



FUTURE
Do we start losing our deltas this century?

IPCC 2021:
- 1.5° or 2° C target increasingly uncertain
- Weather extremes intensify beyond model projections

IPCC 2022:
- No signs of adequate adaptation responses
- Spatial developments increase exposure
- Hardly transformational approaches found

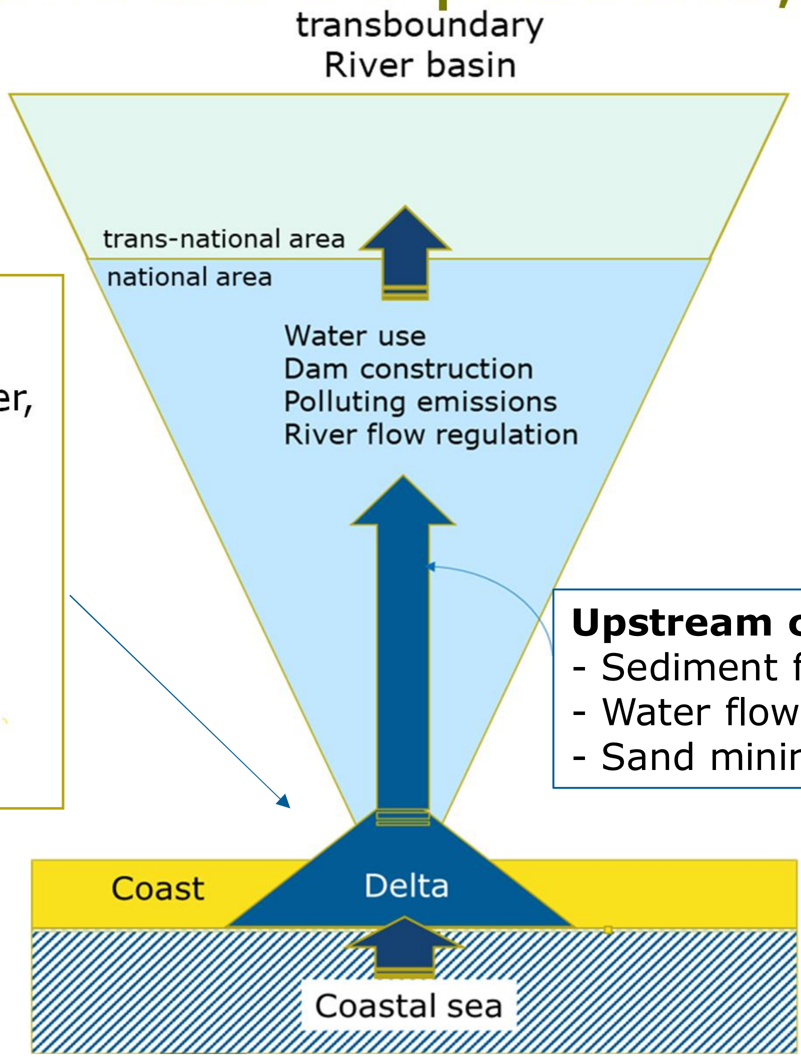
The future: bending the trend should be possible, but a complex challenge

PBL Netherlands Environmental Assessment Agency

Reducing land subsidence
=> restructuring fresh water supply
(treated river water, brackish groundwater, seawater, off-shore fresh groundwater)

Improving flood protection
=> integrating NBS and sedimentation

Steering spatial development
=> water robust development, reducing exposure



Whole system approach needed

Upstream challenges
- Sediment flows
- Water flows
- Sand mining

Navigating deltas towards a sustainable future

Still questions rather than answers:

- How long can populated delta systems be sustained, under what strategies?
- How can upstream and downstream measures contribute?
- Will it be possble to reduce land subsidence and restore sediment dynamics? How relevant is this, if sea level rise really accelerates?
- How far can nature-based approaches in the deltas take us?

- What approaches today are interesting '*to bend the trend*' : *from short-term sectoral to long-term systemic strategies?*

PBL Netherlands Environmental Assessment Agency

Thank you!

Website in progress:
https://themasites.pbl.nl/future-water-challenges/river-basin-delta-tool/

- Ø Rhine
- Ø Yangtze
- Ø Mekong
- Ø Mississippi

Jaap Kwadijk

Deltares

Rhine-Meuse delta

The evolution of Dutch Water Management

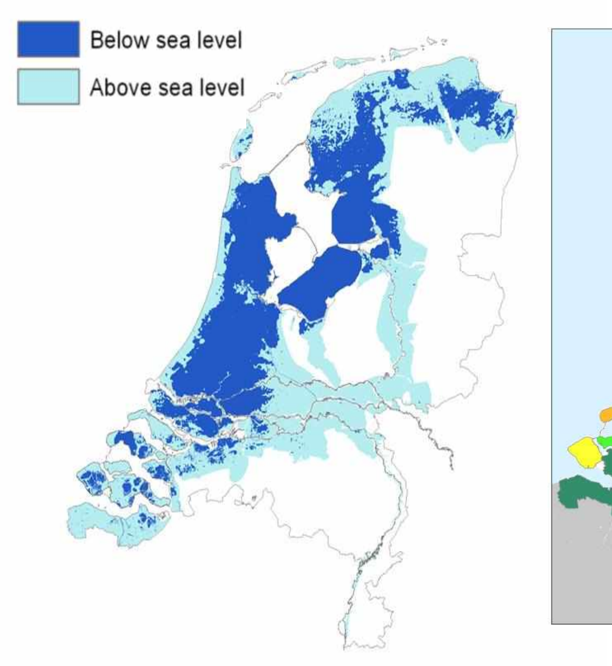
Jaap Kwadijk, Marjolijn Haasnoot

Deltares & Universiteit Twente, Utrecht University

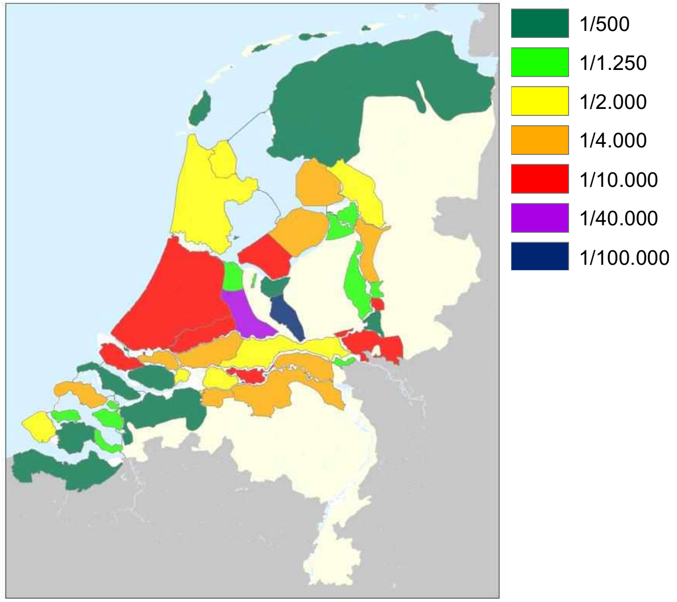
September , 2022

enabling delta life

The Netherlands

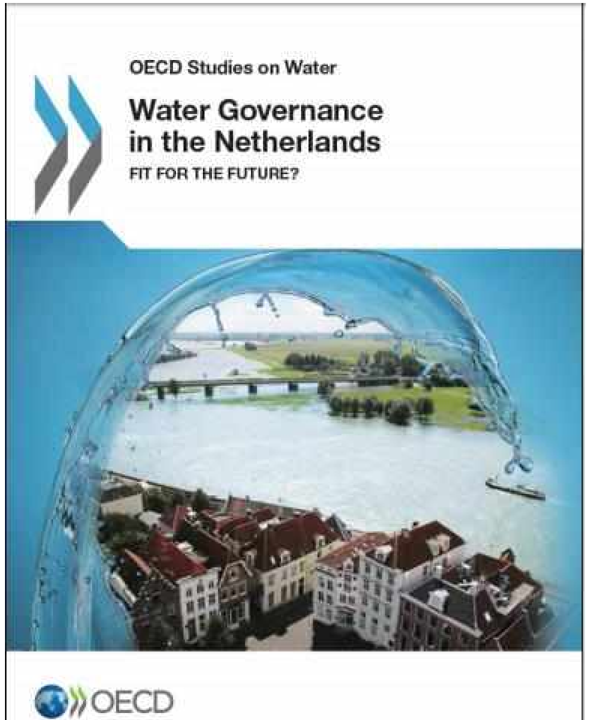


2/3 flood-prone,
9 million inhabitants,
65% GNP,
€ 1800 B invested value



The flood standards
Sophisticated risk-based approach

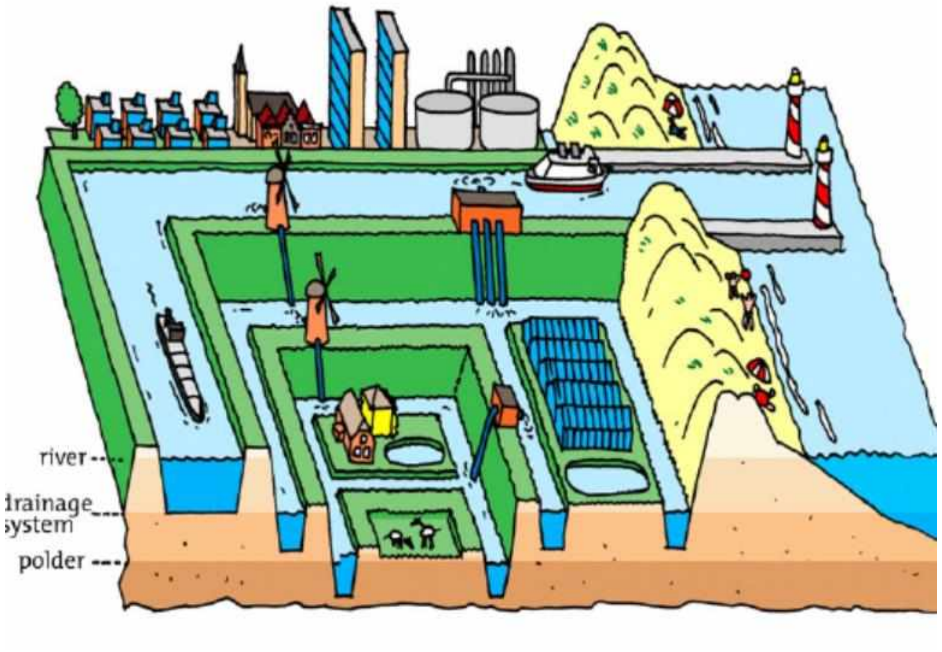
The Dutch



(OECD, 2014)

Awareness gap of the Dutch

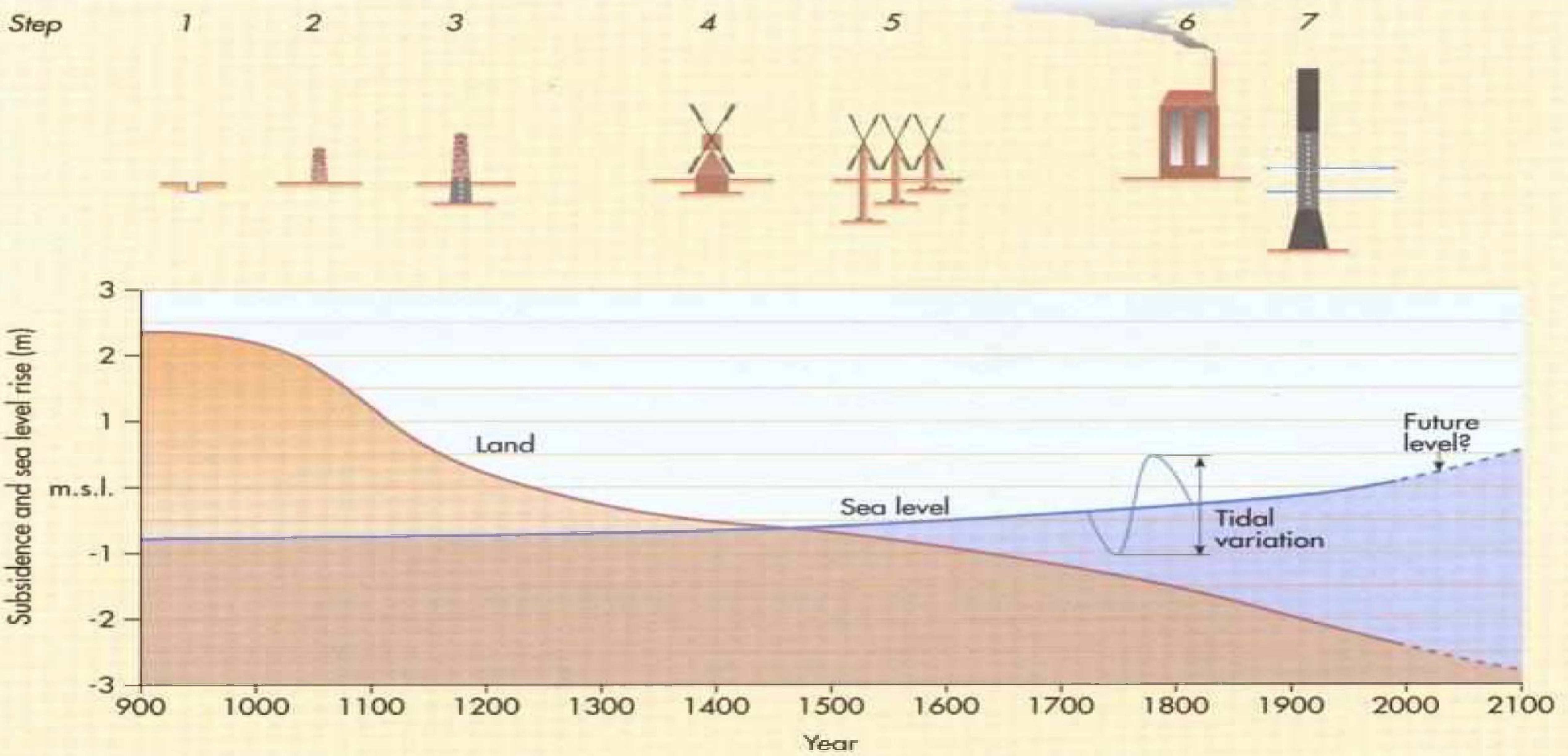
"the "awareness gap": …Dutch citizens take current levels of water security for granted. As a consequence, they tend to be less involved in water policy debates, to ignore water risks and functions when they develop property, and to be little concerned with water pollution…. (OESO, 2014)



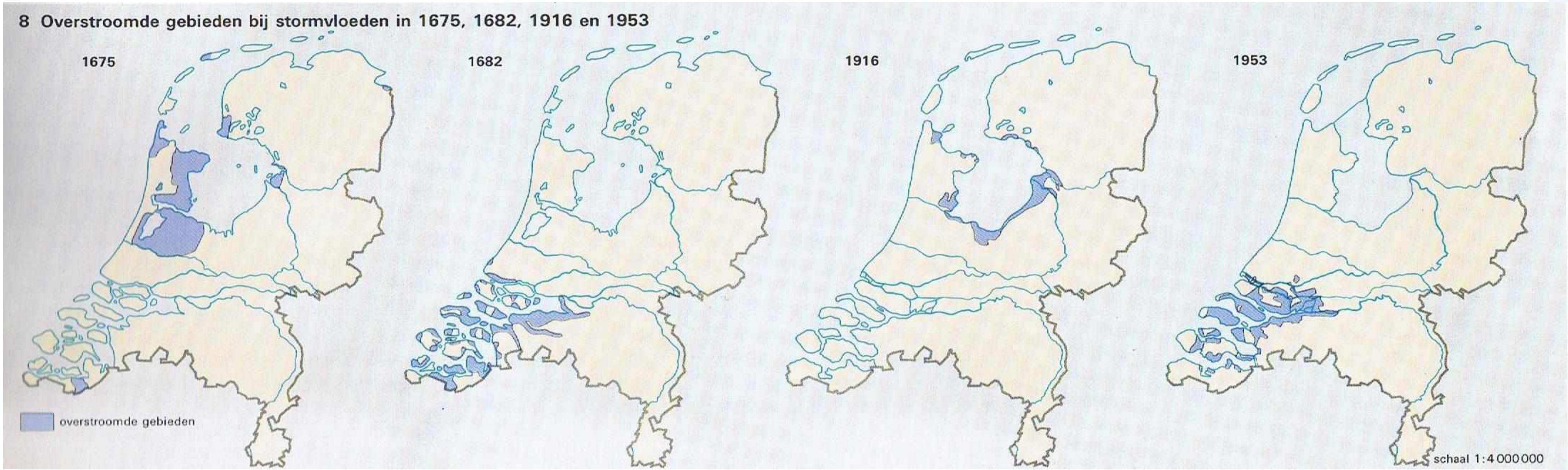
Deltares


Greetings from Holland

The Dutch are draining down their land



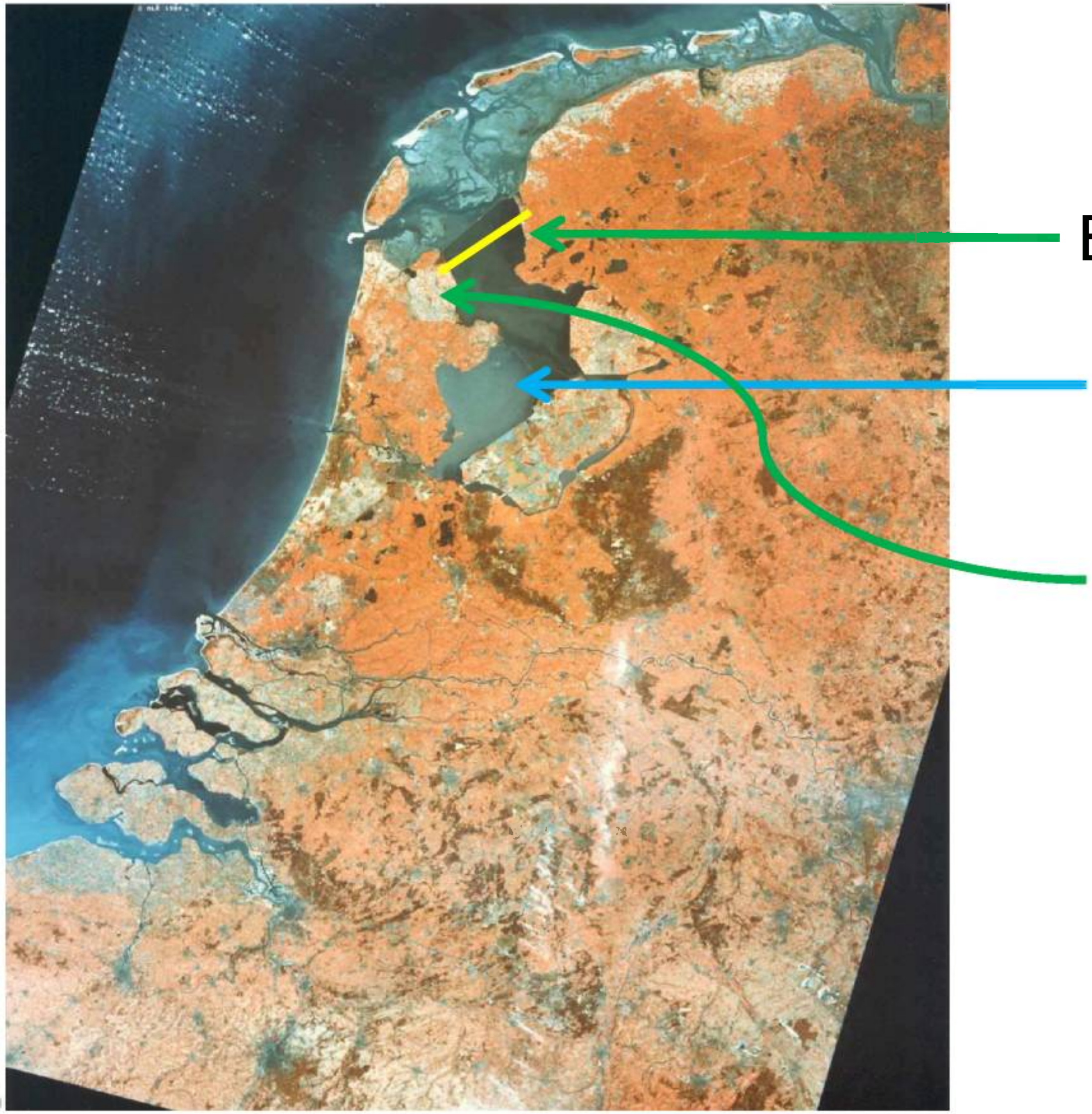
Main flood events (all generations have their own flood)



1675 1682 1916 1953

Deltares

Following the 1916 flood the Dutch reacted by



Building the closure dike
=>
Creation of IJssel Lake
and
the Wieringermeer
polder

Following the 1953 flood the Dutch reacted by

- Dikes and barriers
- The delta works

Deltares

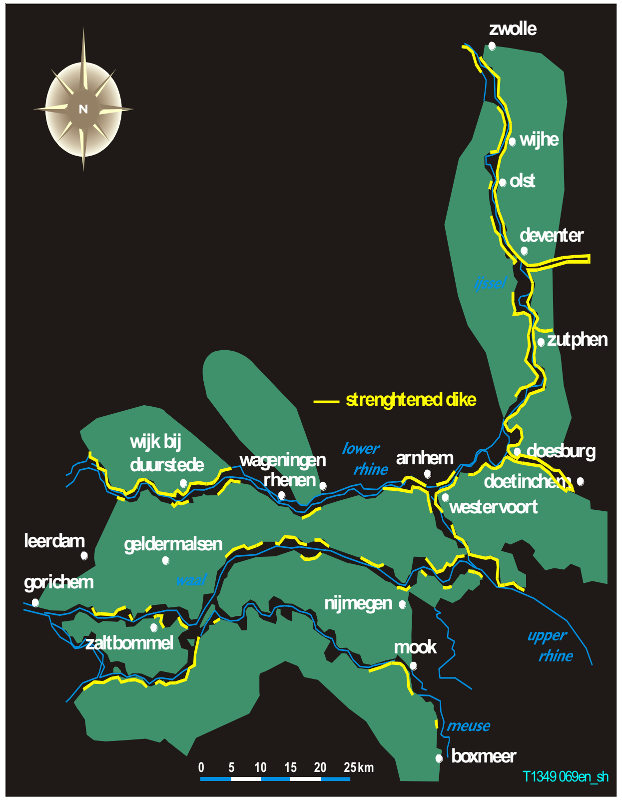
THE TRANSITION

Flooding from rivers (my generation flood 1993,1995)

1995

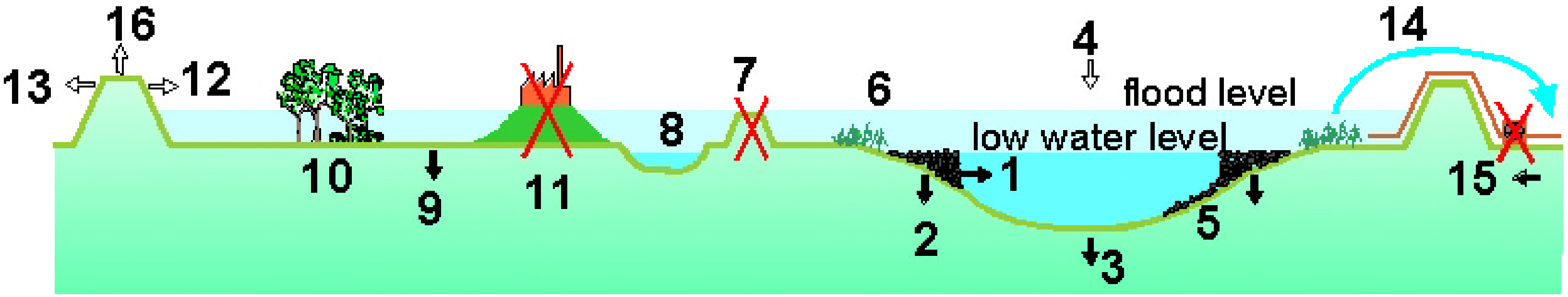
Deltares

The Dutch reacted by Room for the River

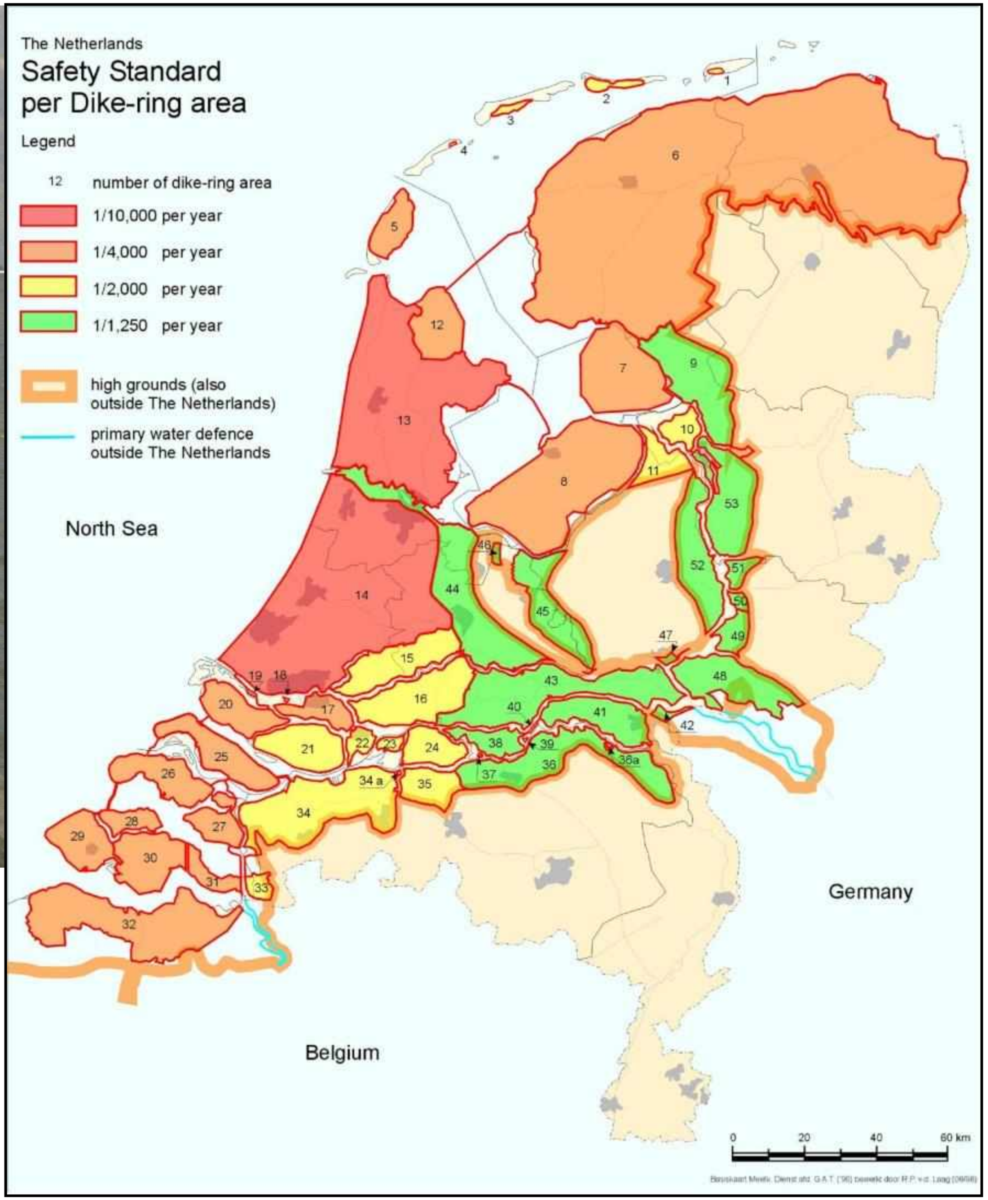


Flood reduction by:
2 - lowering groynes
3 - deepening main channel
7 - removal embankments
8 - side channels
9 - lowering floodplain

10 - changing vegetation
11 - removal of obstacles
13 - displacement main river dike
14 - retention behind dike
15 - stopping lateral inflow



~2000
Water Policy for the 21st century included Sea level rise and Climate Change



Extremely high safety standards + maintenance
were put in the law =>
Safest delta in the world

Deltares

2005-2006

New Orleans
Hurricane Katrina

Al Gore,
inconvenient truth

Now we had a problem:

The risk of climate change /
sea level rise is not the flood hazard itself

but

The image that the Netherlands might
not be safe anymore for investments

Now that is a major risk!!

2nd Delta commission

Finding: Scientists do not agree on magnitude of Climate Change and Sea Level Rise

Asked basically four questions

1. What is the maximum plausible SLR between now and 2100 **(130cm)**

2. Are we able to defend the Netherlands to that rise **(YES)**

3. What will it cost **(~ € 1 B / yr)**

4. Can we pay this **(YES)**

OK, than that is what we will do, discussion closed
=> Parlement agreed upon the Delta Act

Deltares

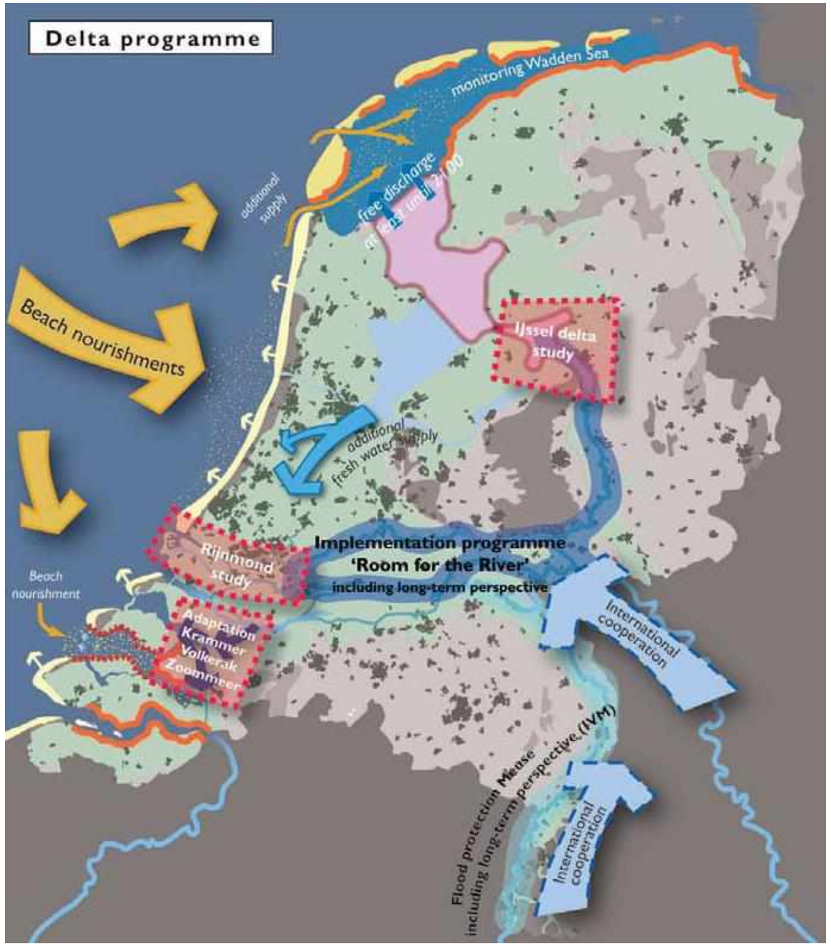
Essentials for adaptive prevention

A budget (€1B annually)

A law (the Delta act)

A Plan(Delta programme)

A delta commissioner (at Minister-level)



Li Yuanyuan

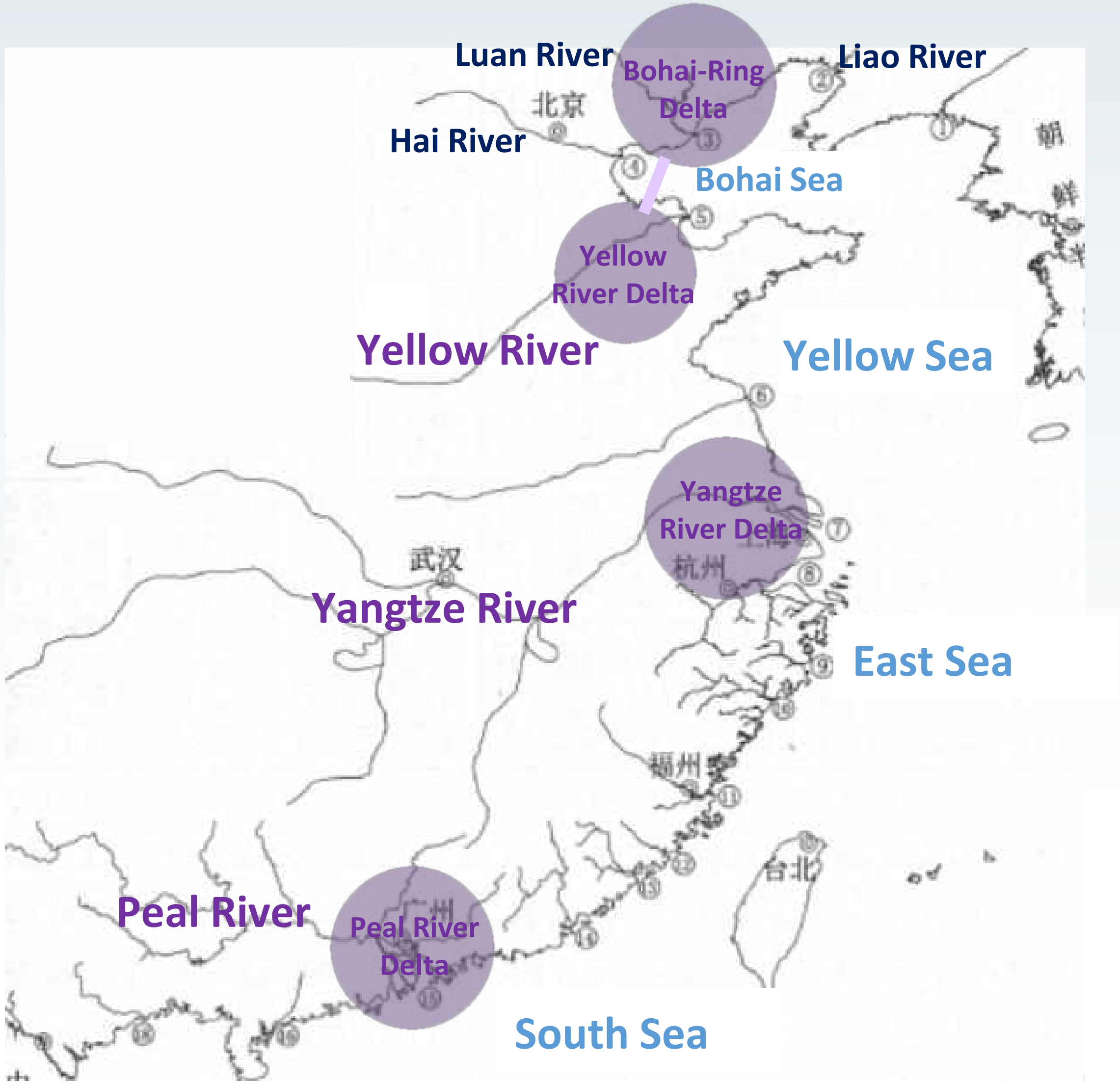
Water Security of Large River Deltas in China

Yuanyuan LI

Vice President, General Institute of Water Resources and Hydropower Planning and Design (GIWP)，Ministry of Water Resources, P. R. China
President, International Water Resources Association (IWRA)

11 October 2022

Major delta distribution in China



Estuary Formation

Drastic changes in river deltas promoted the formation of modern deltas of large rivers

- **Yangtze River Estuary.** With moderate tidal environment and rich incoming water and sediment, modern estuary has developed since the middle of 17 century, spatial pattern is three-tier branches and four outlets into the sea
- **Yellow River Estuary.** With weak tide, sandy inflow and frequent oscillation, modern estuary has developed since the large-swing of river channel in 1855, entering Bohai Sea through Shandong province
- **Peal River Estuary.** As a relatively-weak tidal estuary with more water and less sediment, network water system pattern is three rivers converge and eight outlets diverge

Yangtze River Estuary

Yellow River Estuary


Peal River Estuary

CONTETS

01

Water Characteristics

- Water Dynamics
- Socio-economic Dynamics
- Ecological-environmental Dynamics

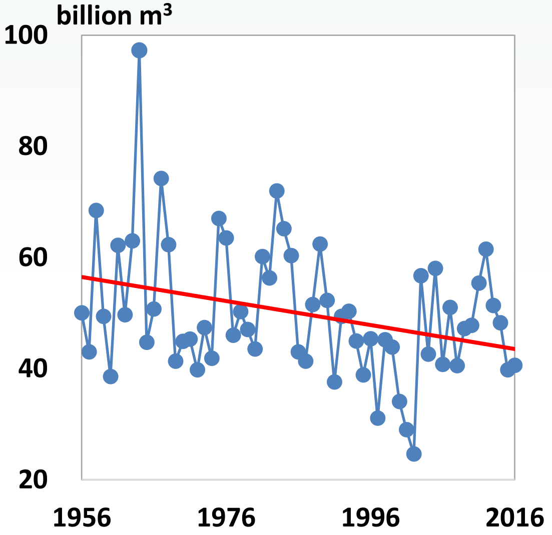
1.1 Water Dynamics

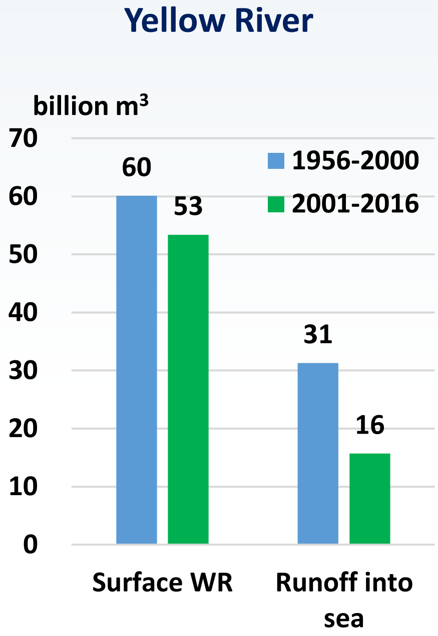
- **High impact of basin scale.** Since 2000, runoff into sea has slightly decreased, especially that from deltas in North China due to impacts of rainfall, land surface change and obvious water consumption increase
- **Large runoff variation.** For major rivers, runoff in wet years are 15-80% more than annual mean runoff, runoff in dry years are 22-63% less than annual mean runoff

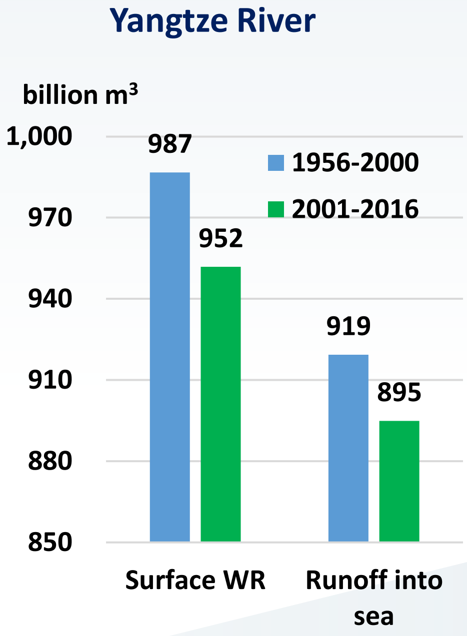
Annual runoff at Datong Station (last) of Yangtze River

Maximum annual runoff (m^3/s)			Minimum annual runoff (m^3/s)			Maximum - minimum ratio
Year	Average annual flow	Compared to yearly average	Year	Average annual flow	Compared to yearly average	
1954	43100	1.51	1978	21400	0.75	2.02

Natural runoff of Lijin

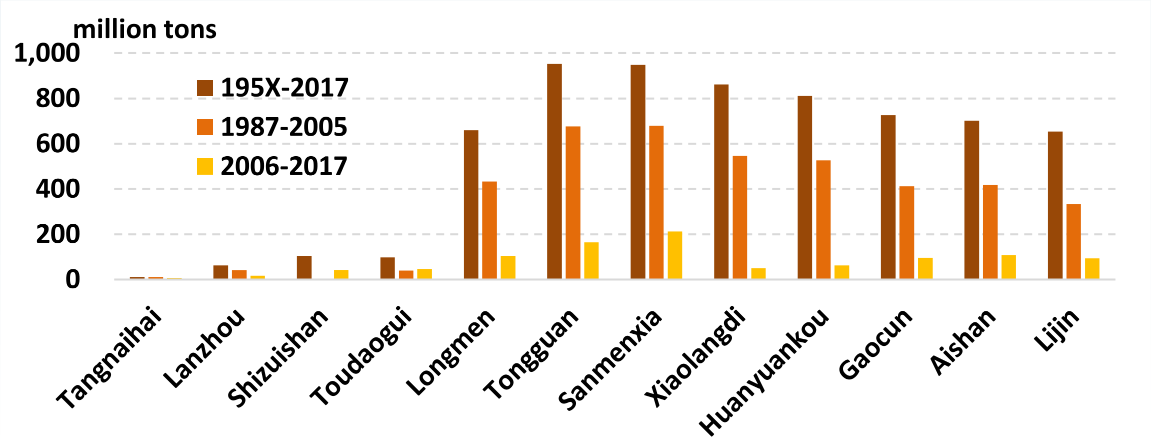




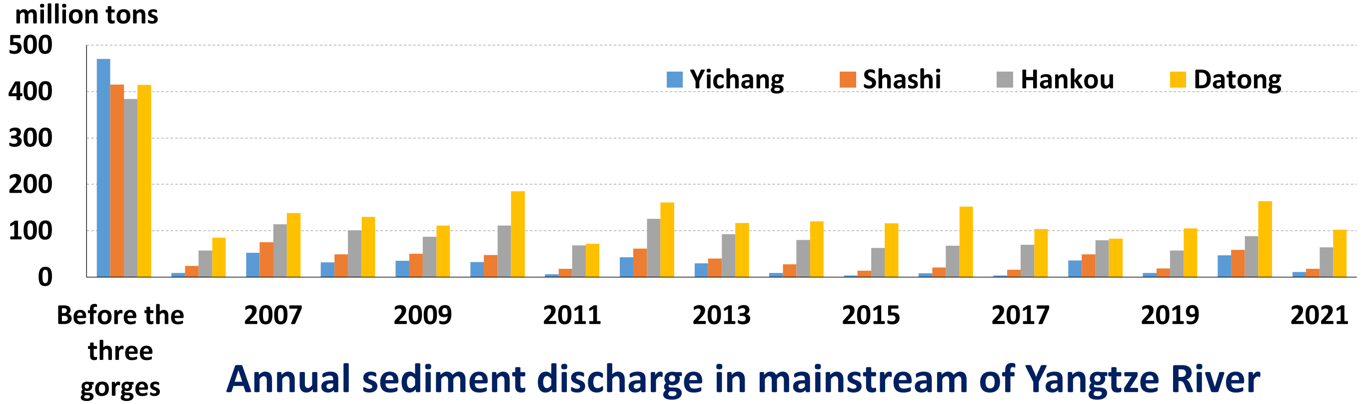


1.1 Water Dynamics

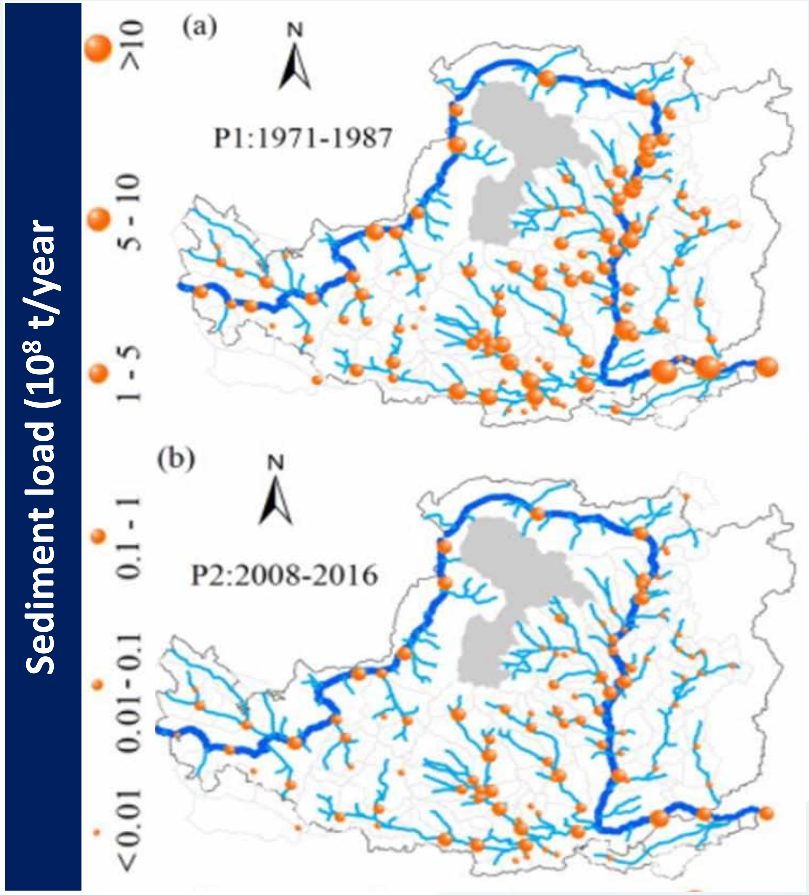
- **Sediments discharge reduced.** **Sediment amount into sea reduced sharply due to soil and water conservation and construction of water projects in upper and middle reaches as well dredging sediment, which exacerbate unbalanced water-sediment relationship**
  - **Sediment into sea from Yellow River accounts for more than 50% of that from China**



Annual sediment discharge in mainstream of Yellow River



Annual sediment discharge in mainstream of Yangtze River

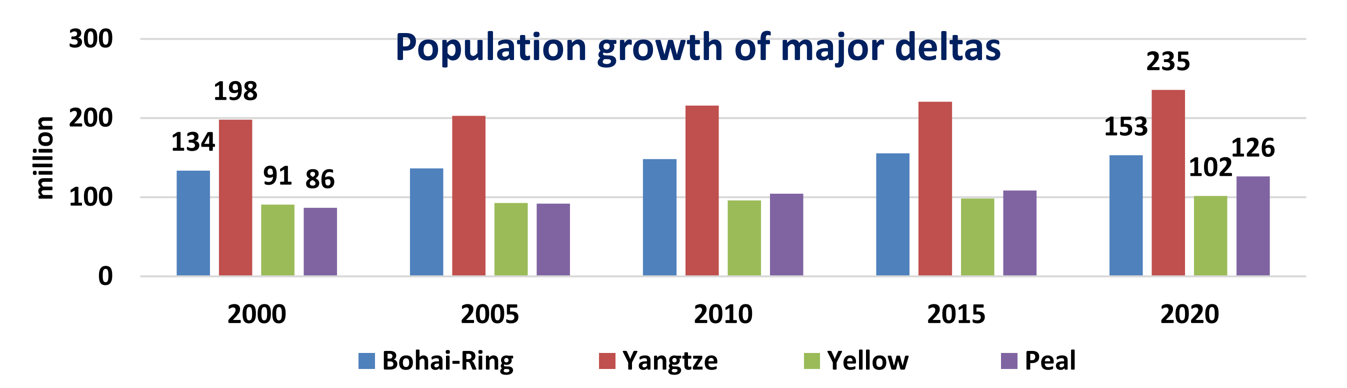


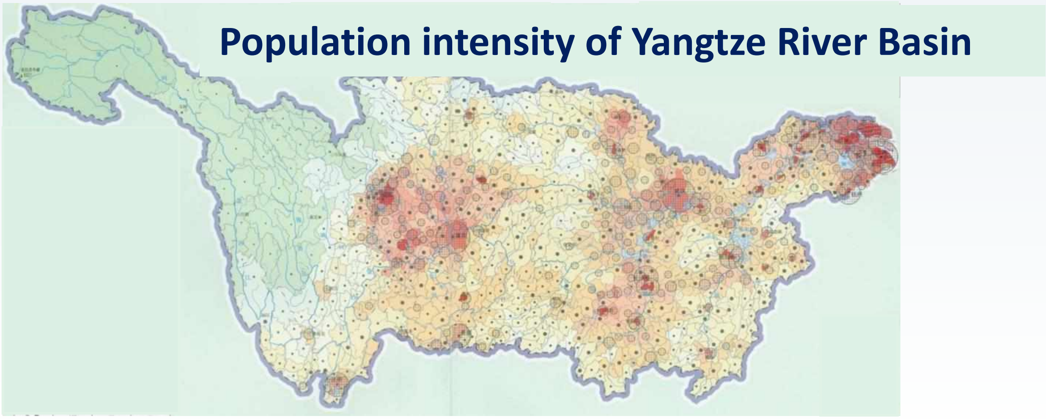
Loess Plateau reach of Yellow River: **Annual sediment discharge decreased by 74% (2008~2016 vs 1971~1987).**
(Zheng et al., Sci Total Environ, 2019)

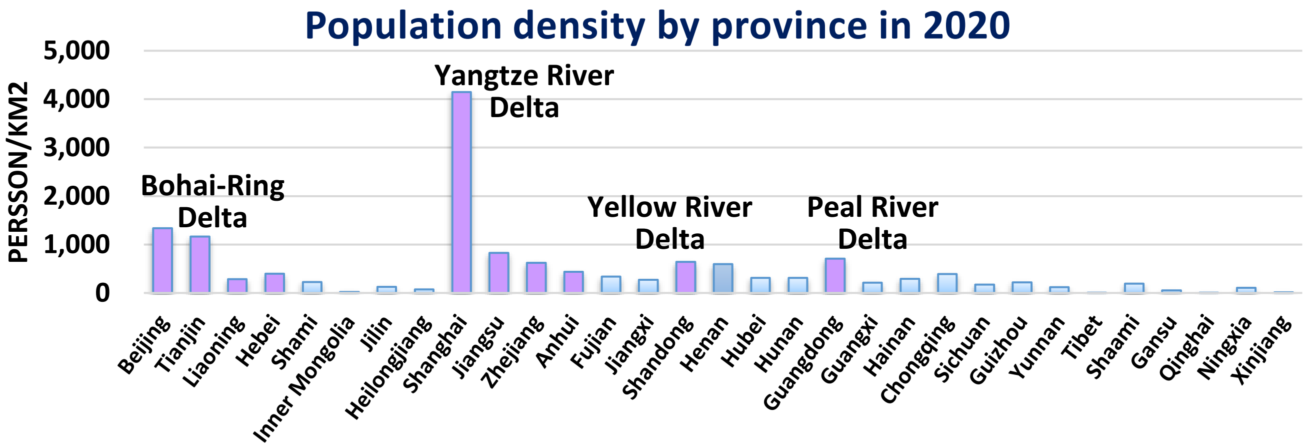
1.2 Socio-economic Dynamics

➢ **Aggregated population growth.** **The vibrant delta areas attracted population to aggregate, the major deltas cover 44% of national population, with 108 million increase from 2000-2020, accounting 74% of national increase**

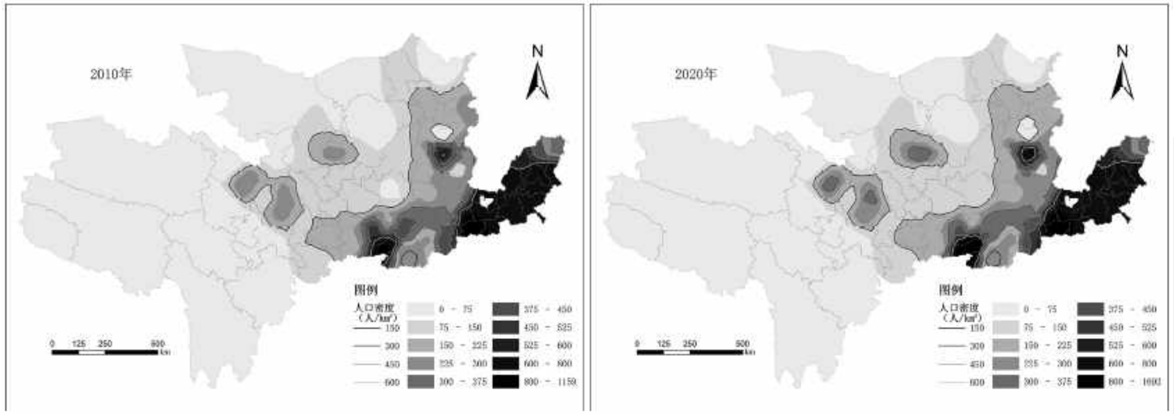
- **Population density are the highest in these deltas except Beijing and Tianjin in China**
- **Urbanization rate reached 89% in Shanghai, which is highest in China**





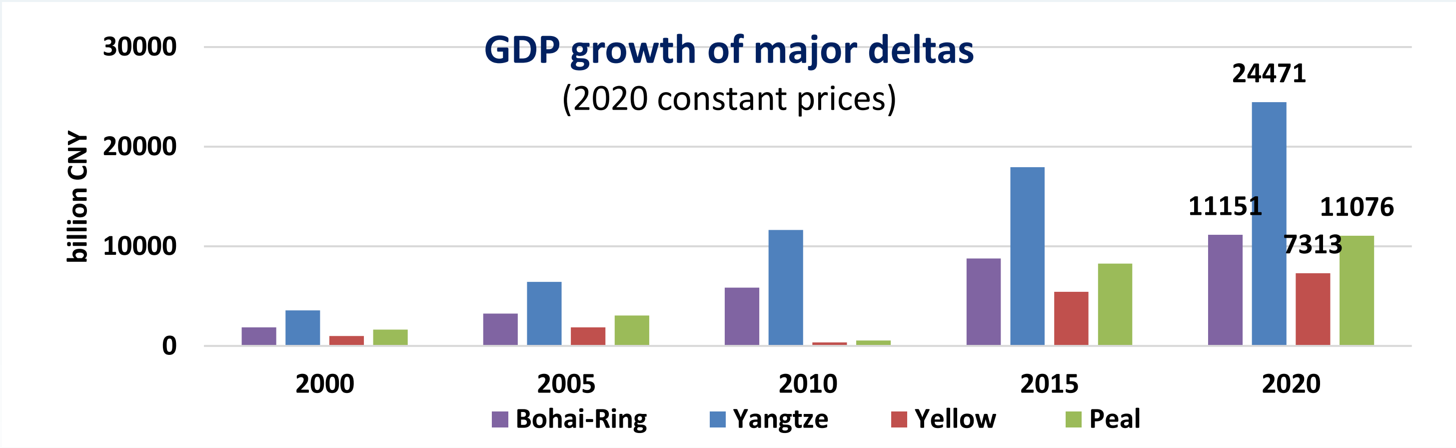


Population intensity change of Yellow River Basin

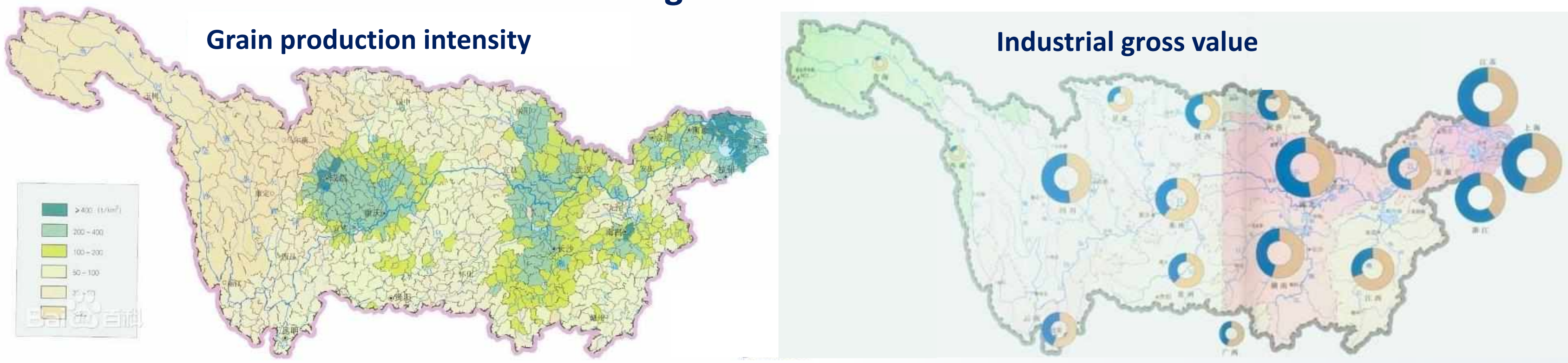


1.2 Socio-economic Dynamics

➢ **Rapid economic development.** With convenient inland-outsea transportation, rich land and water resources, these major deltas are the most rapidly developed regions with several megacities in China, converge 53% of national GDP



Yangtze River Basin

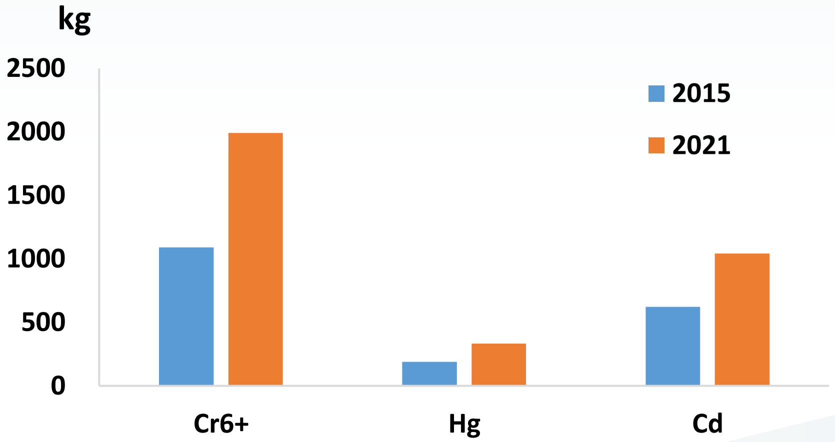


1.3 Ecological-environmental Dynamics

- **Accumulative impacts.** As gradual transition from rivers to estuaries, deltas owns rich aquatic biodiversity, which reflects long-term cumulative impacts of water-land development and pollution basin-wide and within the deltas
- **Beach space reduced.** Coastal reclamation activities have experienced the development with rapid speed, large area and wide range since 2000
- **Heavy metal emissions increased.** Although water eco-environment shows improving trend, directly discharge of some heavy metals into sea by coastal provinces such as Cr^{6+}, Hg & Cd, increased by 70-80% from 2015 to 2021

Beach space change of Yellow River Estuary

Year	Beach space (km^2)
1968	851.5
1980	853.1
2000	875.7
2010	802.7
1968-1980 change	1.6
1980-2000 change	22.6
2000-2010 change	-72.9



Directly discharge increase of some heavy metals into sea by coastal provinces

Source: China Bulletin of Sea Ecological-Environmental Condition

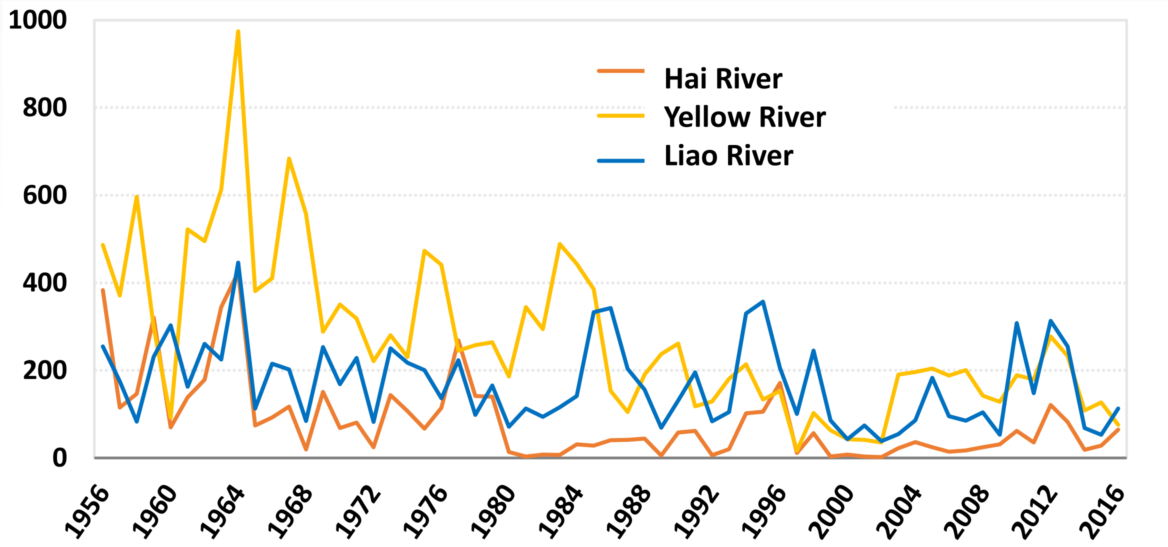
02

Water Security Challenges

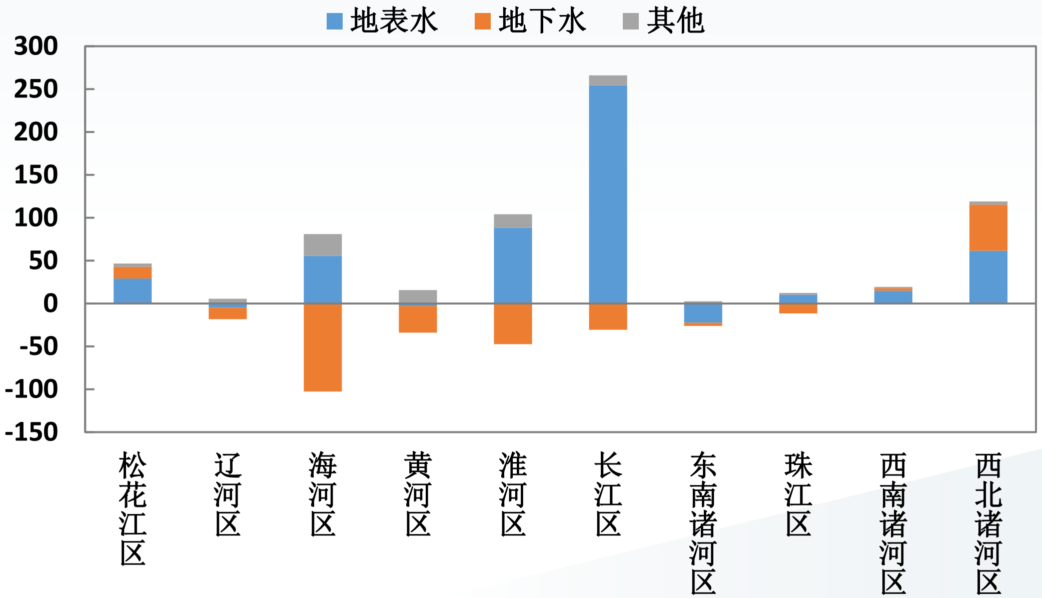
- Water Shortage
- High Resources Use and Demand
- Flooding Risks
- Ecological-environmental Degradation
- Higher security Standards Required

2.1 Water Shortage

- **Estuarine hydrodynamic processes changed greatly.** Influenced by declined surface water inflow and enhanced water resources development and utilization, the rates of runoff into the sea to surface water resources decreased by 36%, 75% and 89% respectively for Liaohe River, Haihe River and Yellow River (2001-2019 vs. 1956-1979)
- **Available water resources varied obviously.** Global climate changes, land surface change within river basins, and water utilization of upper and middle reaches have changed water resources availability
  - Since 2000, water supply in Yangtze River Basin has increased by 23.5 billion m^3, accounting for 80% of national increase, runoff amount and hydrological process entering into basin downstream (beyond Hukou) changed



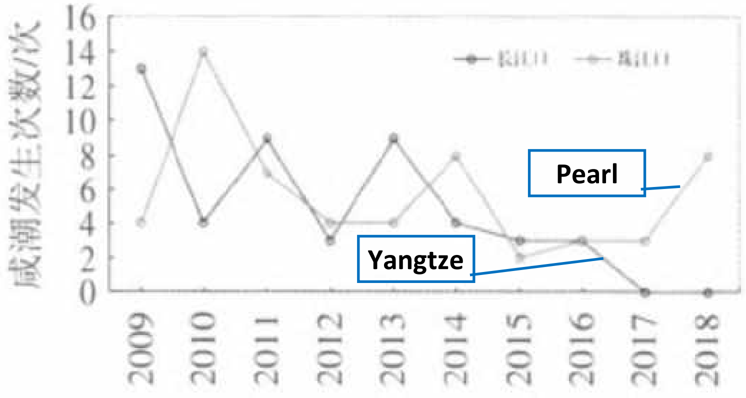
Variation of runoff into the sea of Liaohe River, Haihe River and Yellow River



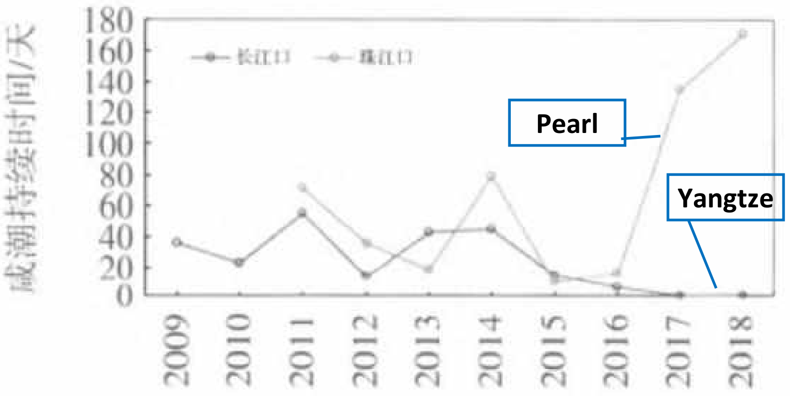
Change of water supply in water resources zones in 2019 compared with 2000

2.1 Water Shortage

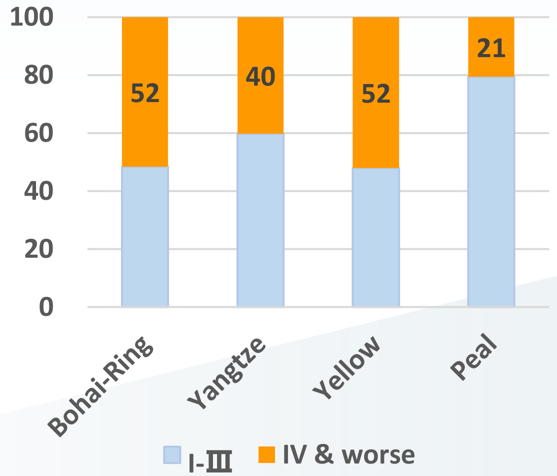
- **Seawater intrusion influence water supply in dry season.** Influenced by continuous water use increase in the estuaries, less inflow from upperstream, sea level rise, and riverbed cutting- down, seawater intrusion in Pearl River estuary has intensified in recent years
  - Pearl: Serious in Dec-Mar , with farthest upstream distance 70km, both intrusion distance and quality-excess time of main water intakes increases under the same runoff condition
  - Yangtze: Serious in Jan-Mar. When flow of Datong Station in dry season is less than 10000m^3/s, salinity of each representative station generally increases. In Feb 2014, water sources suffered the longest seawater intrusion
- **Deteriorated water quality threaten water supply.** Wastewater of Yangtze Delta is 1/5 of national total, wastewater from Peal Delta increased by more 3 time since 1980’s. Poor quality together with weak hydrodynamics in coastal plains, local resources is difficult to support water supply with unstable mainstream inflow



Seawater intrusion times from 2009 to 2018



Seawater intrusion days from 2019 to 2018

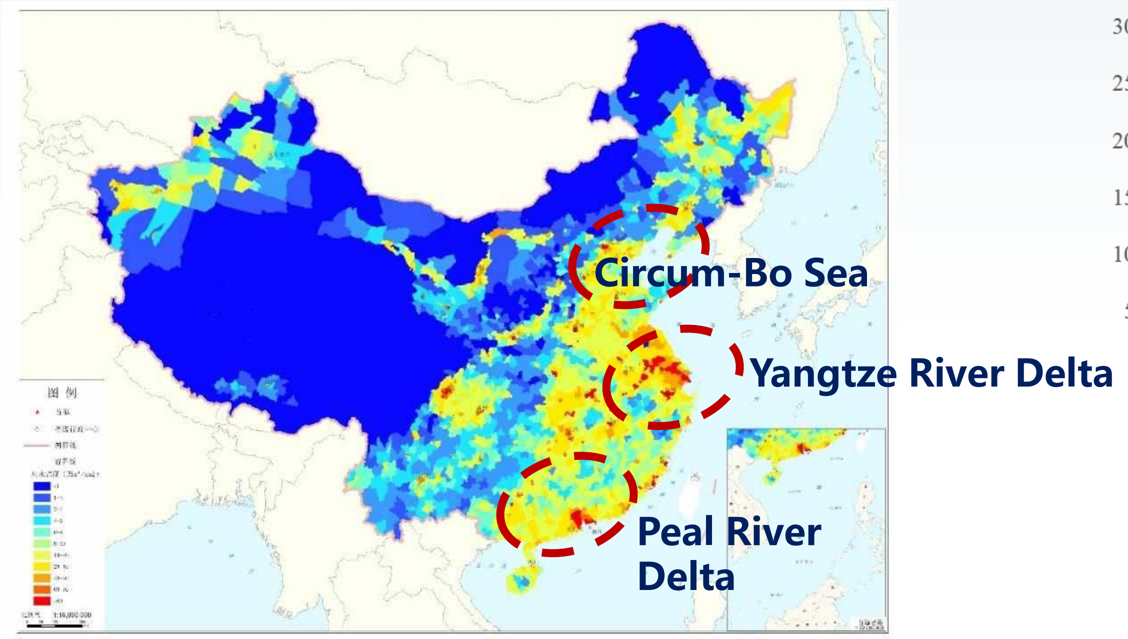


Water quality by river length in 2018

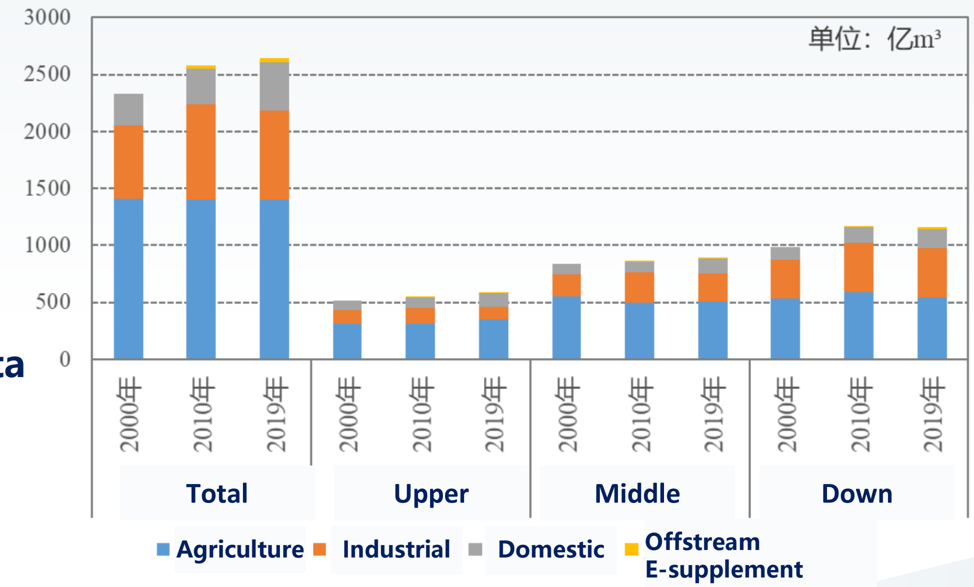
Source: China Bulletin of Water Resources

2.2 High Resources Use and Demand

- **Huge pressure on water resources & ecological-environment.** The major deltas support 44% population and 53% GDP with 11% territory at national scale
- **Higher future requirements.** With implementation of national strategies of Yangtze River Delta Integration Development, Guangdong-Hong Kong-Macao Greater Bay Area Construction, etc., demand to water/land/sea resources will continue to increase, bring higher exposure to disasters



National water use intensity distribution

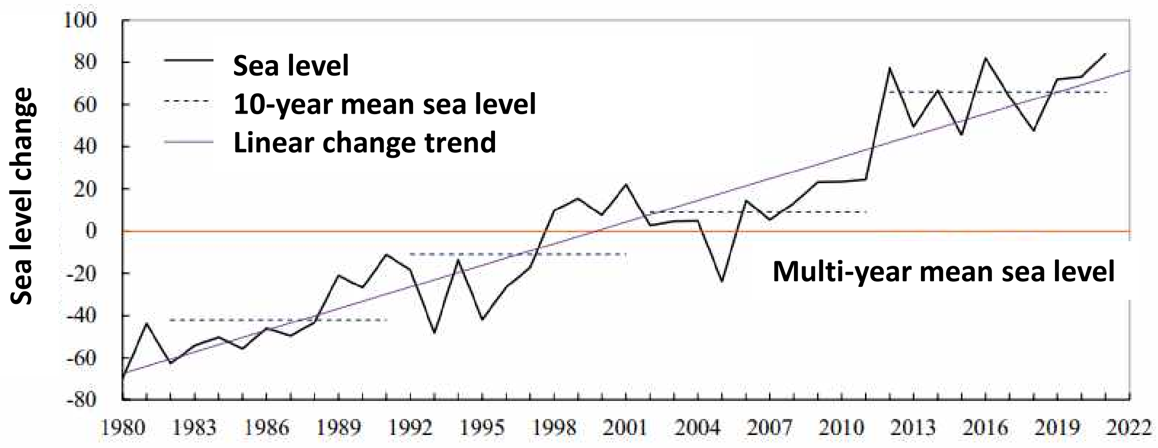


Water consumption change in Yangtze River Economic Belt

2.3 Flooding Risks

- **Vulnerable to disasters.** In low-laying areas close to estuaries, upstream incoming flood together with regional storm and coastal storm surge, these deltas are prone to flood, waterlogging and tide disasters, and storm aggravates the situation when overlapped with astronomical tide
- **Exacerbation of extreme events.** Affected by global climate change, rising sea level and elevated flood water table together with more frequent extreme hydrometeorological events (such as tropical cyclone, rainstorms) intensify disaster risks
  - Rate of sea level rise along China coast is 3.4 mm/yr since 1980s
- **Flood storage-detention-discharge space occupation.** Expanding urbanization and land reclamation compressed flooding space, flood level continues to rise under the same flood volume

Occupation of flood corridor

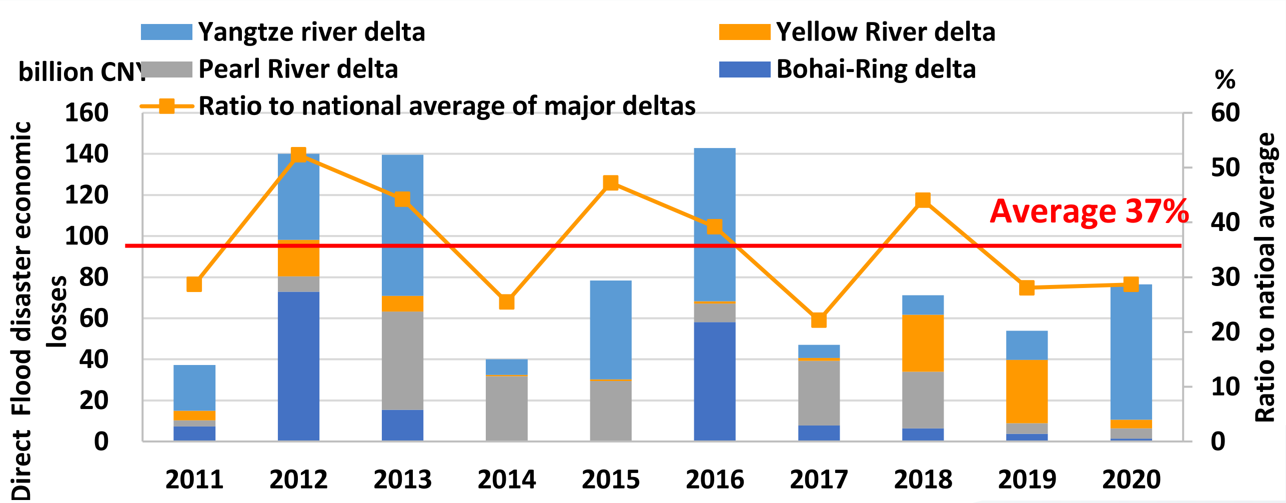


Sea level change along the Chinese coast from 1980 to 2021

2.3 Flooding Risks

- **High tide level backward flood.** The high tide level of the Pearl River has continuously reached new highs since 1990
- **Heavy disaster losses.** Yearly mean economic losses ratio of flood and waterlogging disasters are 83 billion CNY of the major deltas, 37% of national average during 2011-2020, and the ratio of Yangtze River Delta was 16%
    - Over 80% of sea disaster economic losses comes from storm surge in China

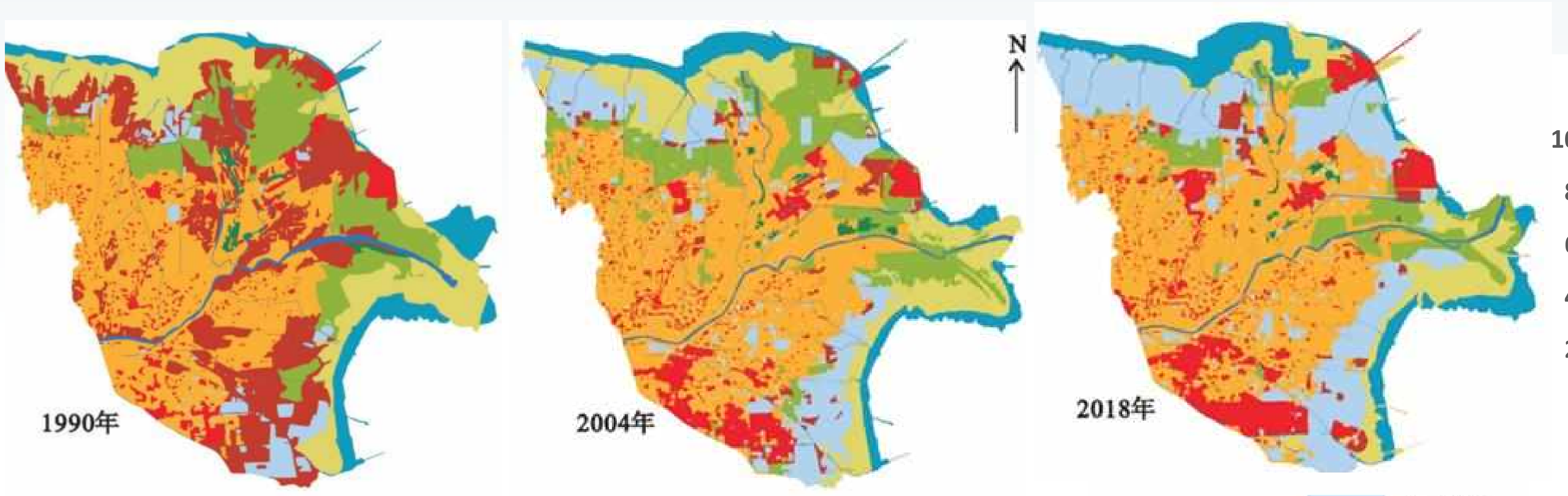
Flood of Weihe River merged into Yellow River



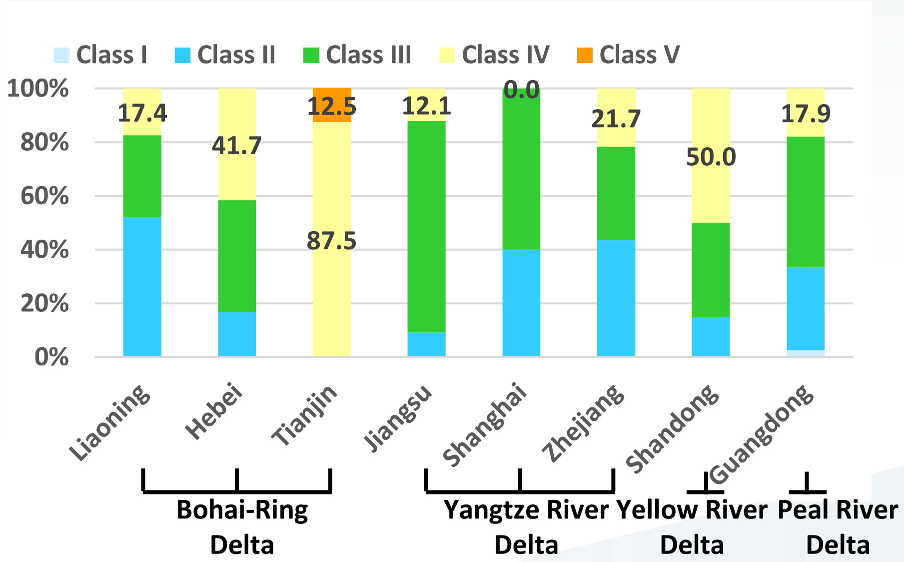
Flood disaster economic losses of major deltas

2.4 Ecological-environmental Degradation

- **Longer water exchange period.** With the change of rivers-lakes relationship, high-intensity landuse and massive beach reclamation, water exchange cycle becomes longer in lower coastal plain areas
- **Natural buffer space decrease.** Land reclamation and beaches reclamation reduced the area of coastal natural buffer space, especially in Yellow River estuary, where wetlands decreased by 55% since 1976
- **Water pollution.** Domestic, industrial and agriculture wastewater from upstream and within deltas threats water quality of estuary and sea, affecting water supply as well as aquatic and sea ecology



Proportion change of natural wetlands in Yellow River estuary

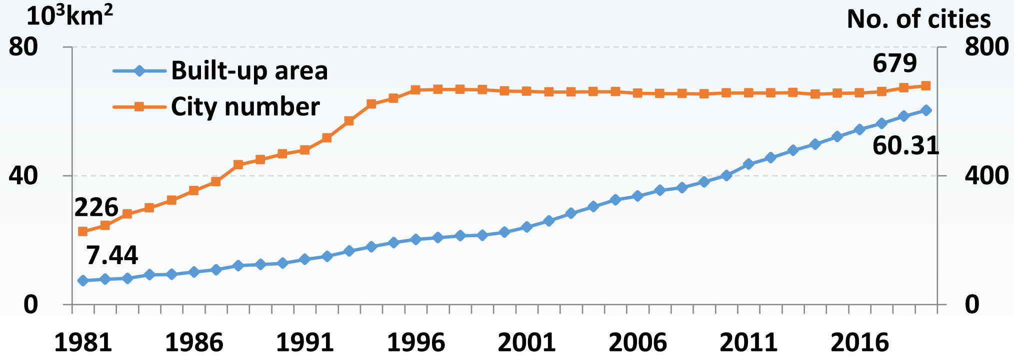


Cross-section water quality of runoff discharge into sea by province

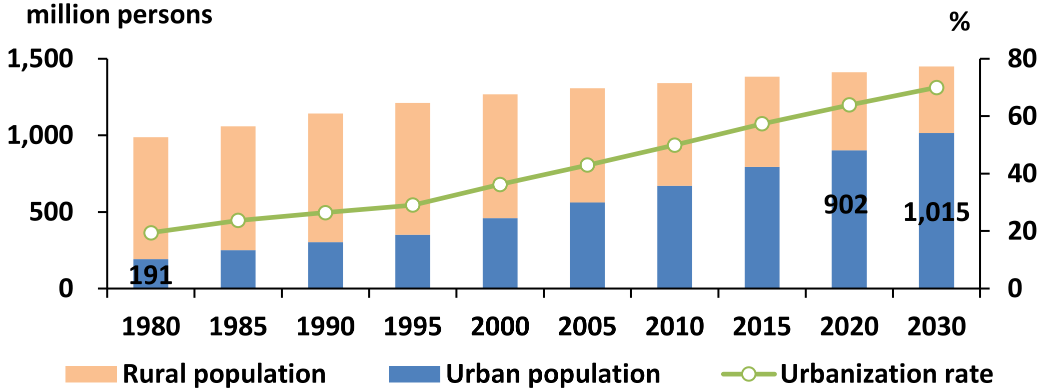
Source: China Bulletin of Sea Ecological-Environmental Condition 2021

2.5 Higher Security Standards Required

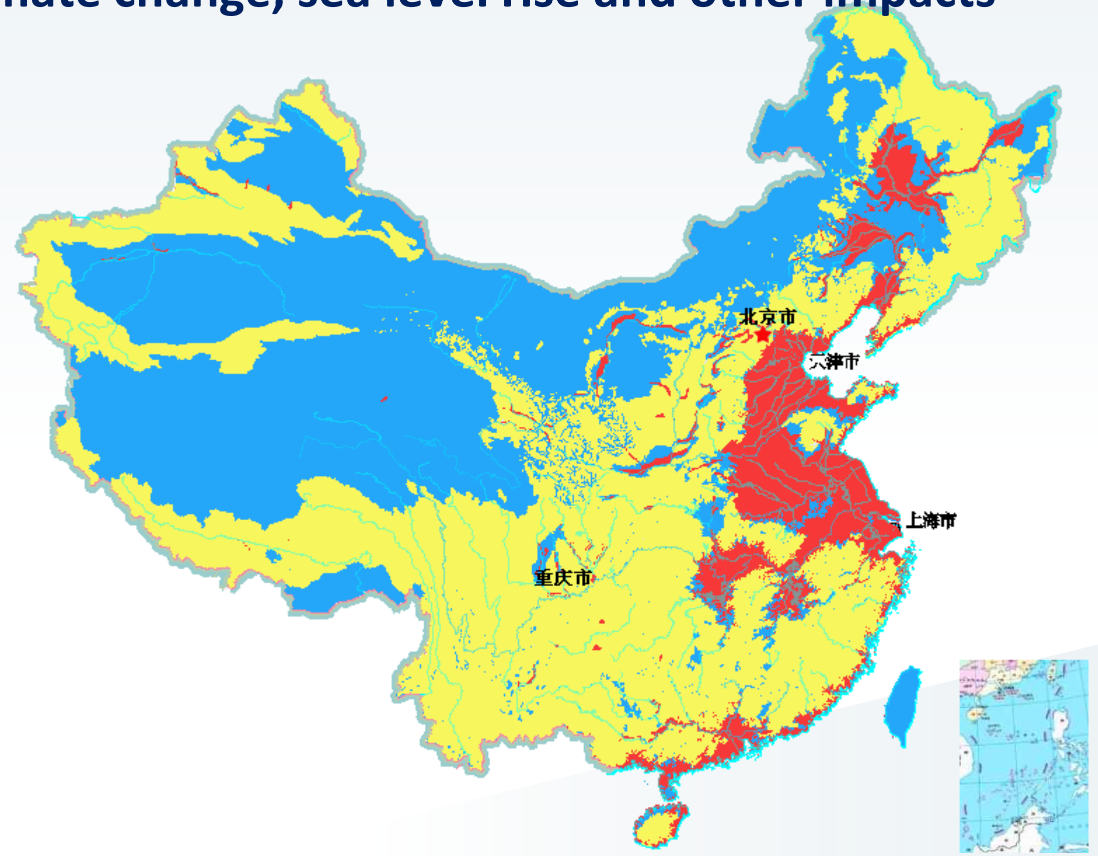
- **Security standard enhancement for water services with higher quality.** Increasing demands for decent life, happiness and health, requires strengthening drinking water security, flood control standards, water quality, and ecological-friendly habitat
- **Inadequate infrastructure for adverse impacts.** Current infrastructure cannot cope with long-term cumulative impacts, basin aggregated impacts, climate change, sea level rise and other impacts



City number and built-up area changes from 1981 to 2018



Population and urbanization rate increase from 1980 to 2030



Flood risks in china

03

General Approach and Major Measures

- General Approach
- Major Measures

3.1 General Approach

Complex Challenges

Upstream transitive influence
- Water resource reduce/utilization
- Flood discharge
- Water pollution

Local accumulative pressure
- Socio-economic development
- geomorphology change
- Beach development

Seaside backward Effect
- Seawater intrusion
- Sea level rise
- Tidal table rise

Nested Linkage

Basin scale → Delta scale ↔ City scale

Targeted Approach

Basin scale
- *Maintain water-sediment balance*
- *Protect river source and soil erosion areas*
- *Strictly control water consumption*
- *Regulate water resources and flood in upper and middle reaches properly*
- *Strengthen pollution control of mainstream and tributary*

Delta scale
- *Maintain natural buffer areas for flood, tide and ecology*
- *Stabilize flow discharge routes to extend their usefulness*
- *Regulate flow rationally to improve hydrodynamic conditions*
- *Prevent and control seawater intrusion*
- *Prevent typhoon and tide disasters by proper sea levees and tide barrages*

City scale
- *Compact city/industrial development space to minimize intervention to deltas*
- *Strength water saving*
- *Coordinate urban waterlogging control and basin flood control*
- *Strength urban and industrial water pollution control*
- *Enhance early warning and emergency response system*

Delta Water Security

- Water supply
- Flood control
- Aquatic ecological health
- Water environment protection

3.1 General Approach

Overall Layout

Yangtze River Delta

Clean river corridor

- Ecological corridor
- Main flood channel
- Main water source allocation

Green ecological barrier

- Water sources protection
- Soil and water conservation

Clear flood-tide corridor and storage

- Maintaining flood-waterlogging discharge & storage capacity
- Combination of flood, waterlogging and tide control
- Estuary regulation

Coastal protection belt

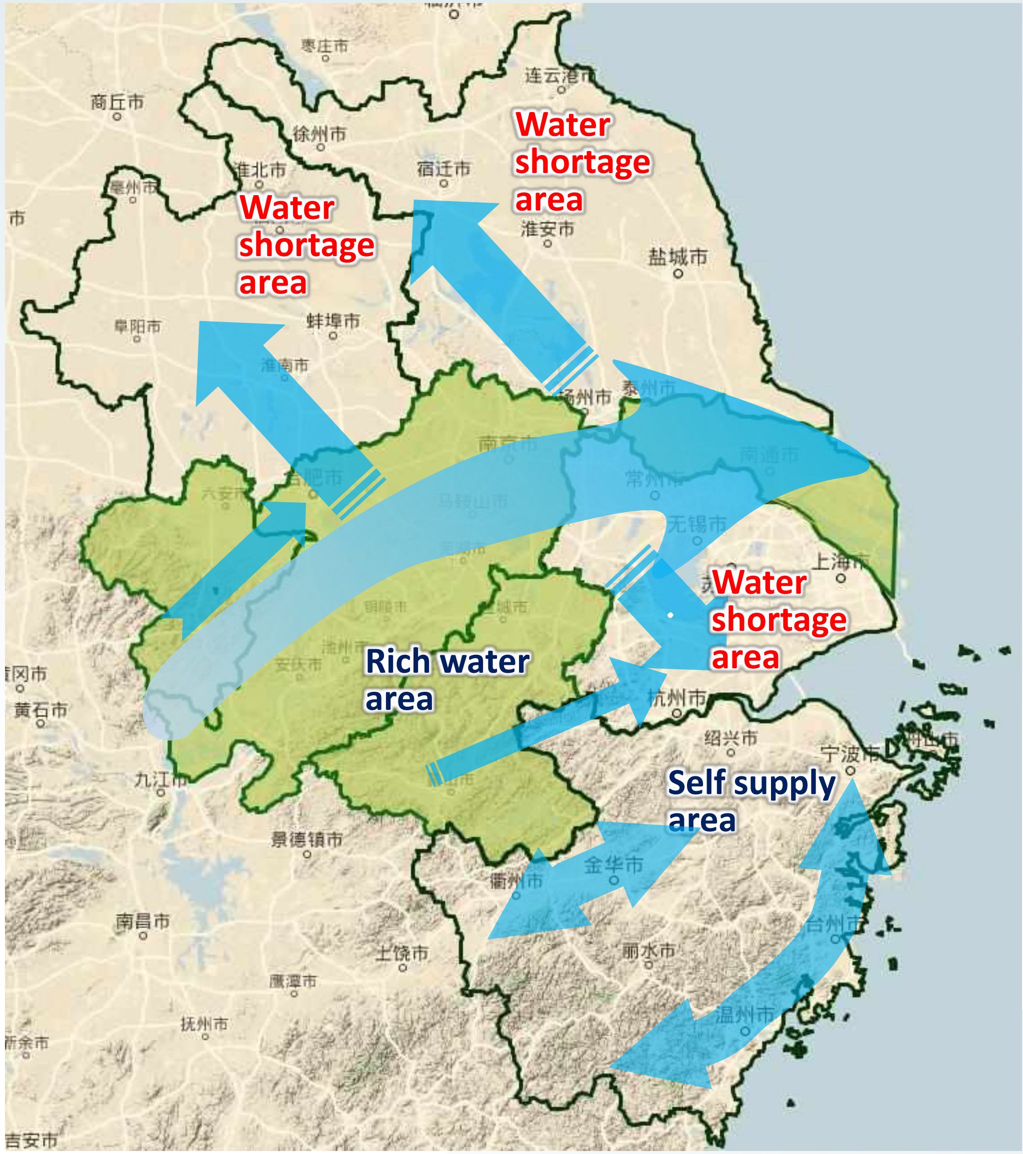
- Ecological sea dike construction
- Estuary & coastal shoal protection & restoration

Compact development zones

- Water use efficiency improvement
- Key habitat protection
- Total water pollutants decrease

3.2 Major Measures – *Water Supply*

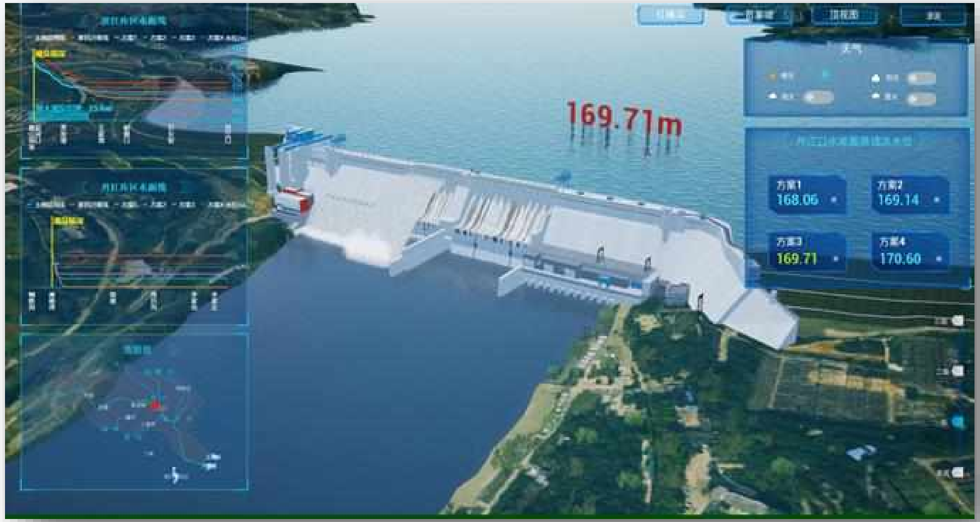
- Develop multiple water sources, remote water sources and independent water sources to control seawater intrusion
- Strength water regulation at basin scale by key reservoir group in dry period, activate water supply potential of key projects in the middle and upper reaches
- Enlarge and interlink water supply network, and promote local emergency and backup water sources to enhance capacity coping with regional drought and pollution accidents
- Optimize layout of local water sources, intakes and sewage outlets
- Promote use of non-conventional water sources, such as flood water and seawater desalination or direct use



3.3 Major Measures *– Flood control*

- **Better prepare for channel swing and estuary recession through rationally changing flow diversion ratio, and improving channel shape and water depth conditions to stabilize overall estuary pattern**
- **Properly arrange flood discharge route, strengthen flood discharge capacity of backbone waterways, keep estuaries stable and unblocked, and give room to flood**
- **Strengthen joint operation of flood controlling reservoirs in middle and upper reaches, and strengthen proper use of flood storage and detention areas in middle reaches to reduce flood pressure in estuaries**

Clear flood drainage route



Projects regulation system (Yangtze River)

3.3 Major Measures – *Flood control*

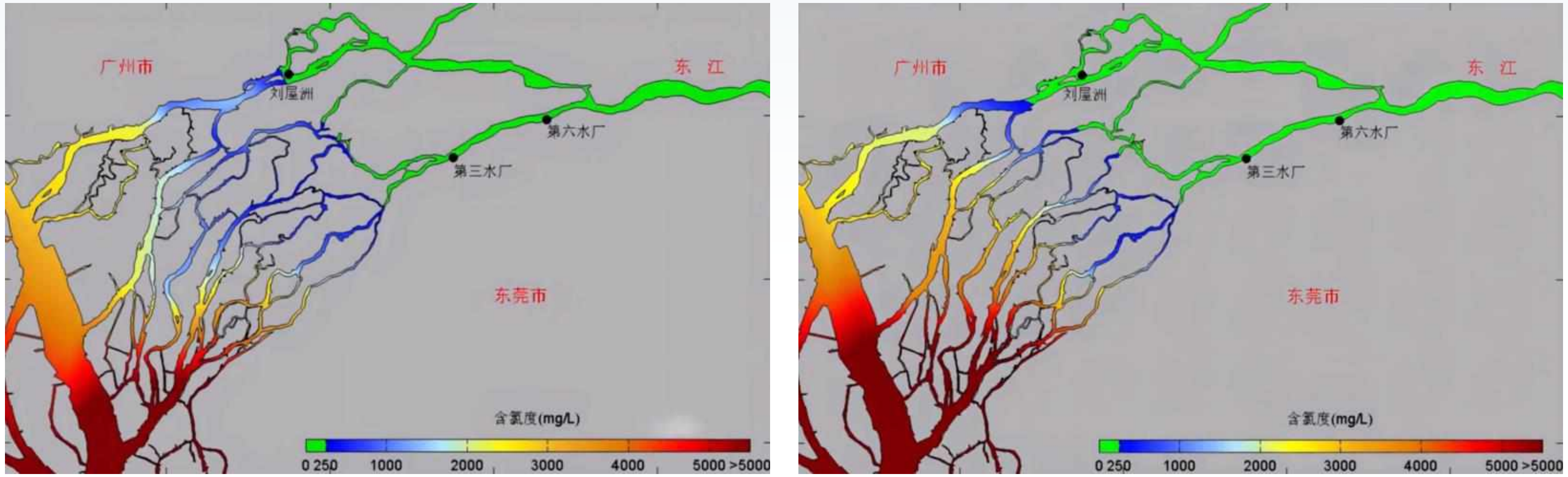
- **Upgrade existing tide barrages, build necessary tide barrages to reduce backwater effect of high tide level and enhance flood discharge capacity**
- **Enhance risk management capability, improve the system of flood monitoring, prediction, warning and emergency response plan, strengthen the control of flood storage space, pay more attention to climate disaster events and over-standard flood, and improve flood risk analysis, assessment and mapping**
- **Construct resilient flood control system, explore Nature-based Solutions in deltas by ecological sea dike construction, rivers-lakes connection, natural wetlands restoration, sponge city, returning farmland to wetlands and beaches, etc.**

Flood prediction and risk analysis

Wetland protection in Yellow River Delta

3.4 Major Measures – *Ecological-environmental Protection*

- **Strength water source conversation & soil and water conservation**
- **Strengthen the protection and regulation of shoreline, tidal beaches and estuaries to enhance the resilience for flood discharge, tidal absorption, sediment discharge, navigation and ecological functions**
- **Ensure ecological flows in dry seasons through joint operation of upstream reservoirs, and maintain the balance of salt and fresh water interface in estuaries**



Mitigate seawater intrusion by joint-operation of upper key reservoirs of Peal River Delta

Water release from Datengxia Water Control Project in Guangxi Province (upstream of Peal River)

3.4 Major Measures – *Ecological-environmental Protection*

- **Promote rivers-lakes connectivity and joint-operation of water projects to improve hydrodynamic conditions in lower river network**
- **Strengthen investigation and optimization of sewage outlets into the sea, conduct urban-rural pollution control as well as mariculture and ships-ports pollution control**
- **Protect habitats for rare and endangered aquatic species, such as Chinese sturgeon and Yangtze finless**
- **Strength comprehensive monitoring for water, sediment, salinity, tidal flat, and biological population**
- **Establish and improve the compensation mechanism of river basin ecological protection, especially for upper regions**

Comprehensive Harness of Taihu Lake and Lixiahe Region

THANK YOU !

Justin Ehrenwerth

RIVER BASINS AND DELTAS WATER SYSTEMS AND PORT ECONOMIES IN TIMES OF CLIMATE CHANGE

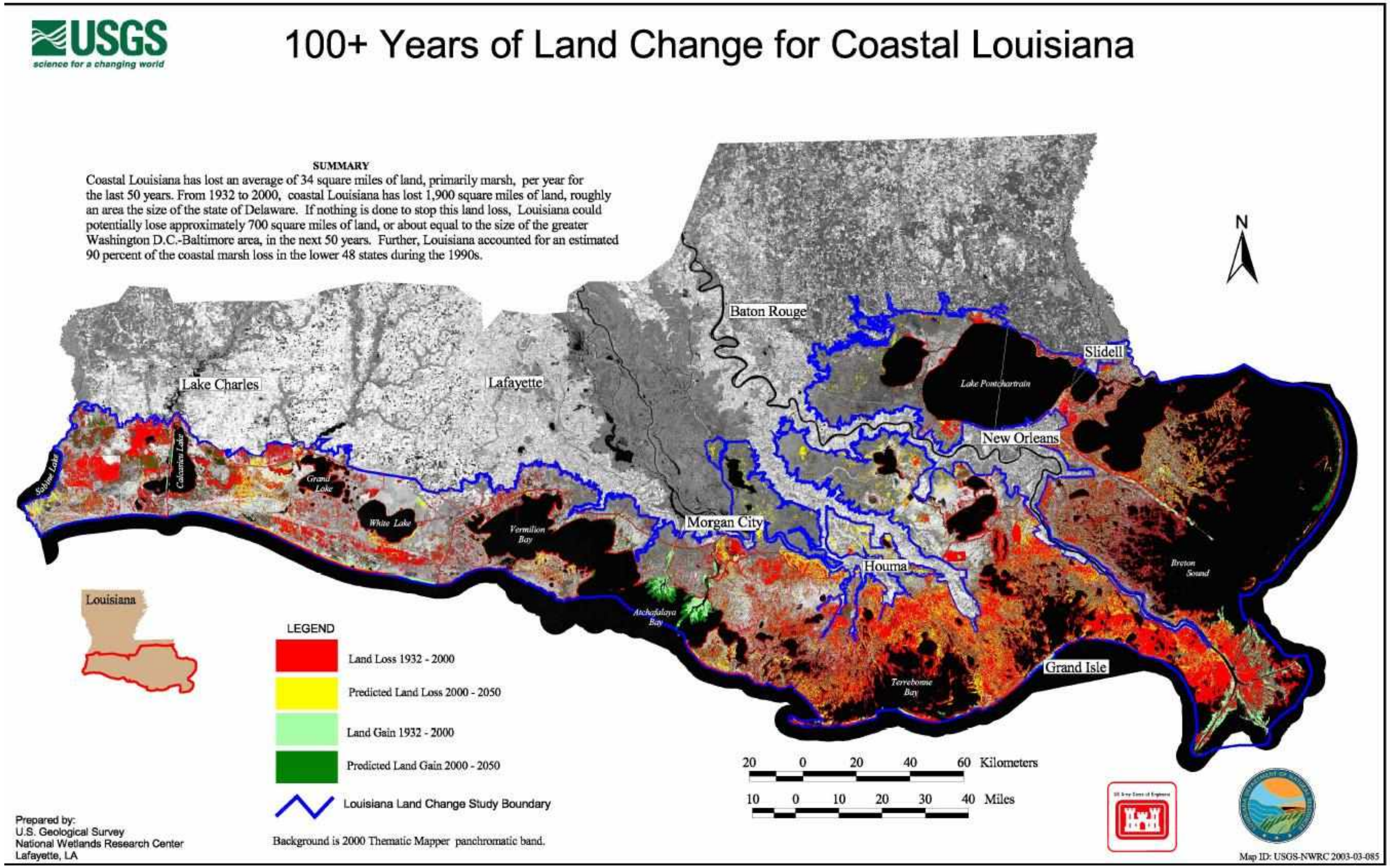
The Mississippi River Delta

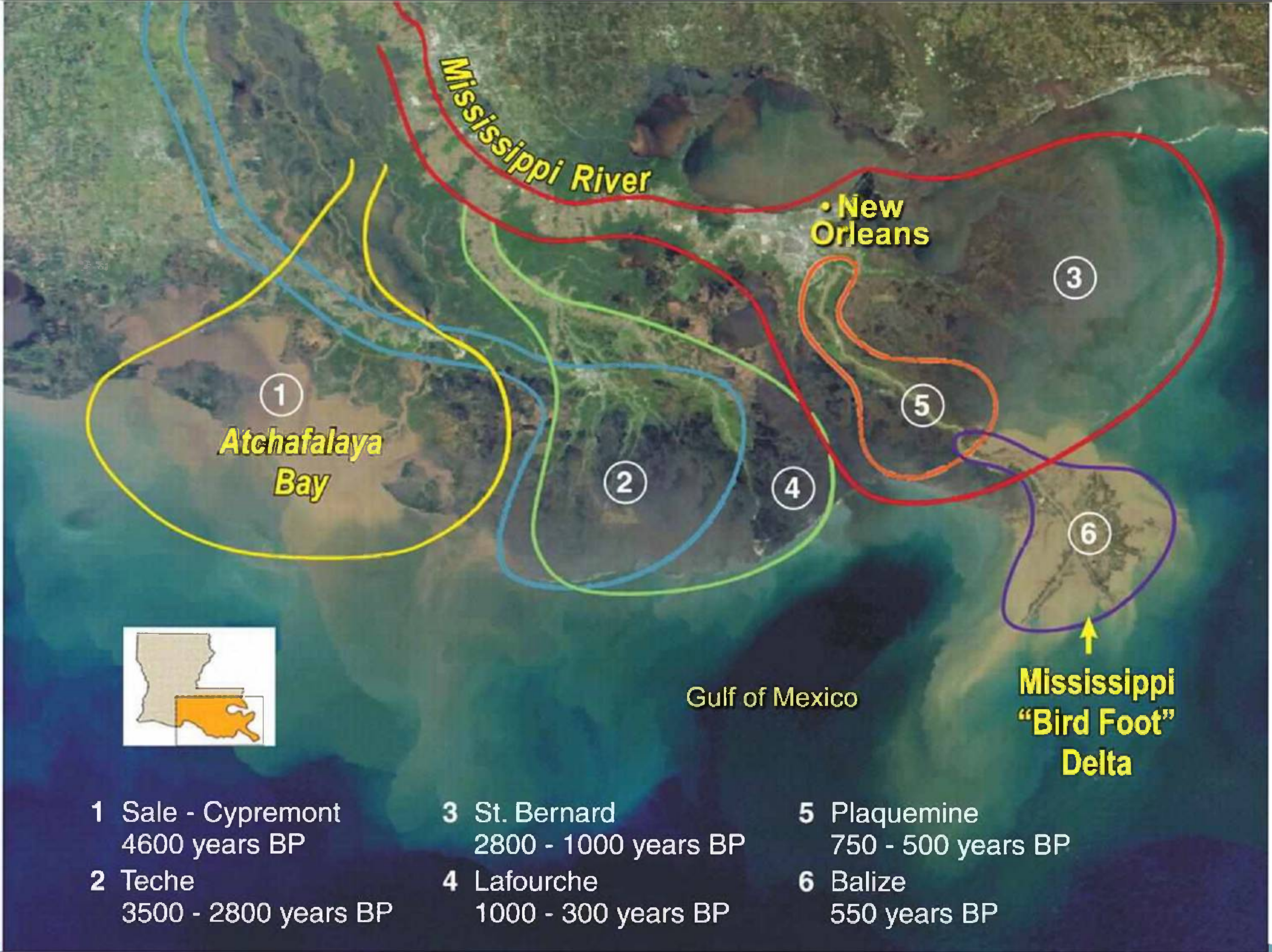
Justin R. Ehrenwerth

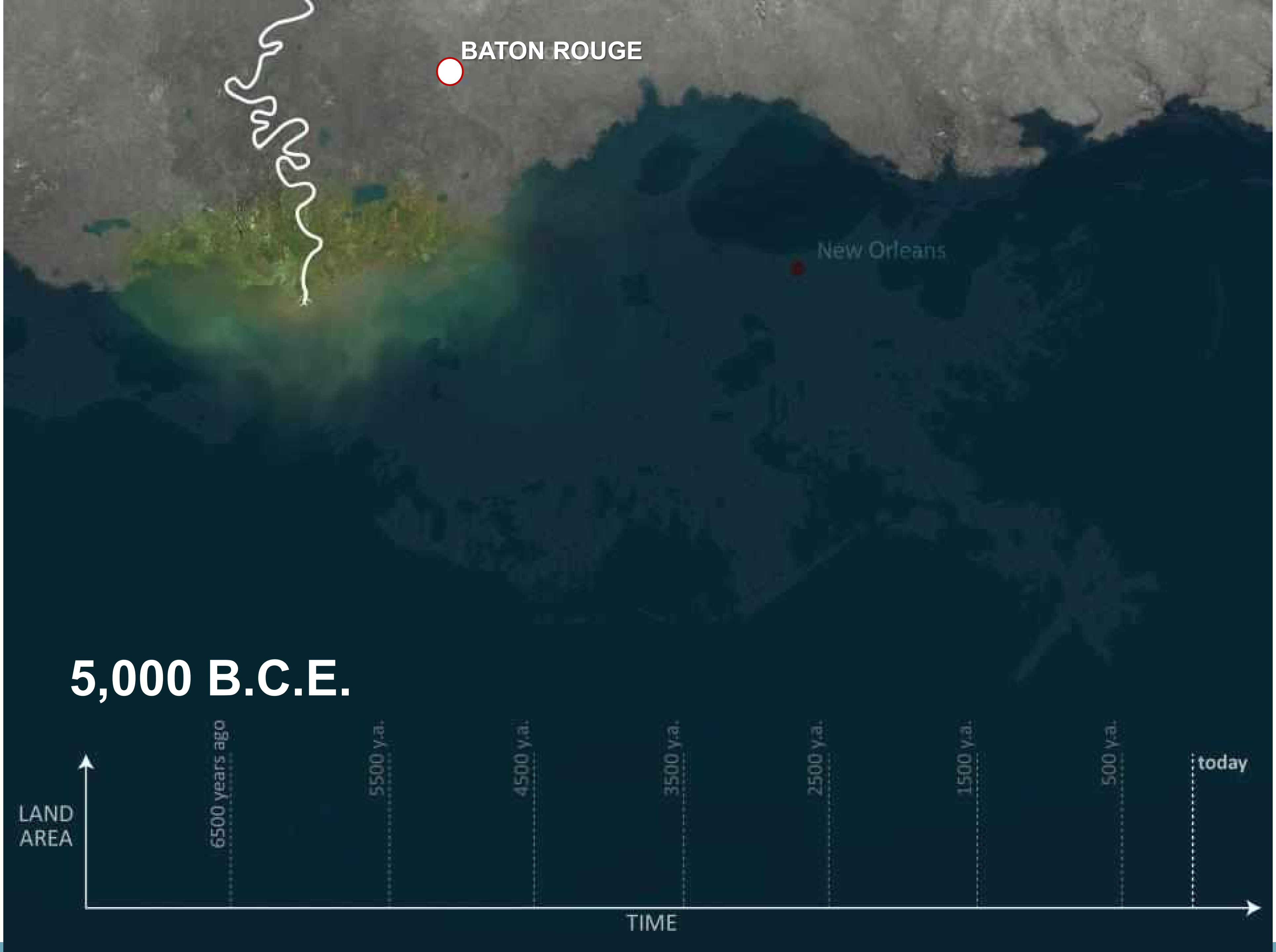
President & CEO

11 October 2022

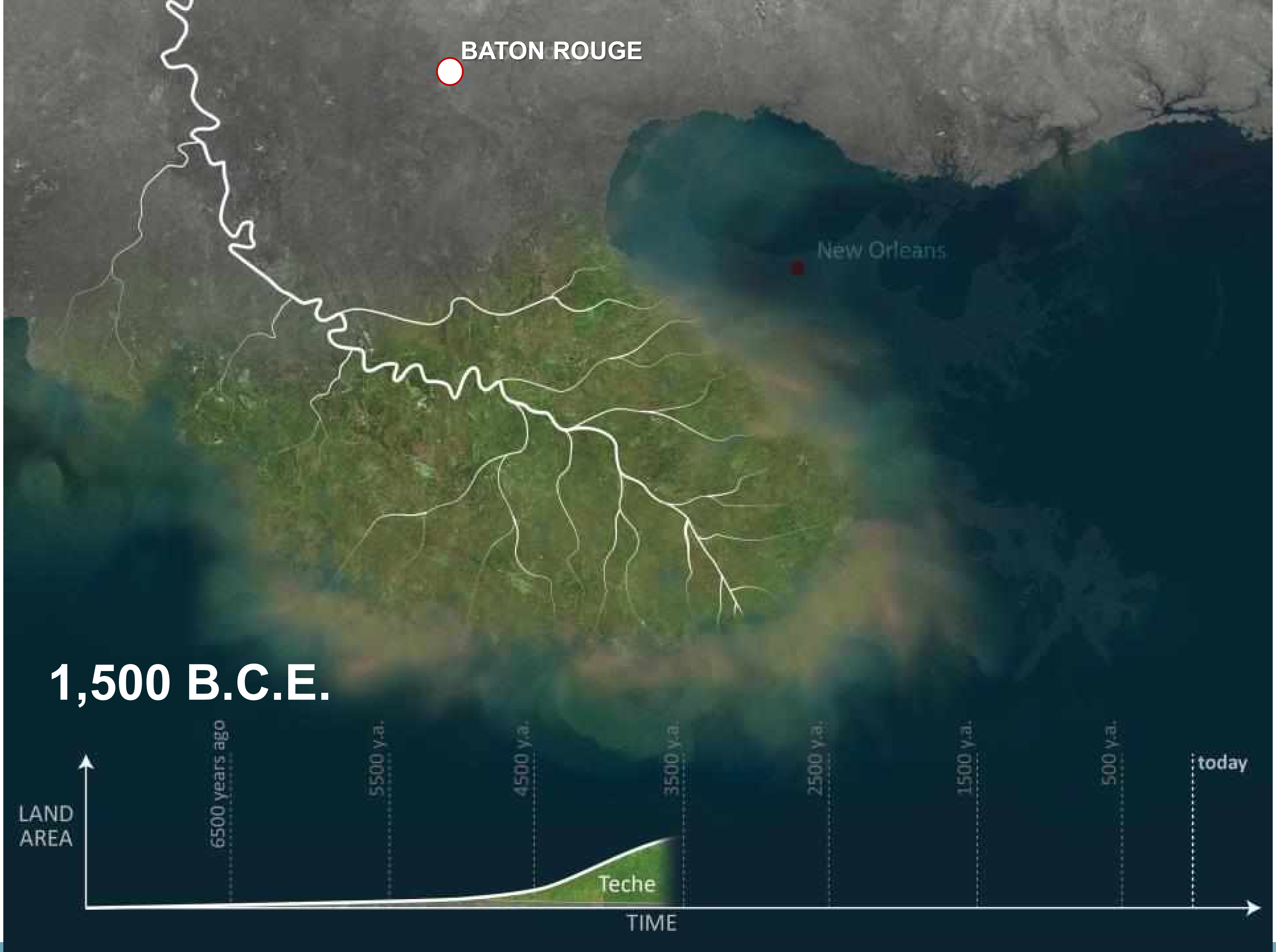
COASTAL LOUISIANA FACES ON OF THE HIGHEST LAND LOSS RATES IN THE WORLD

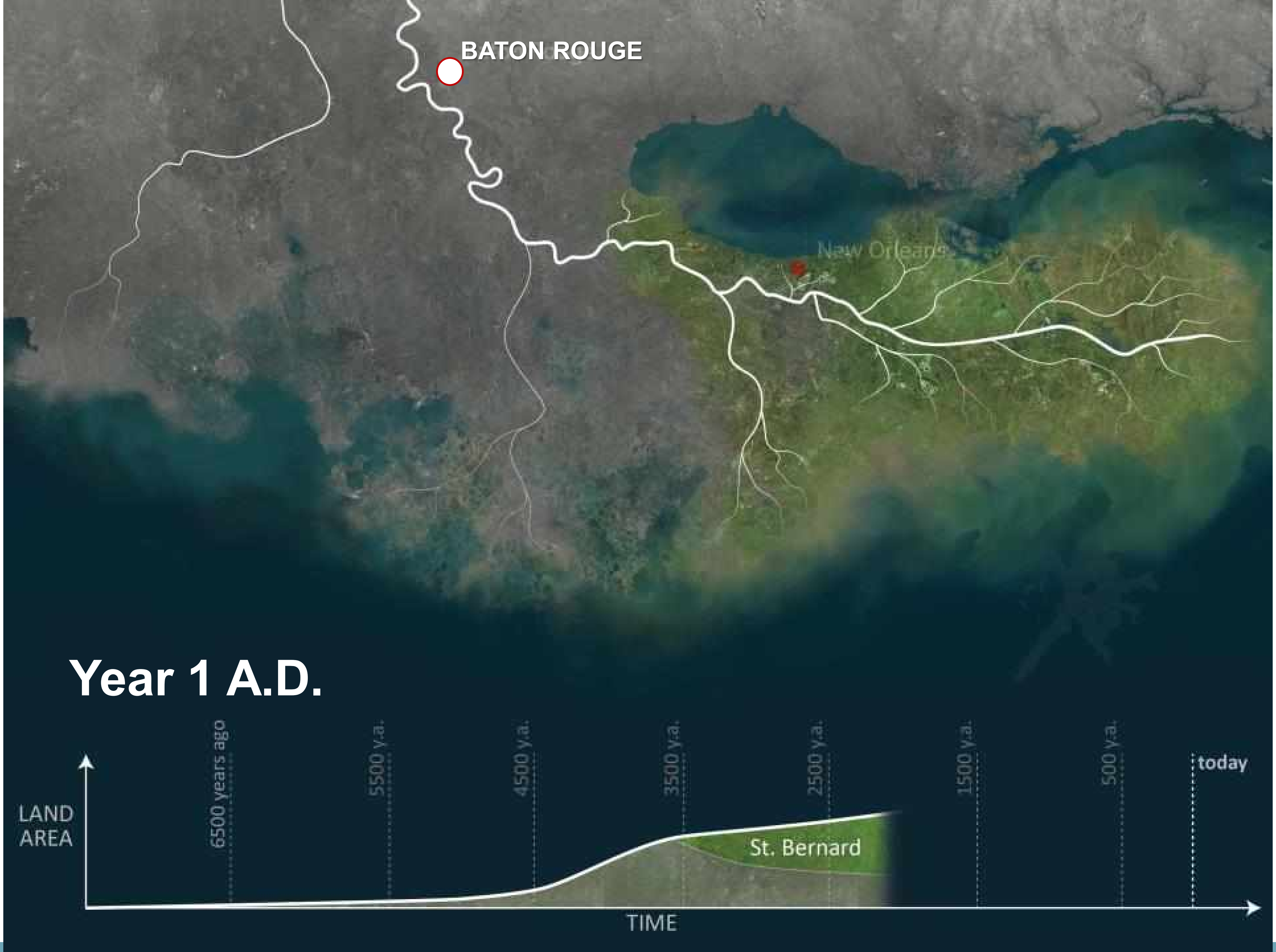


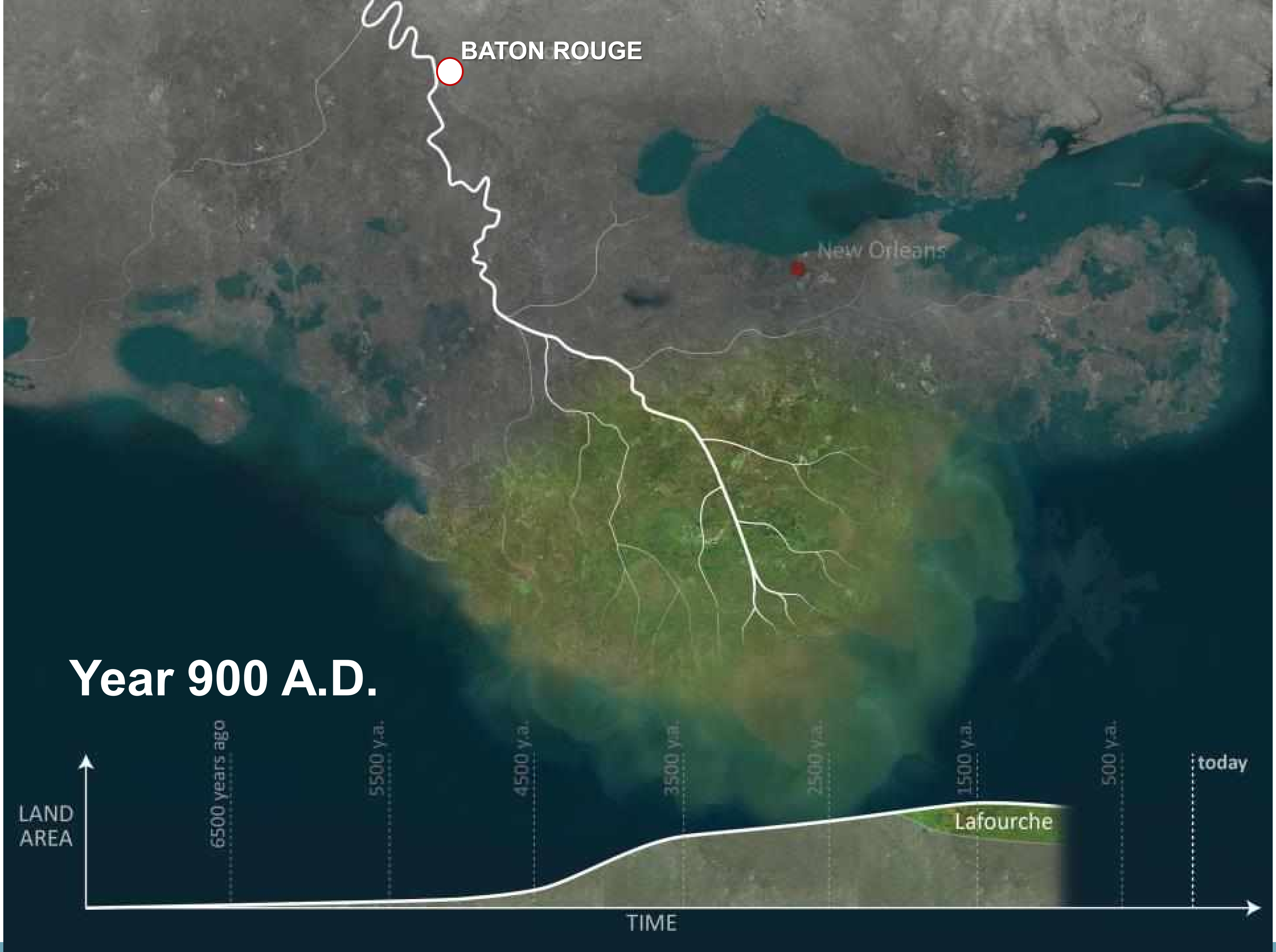

Mississippi River
• New Orleans
Atchafalaya Bay
1
2
3
4
5
6
Gulf of Mexico
Mississippi "Bird Foot" Delta
1 Sale - Cypremont 4600 years BP
2 Teche 3500 - 2800 years BP
3 St. Bernard 2800 - 1000 years BP
4 Lafourche 1000 - 300 years BP
5 Plaquemine 750 - 500 years BP
6 Balize 550 years BP

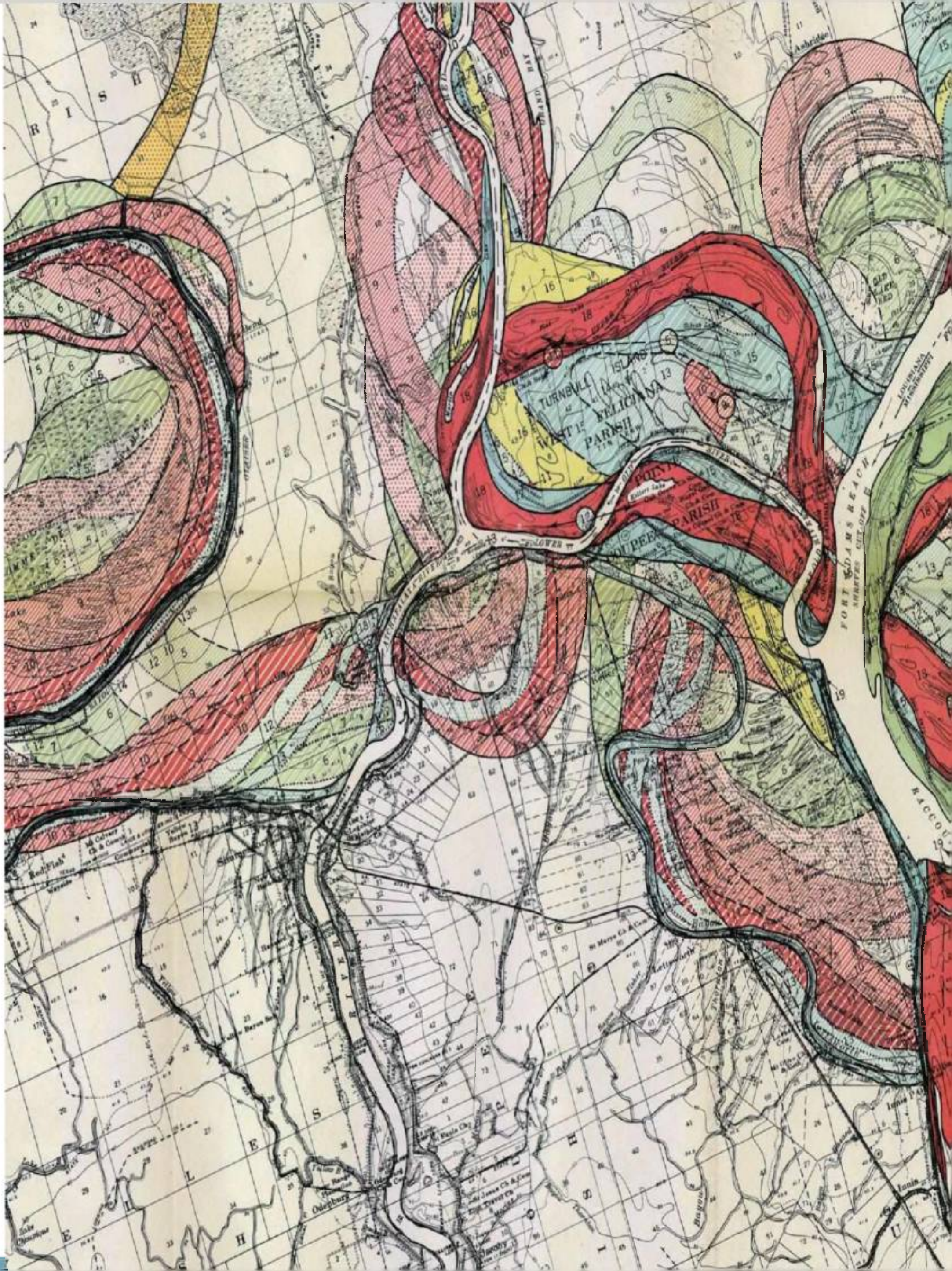

BATON ROUGE
New Orleans
5,000 B.C.E.
LAND AREA
6500 years ago
5500 y.a.
4500 y.a.
3500 y.a.
2500 y.a.
1500 y.a.
500 y.a.
today
TIME

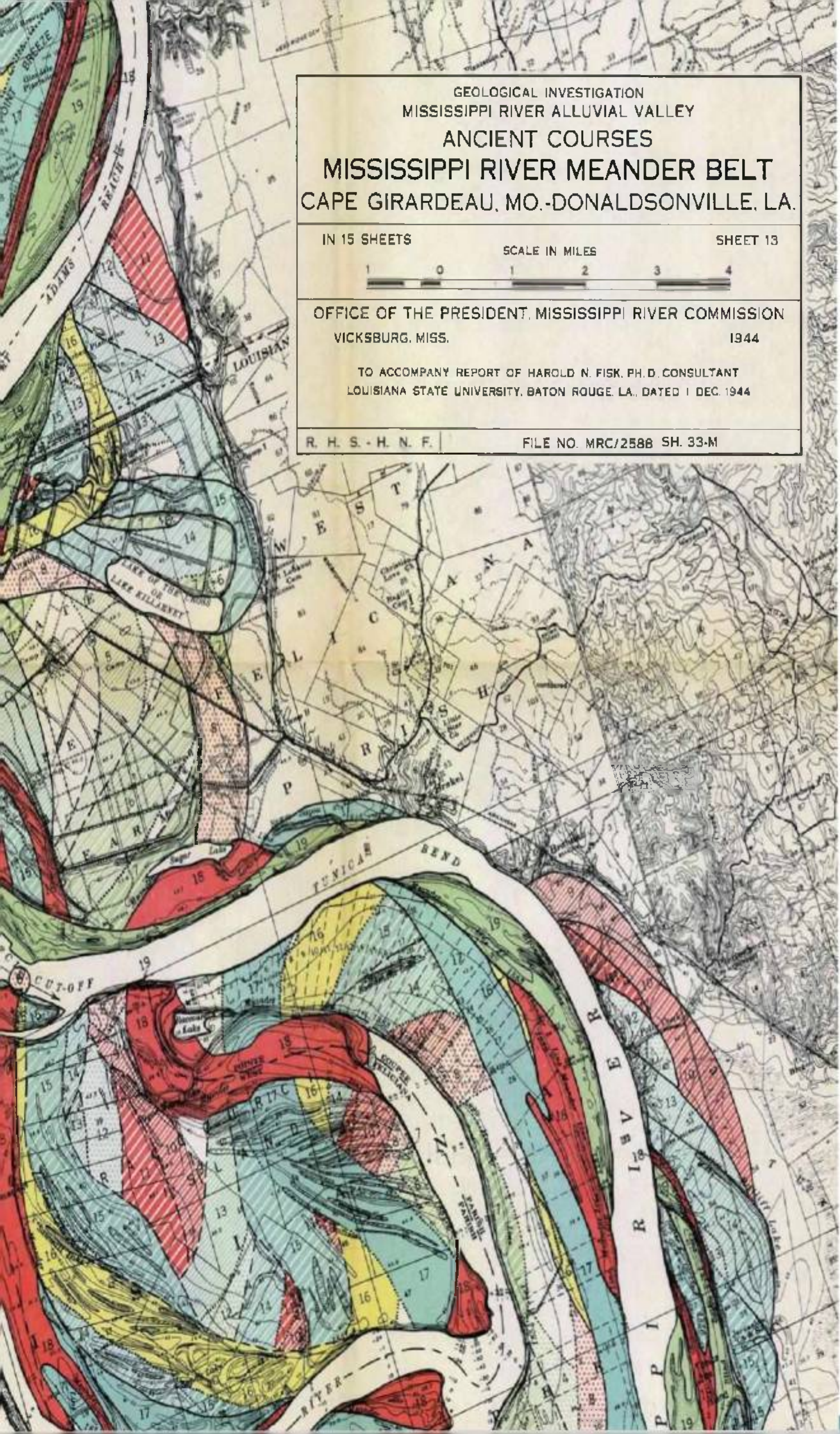

BATON ROUGE
New Orleans
3,000 B.C.E.
6500 years ago
5500 y.a.
4500 y.a.
3500 y.a.
2500 y.a.
1500 y.a.
500 y.a.
today
LAND AREA
Maringouin
TIME

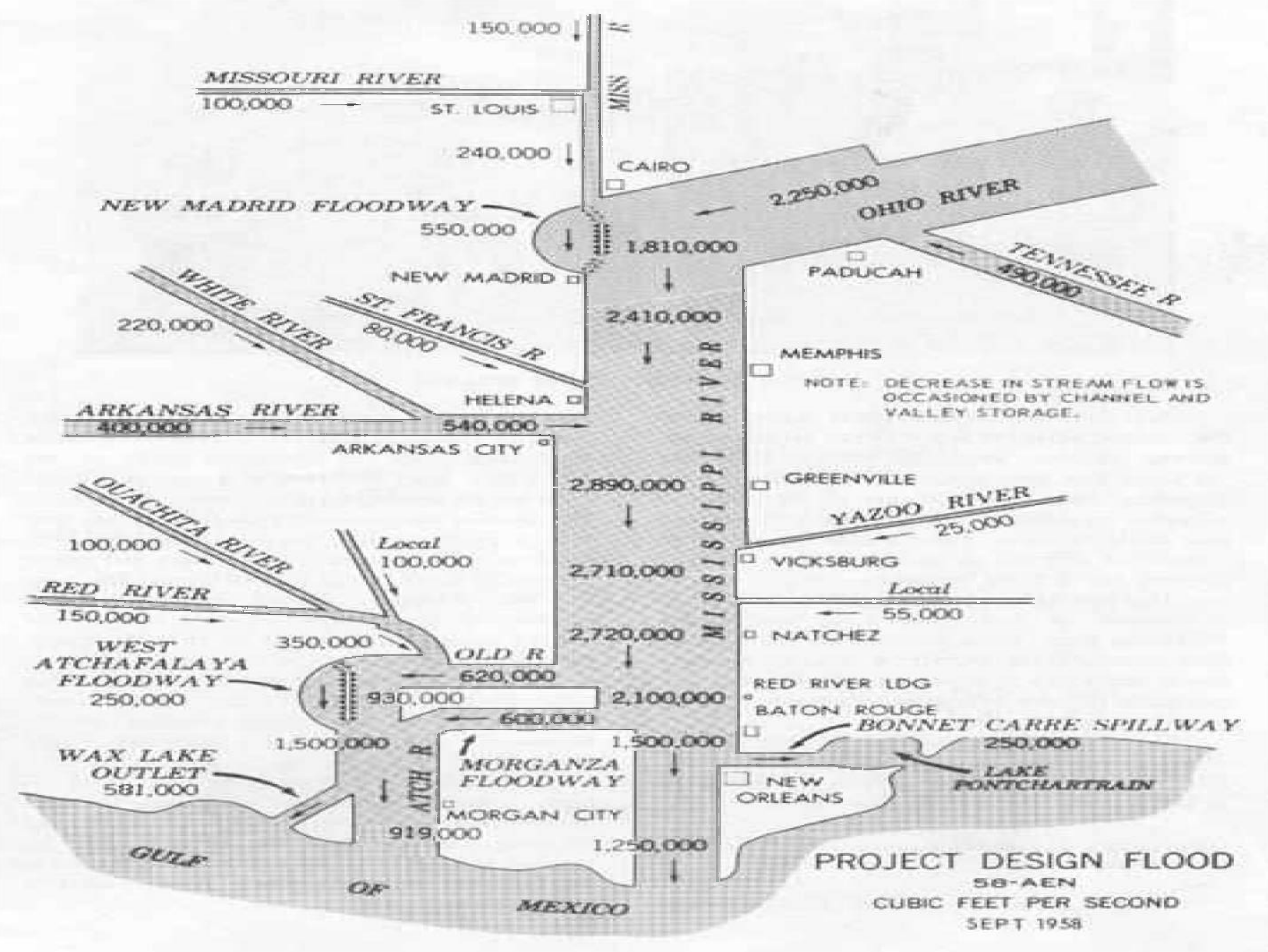

BATON ROUGE
New Orleans
1,500 B.C.E.
6500 years ago
5500 y.a.
4500 y.a.
3500 y.a.
2500 y.a.
1500 y.a.
500 y.a.
today
LAND AREA
Teche
TIME


BATON ROUGE
New Orleans
Year 1 A.D.
LAND
AREA
6500 years ago
5500 y.a.
4500 y.a.
3500 y.a.
2500 y.a.
1500 y.a.
500 y.a.
today
St. Bernard
TIME

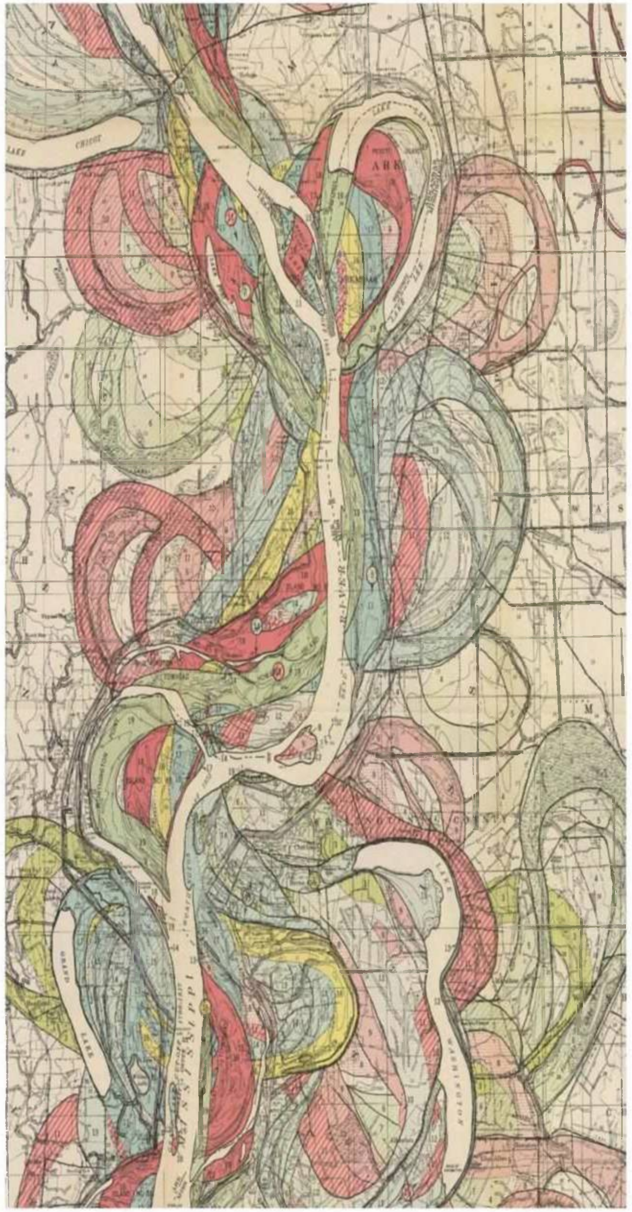

BATON ROUGE
New Orleans
Year 900 A.D.
LAND AREA
6500 years ago
5500 y.a.
4500 y.a.
3500 y.a.
2500 y.a.
1500 y.a.
500 y.a.
today
Lafourche
TIME


TURNBULL ISLAND
WEST FELICIANA PARISH
FORT ADAMS REACH


GEOLOGICAL INVESTIGATION
MISSISSIPPI RIVER ALLUVIAL VALLEY
ANCIENT COURSES
MISSISSIPPI RIVER MEANDER BELT
CAPE GIRARDEAU, MO.-DONALDSONVILLE, LA.
IN 15 SHEETS
SHEET 13
SCALE IN MILES
1 0 1 2 3 4
OFFICE OF THE PRESIDENT, MISSISSIPPI RIVER COMMISSION
VICKSBURG, MISS.
1944
TO ACCOMPANY REPORT OF HAROLD N. FISK, PH. D. CONSULTANT
LOUISIANA STATE UNIVERSITY, BATON ROUGE, LA., DATED 1 DEC. 1944
R. H. S. - H. N. F.
FILE NO. MRC/2588 SH. 33-M
TUNICA BEND
CUT-OFF
WEST FELICIANA PARISH
RIVER
MISSISSIPPI RIVER

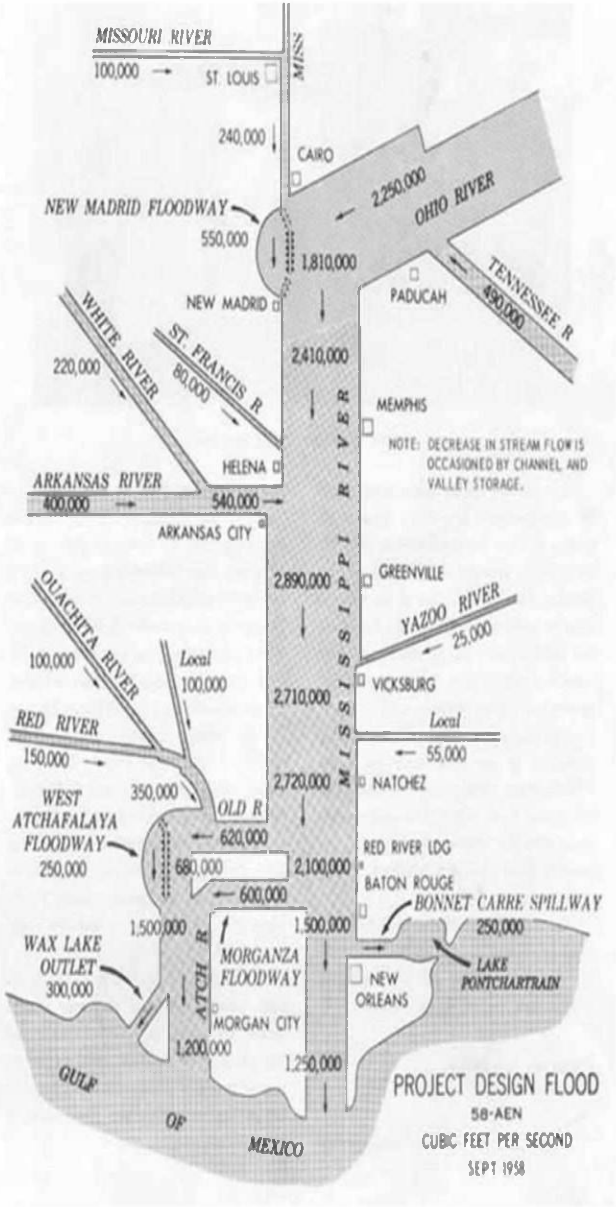


150,000
MISS R
MISSOURI RIVER
100,000
ST. LOUIS
240,000
CAIRO
NEW MADRID FLOODWAY
550,000
1,810,000
2,250,000
OHIO RIVER
TENNESSEE R
490,000
PADUCAH
NEW MADRID
WHITE RIVER
220,000
ST. FRANCIS R
80,000
2,410,000
MEMPHIS
NOTE: DECREASE IN STREAM FLOW IS OCCASIONED BY CHANNEL AND VALLEY STORAGE.
HELENA
ARKANSAS RIVER
400,000
540,000
ARKANSAS CITY
MISSISSIPPI RIVER
2,890,000
GREENVILLE
YAZOO RIVER
25,000
OUACHITA RIVER
100,000
Local
100,000
2,710,000
VICKSBURG
Local
55,000
RED RIVER
150,000
350,000
OLD R
2,720,000
NATCHEZ
WEST ATCHAFALAYA FLOODWAY
250,000
620,000
930,000
2,100,000
RED RIVER LDG
BATON ROUGE
600,000
BONNET CARRE SPILLWAY
250,000
1,500,000
ATCH R
MORGANZA FLOODWAY
1,500,000
LAKE PONTCHARTRAIN
WAX LAKE OUTLET
581,000
NEW ORLEANS
MORGAN CITY
919,000
1,250,000
GULF OF MEXICO
PROJECT DESIGN FLOOD
58-AEN
CUBIC FEET PER SECOND
SEPT 1958



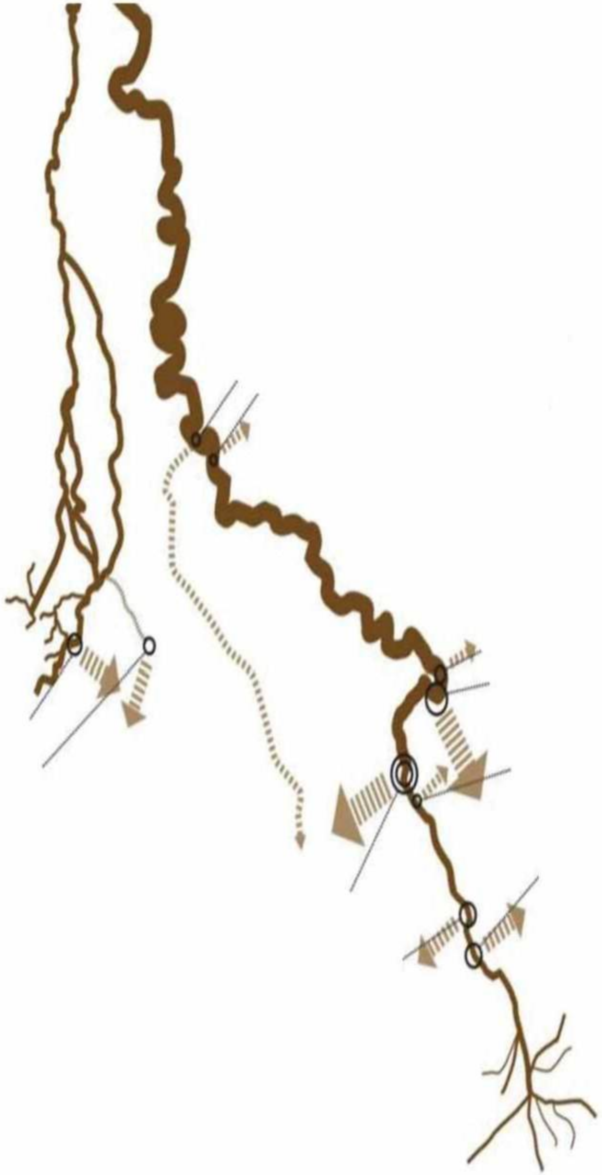
Past

Harold Fisk 1944 Mississippi River Map



Current

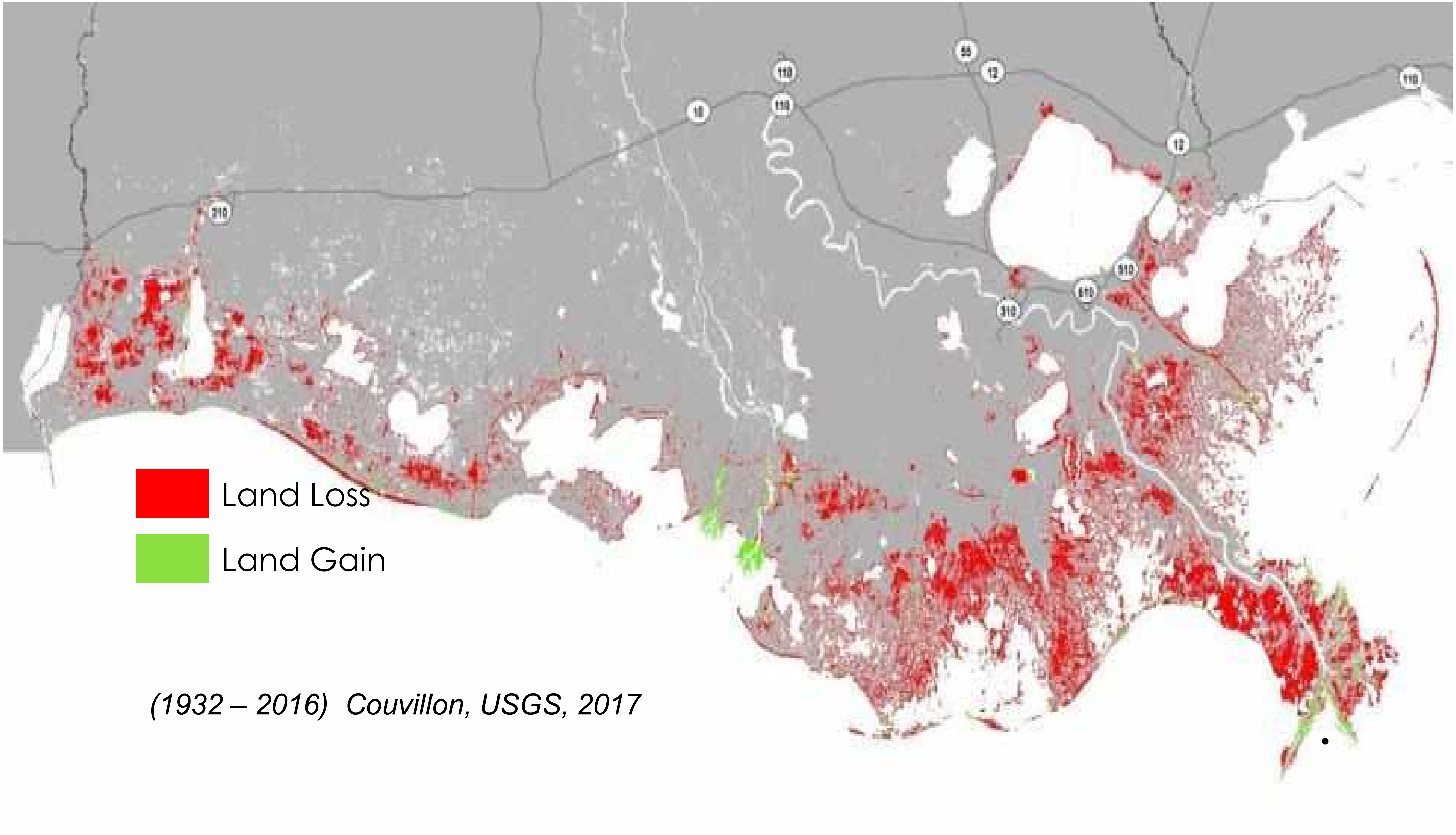
1858 USACE Mississippi River Diagram



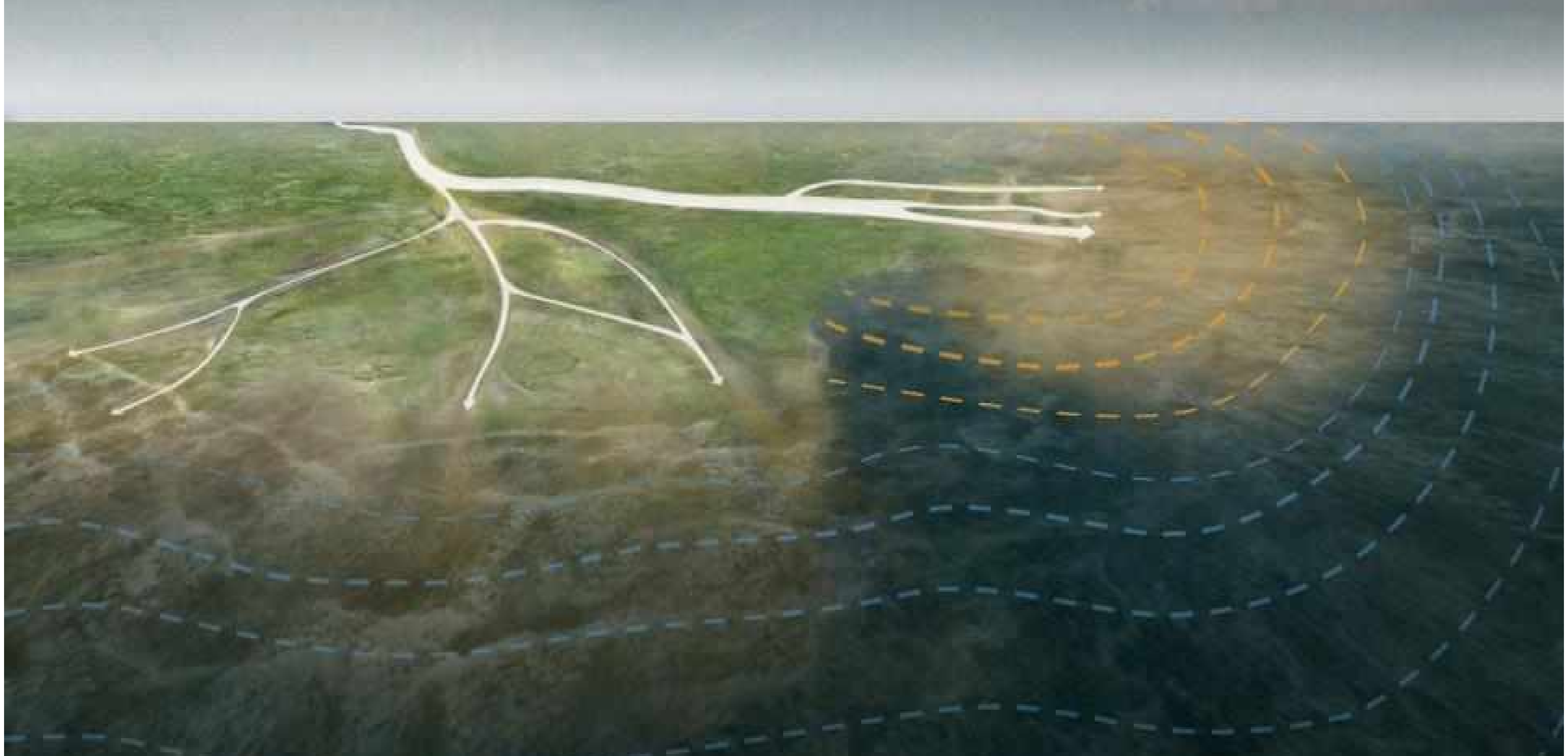
Future

2017 CPRA Diversion Diagram

FUTURE WITHOUT ACTION (THE RED MAP)



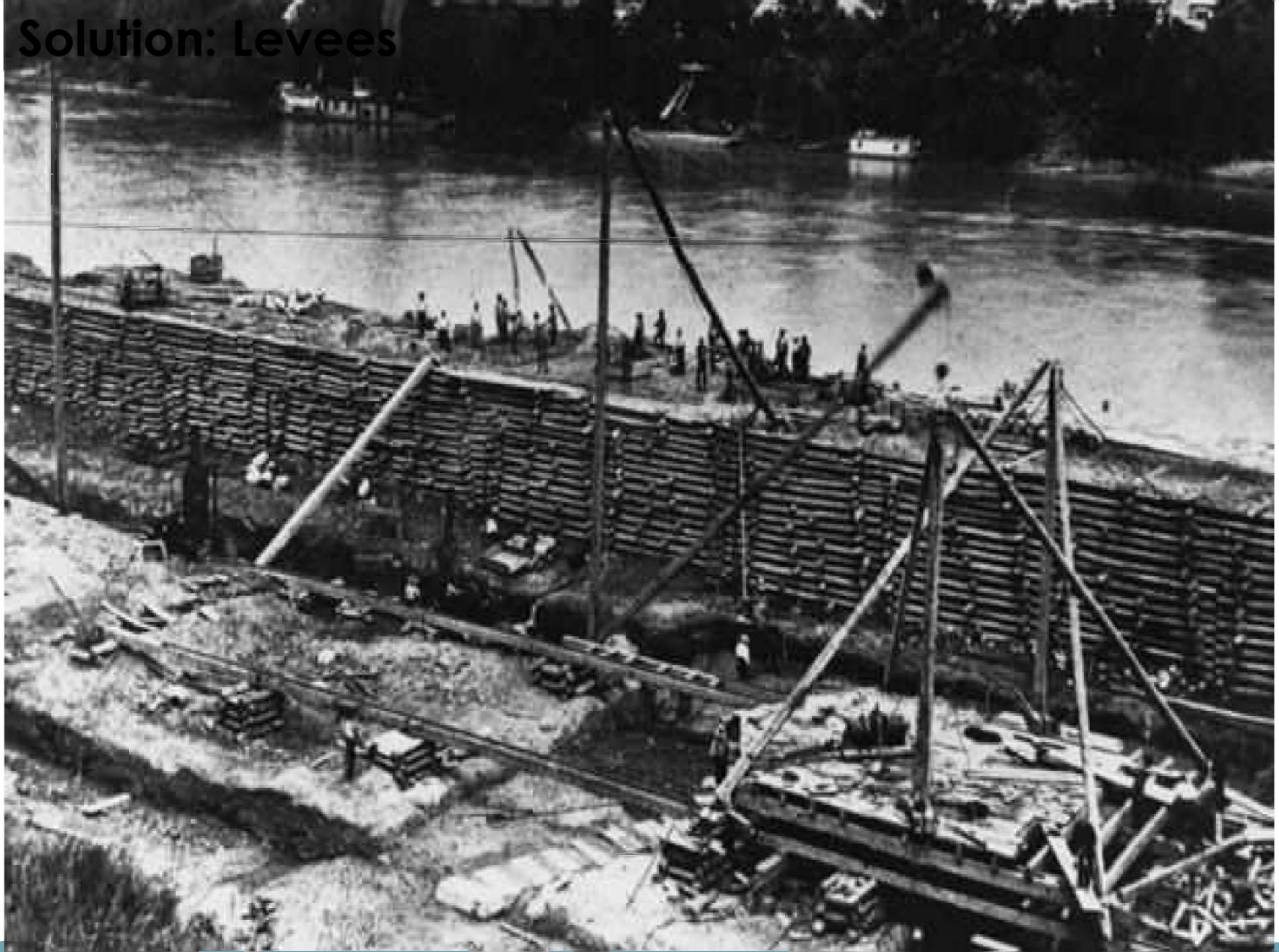
Historic Causes of Land Loss



Climate change, subsidence, sea level rise, and tropical storms, exacerbated by levees and canals.

THE GREAT FLOOD OF 1927

Solution: Levees

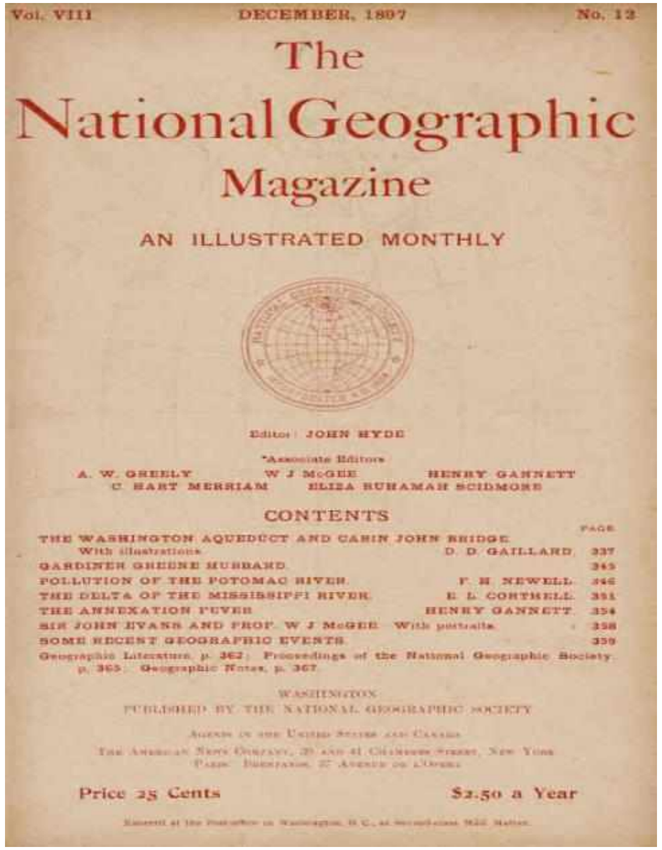


COULD HAVE SEEN IT COMING

- "...A complete system of absolutely protective levees… [will create] disadvantages to future generations from the subsidence of the Gulf delta lands below the level of the sea and their gradual abandonment due to this cause."

- *"No doubt the great benefit…will be so remarkable that the people of the whole United States can well afford…to build a protective levee against the Gulf waters, as the city of New Orleans has done on a small scale."*

- *Dr. E.L. Corthell, President of the American Society of Civil Engineers National Geographic, December 1897*



Vol. VIII DECEMBER, 1897 No. 12

The National Geographic Magazine

AN ILLUSTRATED MONTHLY

Editor: JOHN HYDE

Associate Editors

A. W. GREELY W J McGEE HENRY GANNETT
C. HART MERRIAM ELIZA RUHAMAH SCIDMORE

CONTENTS

WASHINGTON
PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

Price 25 Cents $2.50 a Year


Bayou Dupont, 1952

Bayou Dupont, 2005

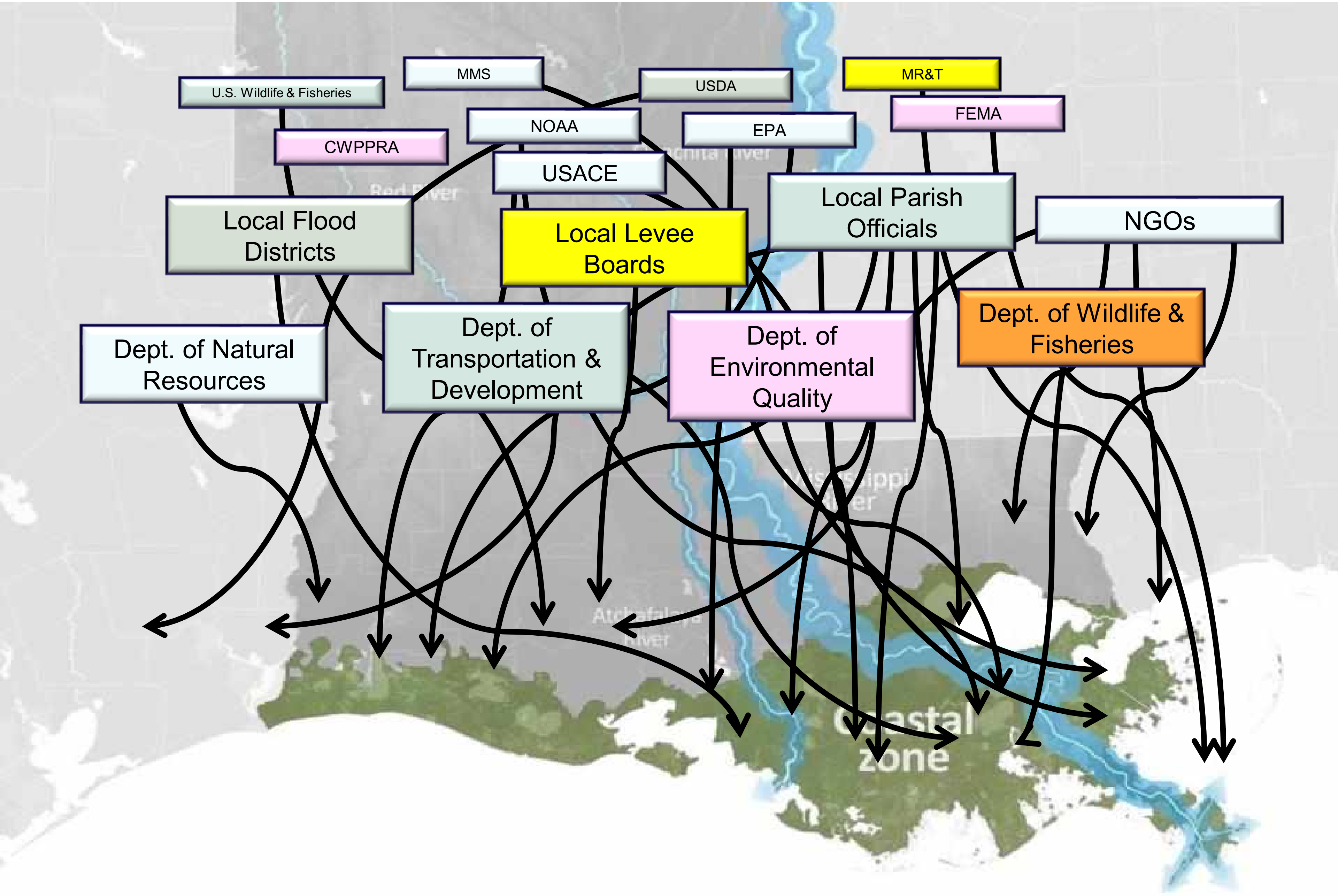

BAYOU TERREBONNE
WONDER LAKE
BAYOU ST. JEAN CHARLES
South Terrebonne, 1971

South Terrebonne, 1998


BAYOU TERREBONNE
BAYOU ST. JEAN CHARLES
WONDER LAKE
South Terrebonne, 2010


1,880
SQUARE MILES OF LAND
HAVE BEEN LOST
IN THE LAST 80
YEARS
UP TO
4,100
SQUARE MILES OF LAND
ARE AT RISK IN
THE NEXT 50 YEARS

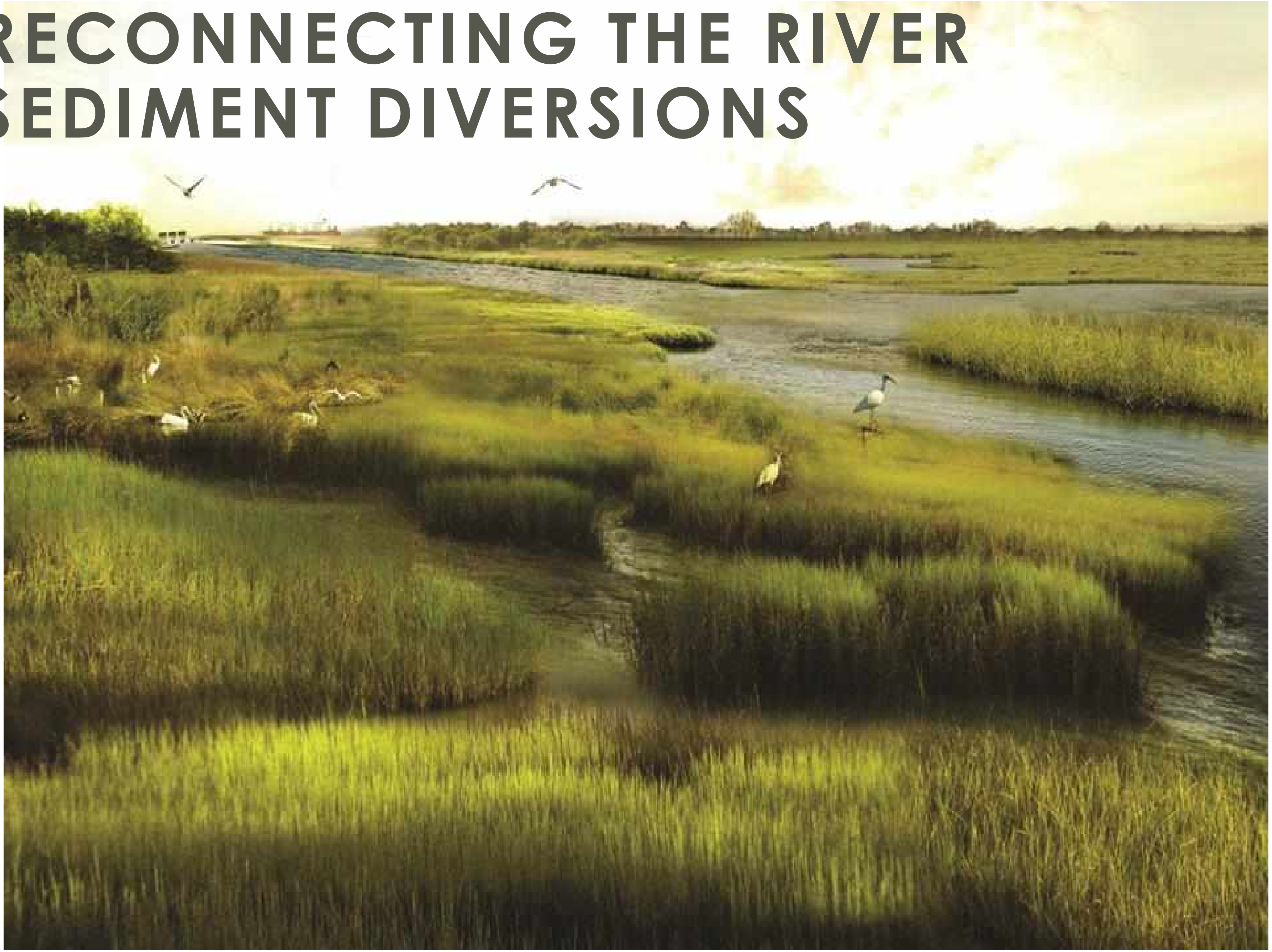
AGENCY CONSOLIDATION



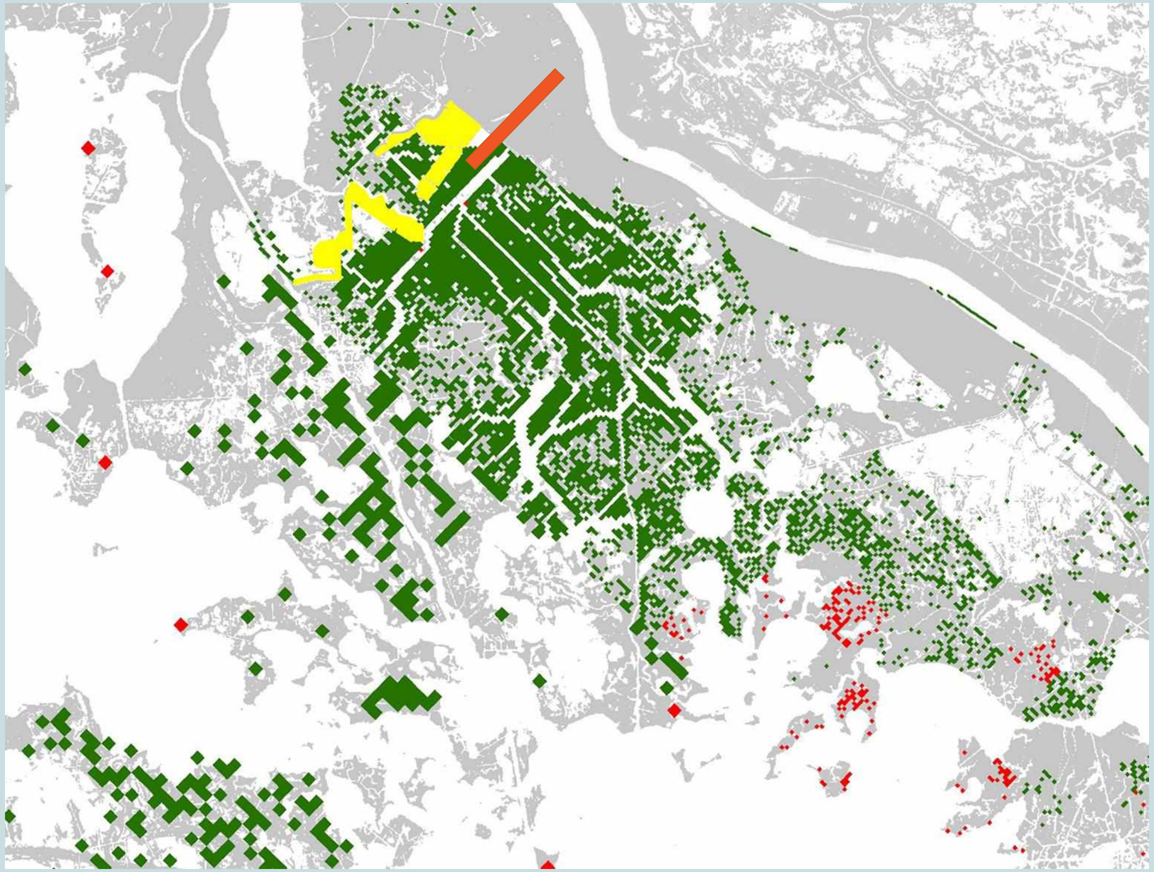
LOUISIANA'S COASTAL MASTER PLAN

WHAT THE COASTAL MASTER PLAN DELIVERS

RECONNECTING THE RIVER SEDIMENT DIVERSIONS



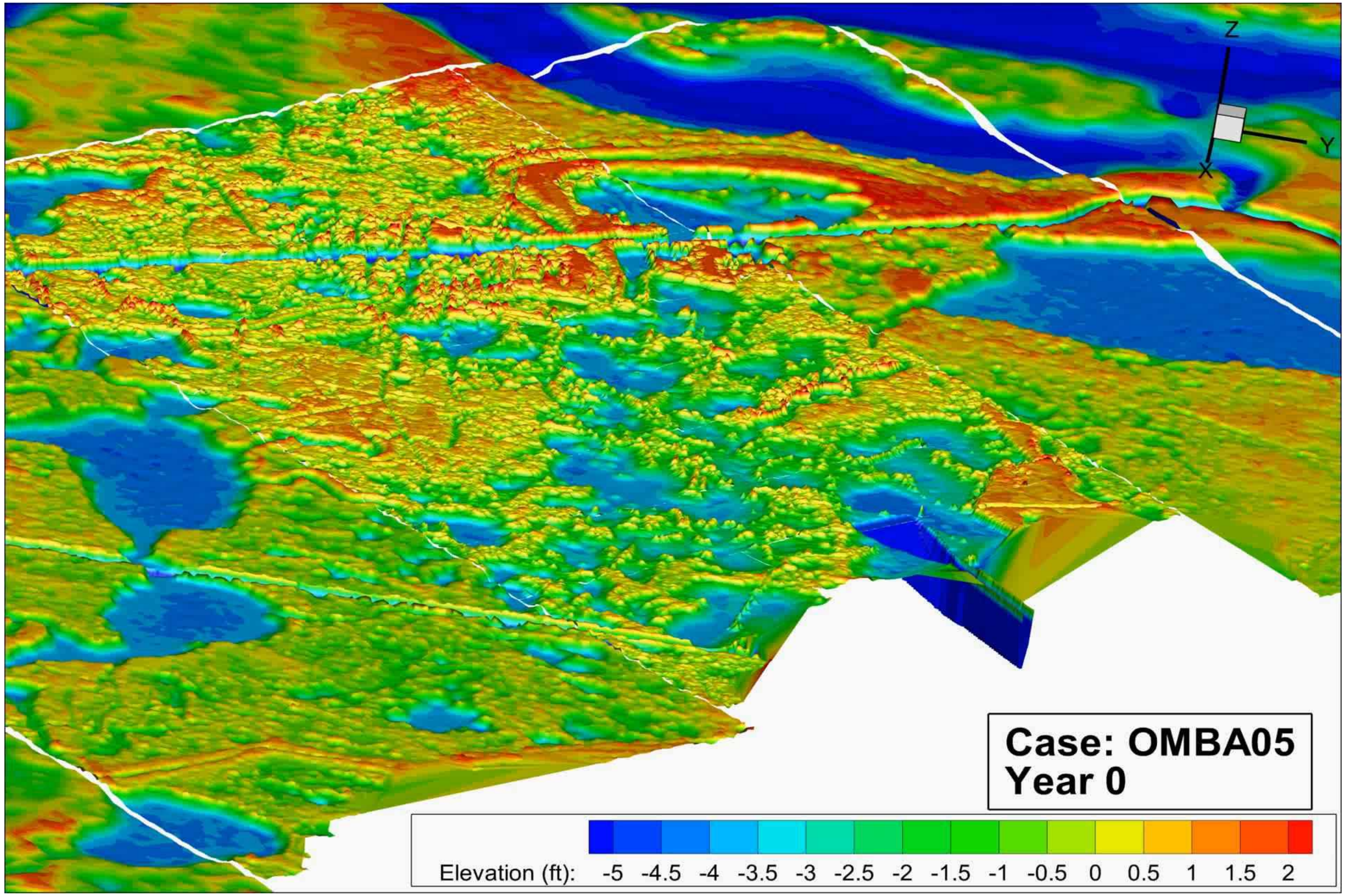
RECONNECTING THE MISSISSIPPI RIVER



■ PROPOSED MID-BARATARIA PROJECT SITE
■ LAND GAINED AND SUSTAINED
■ MARSH CREATION PROJECT

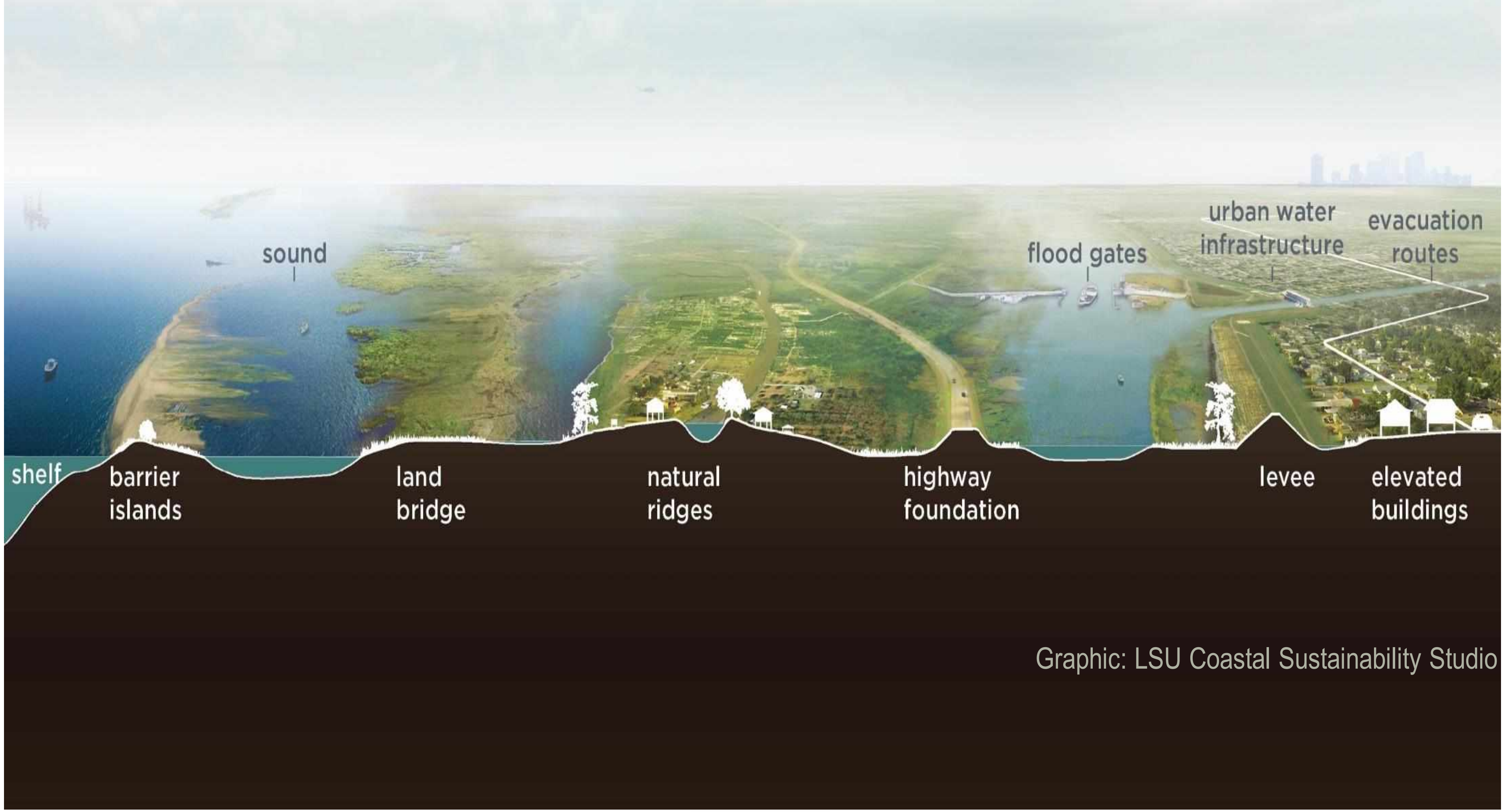
Modeling to inform design

MODEL PROJECTS



DESIGNING AT MULTIPLE SCALES

MULTIPLE LINES OF DEFENSE: FROM COAST TO CURB



Graphic: LSU Coastal Sustainability Studio

ABOUT THE WATER INSTITUTE

VISION

Resilient and equitable communities
Sustainable environments
Thriving economies

MISSION

Advancing science and developing integrated methods to solve complex environmental and societal challenges

RESEARCH AREAS

Applied Geosciences

Coastal and Deltaic Systems Modeling

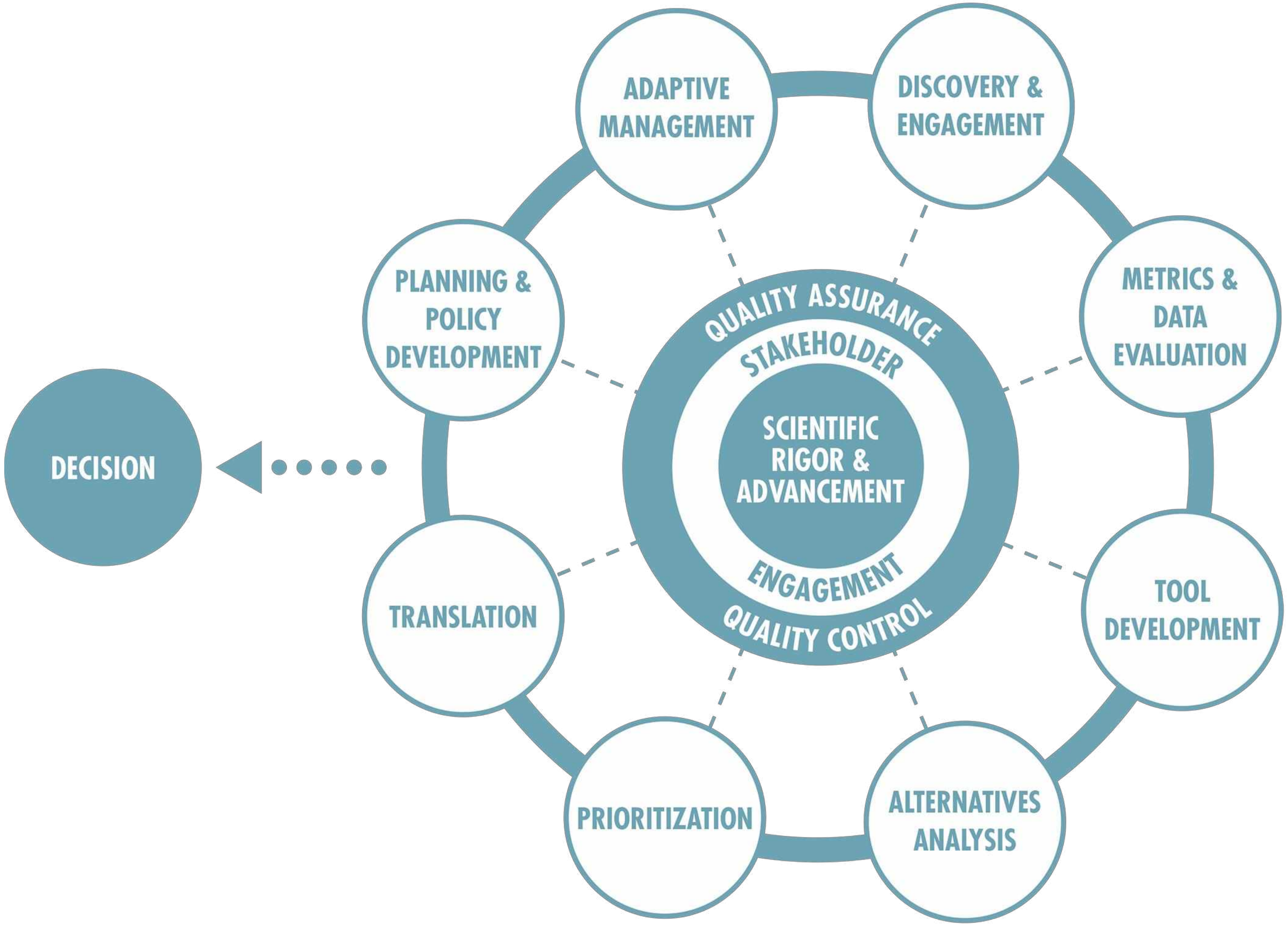
Coastal Ecology

Human Dimensions

Planning and Policy

HOW WE WORK

We employ applied science to assist communities to make informed decisions and plan for an uncertain future



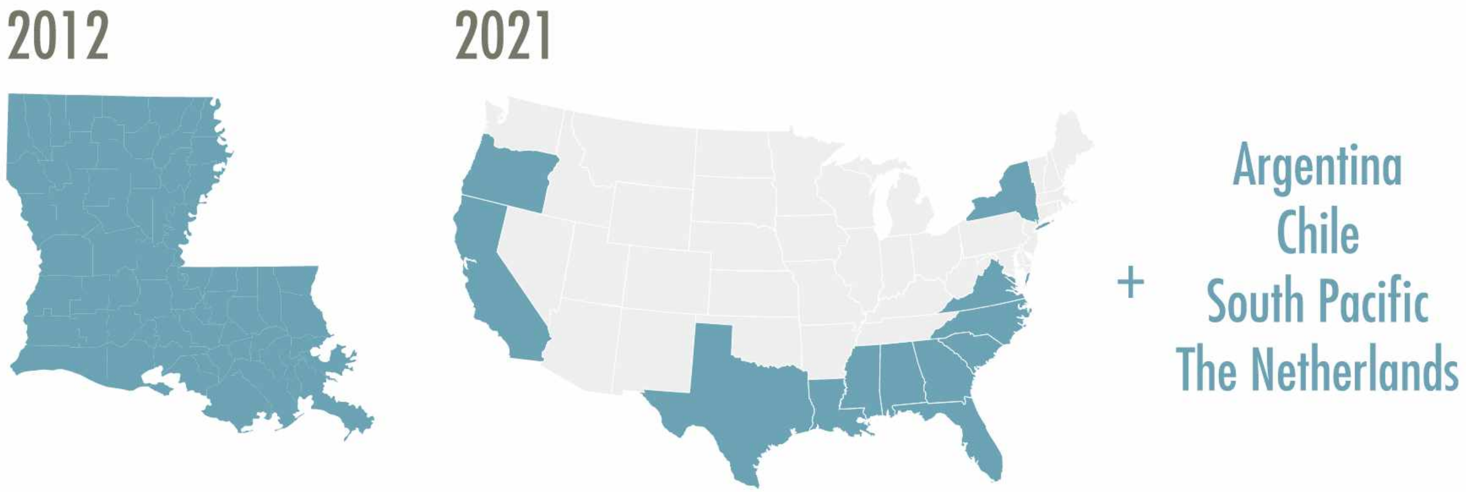
Celebrating
10 Years of science & collaboration

HISTORY

More than 10 years of connecting public, private, and academic knowledge to address some of the most pressing challenges facing Louisiana and Coastal communities everywhere

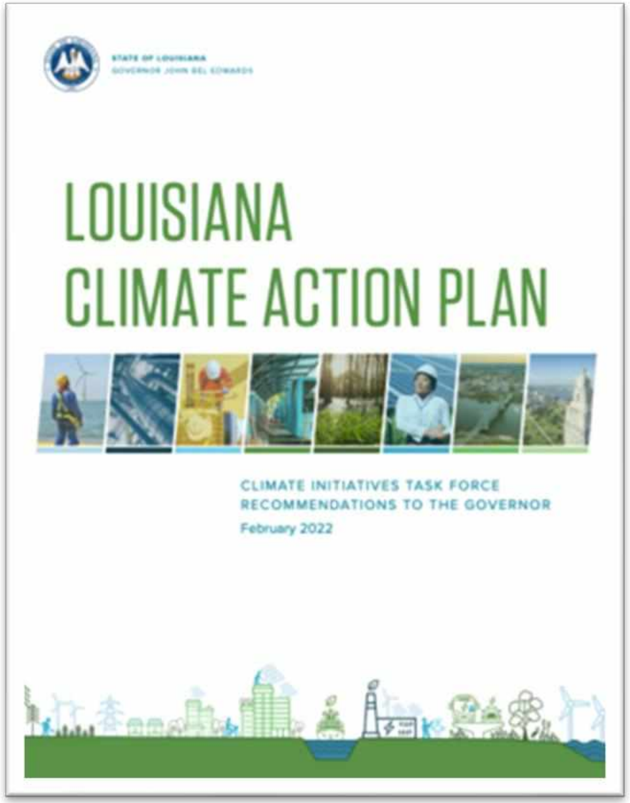
WHERE WE WORK

Then and now



STRUCTURED DECISION MAKING

"A formalization of common sense for decision problems which are too complex for informal use of common sense." (Keeney 1982)

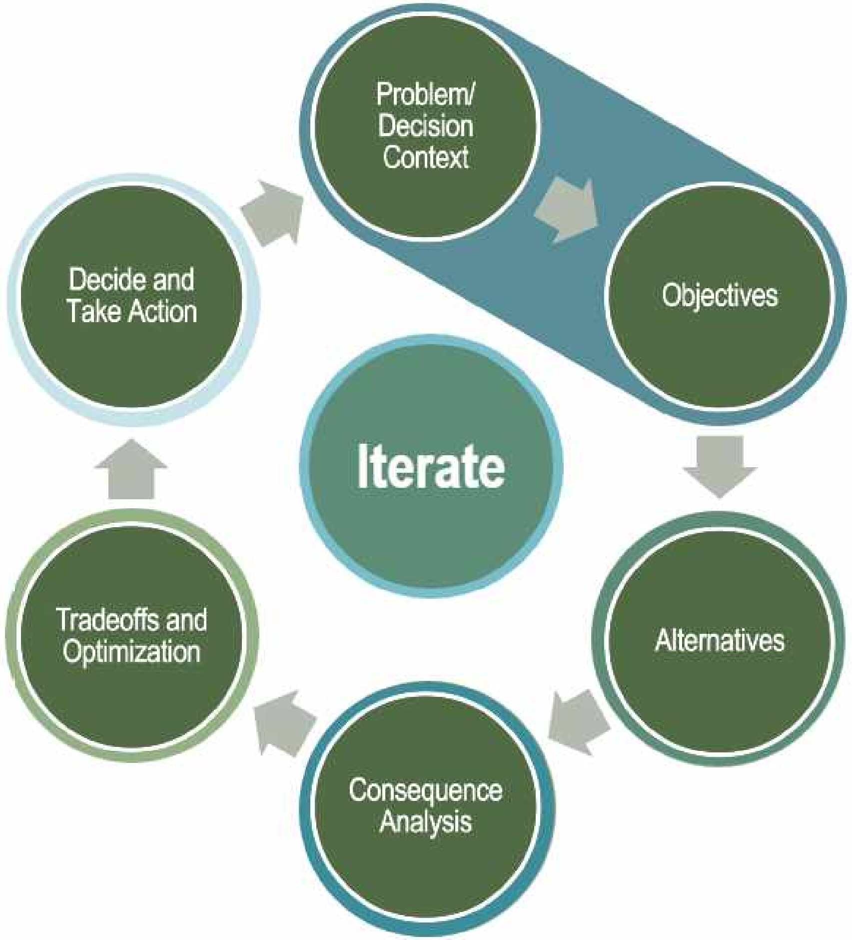


CAPITAL AREA GROUNDWATER CONSERVATION DISTRICT

WORK THROUGH DECISION-MAKING IN A COLLABORATIVE PROCESS WITH STAKEHOLDERS

PrOACT Framework for Structuring Decisions:

- Defining the Problem (Decision Context)
- Determining the Objectives
- Identifying Alternatives (Solutions)
- Evaluating alternatives and forecasting the Consequences
- Evaluating the Trade-offs
- Making the decision and taking action



PARTNERSHIP FOR OUR WORKING COAST

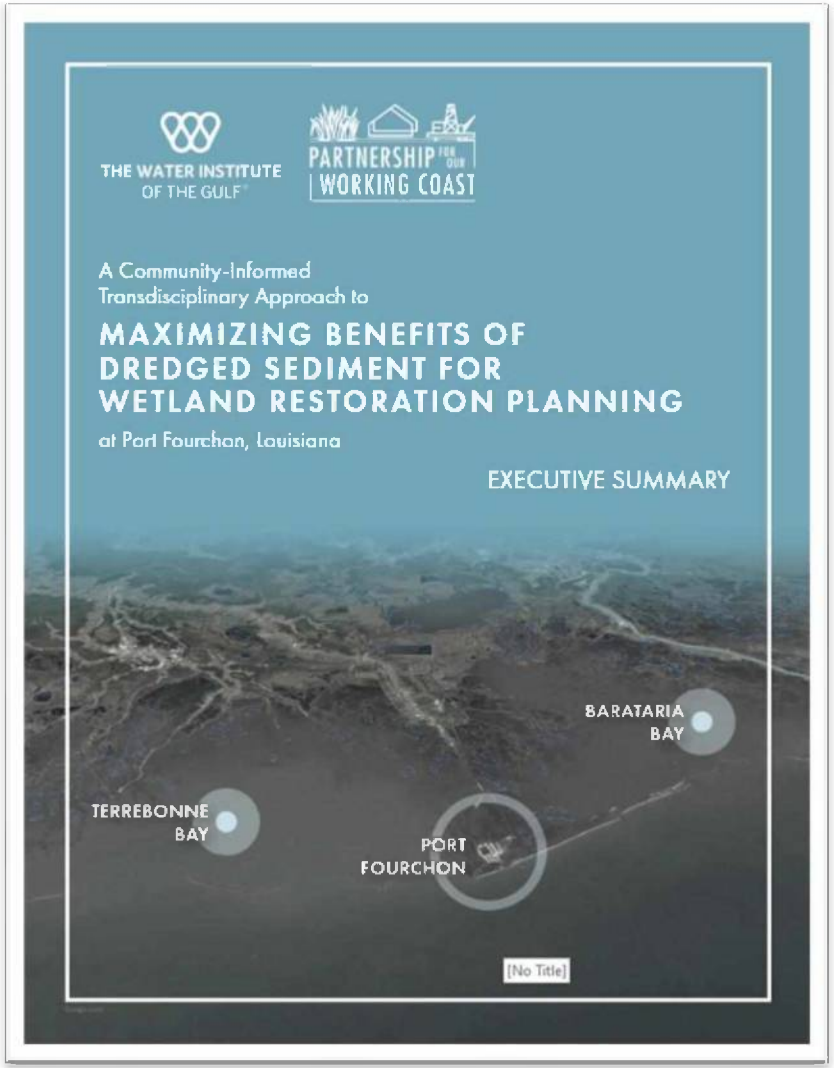
P3+ OBJECTIVES

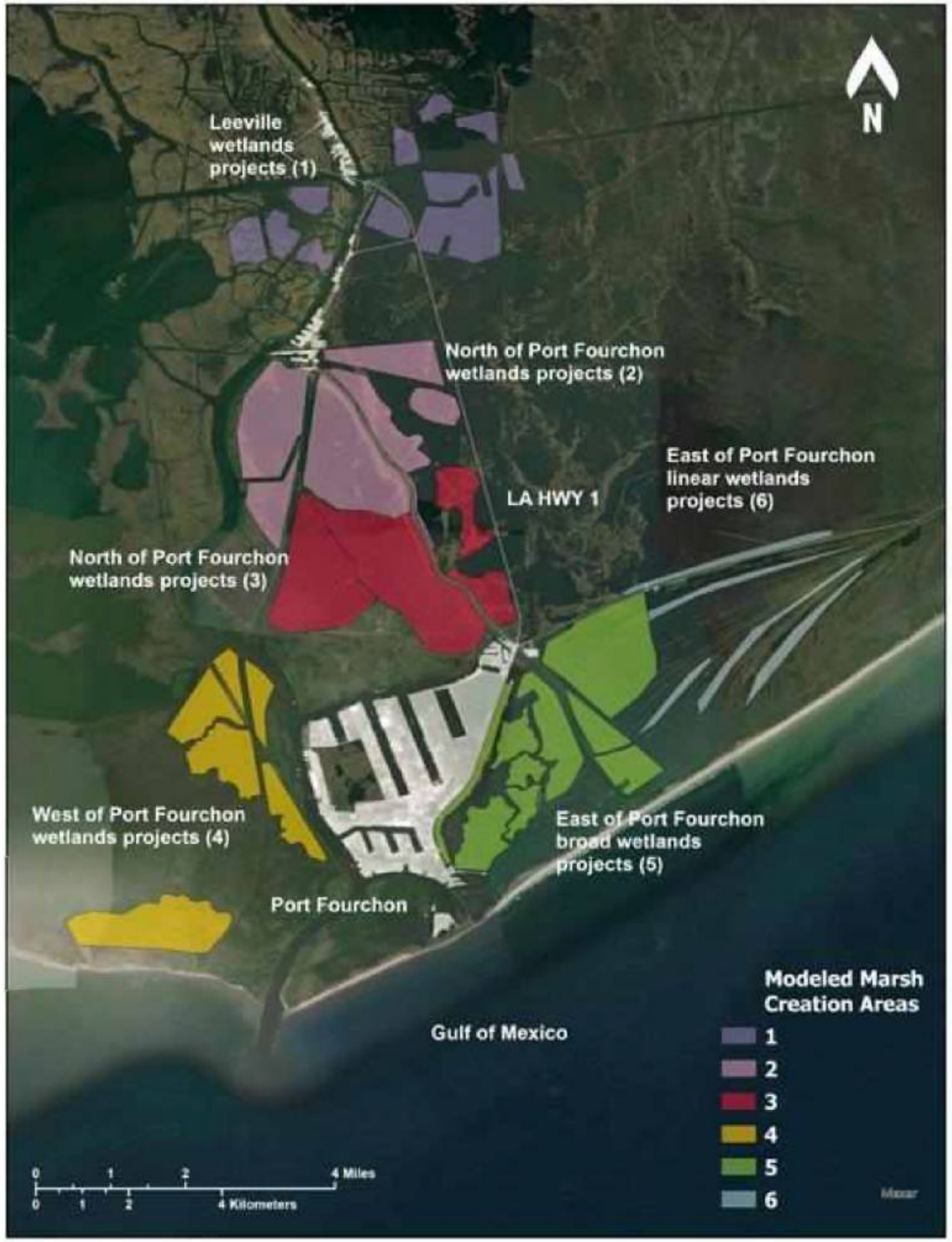
The Public-Private-NGO Partnership (P3+) will combine the resources and expertise of public, private, and non-governmental organizations to enhance coastal habitat and provide protection to critical infrastructure and communities.

MUTUAL BENEFITS

- COMMUNITY
- INFRASTRUCTURE
- HABITATS
- CO^2 CARBON CAPTURE & SEQUESTRATION

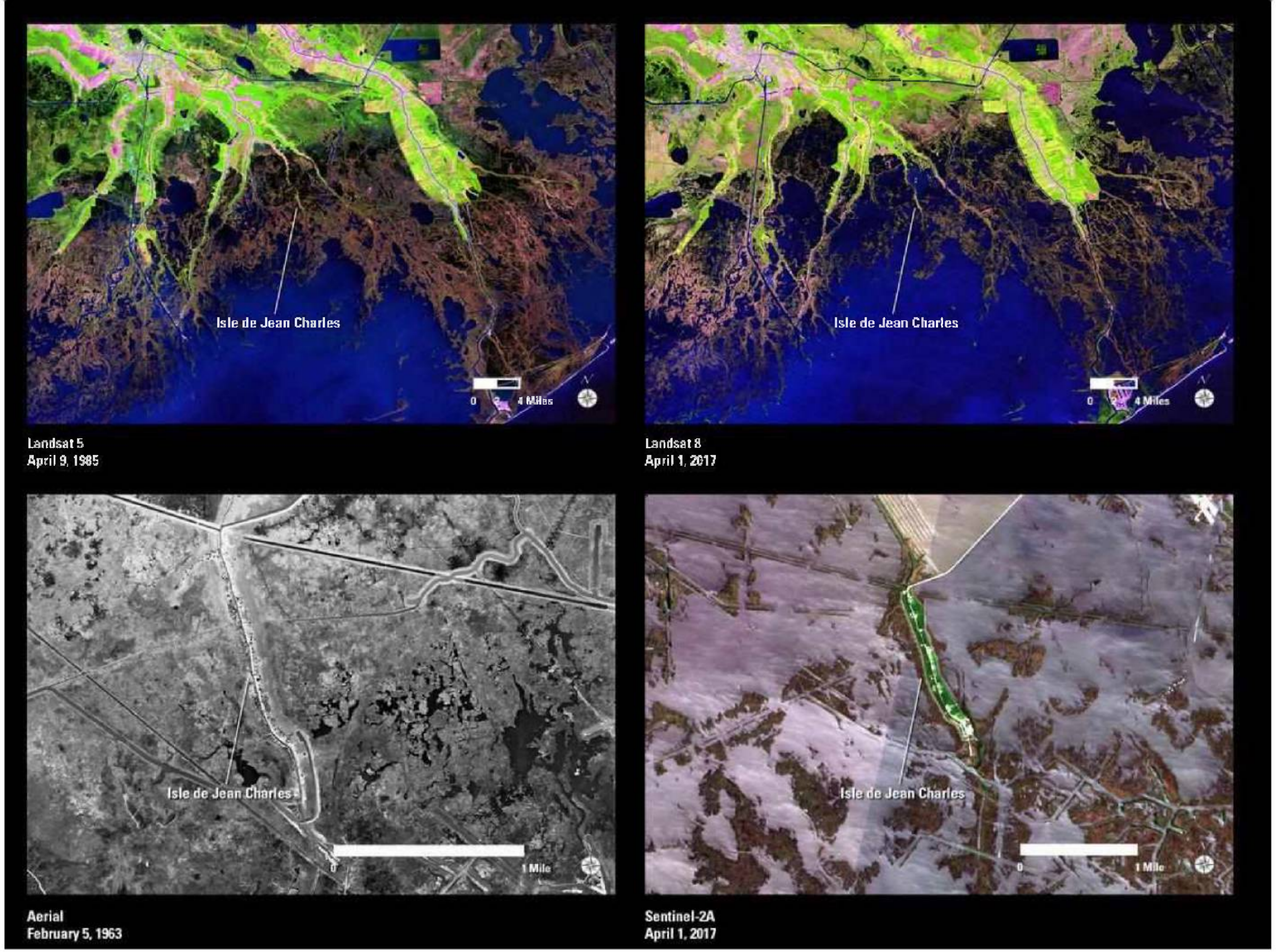
POWC:PHASE 2





December 20, 2022

Thibodaux
24
1
Raceland
Gibson
90
Lake Salvador
Lockport
Preferred relocation site
Houma
182
Larose
Cut Off
Montegut
665
Theriot
Chauvin
57
55
Island Rd.
Golden Meadow
Dulac
315
56
1
Isle de Jean Charles
Baton Rouge
New Orleans
MAP AREA
Gulf of Mexico
Leeville
Cocodrie
Terrebonne Bay
Advocate map


Isle de Jean Charles
0 4 Miles
Landsat 5
April 9, 1985
Isle de Jean Charles
0 4 Miles
Landsat 8
April 1, 2017
Isle de Jean Charles
0 1 Mile
Aerial
February 5, 1963
Isle de Jean Charles
0 1 Mile
Sentinel-2A
April 1, 2017

NATURE ALWAYS BATS LAST

THE WATER INSTITUTE
OF THE GULF®

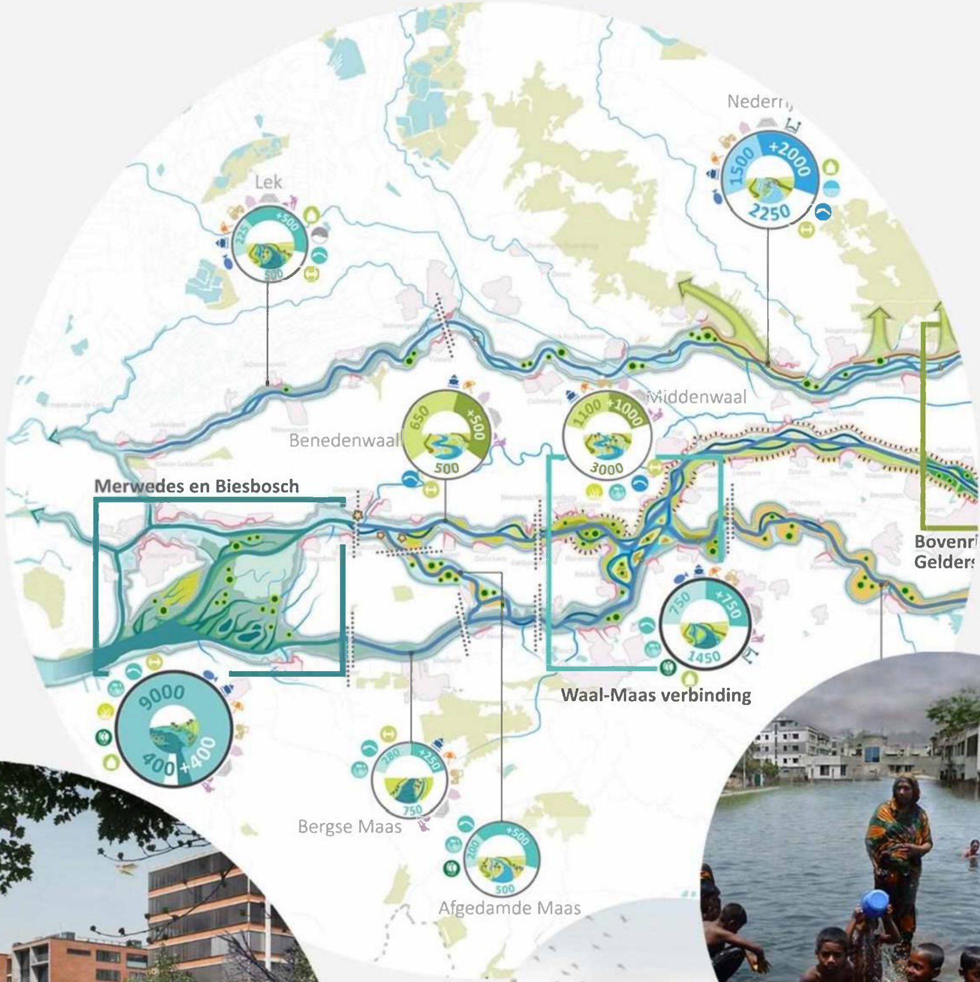
Justin Ehrenwerth

Baton Rouge
1110 RIVER ROAD SOUTH, SUITE 200
BATON ROUGE, LA 70802

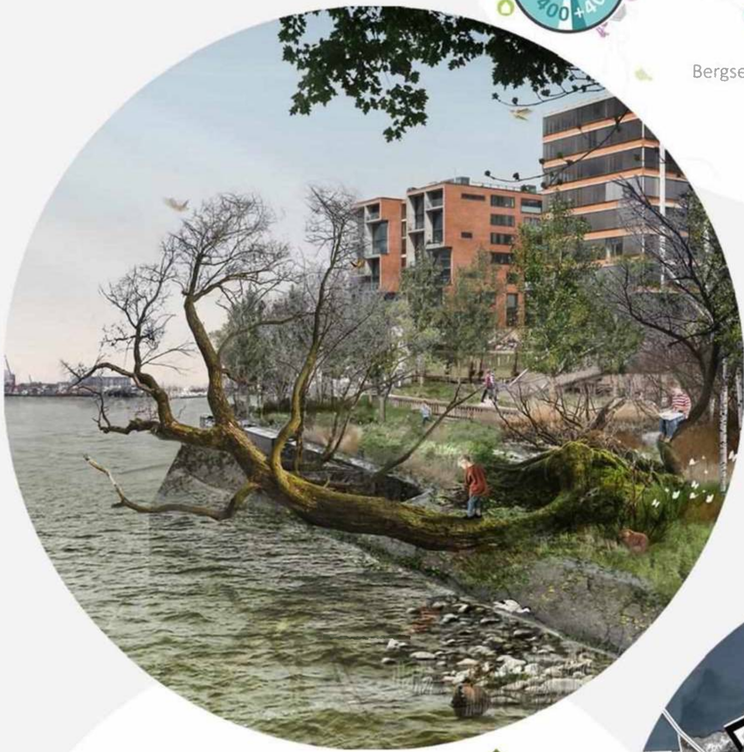
WWW.THEWATERINSTITUTE.ORG
@THEH2OINSTITUTE

New Orleans
2021 LAKESHORE DRIVE, SUITE 310
NEW ORLEANS, LA 70148

Anne Loes Nillesen



Lek
Middenwaal
Benedenwaal
Merwedes en Biesbosch
Waal-Maas verbinding
Bergse Maas
Afgedamde Maas

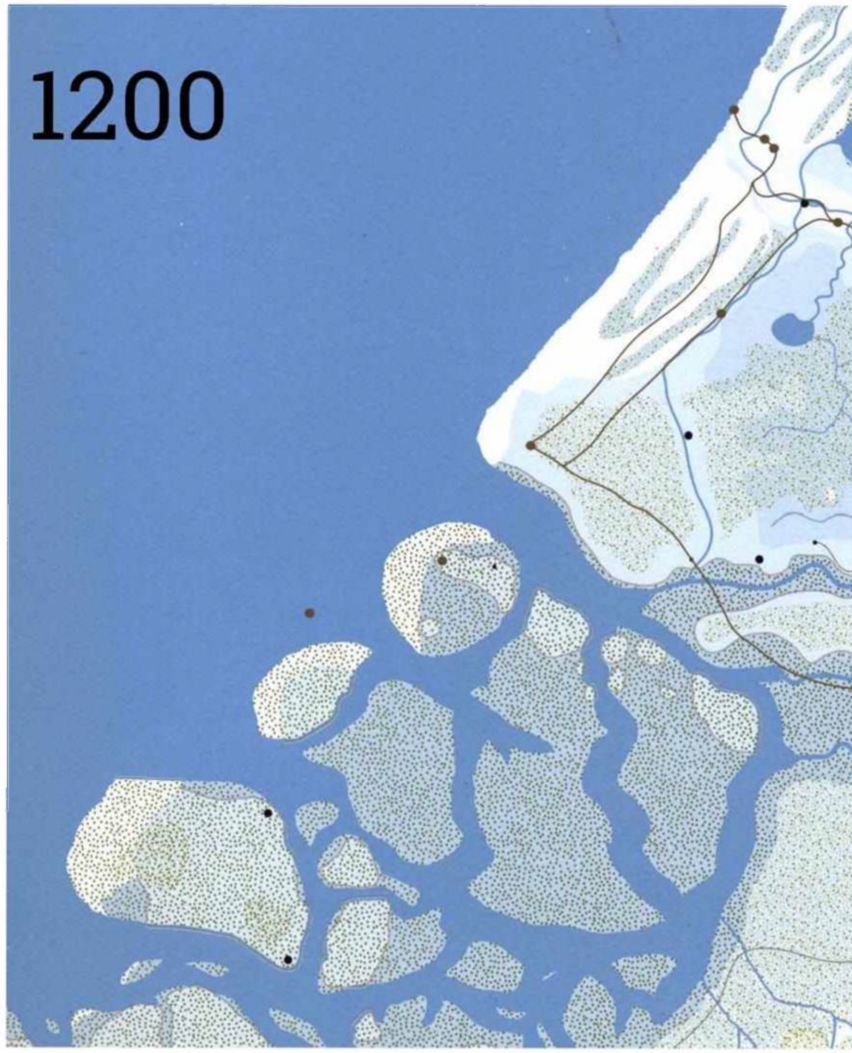


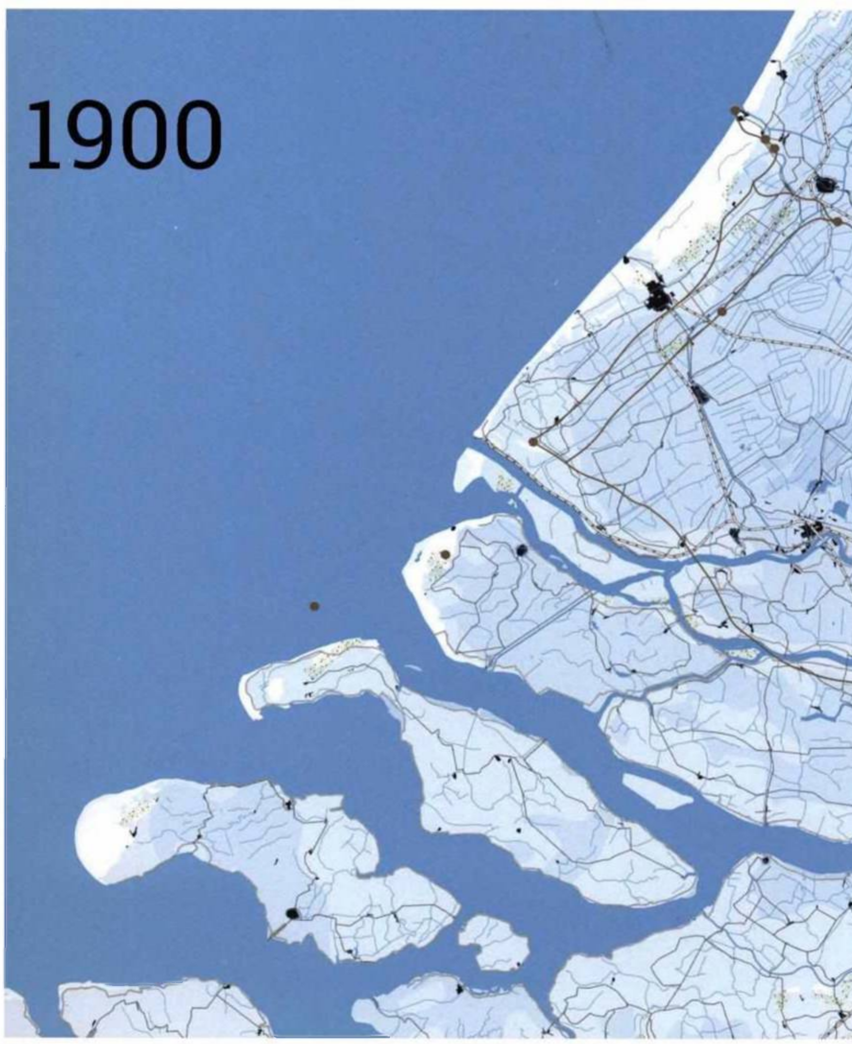
+20
+60
+25

Balgstuw Ramspol vaker dicht op lange termijn. Omvaren, sluis bouwen of andere oplossingsrichting?
Kampereiland: ruimte voor landbouw, waterberging, natuurontwikkeling of een combinatie?
Rekening houden met klimaatrobuuste stedelijke ontwikkeling
Belangrijkste scheepvaartroute Amsterdam-Twente via Benedenloop IJssel of Boven IJssel?
Genemuiden
IJsselmuiden
Kampen
Wilsum

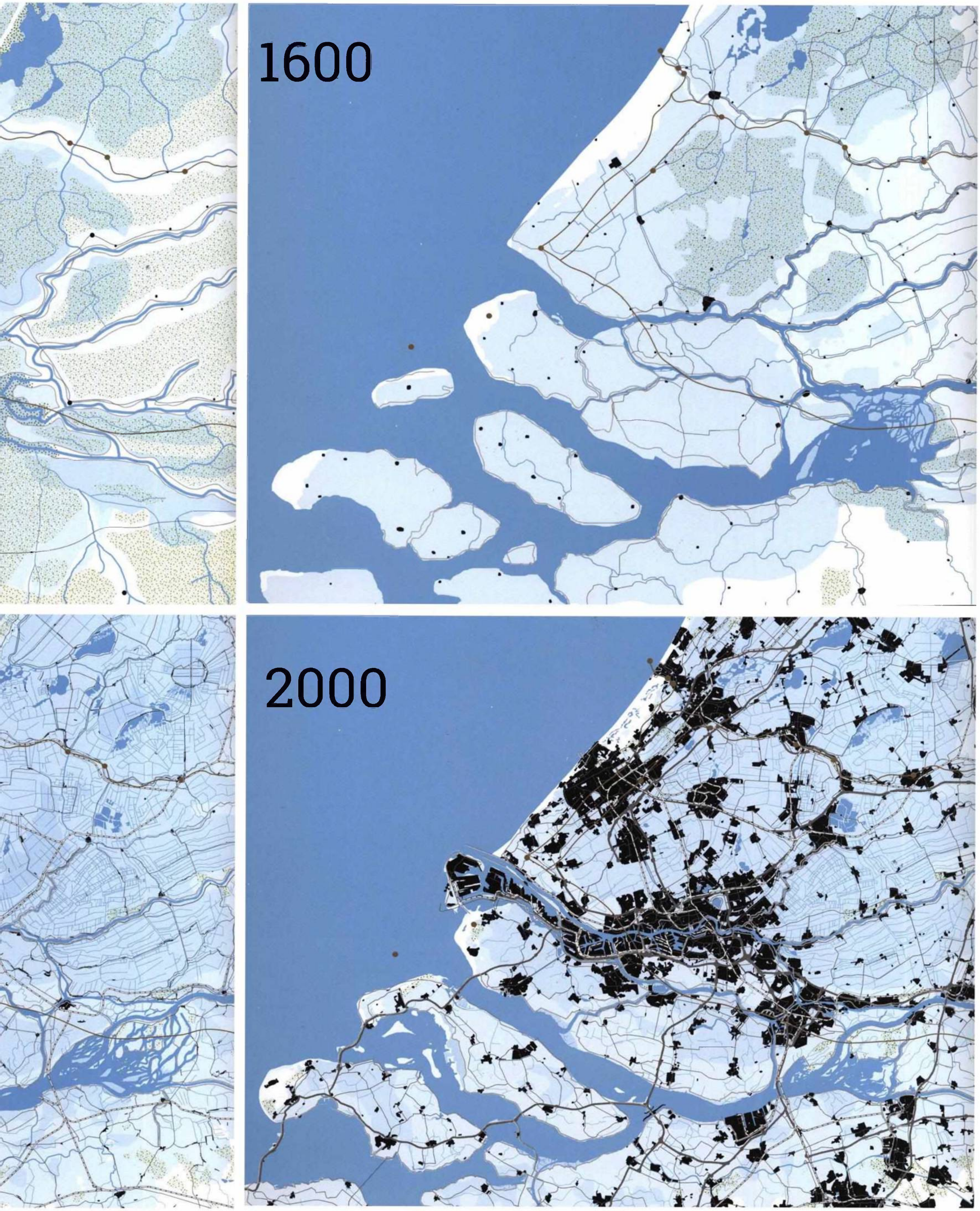

+70
+15
Defacto
urbanism

Human interventions

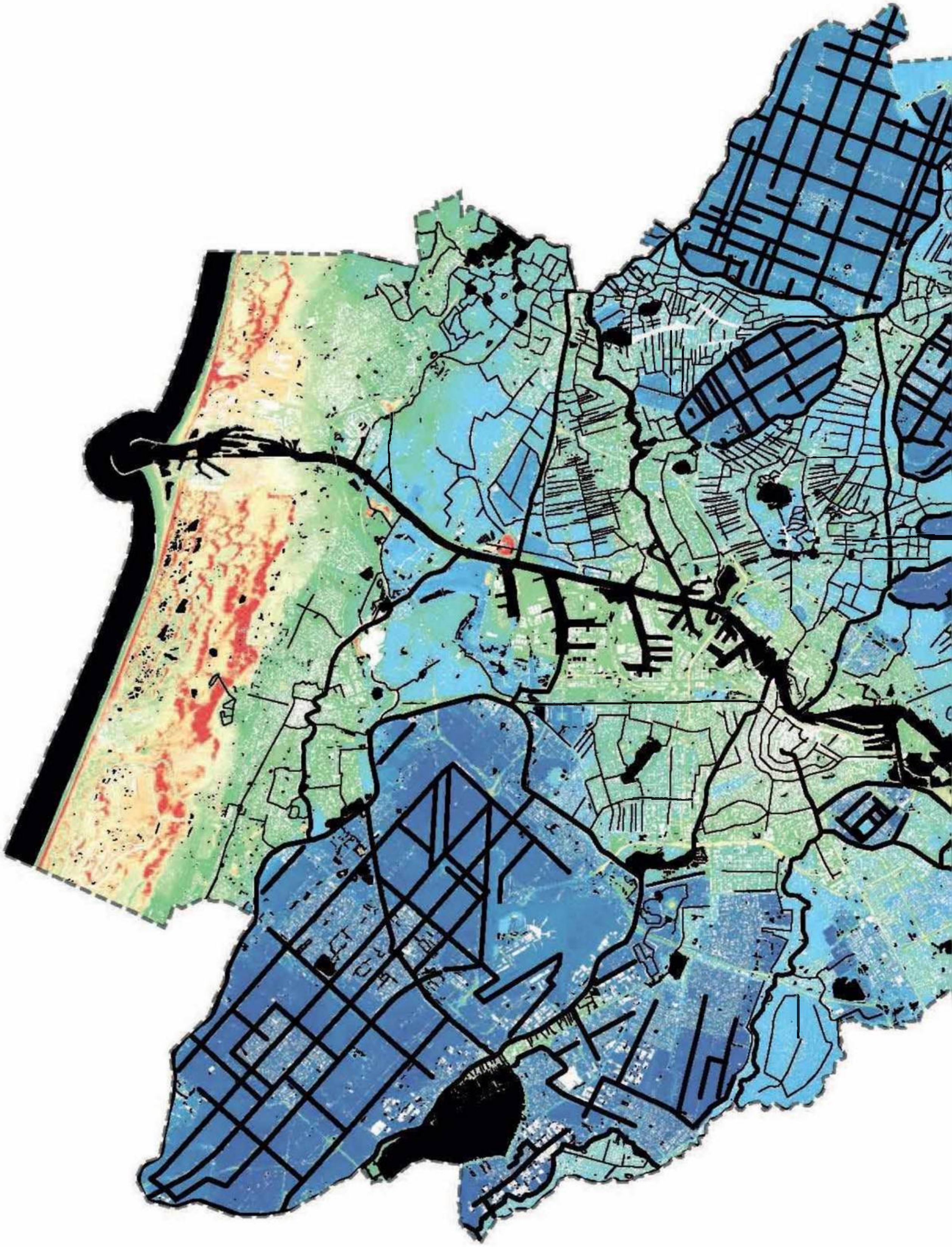




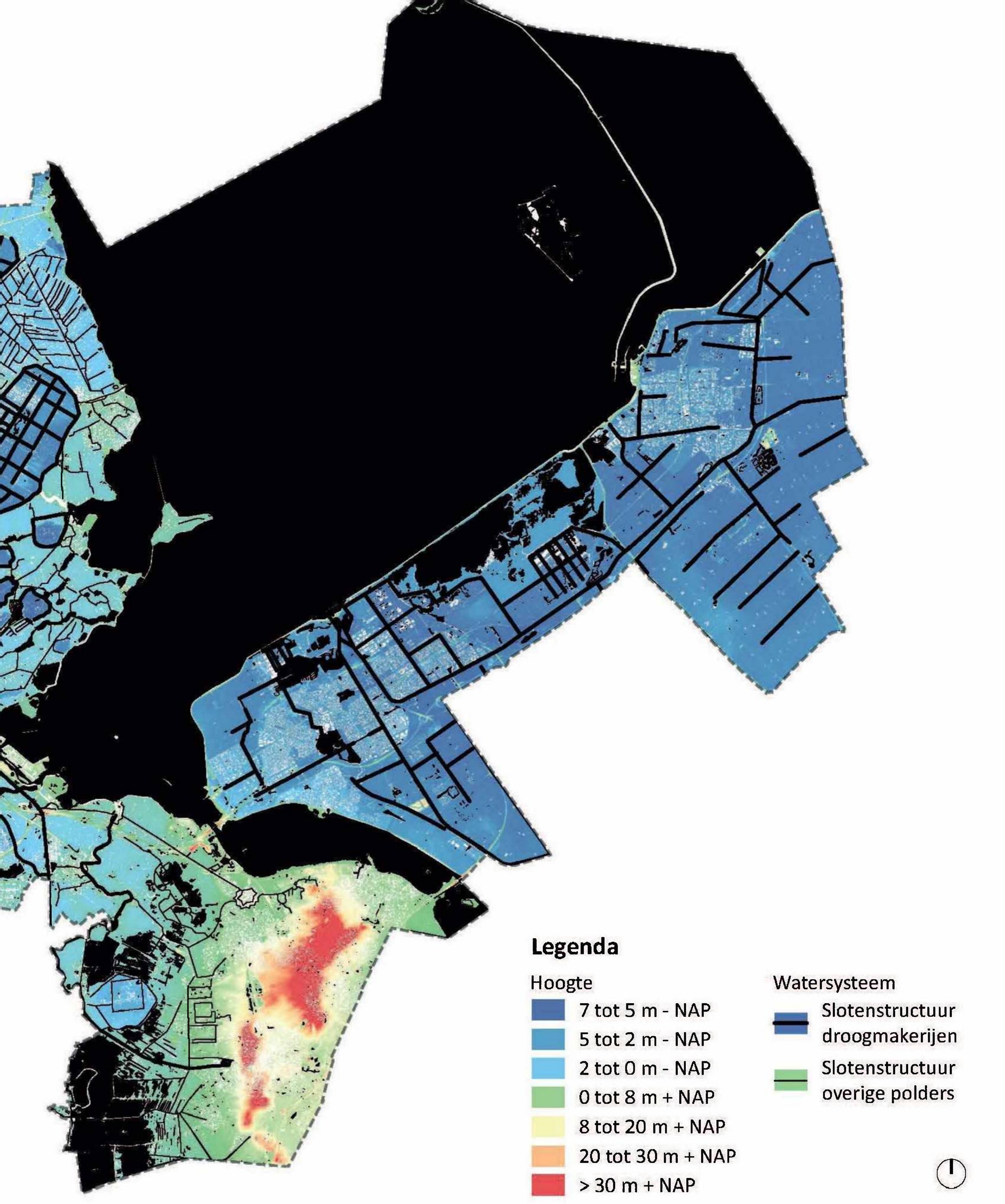
maps Limes atlas


1600
2000

Integrated land use and water system



maps Defacto Metropolitan region Amsterdam (MRA)

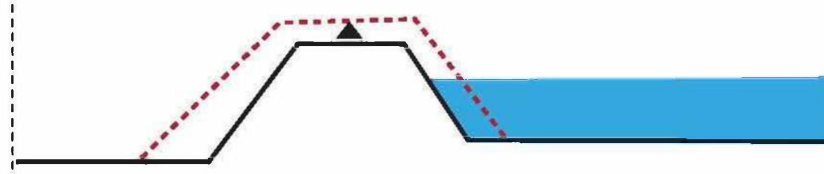

Legenda
Hoogte
7 tot 5 m - NAP
5 tot 2 m - NAP
2 tot 0 m - NAP
0 tot 8 m + NAP
8 tot 20 m + NAP
20 tot 30 m + NAP
> 30 m + NAP
Watersysteem
Slotenstructuur droogmakerijen
Slotenstructuur overige polders

Explore directions

1) EXPANDING TECHNICAL SYSTEM

FLOOD RISK MANAGEMENT

1 Reducing the risk by strengthening the dike



WATER AVAILABILITY

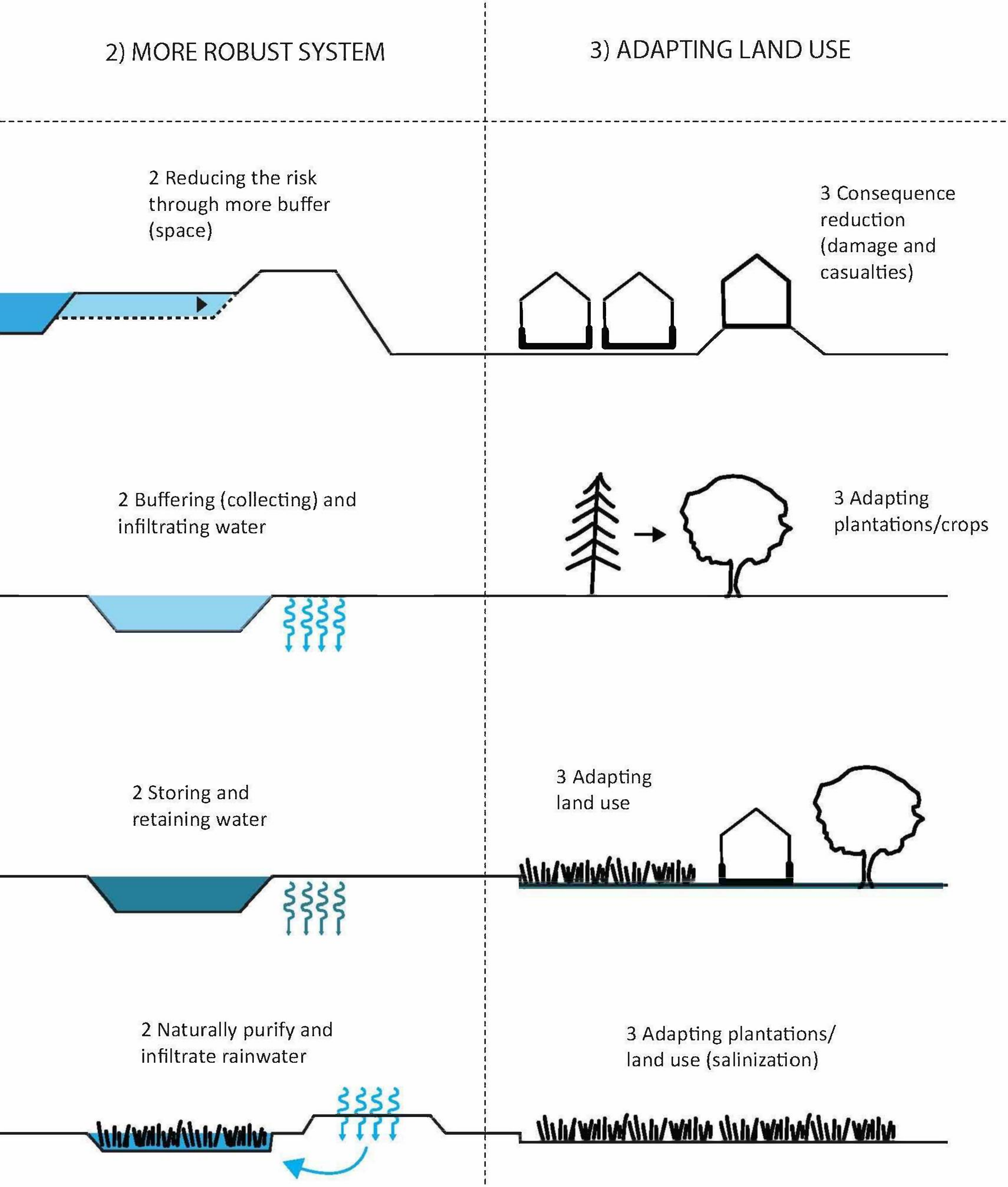
1 Supply extra water

WATER DISCHARGE

1 Discharge extra water

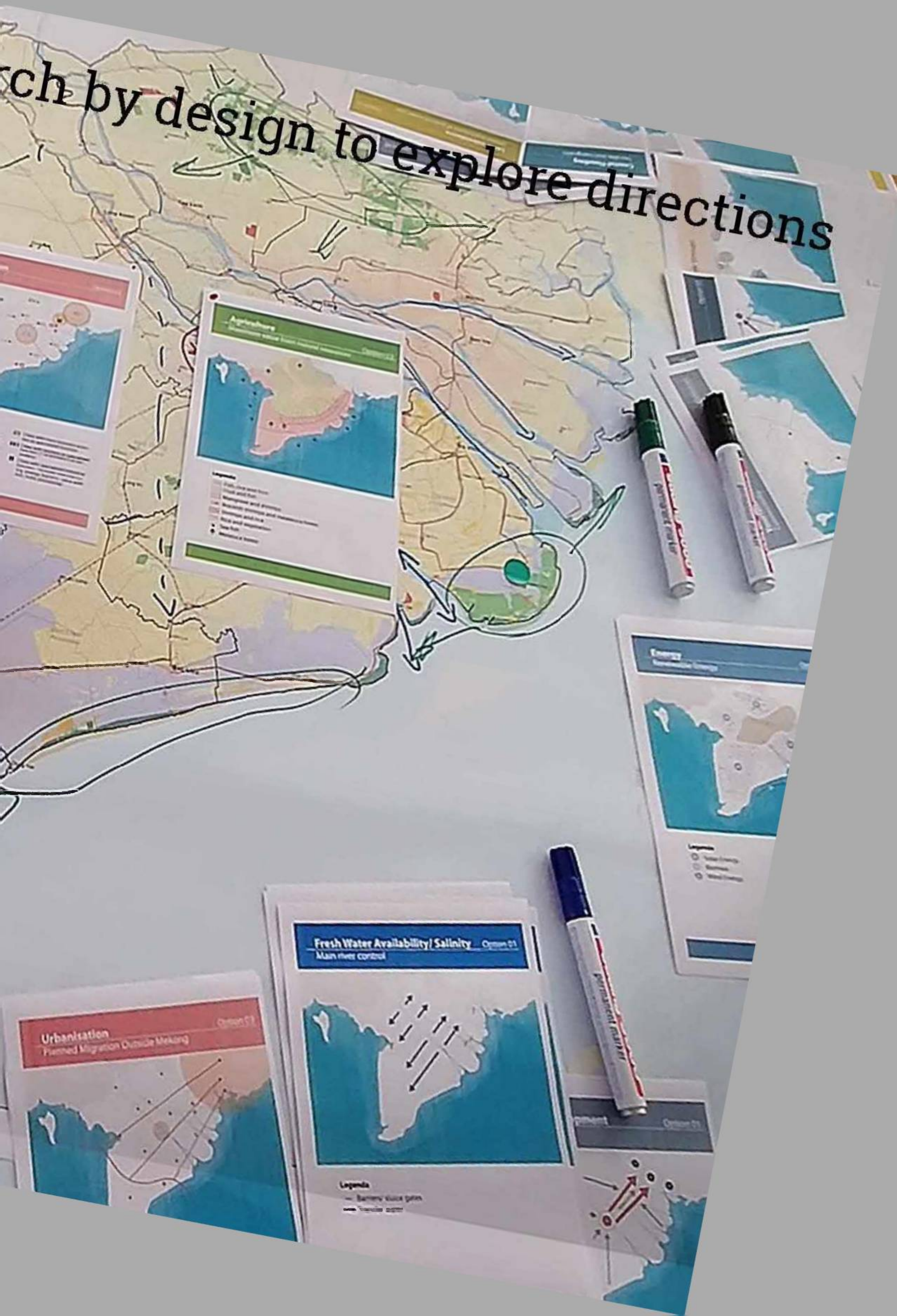
WATER QUALITY

1 Purification plant


2) MORE ROBUST SYSTEM
3) ADAPTING LAND USE
2 Reducing the risk through more buffer (space)
3 Consequence reduction (damage and casualties)
2 Buffering (collecting) and infiltrating water
3 Adapting plantations/crops
2 Storing and retaining water
3 Adapting land use
2 Naturally purify and infiltrate rainwater
3 Adapting plantations/ land use (salinization)


Use resea
Ecology
Title :
Slogan :
Let it go!
Legend
Natural Resources
permanent marker

rch by design to explore directions



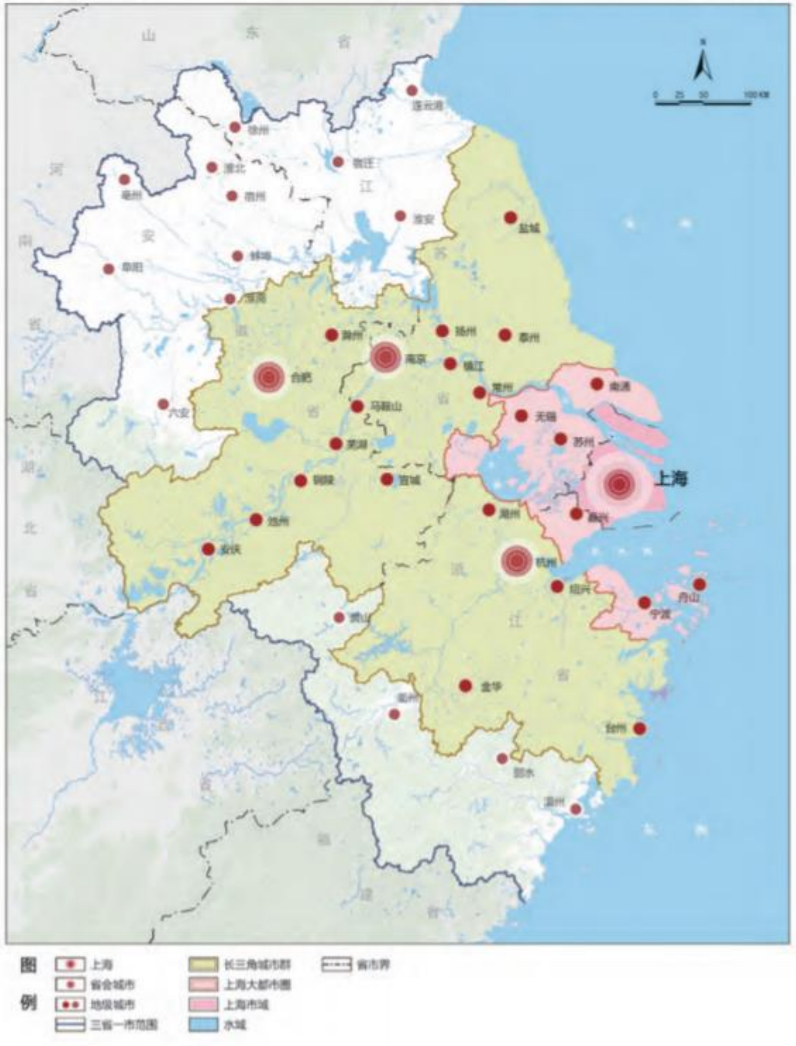
Tu Qiyu

Panel Discussion

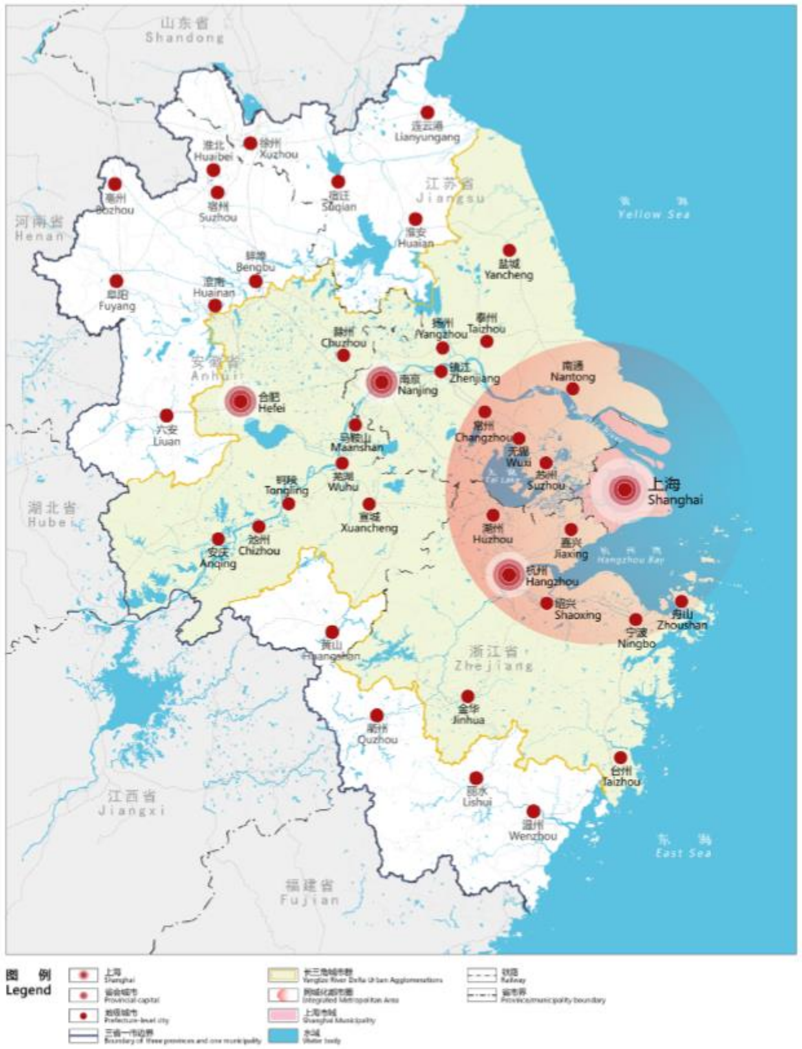
Qiyu Tu
Deputy Director
Institute of Urban and Demographic Studies
Shanghai Academy of Social Sciences

LAKE MATTERS
The Planning of Great Shanghai Metropolitan Area

上海市城市总体规划2016-2040 | 上海区位图 |



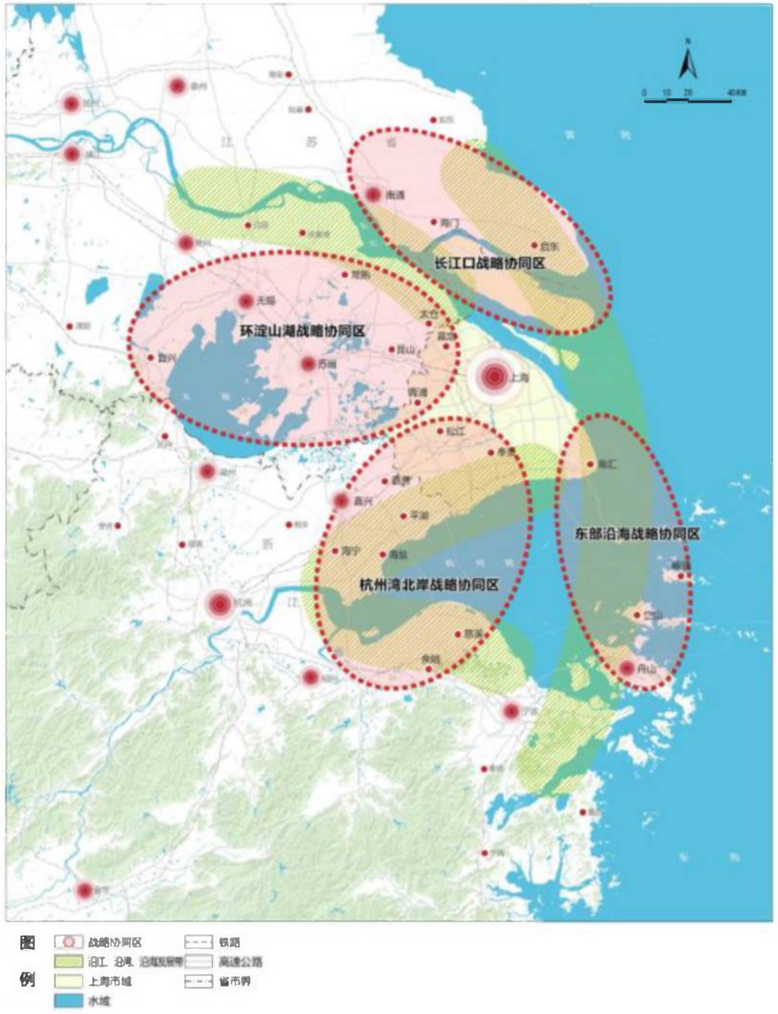
上海市城市总体规划2017-2035 | 上海市区位图 |
Shanghai Master Plan 2017-2035 | Shanghai Location Map |



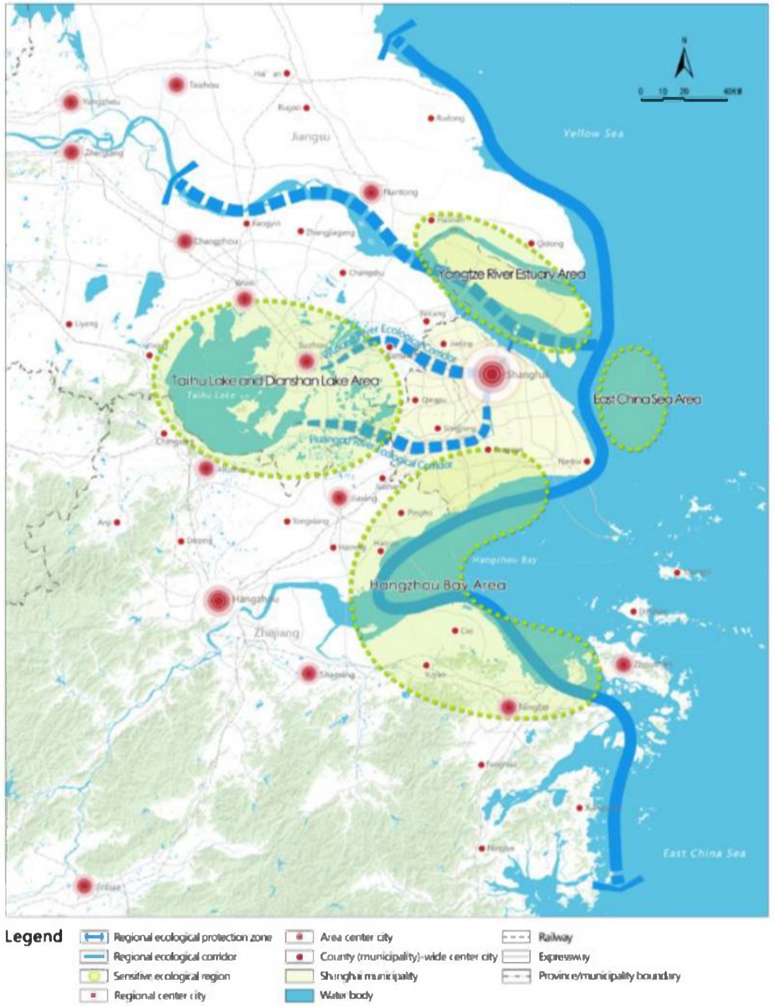
上海市城市总体规划(2017-2035年)

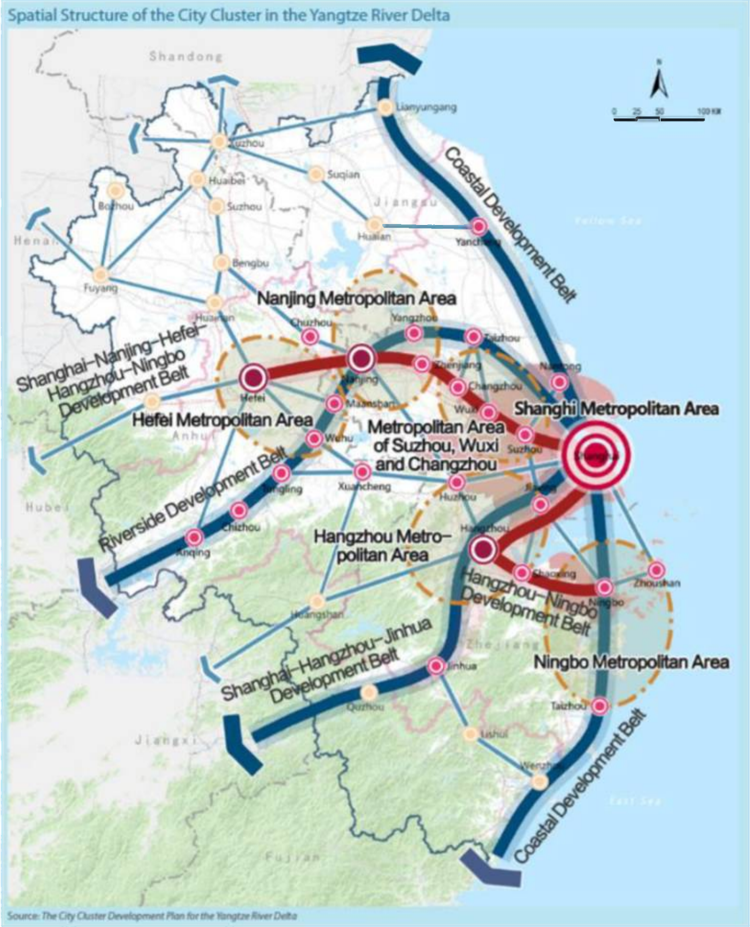
2035 SHANGHAI

上海和近沪地区战略协调区图



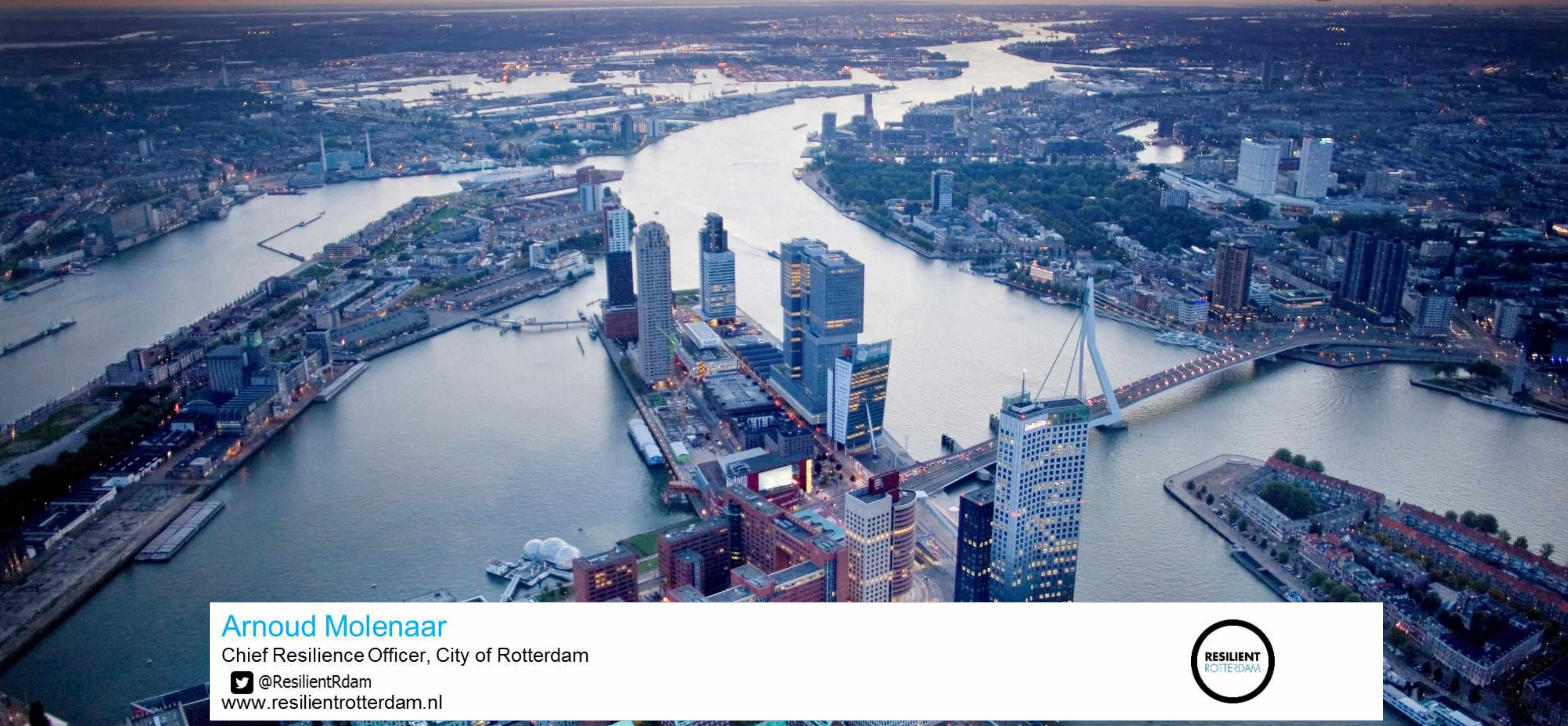
Ecological Coordination in Shanghai and Its Neighboring Areas





Arnoud Molenaar

Rotterdam Resilient Delta City



Arnoud Molenaar

Chief Resilience Officer, City of Rotterdam

@ResilientRdam

www.resilientrotterdam.nl

RESILIENT ROTTERDAM



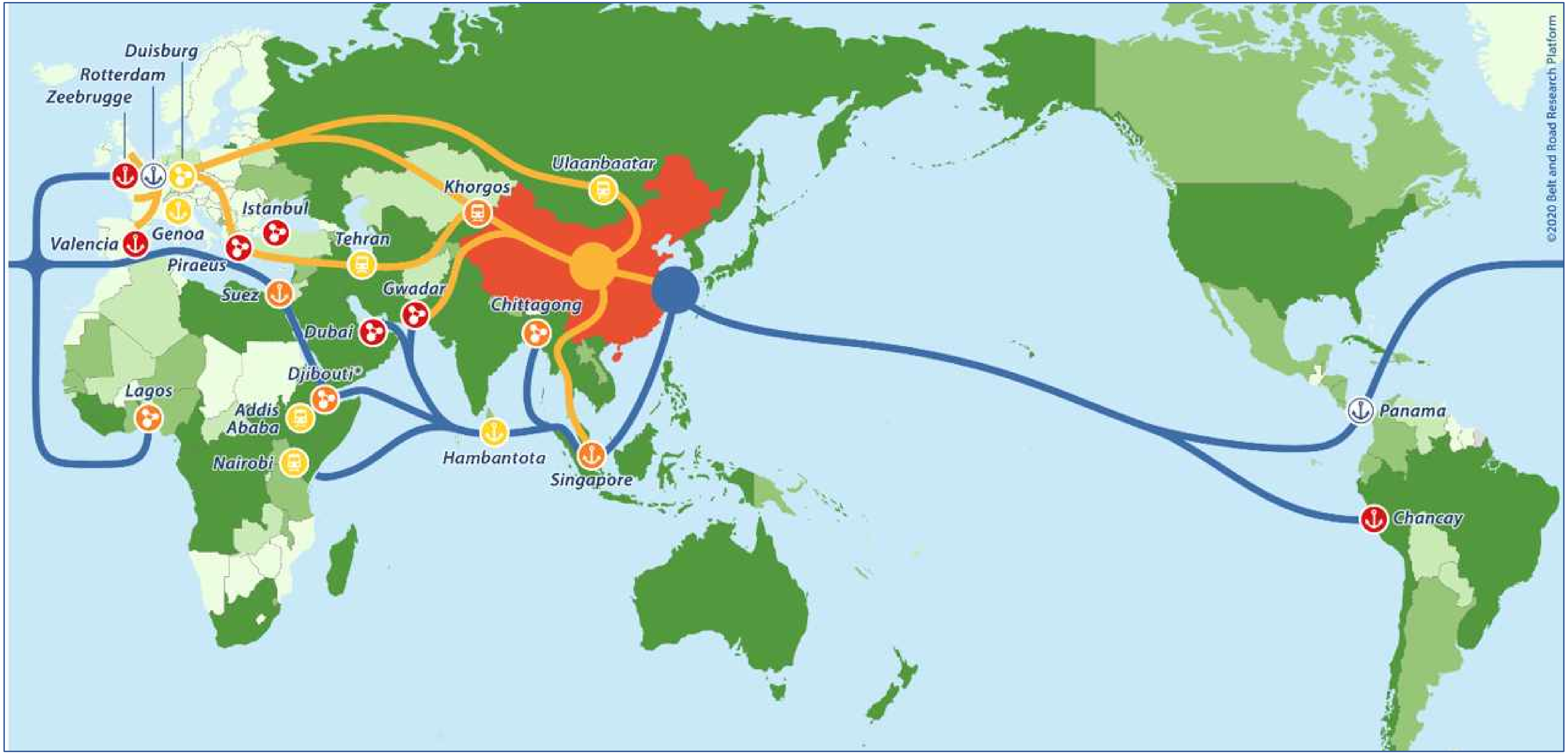






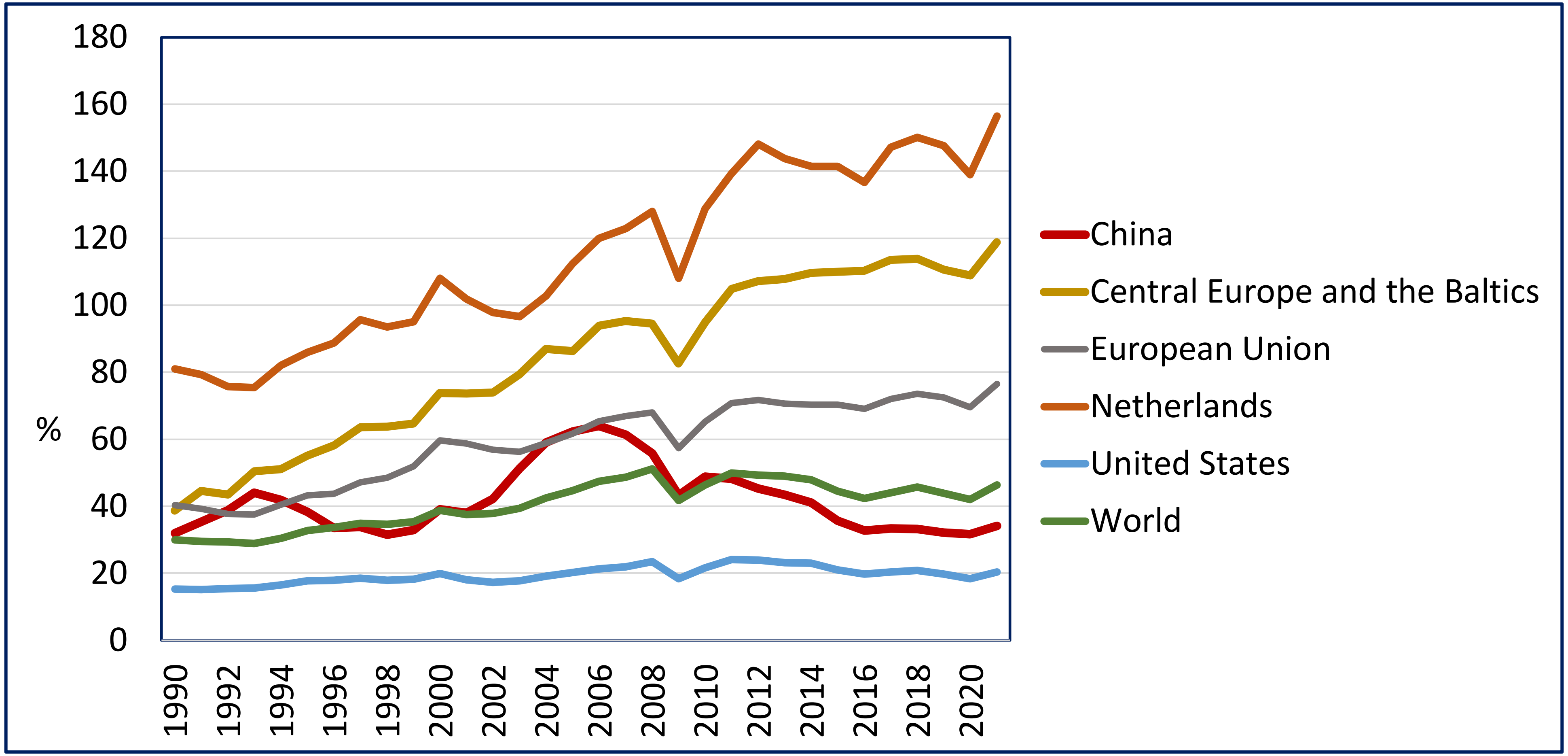
Bart Kuipers

Trend 1. BRI: disruptive developments war Ukraine



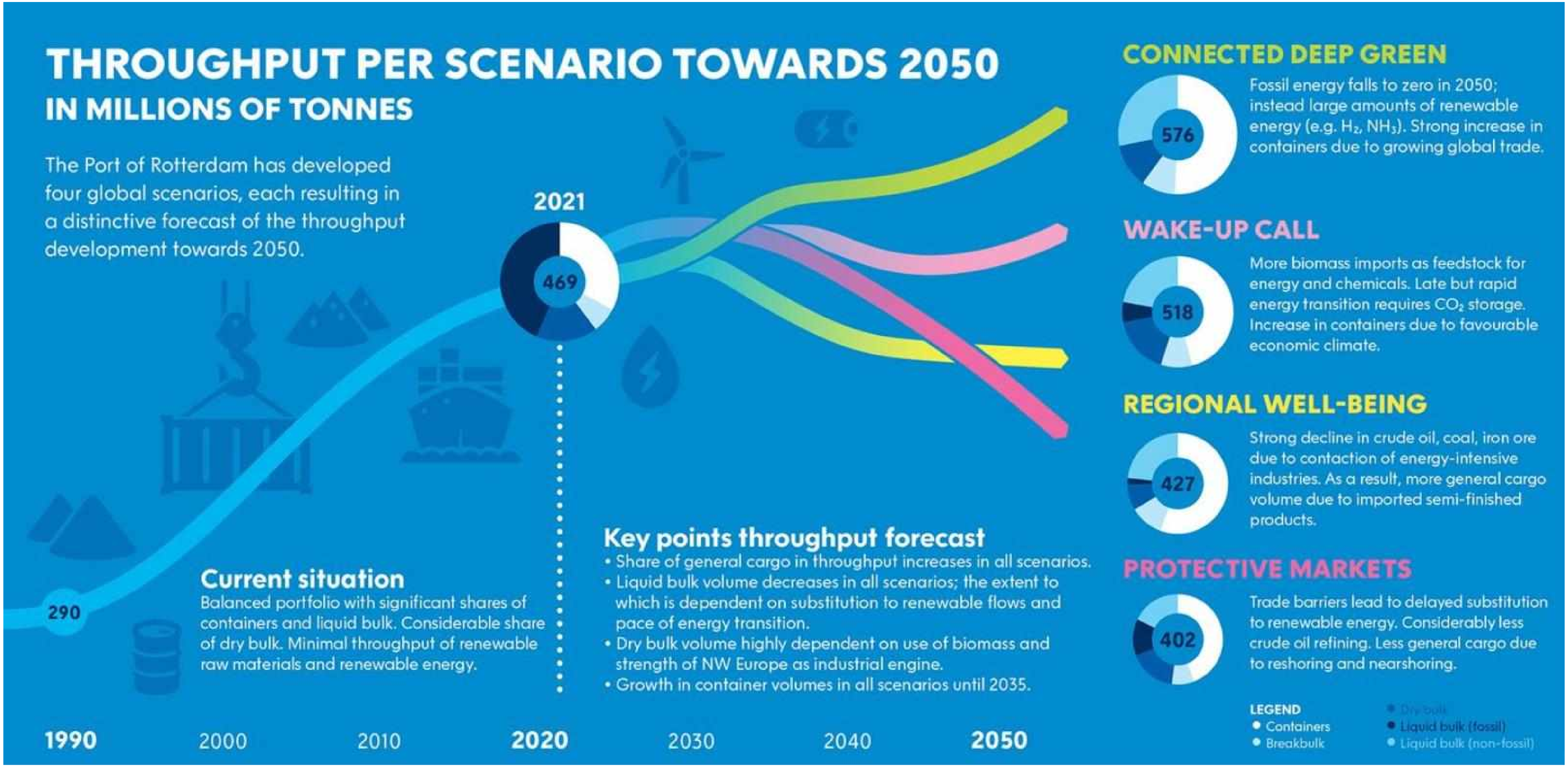
Trend 2. Deglobalization: China is leading since 2006

Merchandise trade as a share of GDP, 1990-2021



Source: Worldbank

Trend 3. Slowing Rotterdam port throughput



Nicole Silk

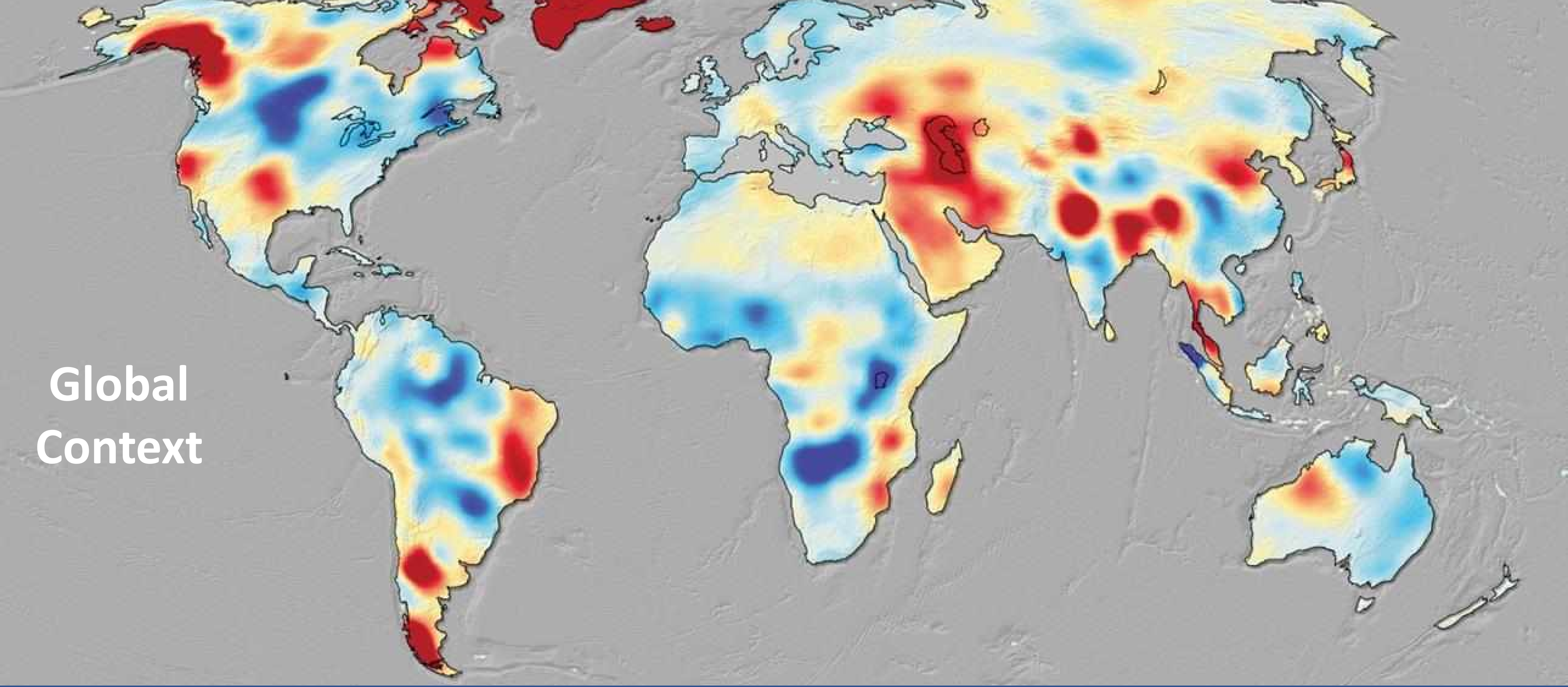
Seminar Programme:
The Future of River Basins and Deltas

The Nature Conservancy

Environmental and Social Implications

Nicole Silk
Global Director of Freshwater Outcomes

Global Context



84% freshwater species loss

30% of freshwater ecosystem loss

50% in water stressed areas by 2025

GRACE trend (cm/yr)


Upper Mississippi
River Basin
Missouri
River Basin
Arkansas - White
River Basin
Ohio
River Basin
Lower Mississippi
River Basin
Red
River Basin

26.4% increase flood risk overall

Disproportionate impacts to black, brown, indigenous, and poor

$40 billion annually


The Nature Conservancy
Thank You!

Lv Xiaobei

中国环境与发展国际合作委员会
China Council for International Cooperation on Environment and Development

气候变化背景下的流域治理

River Basin Governance under Climate Change

李晓江 Li Xiaojiang
中国城市规划设计研究院原院长 Former president of China Academy of Urban Planning and Design

Hans Mommaas
荷兰环境评估署(PBL) 主席 President of PBL

Fernando Miralles-Wilhelm
大自然保护协会(TNC)全球水项目首席专家 Lead Scientist of Global Water of TNC

0 五年研究计划 Research foci in 5 subsequent years of SPS

研究年份	年度研究原则/主题 Principle/Theme of annual research	可能的研究重点# Possible research focus#
2022-2023	**从源头到沿海履行责任** **Make good on your responsibility stretching from the headwaters to the coastal seas**	**区域合作机制** **The mechanism for regional collaboration**
2023-2024	根据百年愿景规划步骤 Adopt a 100-year perspective and plan your steps	积极主动适应气候变化并提高韧性 A proactive approach to adapt to projected climate change and increase resilience
2024-2025	人人参与，形成共同愿景 Engage everybody who can contribute and develop a shared vision	基于多学科利益的协作组织 The organization of collaboration in multi-subjects’ interests
2025-2026	在流域管理各方面考虑气候变化和其他主要压力源 Adapt to climate change and other principal river stressors in every aspect of the management of river areas	应对气候变化、其他压力源和灾害的不确定性 Dealing with the uncertainty of climate change and other stressors, and of disasters
2026-2027	持续加强和创新 Continue to strengthen and innovate	管理方法、知识计划、政策工具和前瞻性融资机制等；国际交流 Management approaches, knowledge programs, policy tools and forward-looking financing mechanisms, etc.; international exchanges

区域协作下的珠江口海岸带地区保护与治理

Protection and Governance of the Pearl River Estuary Coastal Zone under Regional Collaboration

一、珠江口海岸带地区的基本认识

Basic understanding of the Pearl River Estuary coastal zone area

二、珠江口海岸带地区的风险挑战

Risks & Challenges of the Pearl River Estuary coastal zone area

三、珠江口海岸带地区的保护治理

Protection and governance of the Pearl River Estuary coastal zone area

1 珠江口海岸带地区的基本认识—— 研究对象 Research Objects

■ 珠江流域 Pearl River Basin

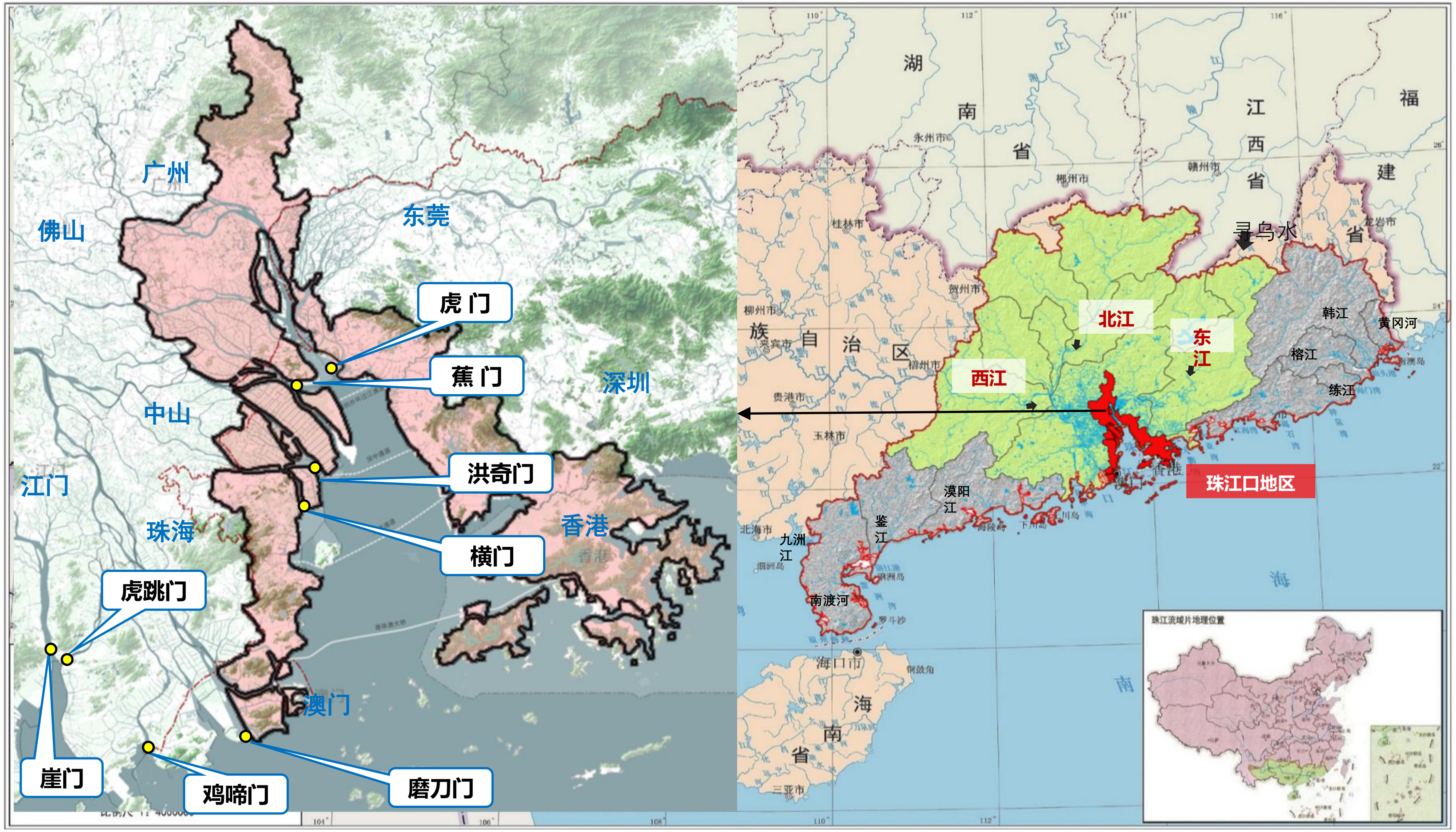
珠江是中国径流量第二大的河流，流域总面积约45.37万平方千米，其中中国境内流域面积44.21万平方千米。 The Pearl River is the second largest river in China in terms of runoff, with a total basin area of about 45.37Km², including a basin area of 44.21Km² within China.

■ 广东省珠江流域地区 Pearl River Basin in Guangdong Province

广东省珠江流域承载全省85%的城镇经济总量、 80%的污染负荷和67的水源需求。The Pearl River Basin in Guangdong Province carries 85% of the province's total urban economy, 80% of the pollution load and 67% of the water demand.

■ 珠江口地区Pearl River Estuary

珠江由八大口门入海, 分布香港、澳门、广州、深圳、东莞、中山、珠海、江门等八个城市，是中国城镇分布最密集，人口最密集的地区。The Pearl River enters the sea from eight major gateways, and is distributed in eight cities, including Hong Kong, Macau, Guangzhou, Shenzhen, Dongguan, Zhongshan, Zhuhai and Jiangmen, which are the most densely distributed and populated areas in China.



1 珠江口海岸带地区的基本认识—— 研究范围 Research Objects

■ **珠江口海岸带地区**

Pearl River Estuary coastal zone area

指珠江口地区海陆交互关系最密切的地区，向海至广东省领海基线，向陆至沿海第一个县（区）级行政单元。It refers to the area with the closest interaction between sea and land in the Pearl River Estuary, seaward to the baseline of Guangdong Province's territorial waters, and landward to the first county (district) level administrative unit along the coast.

■ **总面积：4972Km²**

Total area： 4972Km²

占沿海七市总面积的30%，海岸线总长4100公里

■ **常住人口：3012万人(2018)**

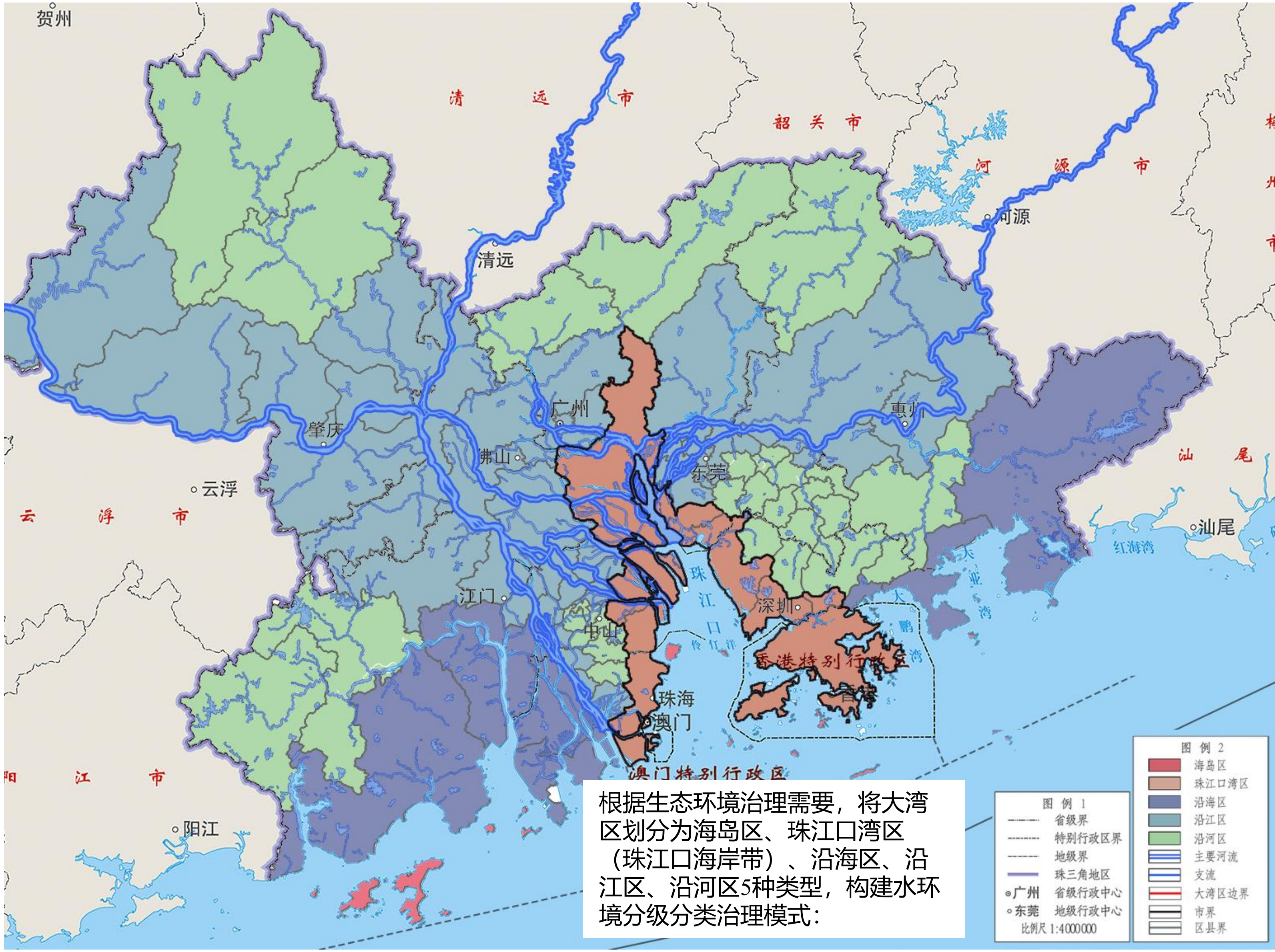
Resident population ： 30.12 million

占沿海七市（深圳、广州、东莞、中山、珠海+香港、澳门）常住人口总量的45.8%

■ **人口密度：**6057人/平方公里。

Population density: 6,057 people/Km²

珠江口海岸带地区



根据生态环境治理需要，将大湾区划分为海岛区、珠江口湾区（珠江口海岸带）、沿海区、沿江区、沿河区5种类型，构建水环境分级分类治理模式：

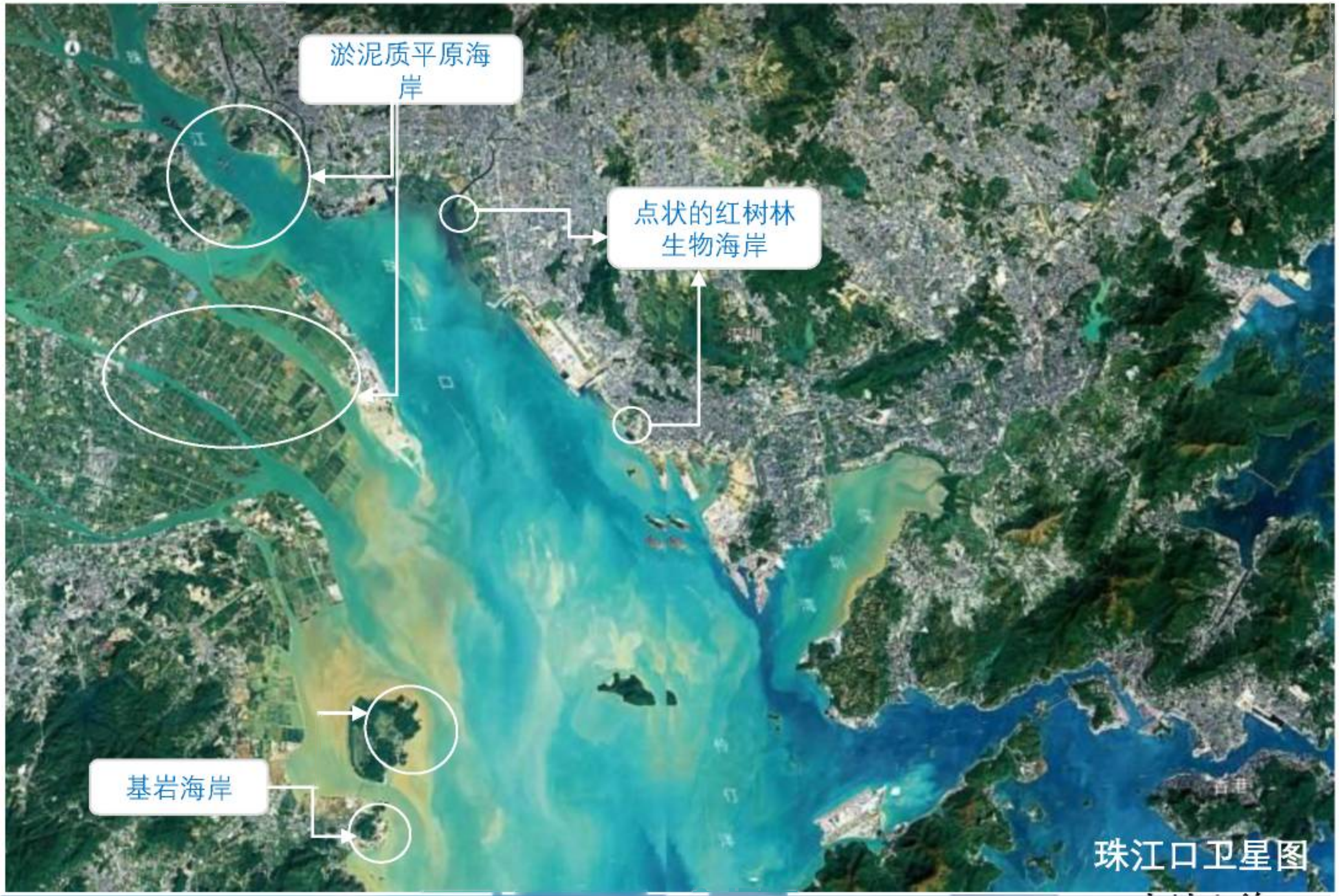
来源：《粤港澳观察蓝皮书2018》

1 珠江口海岸带地区的基本认识—— 自然地理条件 Natural Geographic Conditions

海岸类型
Coastal Type

主要为河口三角洲淤泥质平原海岸，基岩海岸，以及少量珊瑚礁、红树林及人工种养殖而成的生物海岸。

左上：淇澳岛基岩海岸
左下：横琴南岸淤泥质海岸
右：红树林海岸示意



1 珠江口海岸带地区的基本认识—— 自然地理条件 Natural Geographic Conditions

■ **全球重要的鸟类迁徙通道之一**

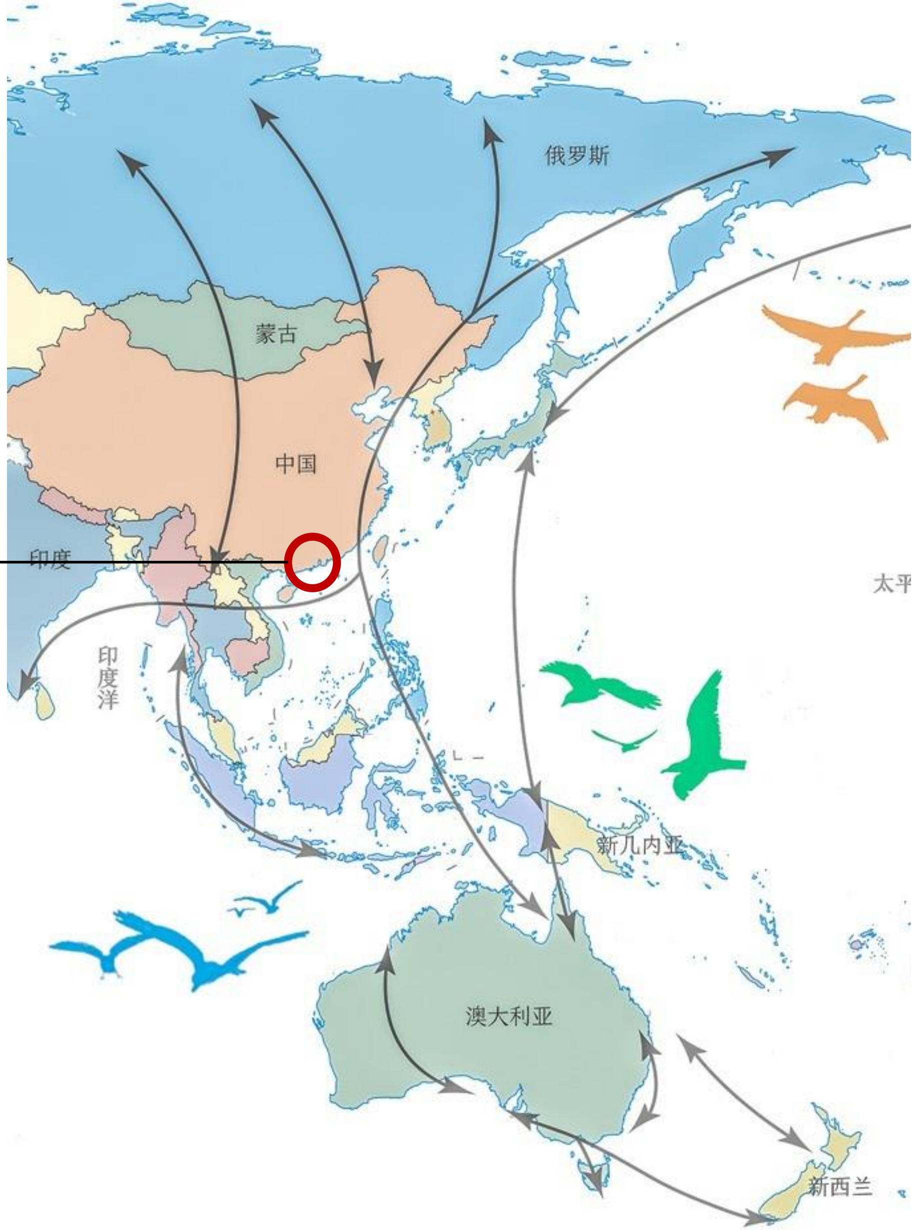
One of the world's most important bird migration corridors

珠江口地区位于东亚——澳大利西亚候鸟迁徙路线上，是国际候鸟迁徙中转站和栖息地。每年冬季停留在珠江口深圳湾的水鸟约为55000只，全年水鸟数目逾10万只。

■ **国家重点保护鸟类多**

Many National key protected bird species

仅深圳湾就发现黑脸琵鹭、小青脚鹬（yu）等23种鸟类属全球濒危物种（来源：www.ramsar.org）。

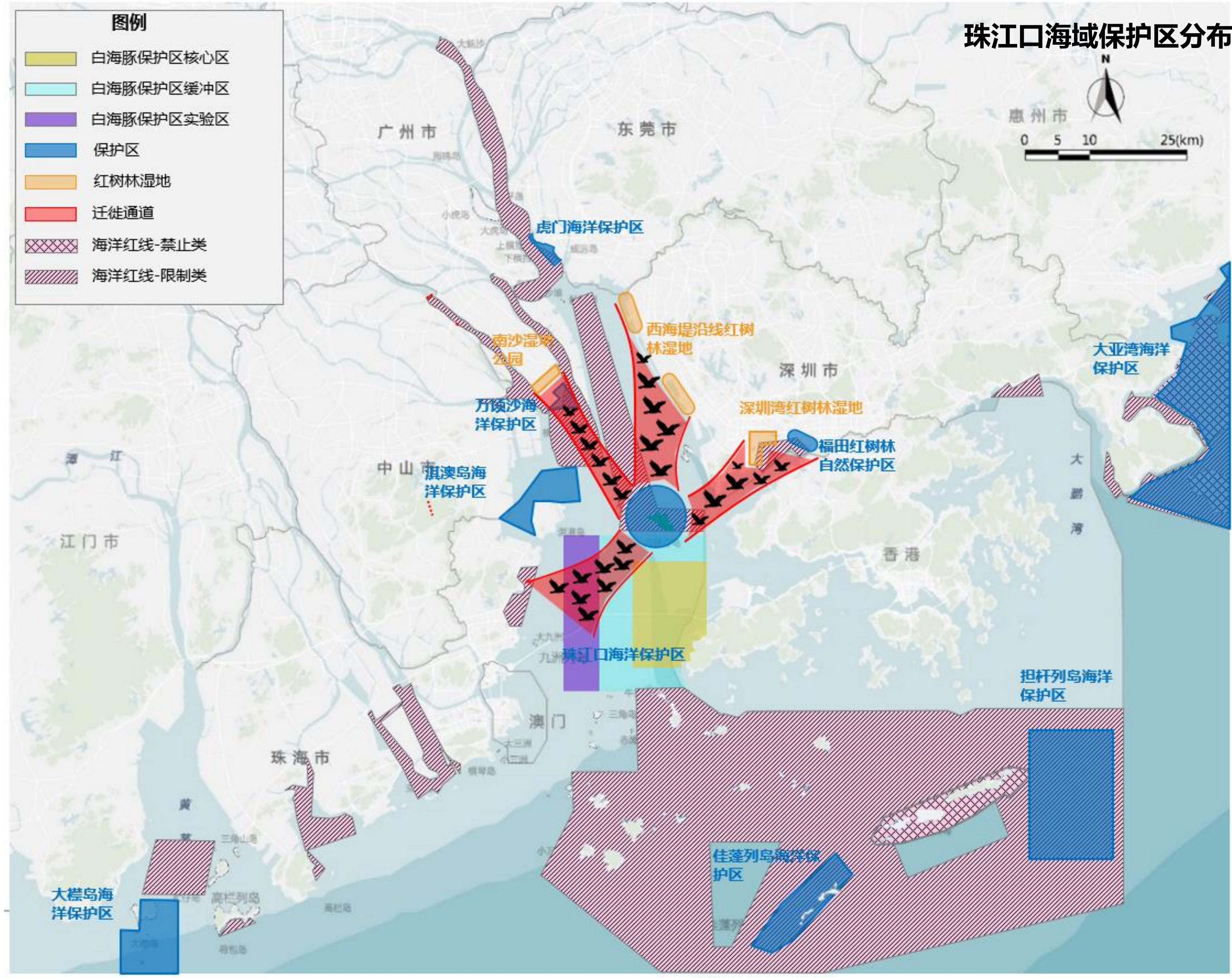


1 珠江口海岸带地区的基本认识—— 自然地理条件 Natural Geographic Conditions

重要的自然保护区
Important Nature Reserves

- 珠江口分布有9处重要动植物保护区，主要分布在河口和近岸海域及海岛地区
- 重点保护红树林以及中华白海豚、猕猴、黄唇鱼、马氏珠母贝、紫海胆等特殊物种

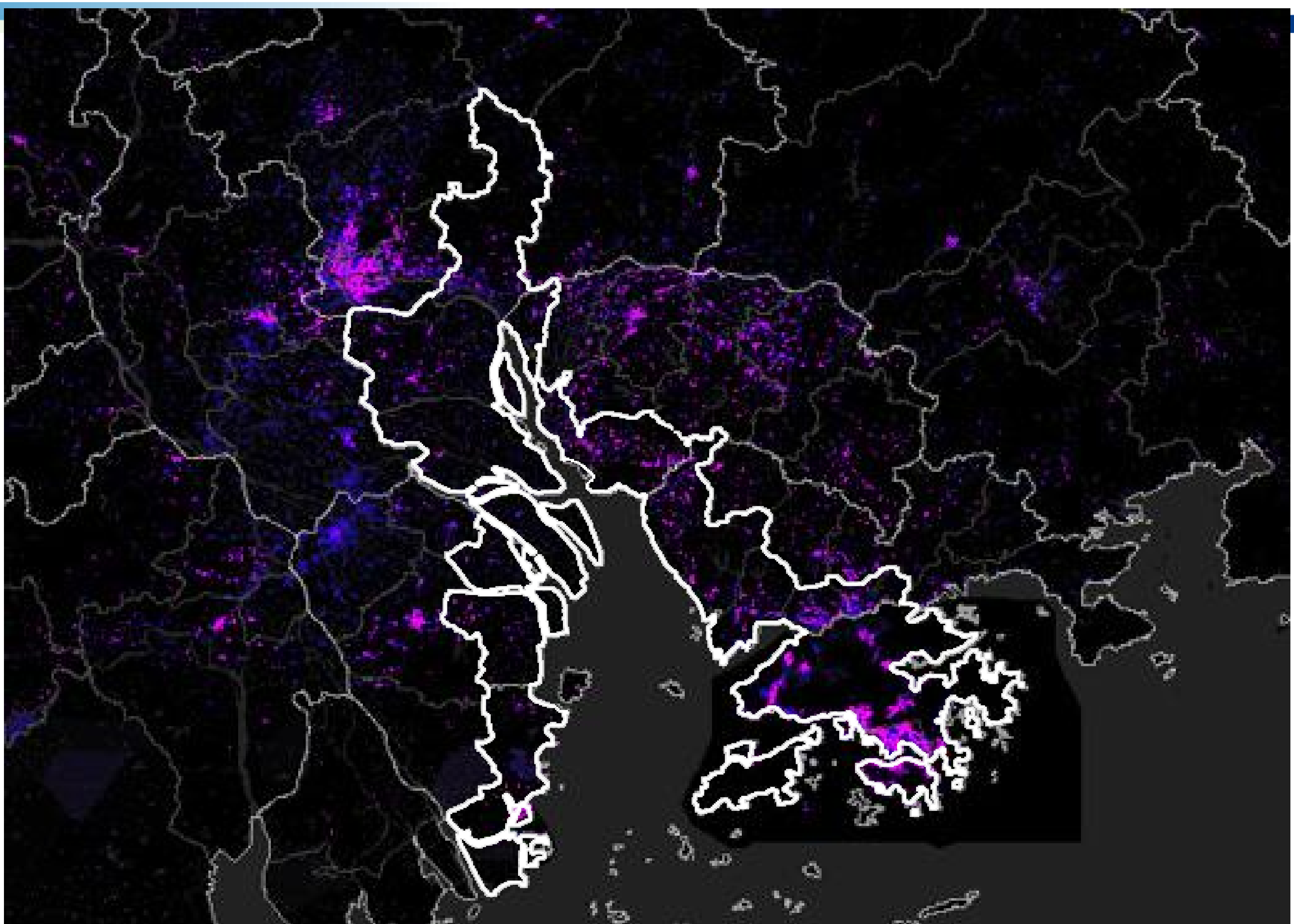
级别	保护区	核心保护对象
国家级	珠江口白海豚国家级自然保护区	中华白海豚
国家级	广东内伶仃-福田国家级自然保护区	猕猴、红树林、鸟类
国家级	佳蓬列岛海洋保护区	珊瑚
省级	淇澳岛海洋保护区	红树林、猕猴、鸟类及海岛生态环境
省级	担杆列岛海洋保护区	猕猴
省级	大襟岛海洋保护区	中华白海豚
省级	大亚湾海洋保护区	马氏珠母贝、紫海胆、龙虾等多种名贵经济种类
市级	虎门海洋保护区	黄唇鱼
市级	万顷沙海洋保护区	红树林及其邻近海域海洋生态环境



1 珠江口海岸带地区的基本认识—— 人口分布情况 Population Distribution

大湾区人口分布-1980

Population Distribution in the Greater Bay Area-1980

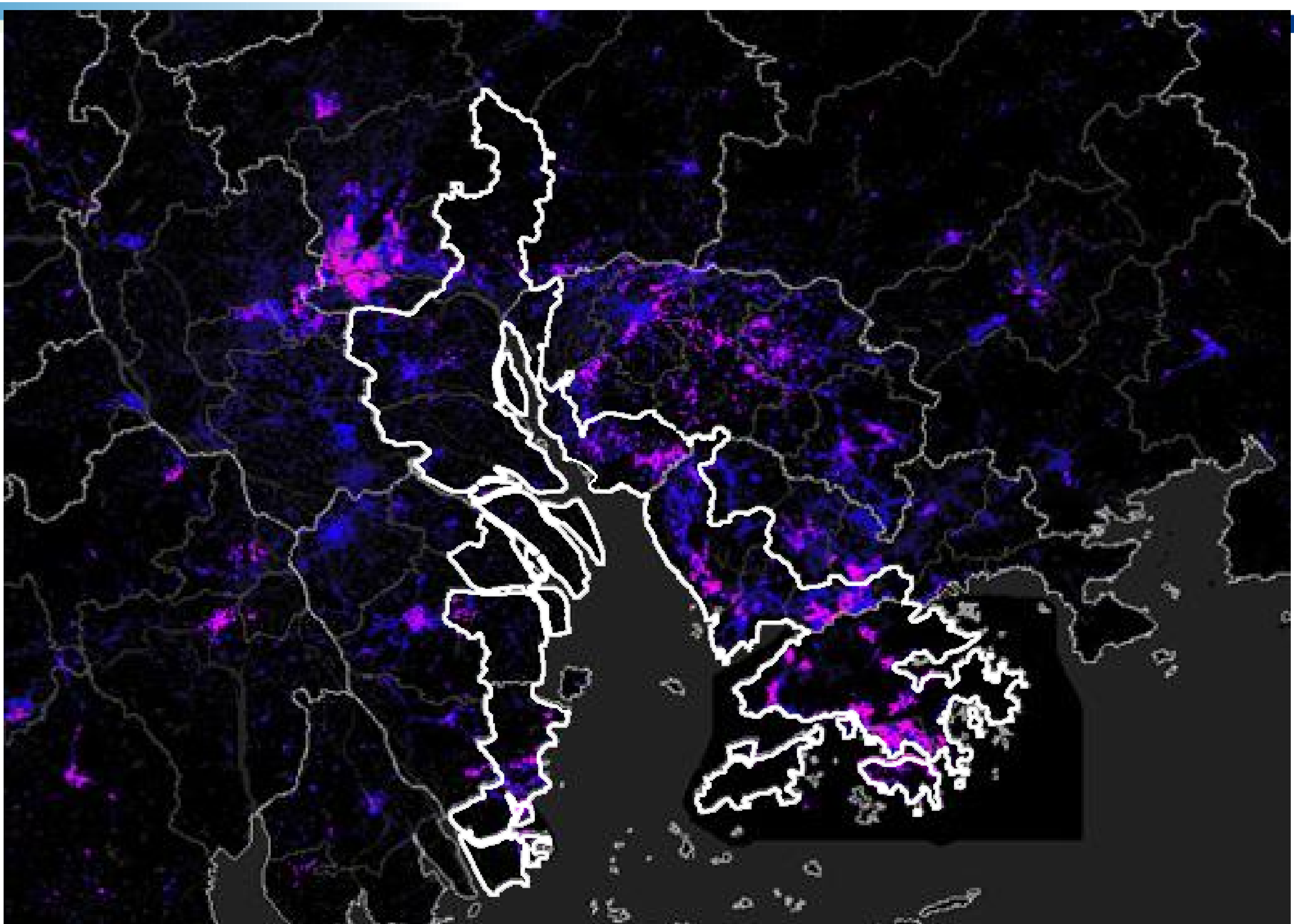


Source：GHSL

1 珠江口海岸带地区的基本认识—— 人口分布情况 Population Distribution

大湾区人口分布-1990

Population Distribution in the Greater Bay Area-1990

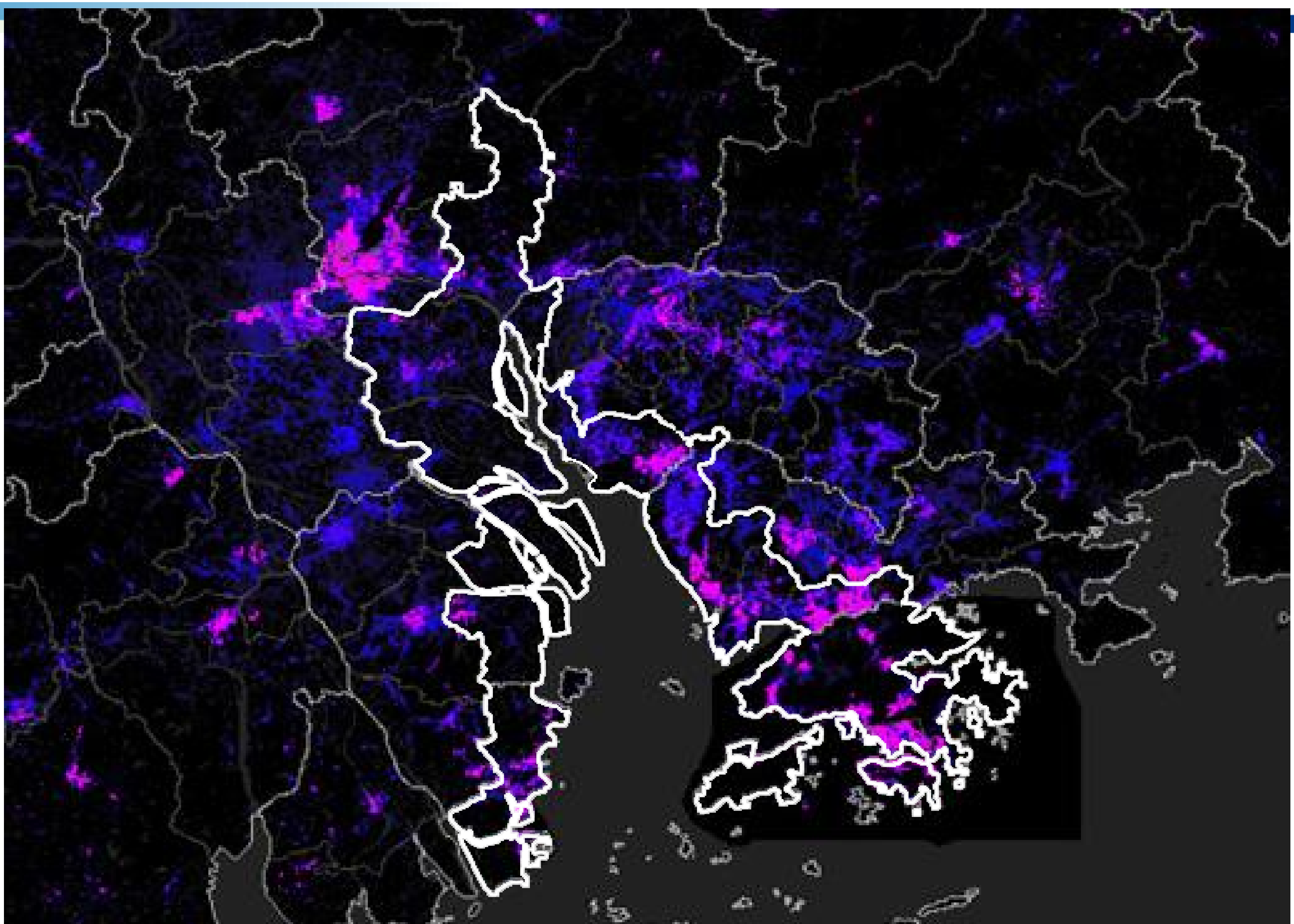


Source：GHSL

1 珠江口海岸带地区的基本认识—— 人口分布情况 Population Distribution

大湾区人口分布-2000

Population Distribution in the Greater Bay Area-2000



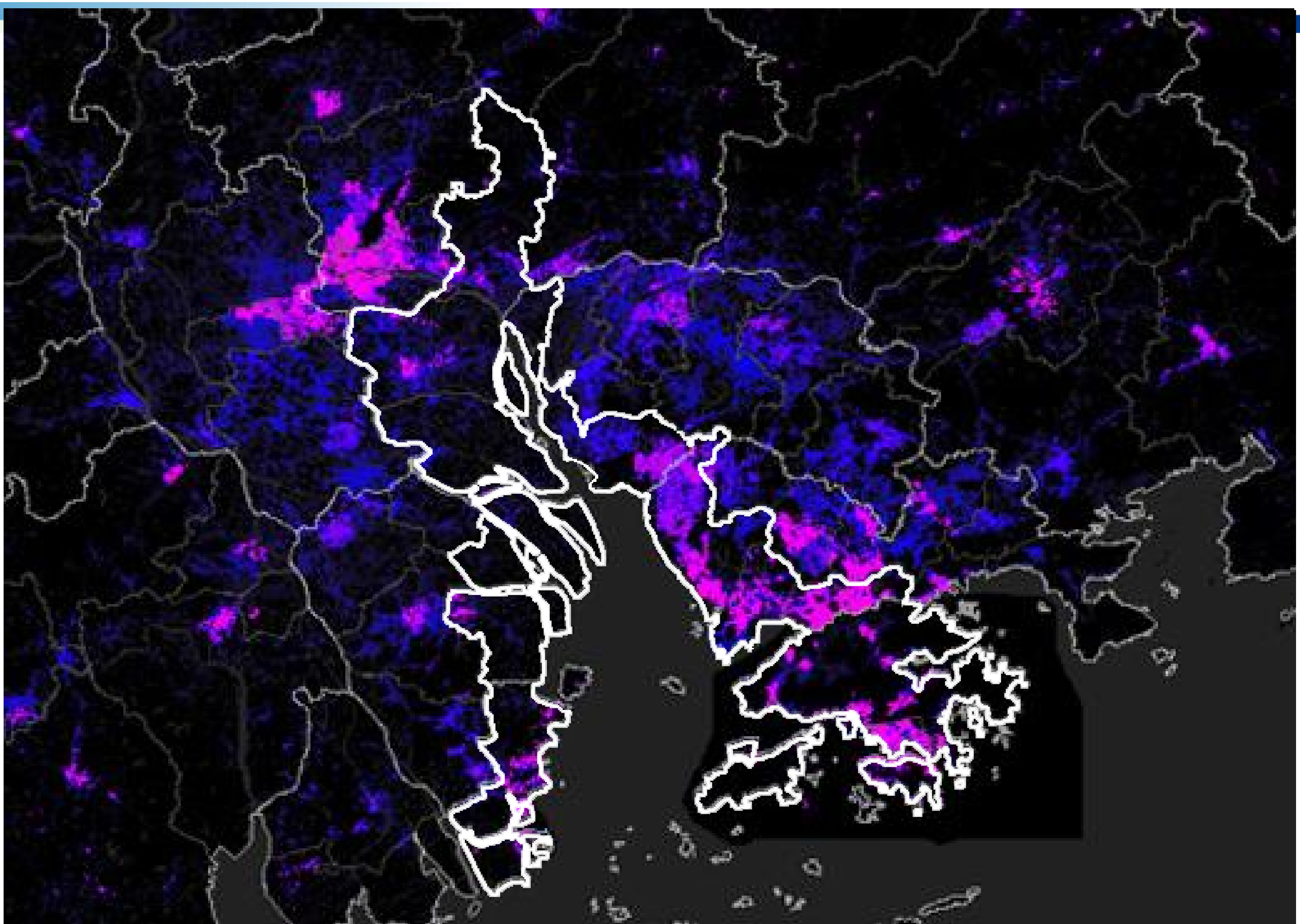
Source：GHSL

1 珠江口海岸带地区的基本认识—— 人口分布情况 Population Distribution

大湾区人口分布-2015

Population Distribution in the Greater Bay Area-2015

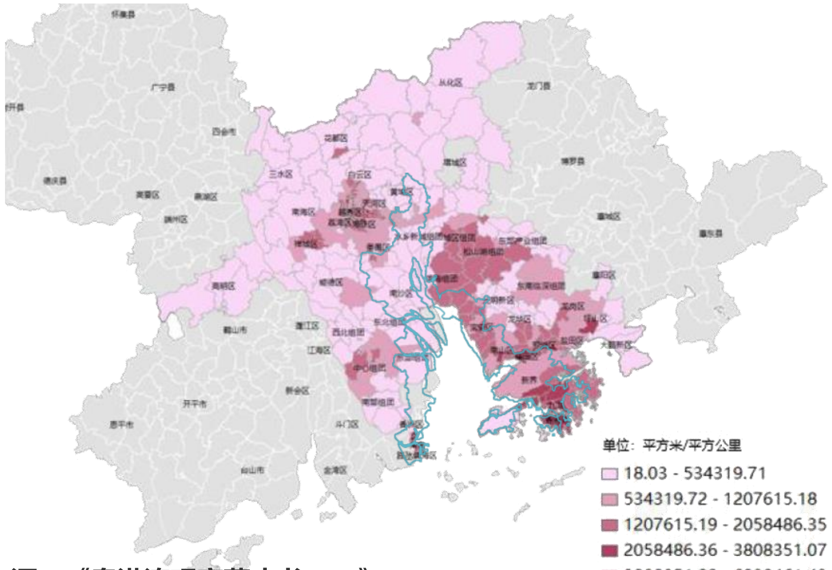
Source：GHSL



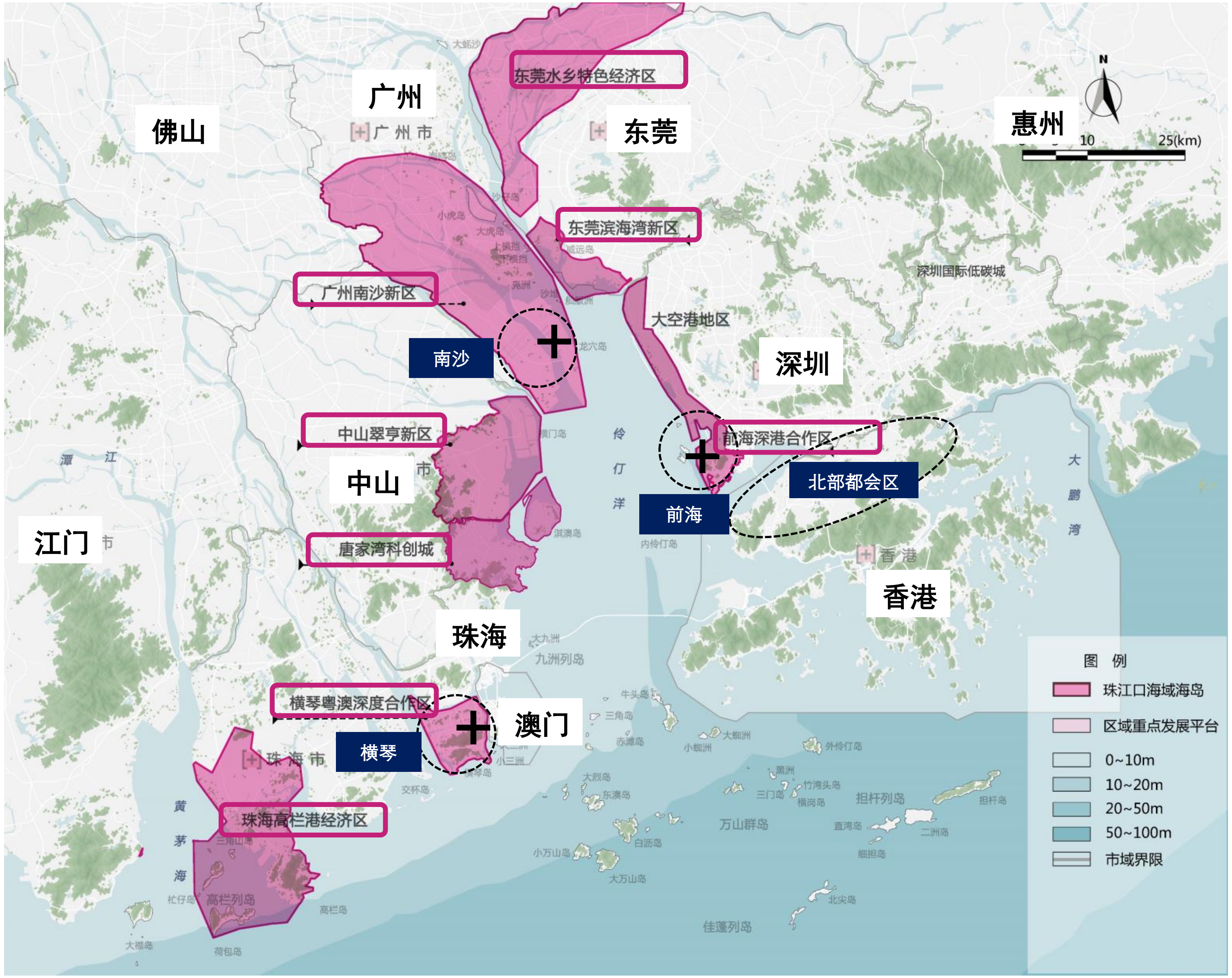
1 珠江口海岸带地区的基本认识—— 城镇建设情况 Town construction

未来城镇和人口增长的地区
Areas of future town and population growth

- 7个城市发展的重要战略地区均分布在珠江口沿岸。The seven strategically important areas for urban development are all located along the Pearl River Estuary.
- 包括三个粤港澳区域合作发展的新城区：前海、南沙、横琴。Including three new urban areas for the development of regional cooperation : Qianhai, Nansha and Hengqin.



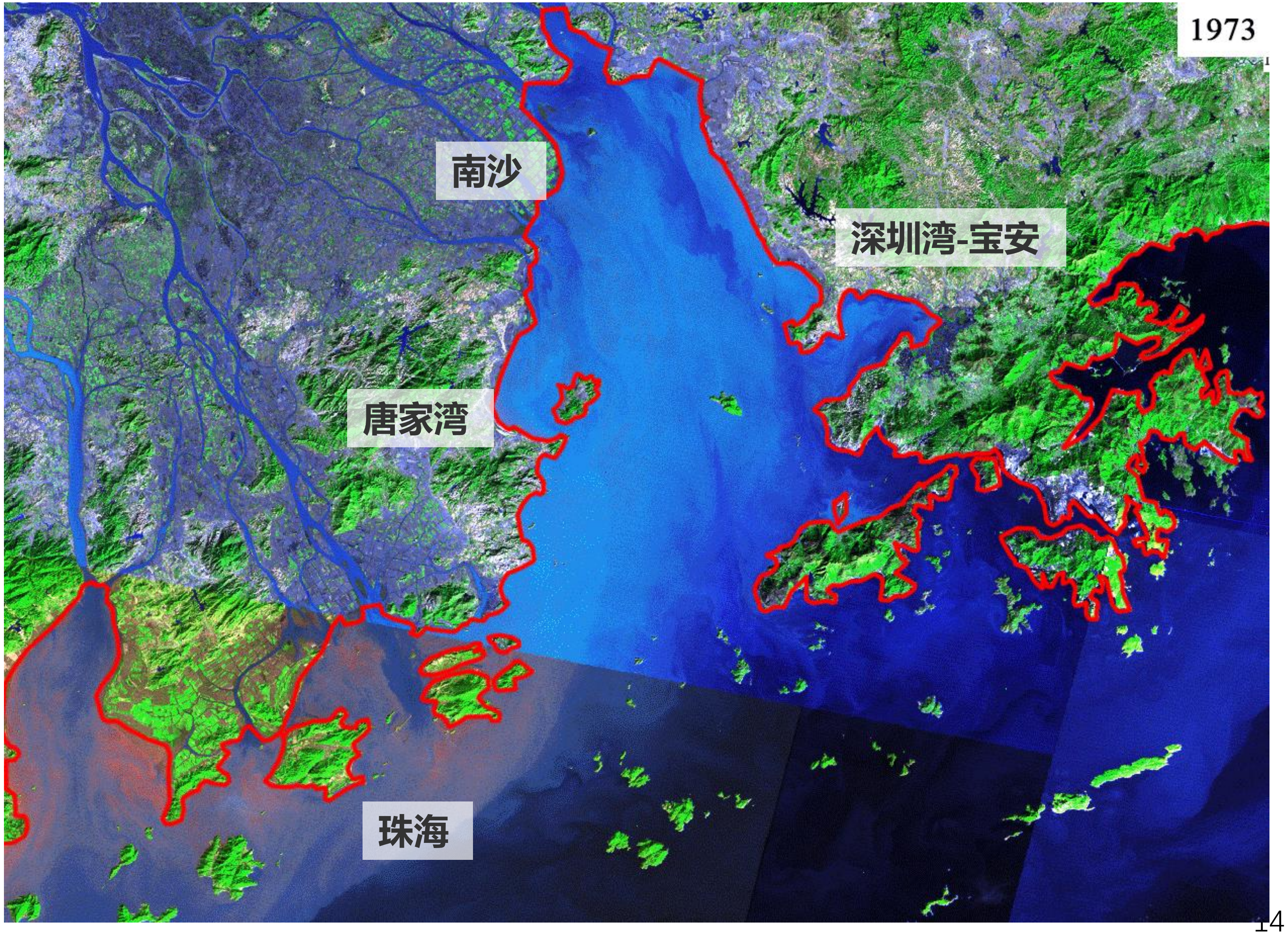
来源：《粤港澳观察蓝皮书2018》



1 珠江口海岸带地区的基本认识—— 岸线利用情况 Shoreline utilization

城镇向海发展的趋势明显，岸线人工化程度逐年提升。
The trend of cities and towns developing towards the sea is obvious, and the artificiality of the shoreline is increasing year by year

- **填海面积居世界前列，**超过东京和旧金山湾区。The area of reclamation is among the largest in the world.
- **海湾面积萎缩，**1973年~2017年，珠江口海域面积缩减了**15%**。 The Gulf is gradually shrinking in size



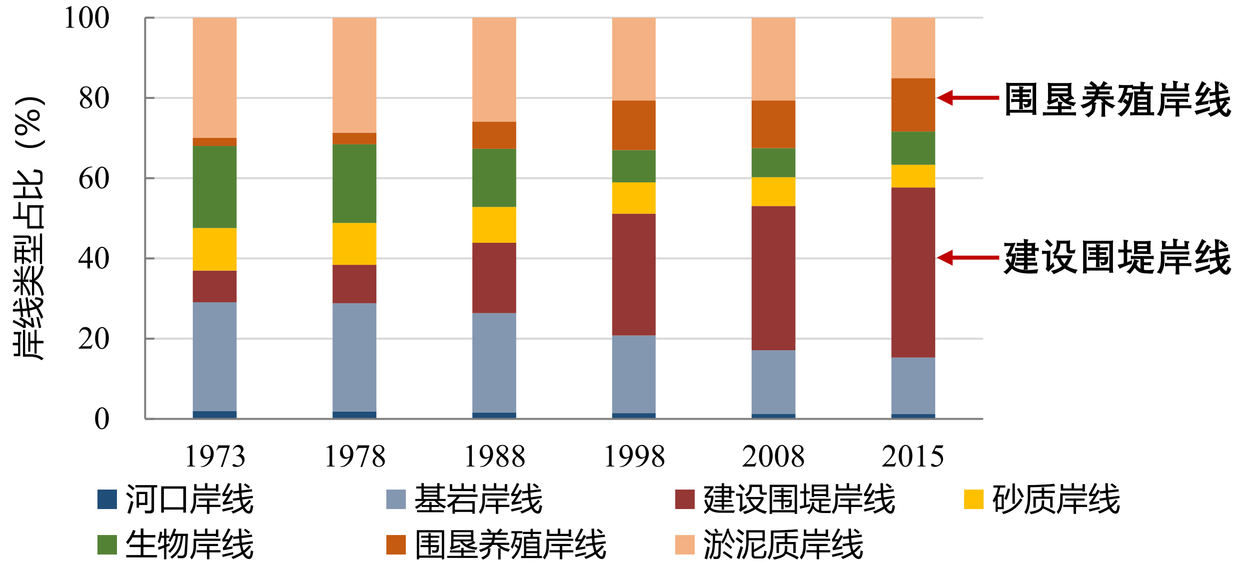
1 珠江口海岸带地区的基本认识—— 岸线利用情况 Shoreline utilization

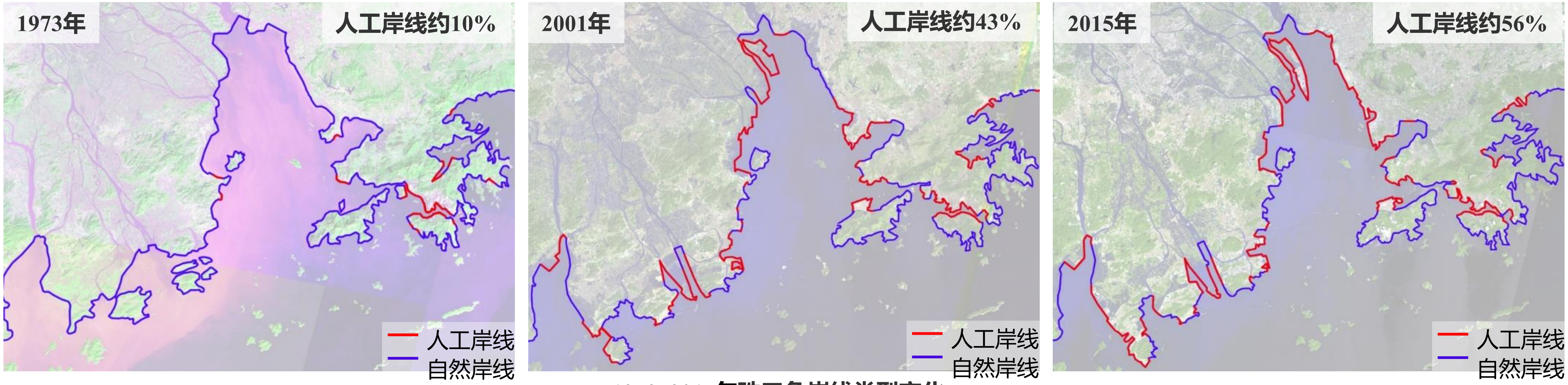
■ **人工岸线占比迅速提升**

The proportion of artificial shoreline is rapidly increasing.

1973年~2016年，从**10%**上升至**65%**。

From 1973 to 2016, it rose from 10% to 65%.



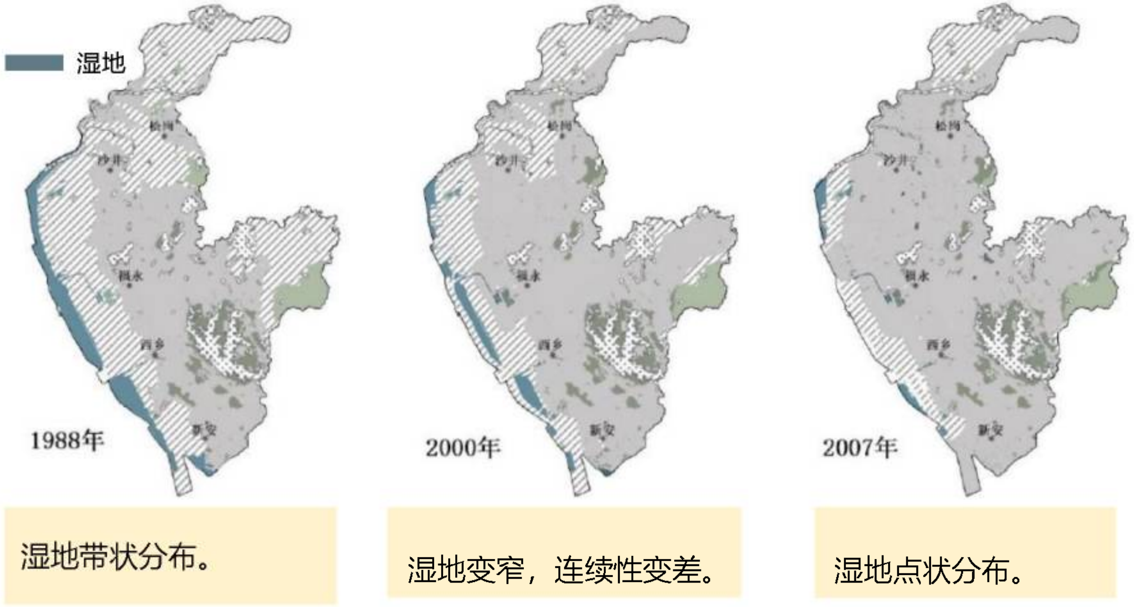


1973~2015年珠三角岸线类型变化

2 珠江口海岸带地区的风险挑战—— 湿地退化 Wetland degradation

以红树林为代表的湿地面积持续退化
Continued degradation of wetland areas represented by mangroves

- **人类活动密集区与鸟类保护优先区高度重叠。**
- 以珠江口东岸，深圳西部滨海地区为例，水污染与海岸工程致使滨海湿地面积持续退化，
- 近年来，通过设立红树林保护区和生态修复，部分地区的湿地得到恢复



1988年、1998年、2008年深圳宝安湿地面积变化图

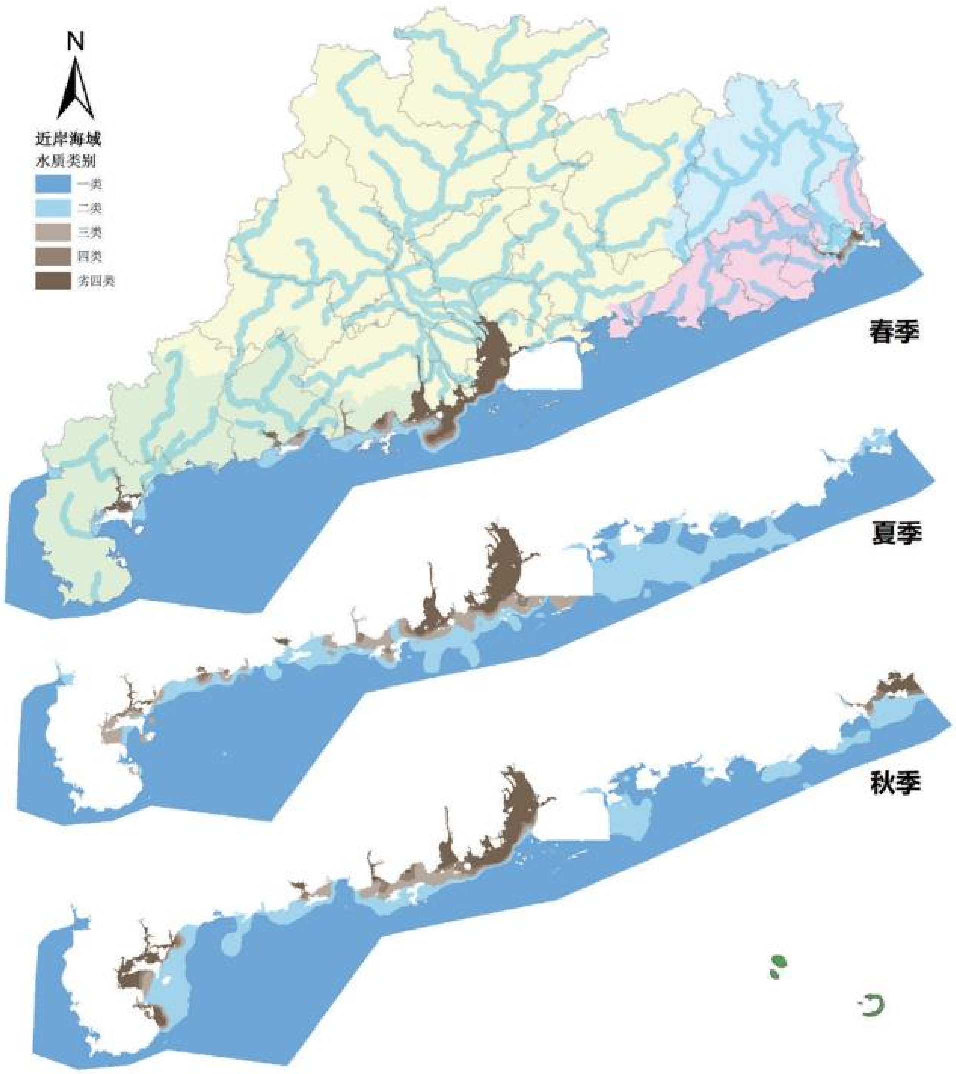
深圳西部原始土地边缘与湿地边缘示意图
资料来源：《宝安西部活力海岸带城市设计》

② 珠江口海岸带地区的风险挑战—— 水环境污染 Water Environment Pollution

- **污染物高强度集中排放。**大湾区入河废污水量曾占广东省的50%以上；广州、深圳、佛山、东莞等核心城市污水网管收集率和处理率均不高，水污染物排放量大，最终污染近岸海域。
- High-intensity concentrated discharge of pollutants. The volume of waste water entering the river in the Greater Bay Area used to account for more than 50% of Guangdong Province.
- **局部水体水污染严重。**珠江口海域出现劣于IV类海水水质并呈现重度富营养化。珠江西岸地表水水质出现IV类。珠江三角洲部分支流和流经城市的局部河段污染较为严重，存在V类及以下水质（2.1%）。
- Serious water pollution in some local water bodies. The Pearl River estuary seawater quality is worse than IV and shows heavy eutrophication.

国考地表水水质状况

来源：《广东省生态环境状况公报2021》



近岸海域水质状况

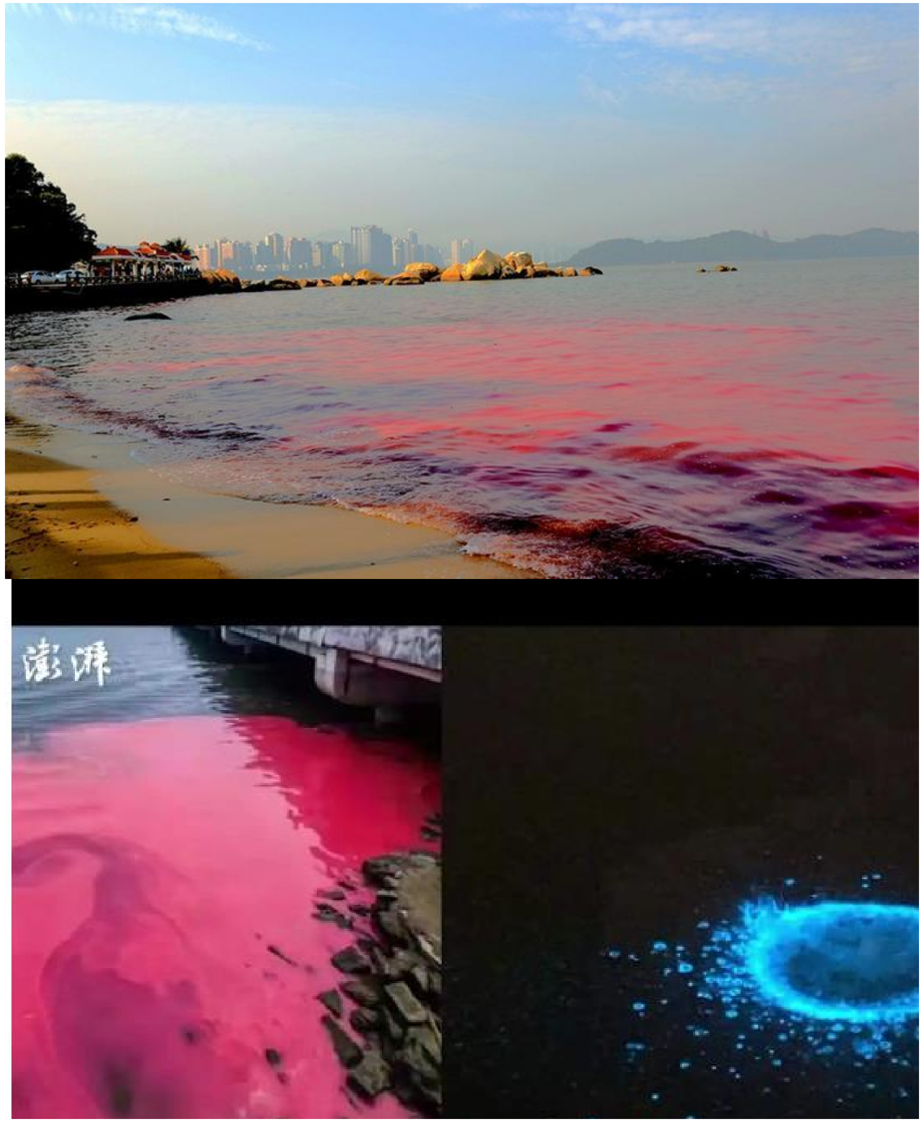
来源：《广东省生态环境状况公报2021》

2 珠江口海岸带地区的风险挑战—— 水环境污染 Water Environment Pollution

- **水质富营养化。**海水水质状况查，海水无机氮、活性磷酸盐含量偏高。海洋生物多样性出现危机。浮游植物密度偏高，浮游动物、大型底栖生物密度和生物量、鱼卵及仔鱼密度偏低。
- Water eutrophication.

- **赤潮：**2020年度，广东省发生赤潮5次，珠江口的深圳湾海域、深圳机场附近以南海域、出现赤潮（且包括有毒赤潮）。2021年度广东省发生赤潮14次，珠江口的深圳前海湾、深圳湾出现赤潮。
- Red tide.

- **近岸海洋垃圾：**珠江口海面漂浮微塑料密度达到2.48个/立方米，远高于大亚湾海域（0.36个/立方米）。
- Nearshore marine litter.



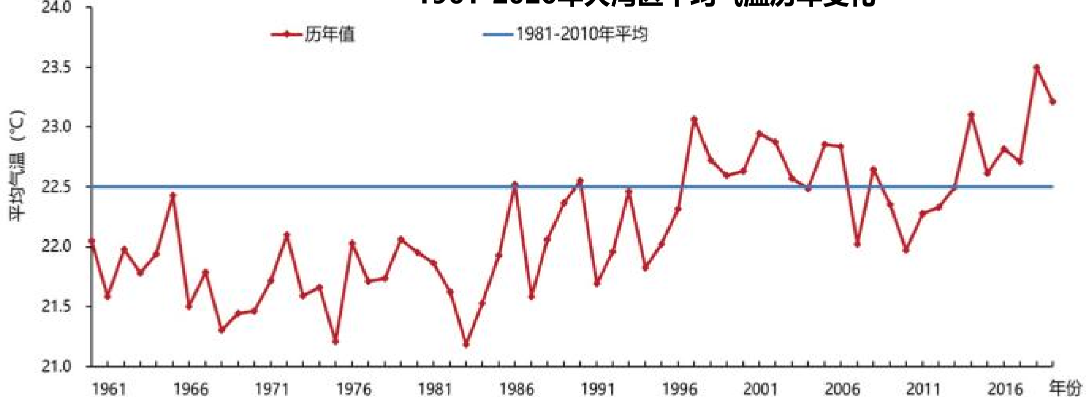
珠海海域2021年监测到的赤潮现象

大湾区平均气温升高，高温干旱加剧

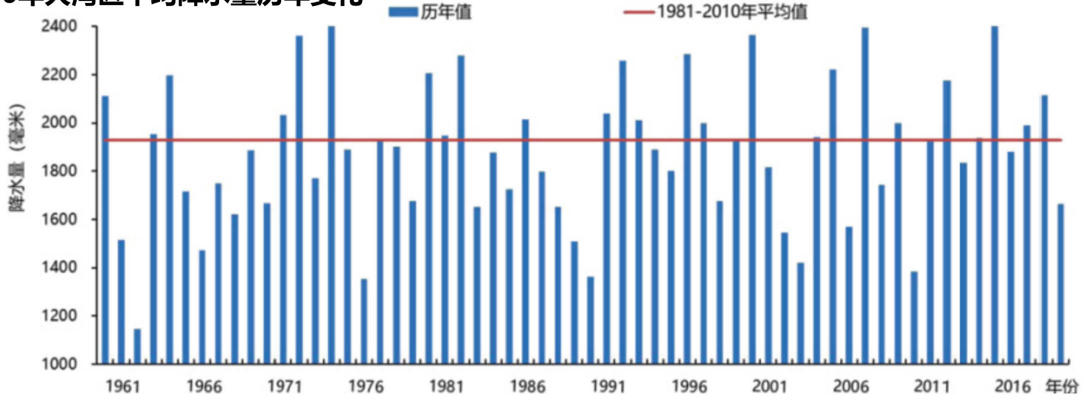
Average temperatures rise in the Greater Bay Area as heat and drought intensify

- **高温**：2021年，大湾区平均气温23.5℃，较常年偏高1.0℃，为1961年以来最高。
- **干旱**：2021年入冬以来，珠江流域遭遇的60年来最严重旱情，2021年平均降水量1550.0毫米，较常年偏少19%。

1961-2020年大湾区平均气温历年变化



1961-2020年大湾区平均降水量历年变化



来源：《粤港澳大湾区气候监测公报2020》

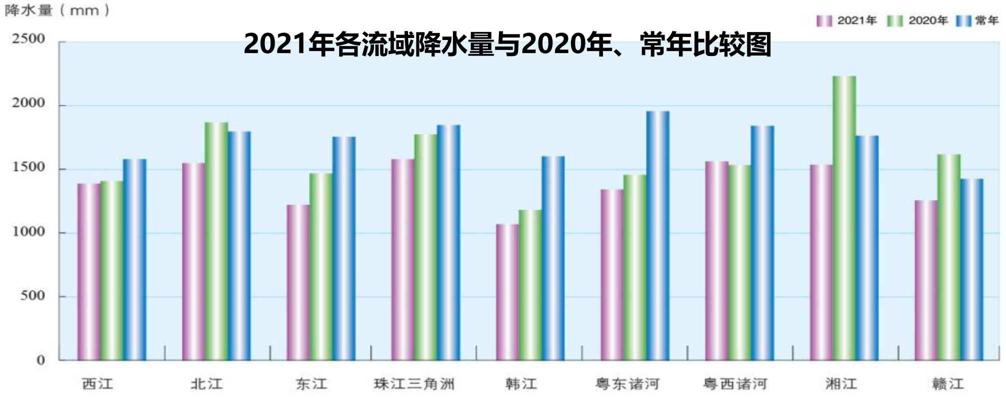


图2 2021年各流域降水量与2020年和常年比较图

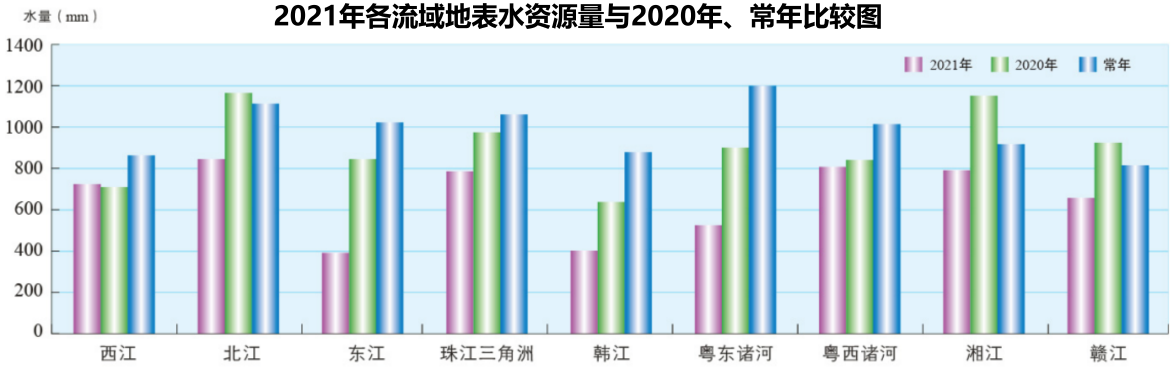


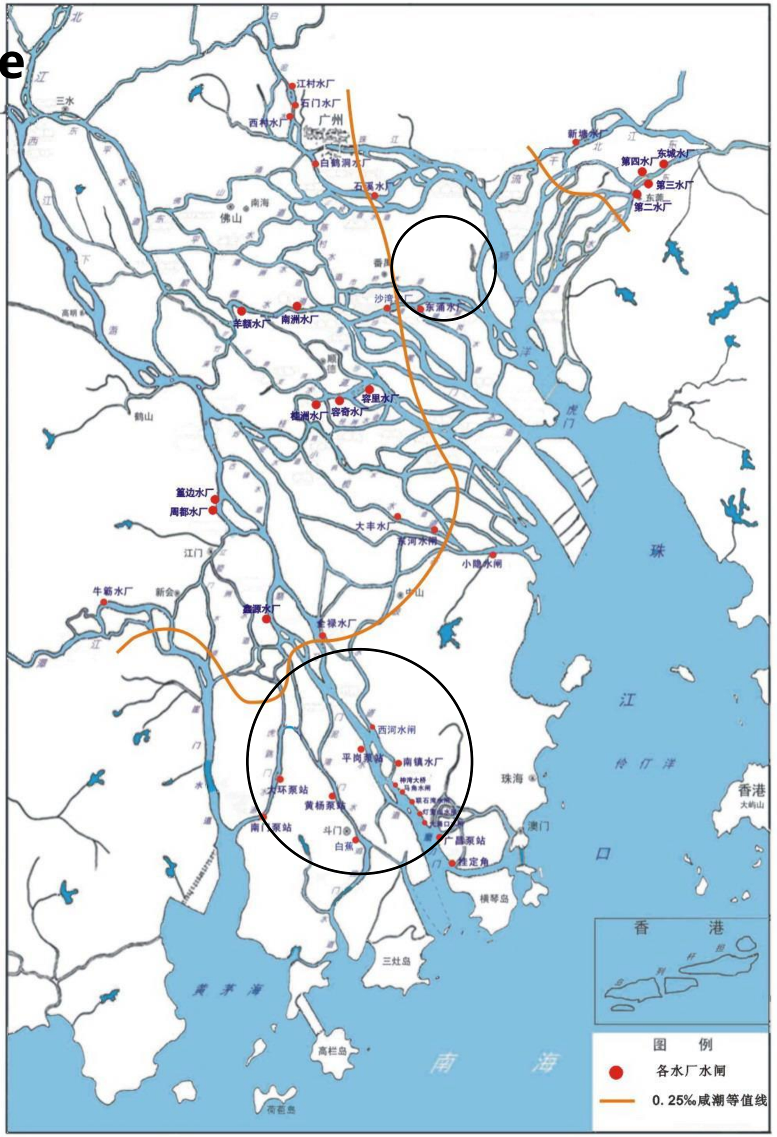
图7 2021年各流域地表水资源量与2020年和常年比较图

咸潮上溯，流域取水面临压力

Salty tide upwelling, Water withdrawals in the basin are under pressure

- 降雨量导致珠江流域地表水资源量大幅减少。如东江2021年降雨量较往年偏少太多，引发了去年东江流域性干旱以及咸潮上溯等问题。

珠江口咸潮上溯的历史情况-2008



径流最枯时咸潮上溯的最大距离

公众日益关注海洋生态保护问题

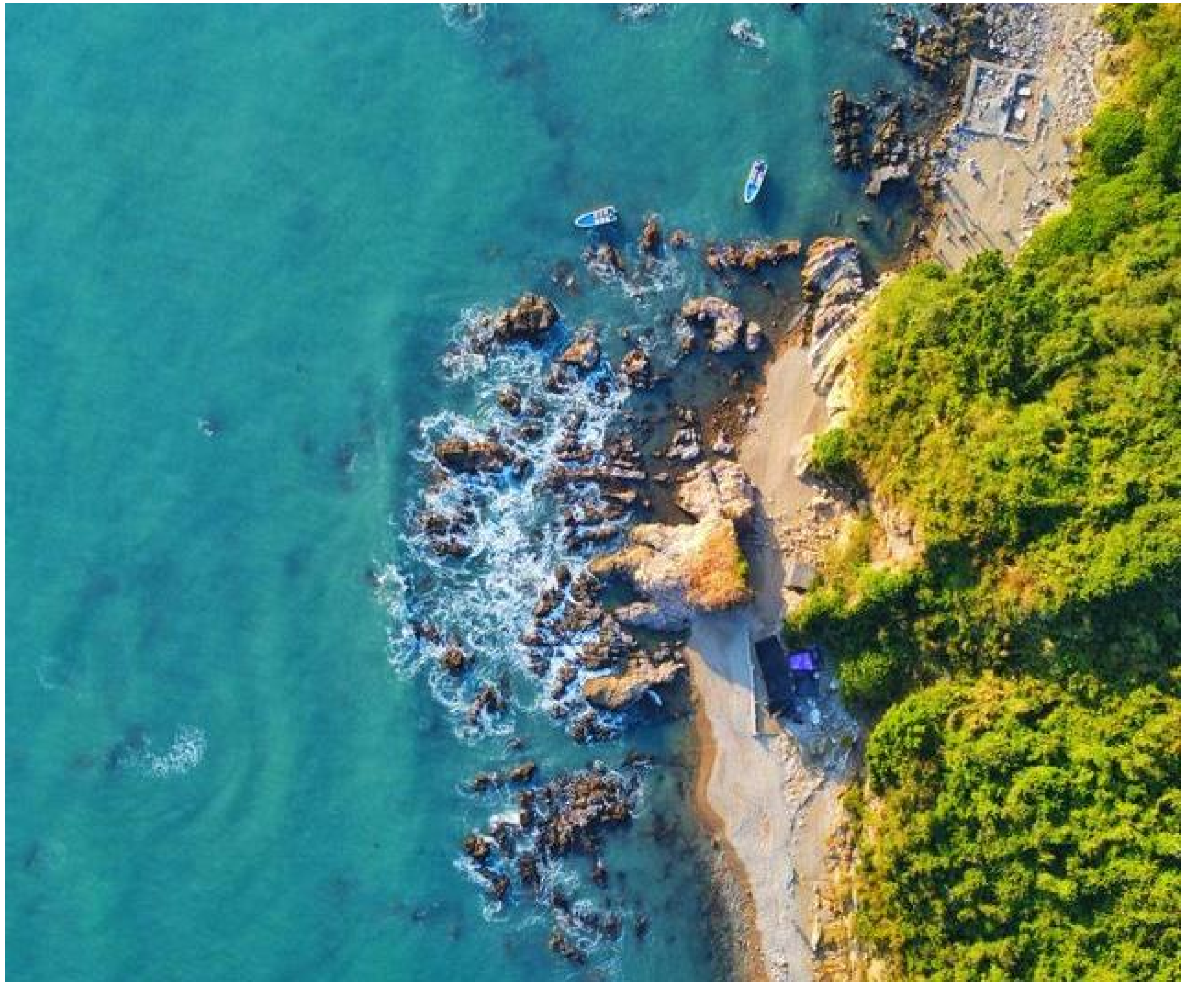
The public is increasingly concerned about marine ecological protection

- **2019年，在环境影响评价公示过程中，公众力量阻止了深圳湾邮轮海上观光航线的延长**，有效遏制了船运对红树林和候鸟的负面影响。
- Public power prevents extension of Shenzhen Bay cruise ship sea tour route.

- **2021年深圳大鹏湾多年以来出现布须鲸**，引发了公众媒体对海洋生物的强烈关注。政府立即开展鲸豚保护联合行动，劝退市民在相关海域的活动，并开展对公众的直播与互动。
- The appearance of baleen whales in Dapeng Bay, Shenzhen in 2021 sparked intense public media attention to marine life.

国家严格管控围填海、保护自然岸线，加强海岸带空间规划管理

The State strictly controls reclamation, protects natural shorelines, and strengthens spatial planning and management of coastal zones.



- 2018年，国务院印发《关于加强滨海湿地保护严格管控围填海的通知》，全面严格管控新增围填海项目审批；
- Comprehensive and strict control over the approval of new reclamation projects.
- 2020年，国家出台《围填海管控办法》加强和规范围填海管理
- State Issues Measures to Control Reclamation
- 2021年，建立实施海洋生态红线制度，广东省海洋生态红线划定了13类、268个海洋生态红线区，明确大陆自然岸线保有率、海岛自然岸线保有率、近岸海域水质优良等控制指标.
- The establishment and implementation of the marine ecological red line system.
- 设立海岸带专项规划，统一用地用海分类标准，并开展陆海毗邻地区统一空间管控。
- Set up a special plan for the coastal zone.

3 珠江口海岸带地区的保护与治理—— 政府举措 Government Initiatives

政府大力开展生态修复整治行动

The government vigorously carries out ecological restoration and improvement actions

- **“美丽海湾”、“蓝色海湾”、沙滩整治修复等生态修复行动取得良好成效**

惠州考洲洋人工种植红树林

近年来广东省实施海岸带生态修复项目100余项，总投资数十亿元，主要项目包括**海岸整治修复、沙滩整治修复、海域综合整治、红树林种植、滨海湿地建设、滨海廊道建设、海洋科普展馆建设**和**海洋保护区**建设等。

In recent years, Guangdong Province has implemented more than 100 ecological restoration projects in the coastal zone, with a total investment of billions of yuan. The main projects include coastal remediation and restoration, beach remediation and restoration, comprehensive improvement of the sea, mangrove planting, coastal wetland construction, coastal corridor construction, marine science exhibition construction and marine protected area construction, etc.

汕头青澳湾

茂名水东湾

汕尾红海湾

惠州考洲洋

3 珠江口海岸带地区的保护与治理—— 区域协作 Regional Collaboration

广东省、香港和澳门开展区域合作，2018-2021年连续三年共同发布粤港澳大湾区气候监测公报

Guangdong Province, Hong Kong and Macao to carry out regional cooperation and jointly publish the Greater Bay Area Climate Monitoring Bulletin for three consecutive years from 2018-2021.

2021年粤港澳大湾区总体气候特征是：温高雨少干旱重，局地暴雨极端性强，台风影响弱。2021年大湾区各种气象灾害共造成直接经济损失约11.4亿元，因气象灾害死亡4人。

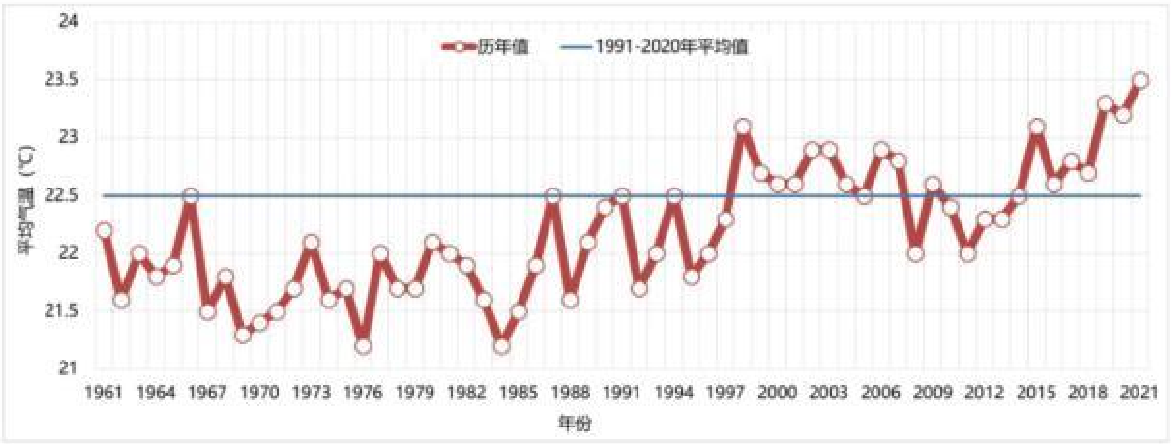


图1 1961–2021年大湾区平均气温历年变化（℃）

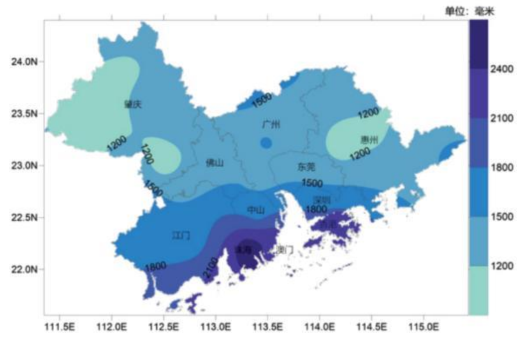


图6 2021年大湾区降水量分布（毫米）

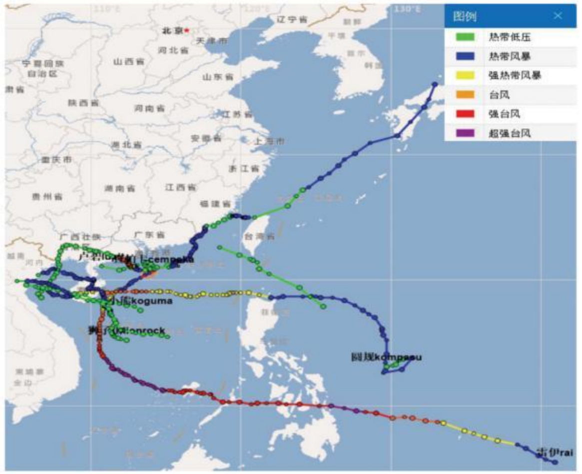
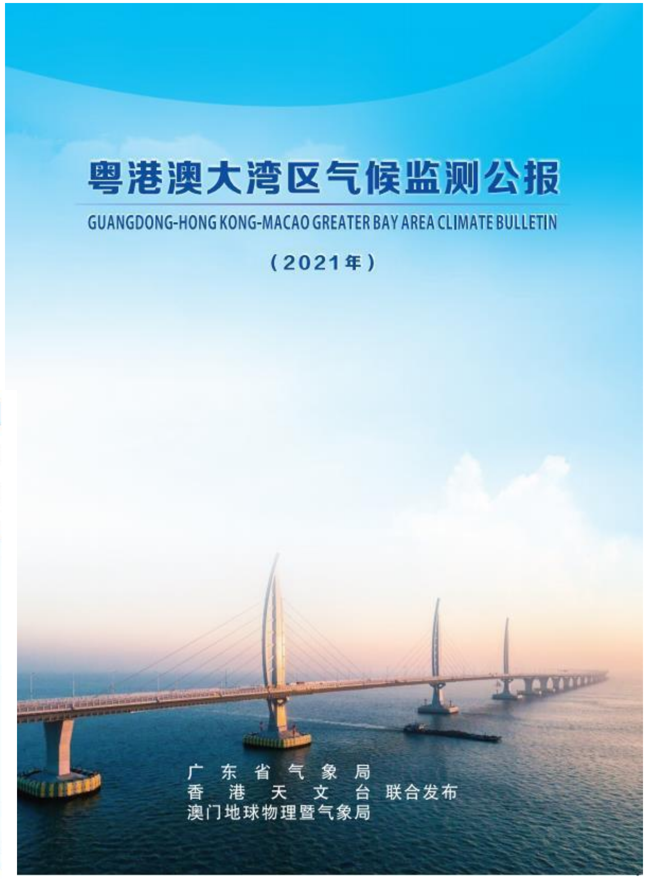


图17 2021年影响大湾区的台风和热带低压路径图



挑战：海洋水质监测标准尚未统一

Challenge: Marine water quality monitoring standards are not yet unified

- **香港**：海水水质标准指标较多，标准高，且数据积累时间较长，对于不同的海域有差异化的监测标准
- **内地**：监测指标于香港有差异，且指标较少，标准值相对较低（如大肠杆菌监测标准明显低于香港）
- **澳门**：没有海域管理权，只有使用权，海水水质标准采用国内标准；

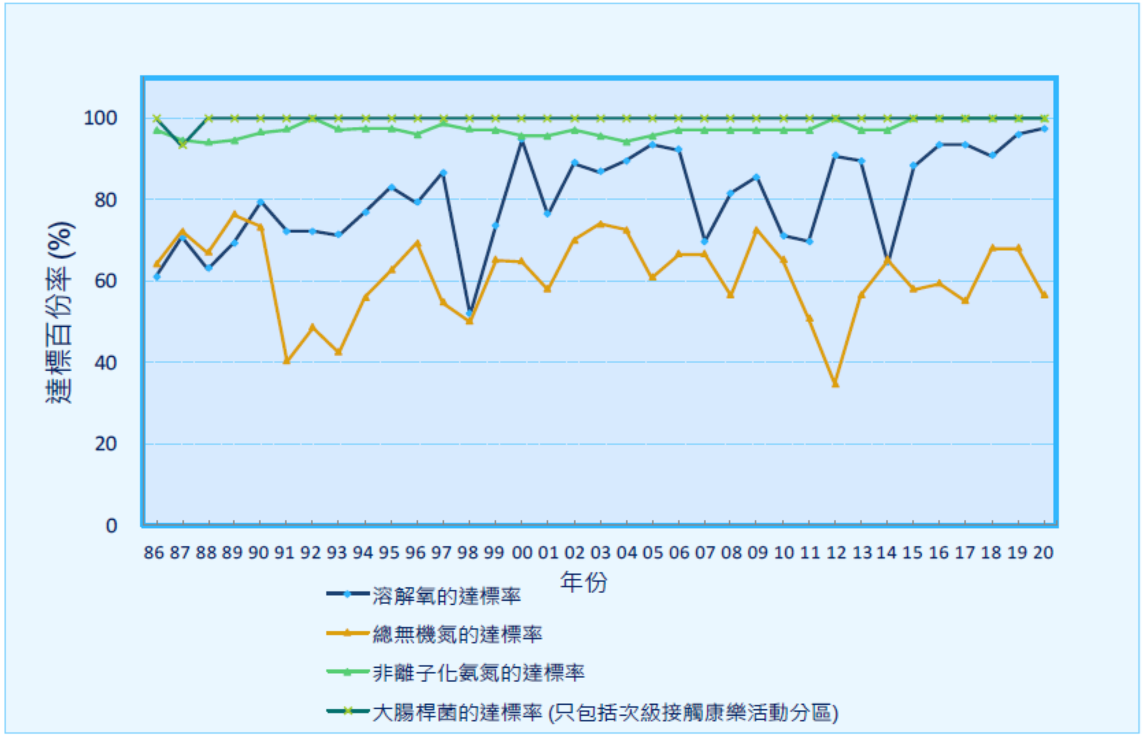


圖 2. 4 個主要海水水質指標達標率（1986-2020 年）

3 珠江口海岸带地区的保护与治理—— 区域协作 Regional Collaboration

挑战：红树林湿地保护的方式和水平存在差异

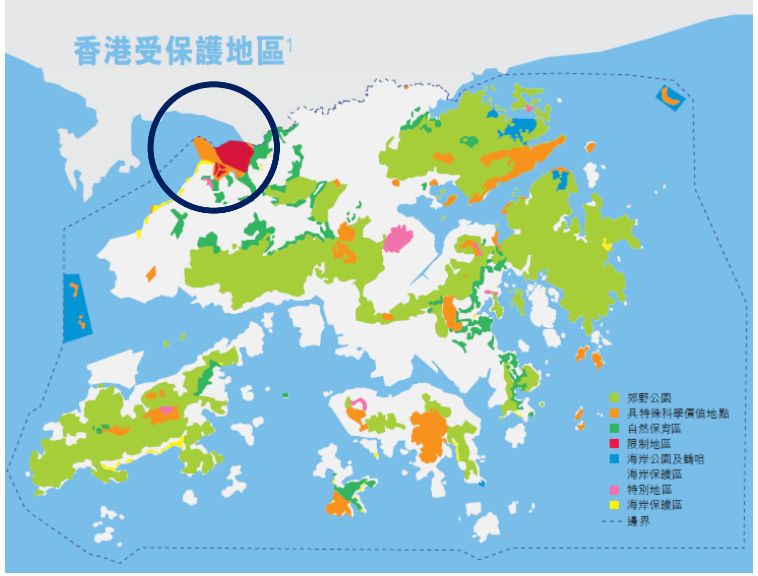
Challenges: Differences in approach and level of mangrove wetland conservation

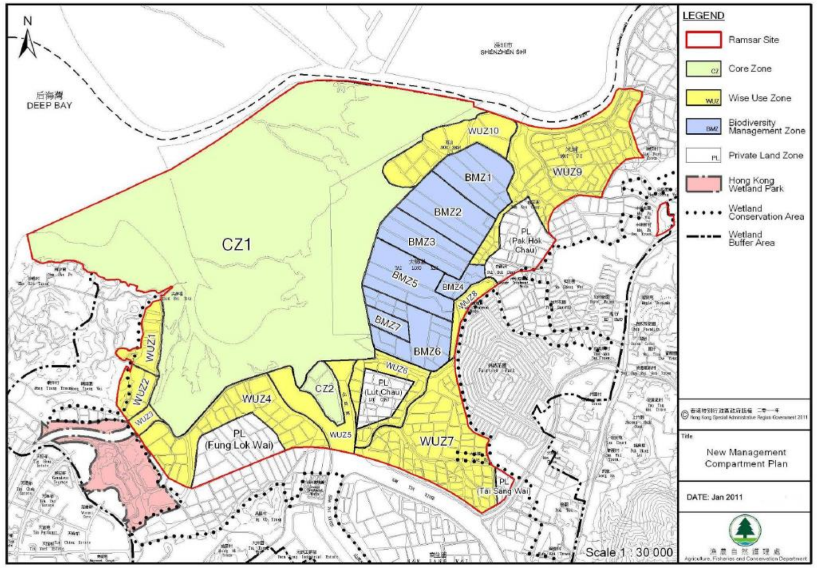
以红树林湿地为例——香港

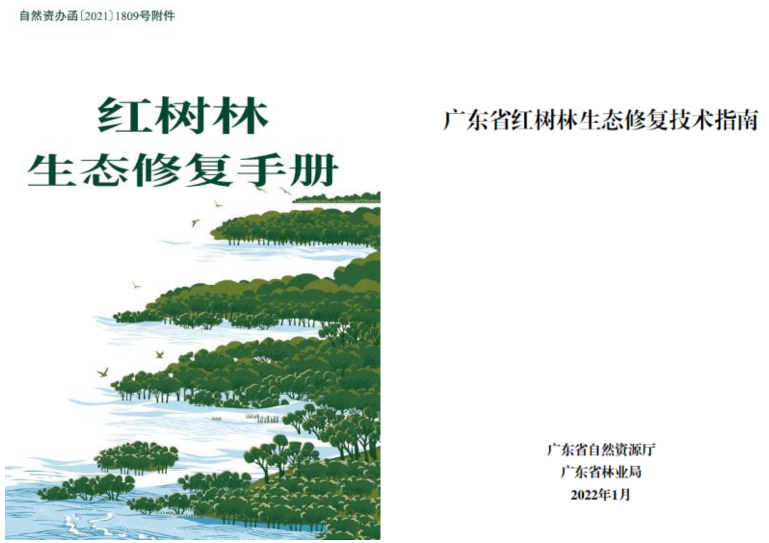
- 精细化的监测、管控，建立海岸公园，机制成熟
- 二十年的指标动态跟踪
- 政府与非政府的公私营 界别合作
- 十分强调公众推广与青少年教育

以红树林湿地为例——内地

- 对红树林的保护仍处在起步与加速的阶段，
- 主要以政府为主导，建立自然保护区和生态公园，开展红树林湿地的生态修复，已有部分技术举措。
- 成立了中国首家由民间发起的环保公募基金会，红树林基金会（MCF），并由政府委托其管理和运营深圳福田红树林湿地公园。





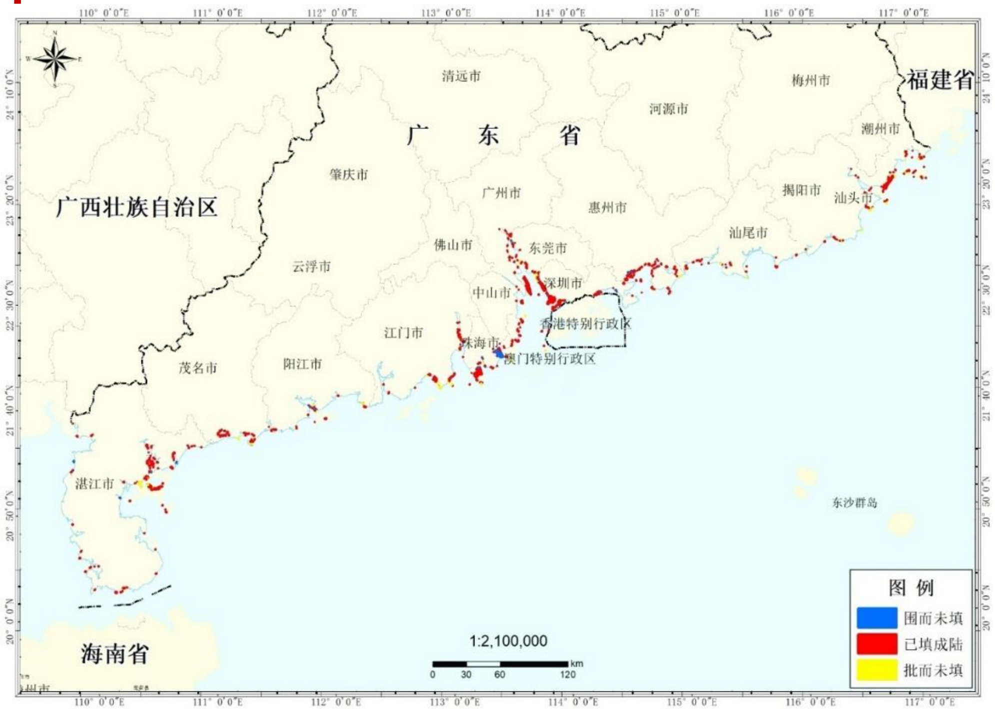


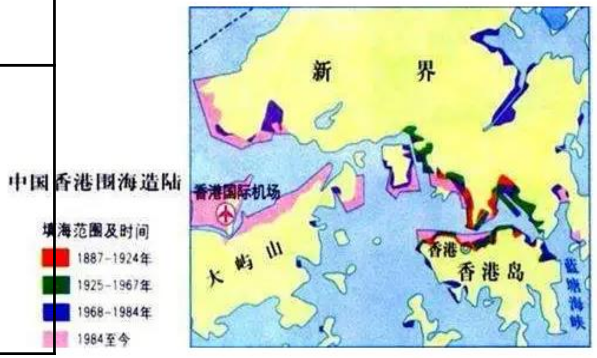
3 珠江口海岸带地区的保护与治理—— 区域协作 Regional Collaboration

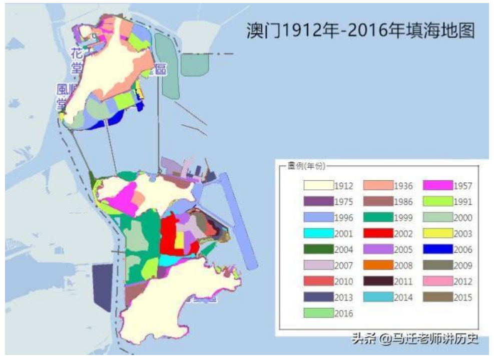
挑战：围填海的决策机制和方式存在差异

Challenges: Differences in decision-making mechanisms and approaches to reclamation

地区	基本情况	填海主要用途	决策过程	原则
香港	始于1852年，已填海面积近70km²，占香港土地总面积的将近8%	居住、商业、机场、码头等	政府决策为主、公众参与度高（如保护海港协会）	• 有迫切及凌驾性的当前需要（包括社群的经济、环境和社会需要） • ·没有其它可行方法 • ·对海港的损害减至最少
内地	广东省沿海14个地市均有围填海，超过10km²的地市有6个累计填海200多平方公里，	居住、商业、商务、港口等	政府决策为主	国家重大战略项目
澳门	1912年的澳门只有11.6km²，大部分靠填海形成，新城区填海3.6km²，填海面积将超60%。	居住、商业、机场、码头等	政府决策为主、公众参与度高	







3 珠江口海岸带地区的保护与治理—— 区域协作 Regional Collaboration

- **建立粤港澳大湾区河海统一管理和联动治理的区域协作机制，首先建立区域统一的污染物监测和控制标准。**

- **Establish a regional collaboration mechanism for unified management and joint management of rivers and seas in the Guangdong-Hong Kong-Macao Greater Bay Area, starting with unified regional standards for monitoring and control of pollutants.**

- **建立珠江口地区港口、桥梁、道路等大型基础设施建设在环境影响评估中的区域协调机制。**

- **Establish a regional coordination mechanism in environmental impact assessment for the construction of large infrastructure such as ports, bridges and roads in the Pearl River Estuary region**

- **建立粤港澳大湾区港口联盟等，通过区域协作提升设施运行和服务效率，逐步减少大型基础设施建设对珠江口生态环境的影响。**

- **Establish the Guangdong-Hong Kong-Macao Greater Bay Area Port Alliance, etc., to improve the operation and service efficiency of facilities through regional collaboration, and gradually reduce the impact of large-scale infrastructure construction on the ecological environment of the Pearl River Estuary.**


深圳盐田港

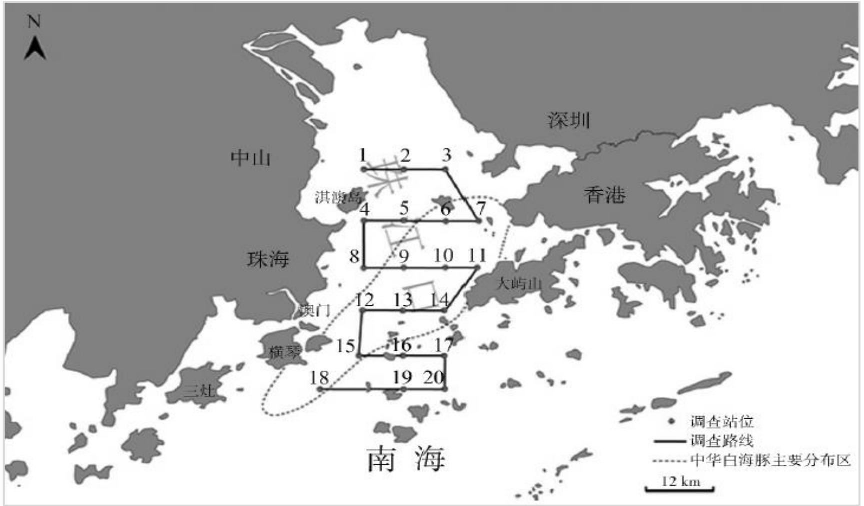
珠三角对外航线及城市群格局示意

针对特殊珍稀物种，建立区域性的生物多样性保护合作平台

Establish regional biodiversity conservation cooperation platforms for special and rare species

- 建立区域性的白海豚常规监测点，完善“**中华白海豚保护联盟**”的工作体系和协调机制
- 在珠江口海岸带地区共同探索划定“**黑天空保护区**”，共同保护鸟类栖息地

珠江口夜间亮度现状图



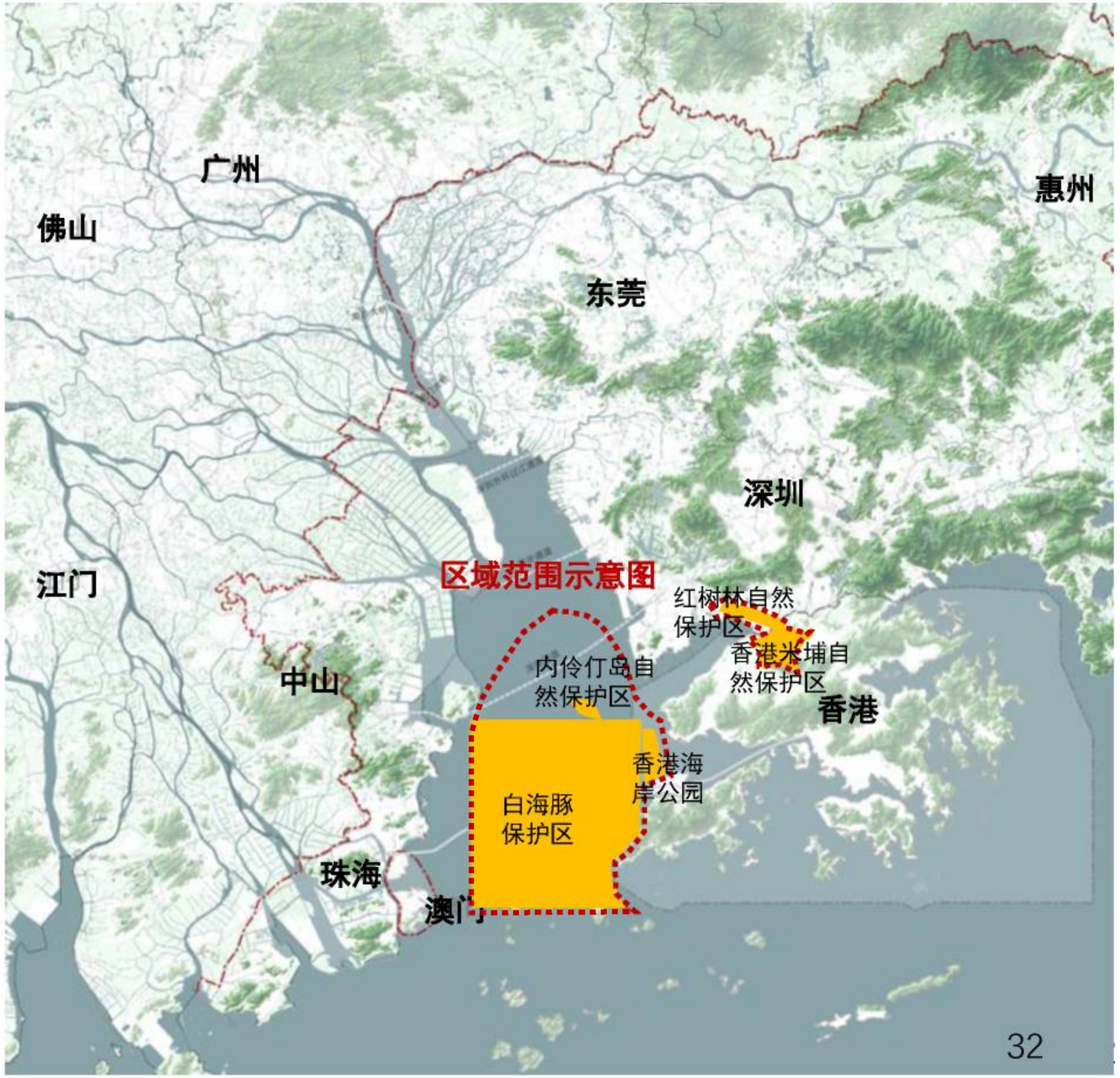
珠江口中华白海豚调查站位设置分布图

3 珠江口海岸带地区的保护与治理—— 区域协作 Regional Collaboration

整合广东省、香港和深圳在珠江口的自然保护区，形成统一联动的区域合作保护举措

Integrating the nature reserves of Guangdong Province, Hong Kong and Shenzhen in the Pearl River Estuary to form a unified and linked regional cooperation conservation initiative

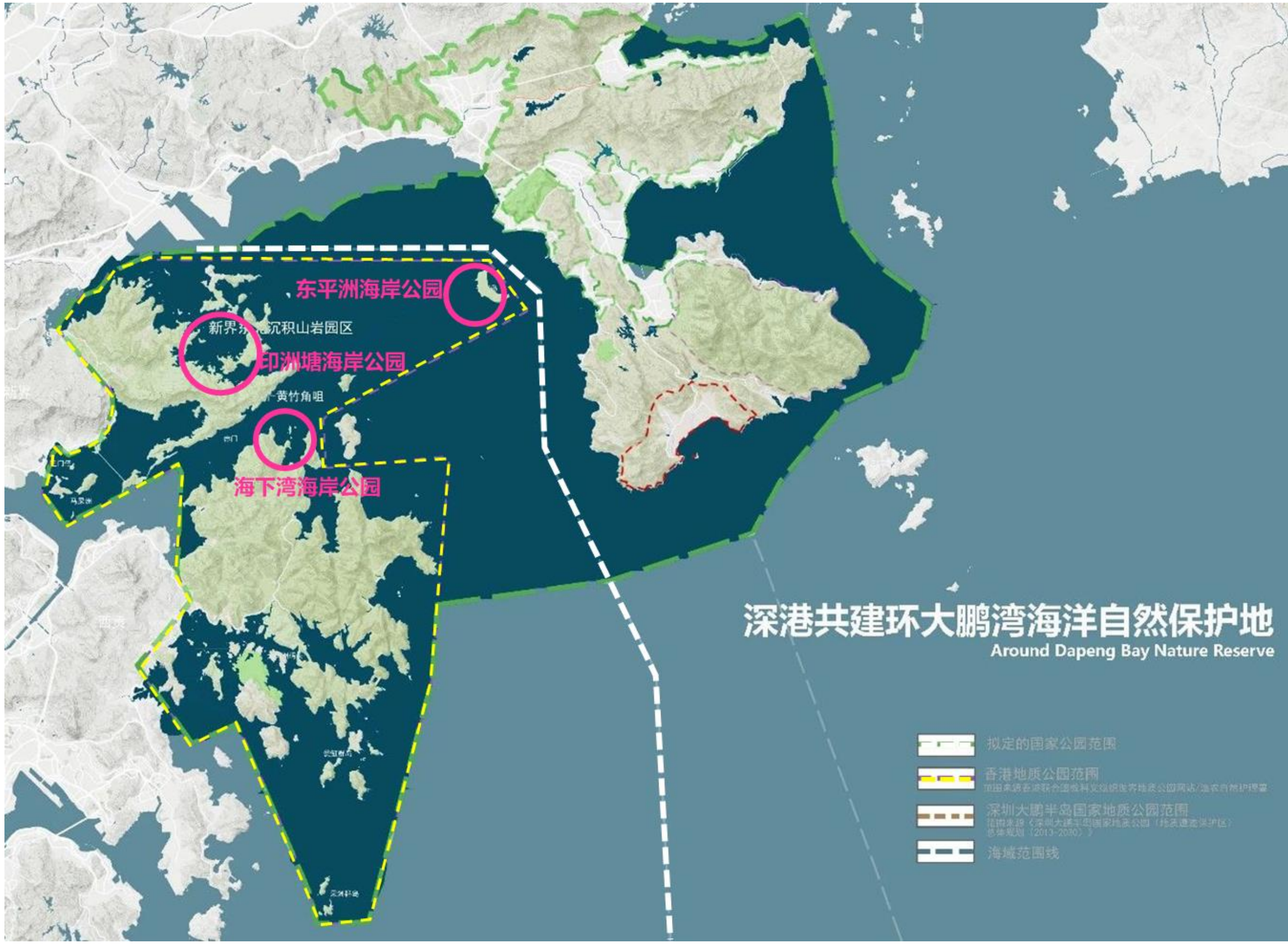
- **优化整合，解决保护管理分割、保护区破碎化问题，保护海陆交界区域完整生态过程。**内伶仃岛—福田国家级自然保护区的内伶仃岛区域和中华白海豚自然保护区、香港米埔湿地位置相邻，可考虑合作管理，适当调整保护区范围，以尽可能覆盖中华白海豚分布区及海陆交界处，保护生态系统的完整性。
- **加强红树林整体保护，建设"空陆海一体化"监测监管网络体系。**
- **提高生态系统服务功能，适度松绑，和谐发展。**适度向公众开放生态科教活动，加强自然科学普及及宣传教育，以发展推动保护，促进人与自然和谐共生。



深圳香港共建环大鹏湾海洋自然保护地

Shenzhen and Hong Kong to build a marine nature reserve around Dapeng Bay

- 在深圳东部沿岸地区（包括烟台和大鹏半岛自然保护区）及香港新界东北地区（包括沙头角、地质公园和印洲塘海岸公园）**共建海洋自然保护地（国家公园）**
- 构建区域海洋生态环境保护战略合作机构与机制（珊瑚、海龟、红树林）；
- 推进渔业资源和海洋生物多样性的调查研究与保护合作；联动应急、救护绿色通道、快速处理等联动机制；



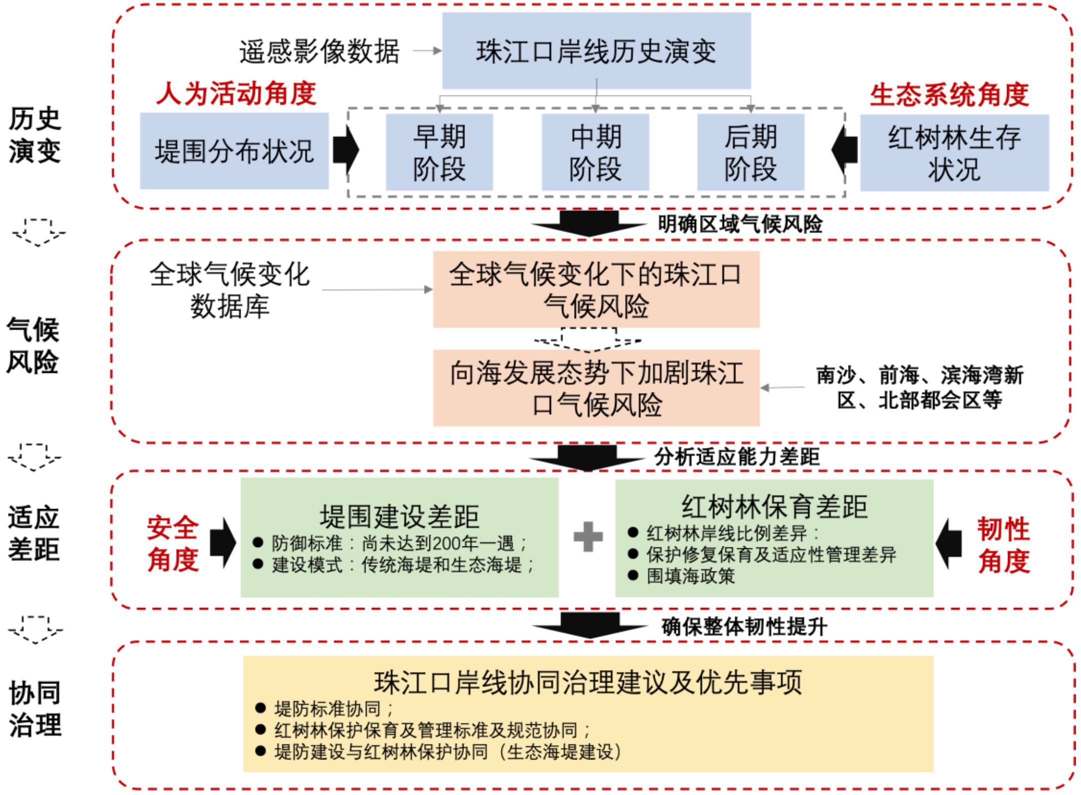
4 研究计划 Research Program

区域协作下珠江口海岸带地区的保护与治理

Protection and governance of the coastal zone area of the Pearl River Estuary under regional collaboration

① 继续研究多年围填海历史演变；岸线类型历史演变和以红树林为代表的自然湿地变化情况；
② 横向比较珠江口三地在河口湿地（红树林）保护修复领域的标准；以及三地在围填海和海岸地区基础设施领域的观念和标准异同；
③ 在粤港澳大湾区的国家战略下，借鉴莱茵河、密西西比河等流域的治理经验经验，提出珠江口海岸带地区保护与治理的区域协作的政策建议框架。

① Years of historical changes of sea reclamation; Years of historical changes of shoreline types & Years of mangrove distribution and status;
② Similarities and differences in mangrove conservation and restoration in the three areas of the Pearl River Estuary; &Similarities and differences in sea reclamation in the three areas of the Pearl River Estuary;
③ Under the national strategy of Great Bay Area, a policy proposal framework for regional collaboration in the protection and management of the coastal zone area of the Pearl River Estuary is proposed, drawing on the experience and lessons learned from the governance of the Rhine and Mississippi River basins.



感谢聆听！
Thanks

中国环境与发展国际合作委员会

China Council for International Cooperation on Environment and Development

Marjolein Haasnoot

Deltares

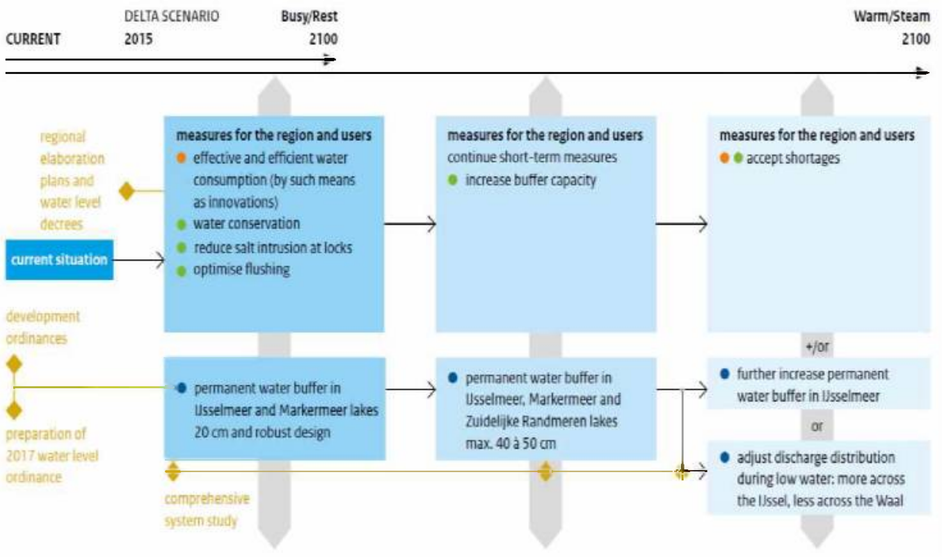
The Rhine-Meuse Delta:
transitioning to a climate neutral and climate robust delta for all

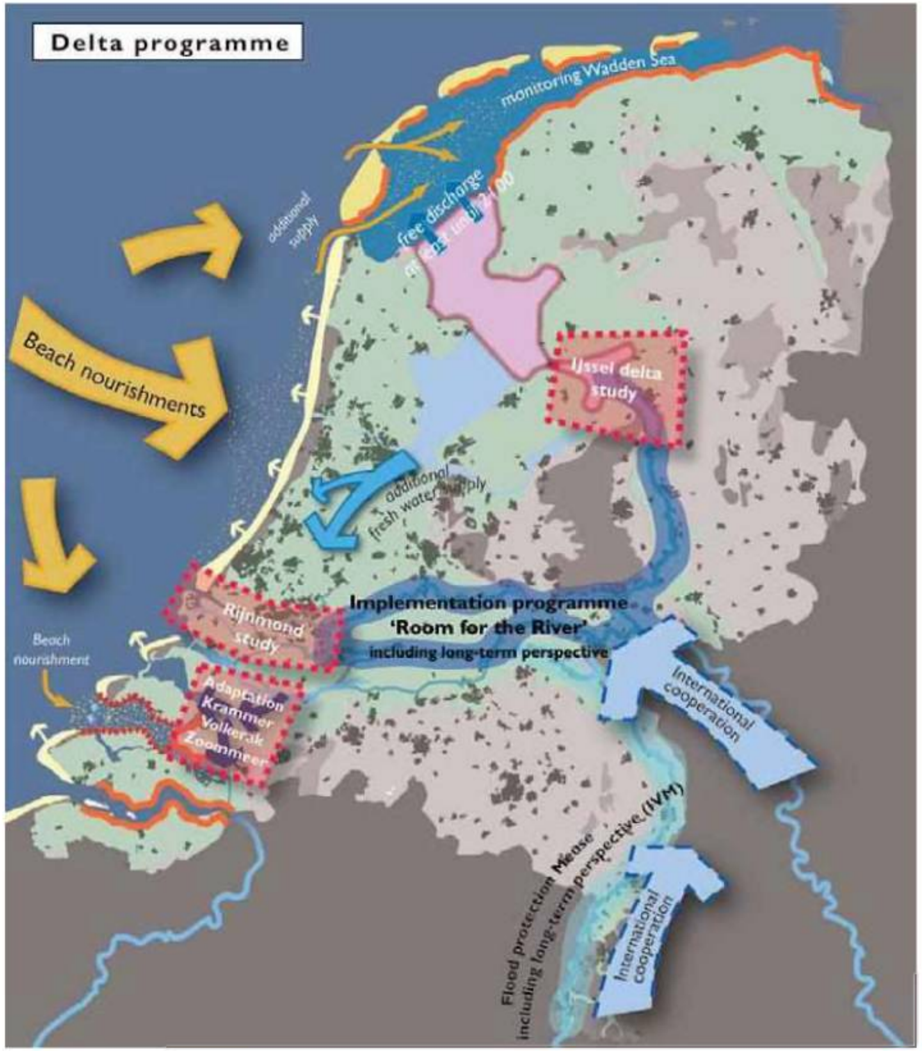
Marjolijn Haasnoot, Jaap Kwadijk

The Netherlands: anticipating change and integrated water management

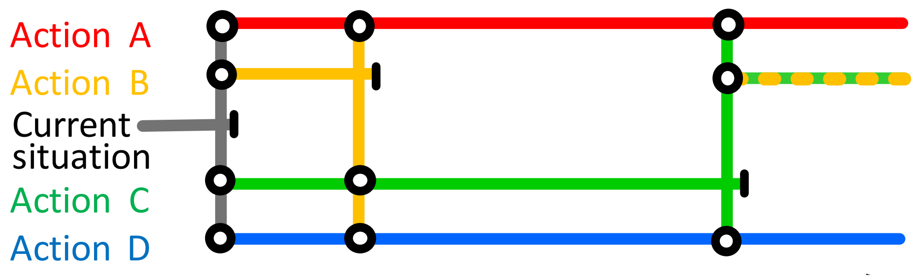
Deltaprogramme:

- A budget (€1B annually)
- A law (the Delta act)
- A Plan (Delta programme)
- A delta commissioner (at Minister-level)





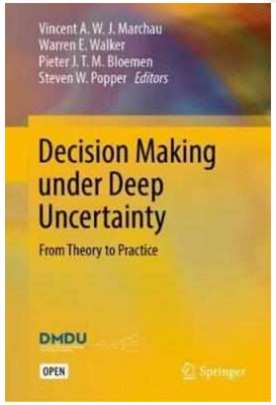
Adaptation pathways



Signals

Anticipate with adaptive plan

Book chapters: Dynamic Adaptive Policy Pathways, Adaptive Delta Management



Deltares

Haasnoot et al 2013 GEC, 2019

A new climate reality?

IPCC WG2:

- Adaptation is happening but the scale and rate is insufficient to keep up with climate change.
- Climate change is already affecting humans and nature.
- Tipping points with low probability but large consequences (Antarctica).

Deltares

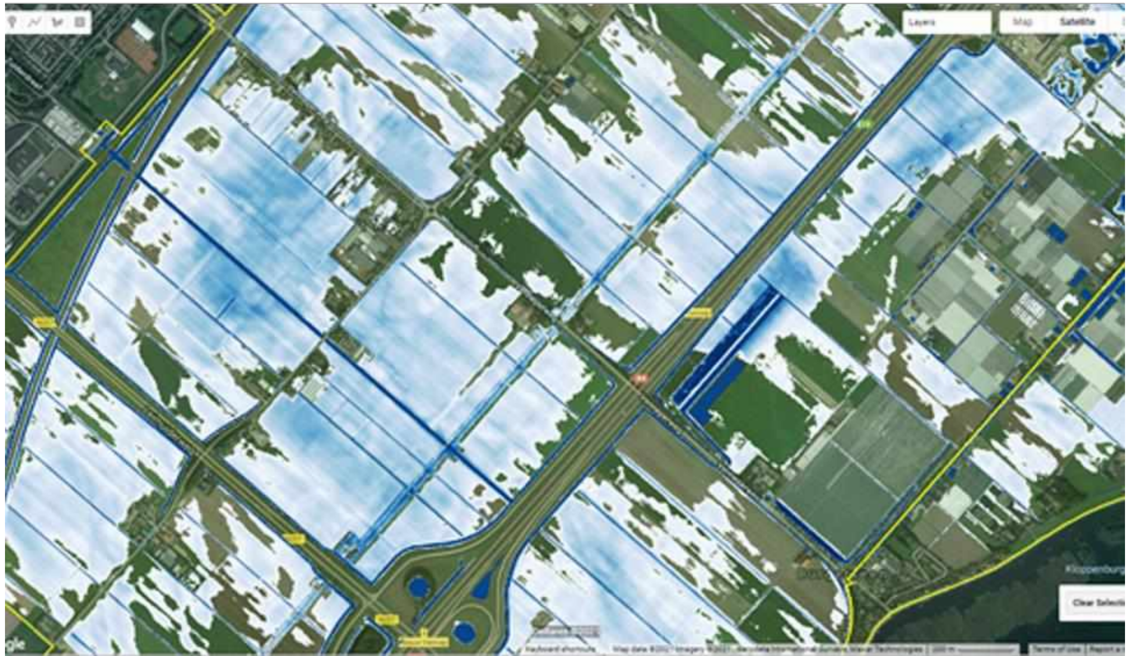
Do we know the (current) climate extremes well enough?

- Floods in Canada, China
- Extreme heat and forest fires Greece, Turkey, Russia, USA
- Extreme heat in Canada-BC en NW. YSA
- Extreme heat in Siberië
- July large flooding “waterbom” Germany, Belgium, Netherlands

https://www.worldweatherattribution.org

What if… the extreme 2021-rainfall happend in the Netherlands?

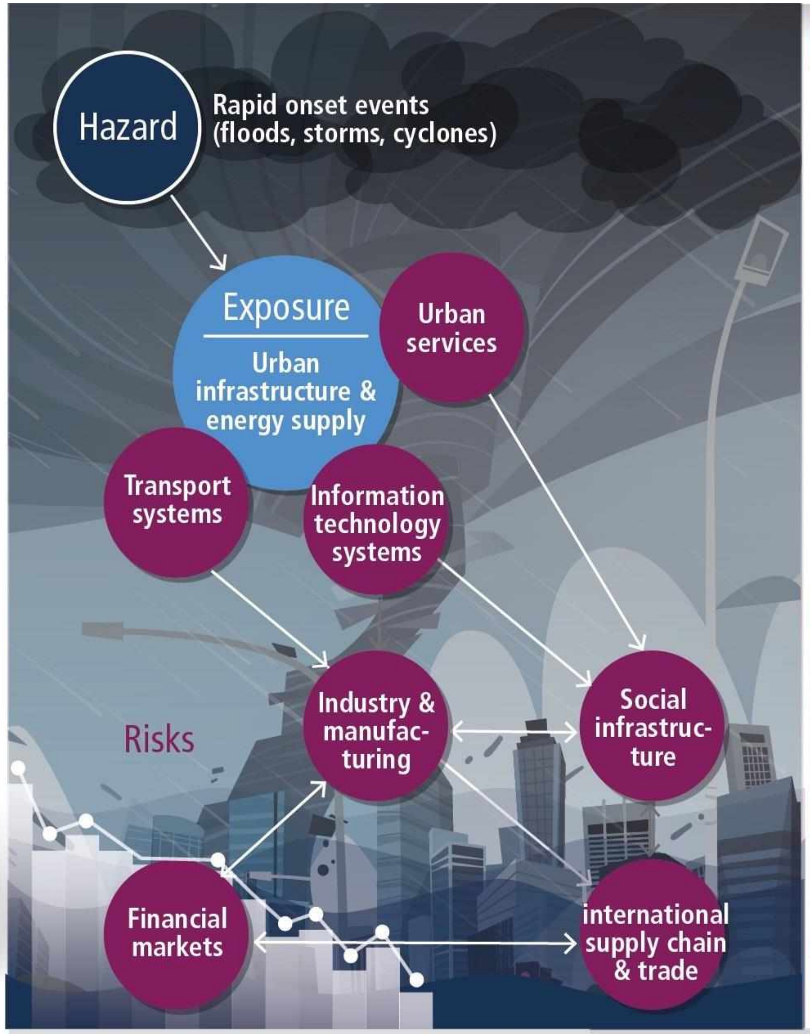
- Flooding of polders > 7 days
- Large damages in a large area
- Crisis management will be difficult
- Levee breaches with casualties cannot be ruled out

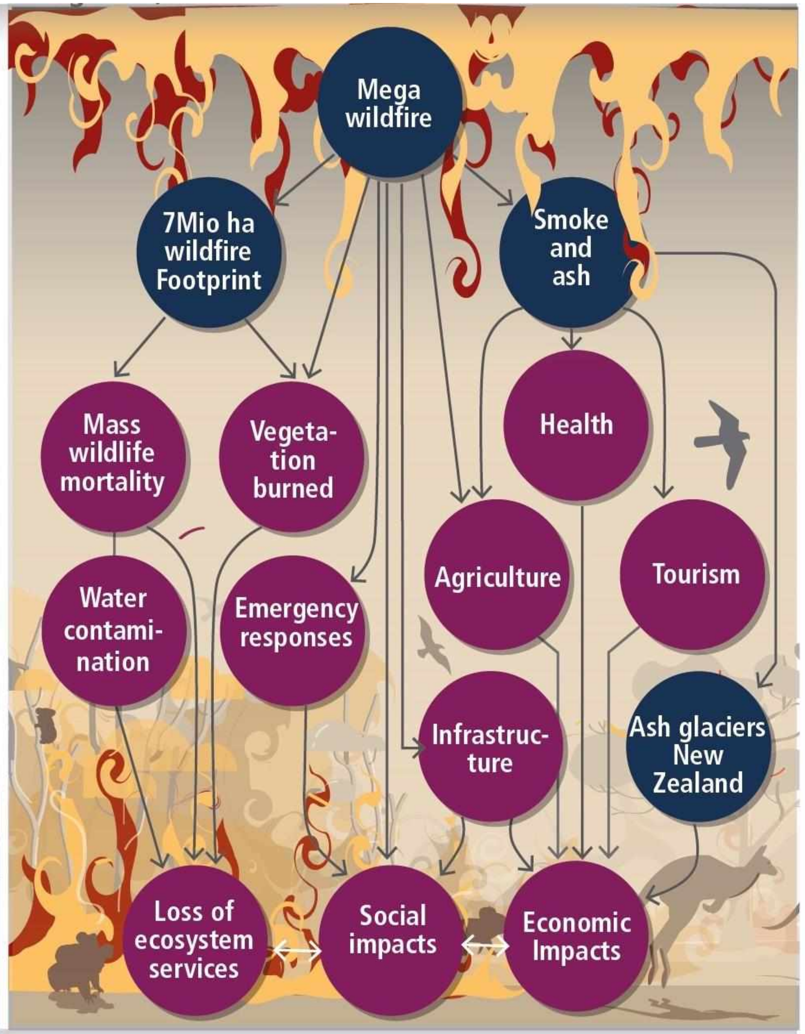


Deltares

Simultaneous extreme events compound risks

- Multiple extreme events that compound the risks are more difficult to manage.
- Risks occur across sectors and regions.



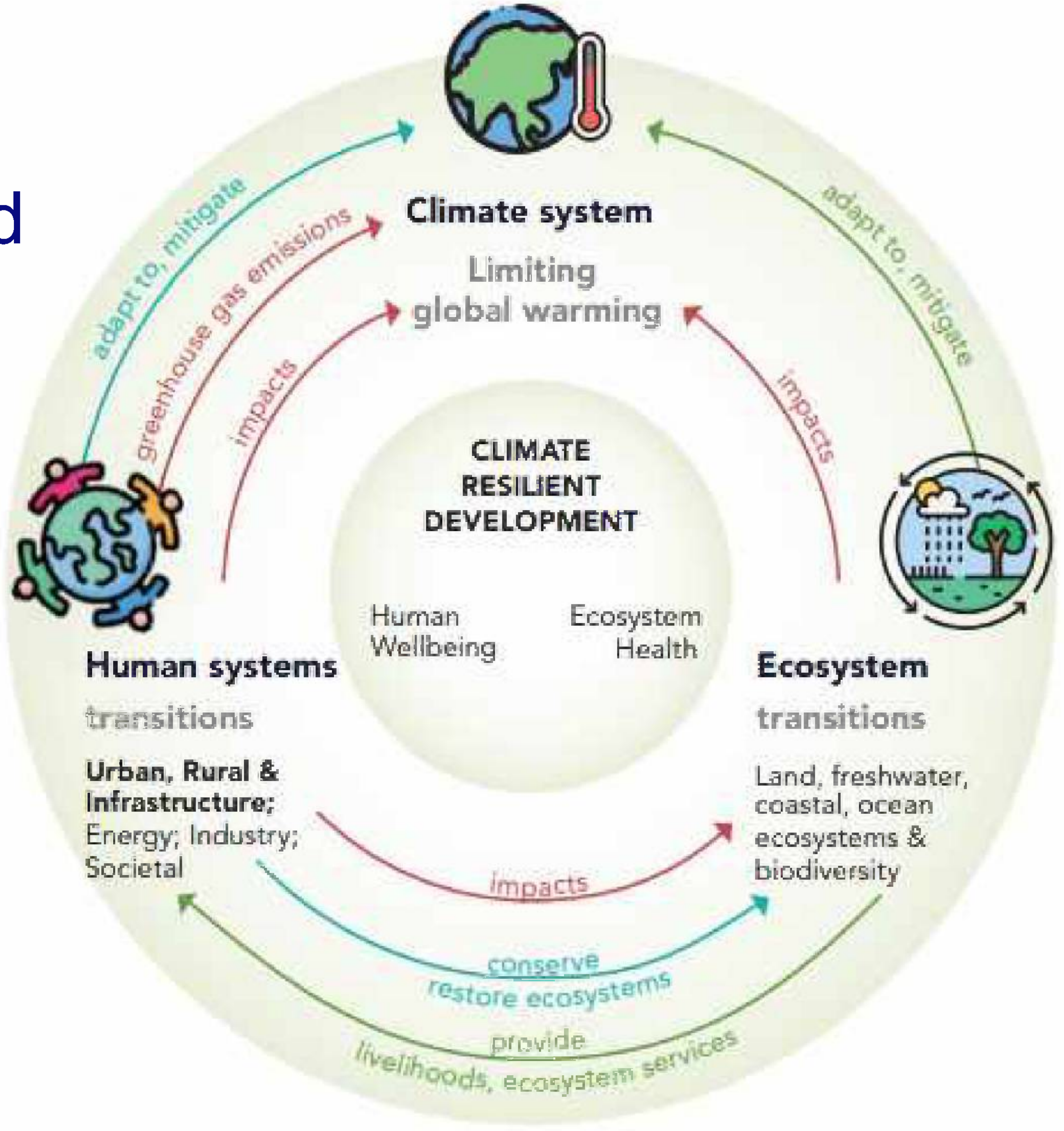


Climate, ecosystems and human society are coupled systems key to climate resilient development

IPCC WG2: We can no longer think in silos.

Examples:

- Increasing (ground) water levels in peat areas and adjustments of land use limits CO2 emissions and helps ecosystem adaptation
- Greening of cities, 15 min cities reduces impacts to humans and ecosystems and has benefits for health and climate



Adaptation has reduced impacts and has additional benefits

Protect / Advance: engineering and ecosystem based

Amsterdam, © Isabel Nabuurs

Accommodate

Avoid

Planned relocation

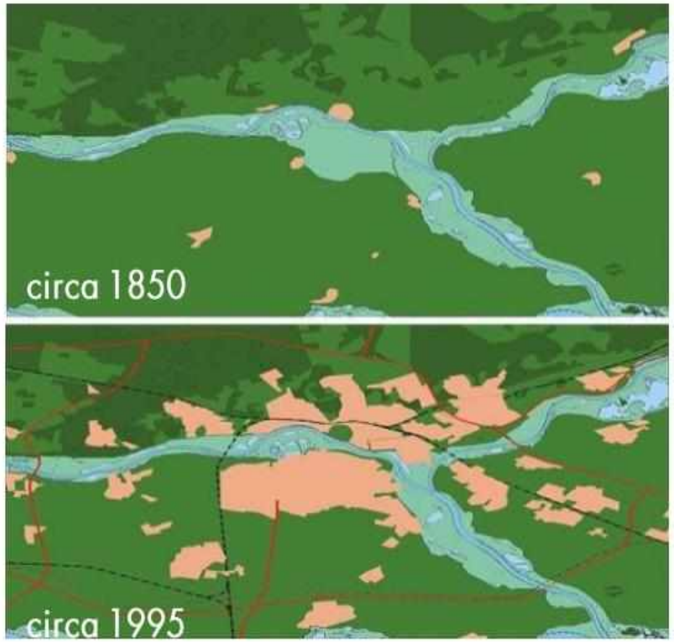
Nature offers significant untapped potential

Deltares

Maladaptation

Adaptation resulting in unintended consequences such as increased risk, emissions and lock-in. Maladaptation can be avoided by multi-sectoral and inclusive planning with flexible pathways that account for long-term adaptation commitment.

Protected areas attract development (Levee-effect), but when it fails…



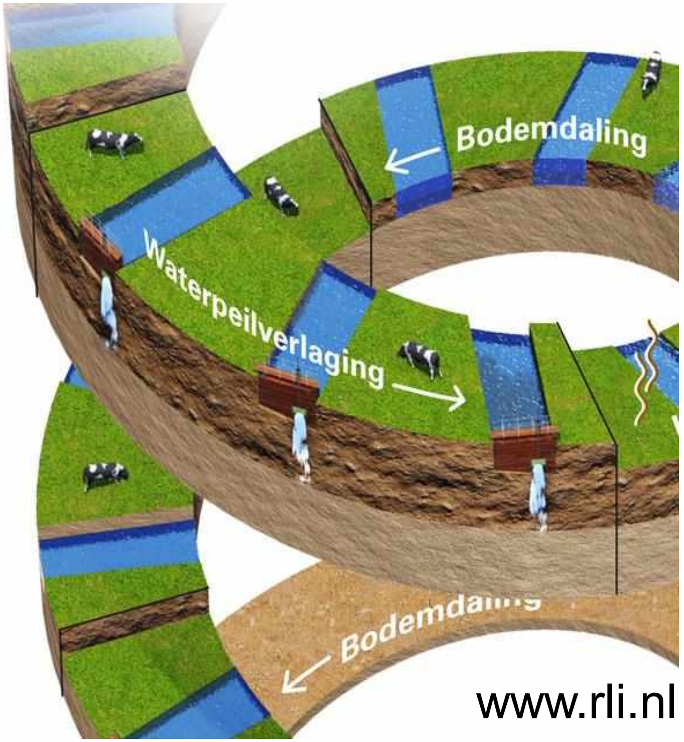
Limits space for adaptation (store water, raise levees)


Netherlands

'820,000 homes planned in area vulnerable to climate change'

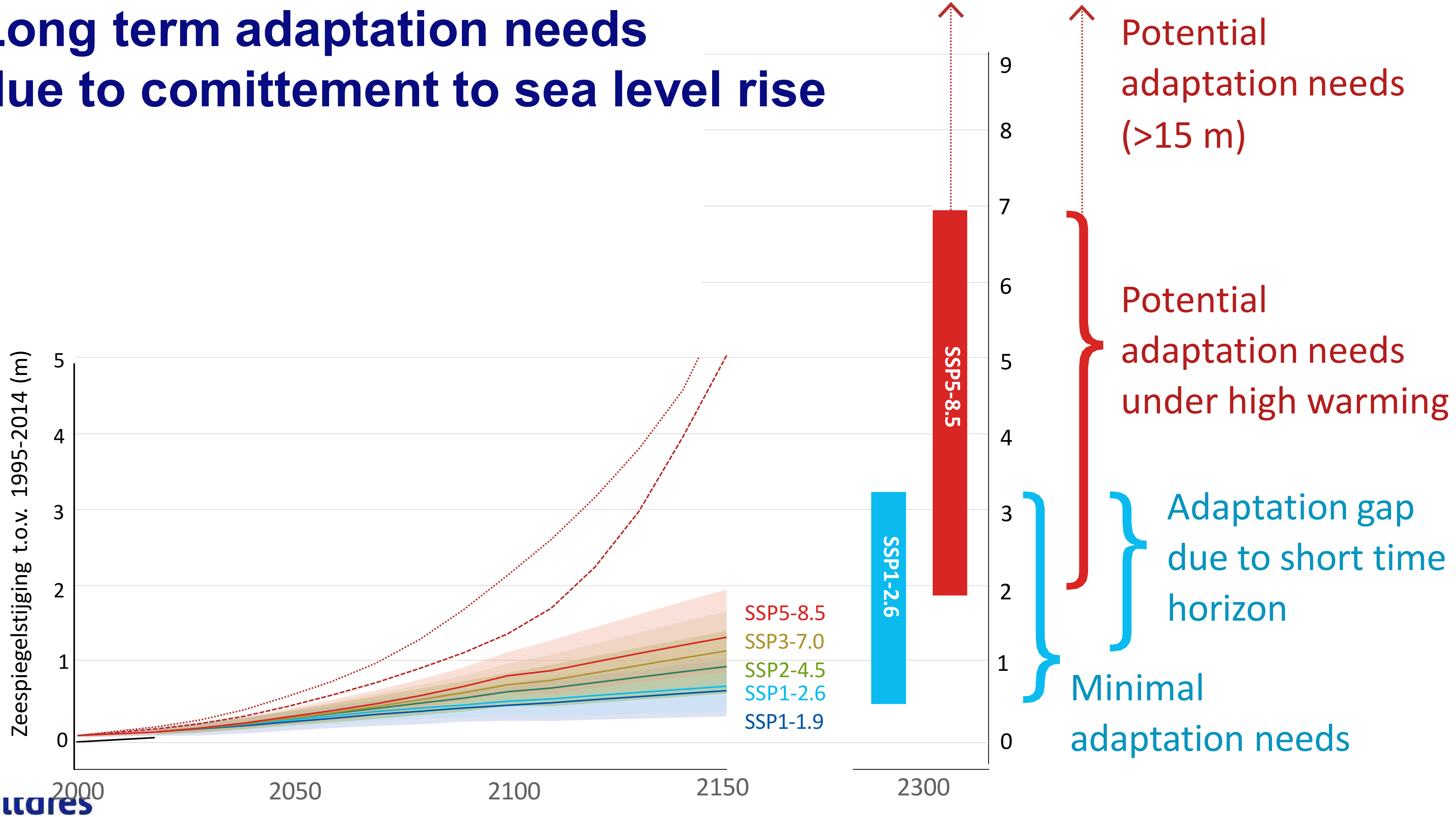
christophercloutier · 2 weeks ago

Drainage → subsidence → drainage



www.rli.nl

Long term adaptation needs due to comittement to sea level rise

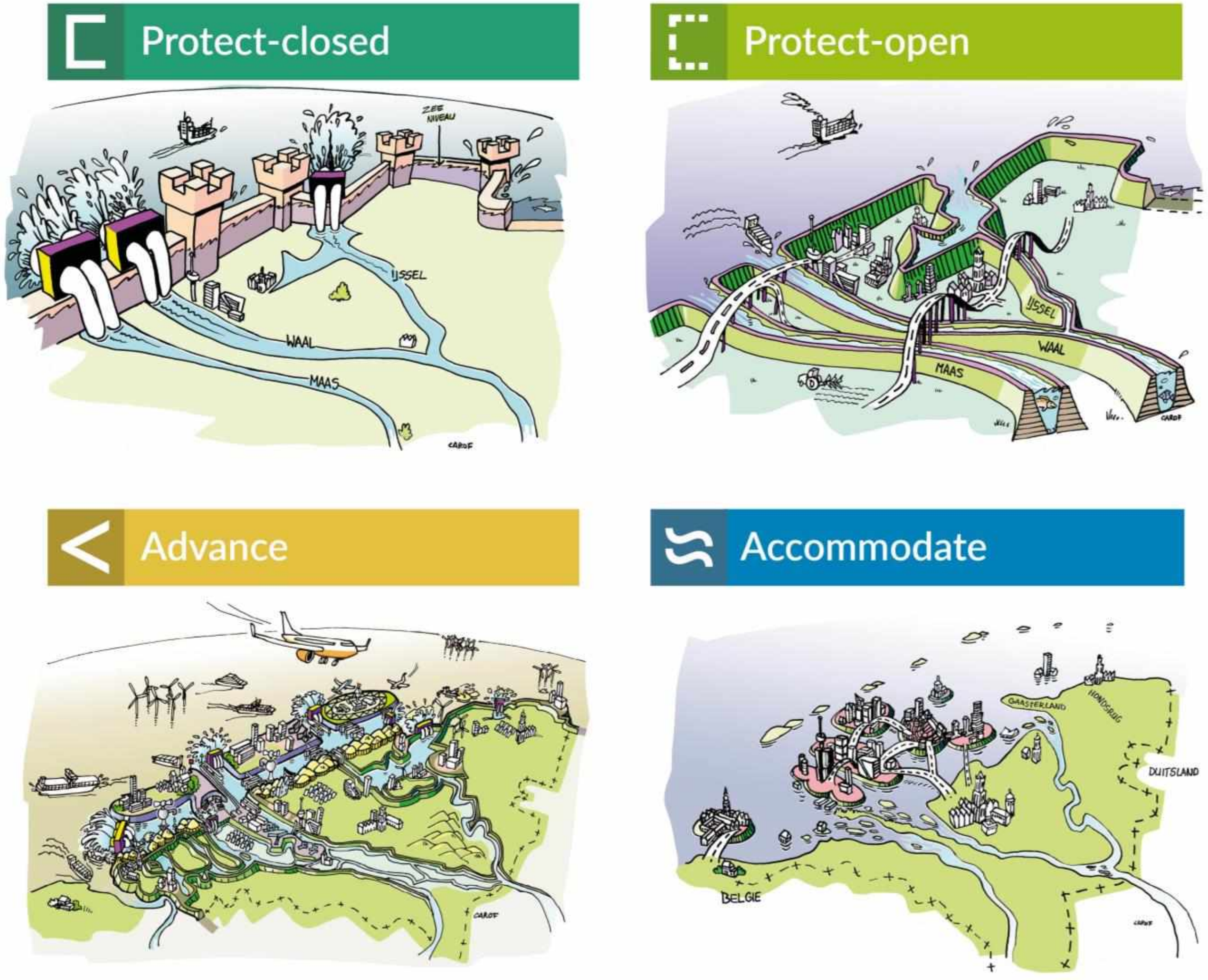


Deltares

Large challenges in the long-term

Assessment of options, pathways, short-term actions

- Rivers: space & pumps ~3000 m3/s
- Large amounts of sand needed:
  - ~240 times Palm island for Advance,
  - scalability of nourishment uncertain
- Salt intrusion cannot avoided

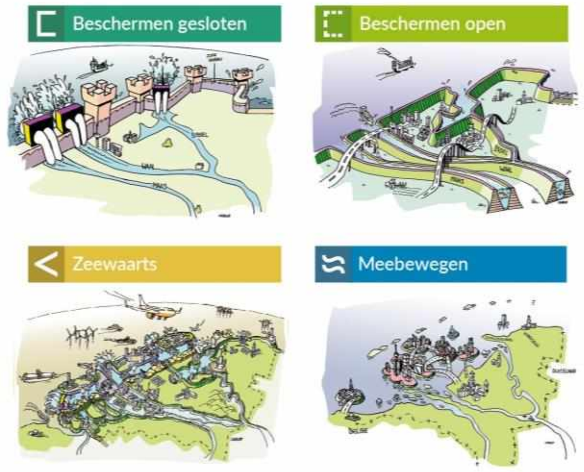


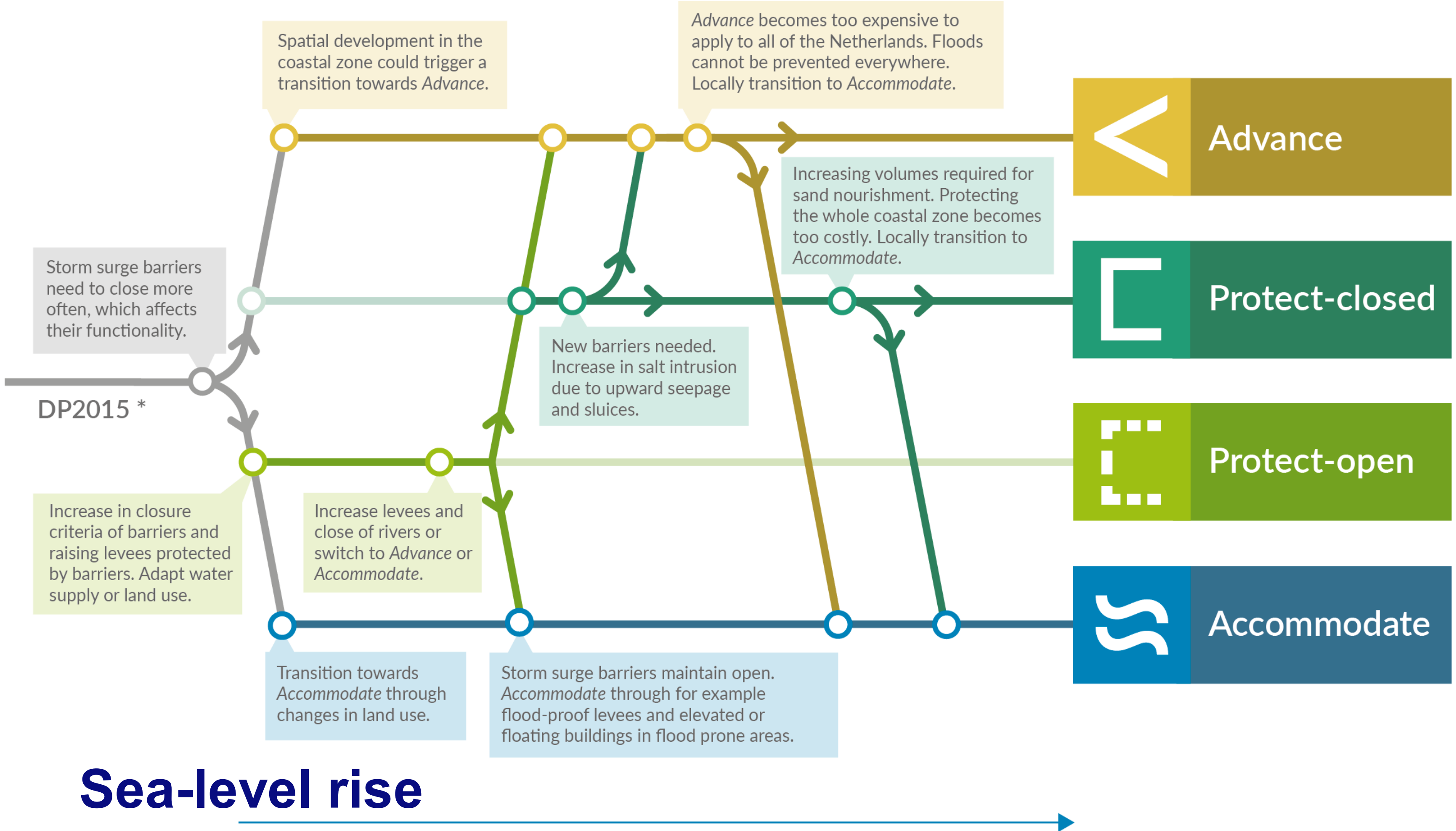
Cartoons developed by Carof for Deltares

Haasnoot et al 2019 (in Dutch), van Alphen 2022
https://www.deltacommissaris.nl/deltaprogramma/documenten/publicaties/2019/09/30/verkenning-deltares---strategieen-voor-adaptatie-aan-hoge-en-versnelde-zeespiegelstijging

Exploring the long-term solution space helps

adaptation pathways can break adaptation into manageale steps and illuminate lock-in and low-regret investments





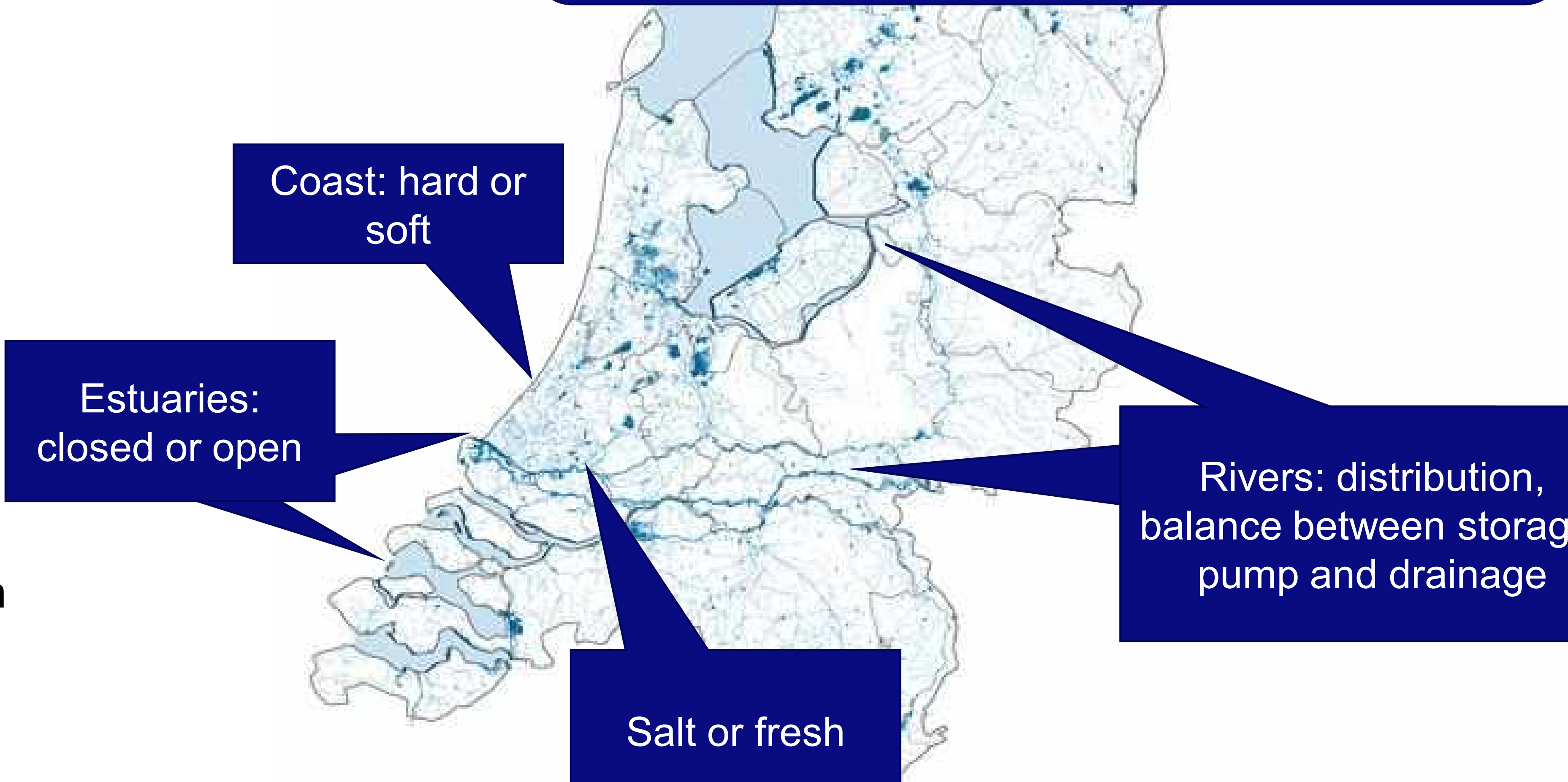
Critical choices (need to) happen also in the near-term

- Maintain , advance or retreat
- Hard, sediment-based, nature-based

In the next 20 years: space is the key, flexible investments, seize opportunities from other developments.

But also:

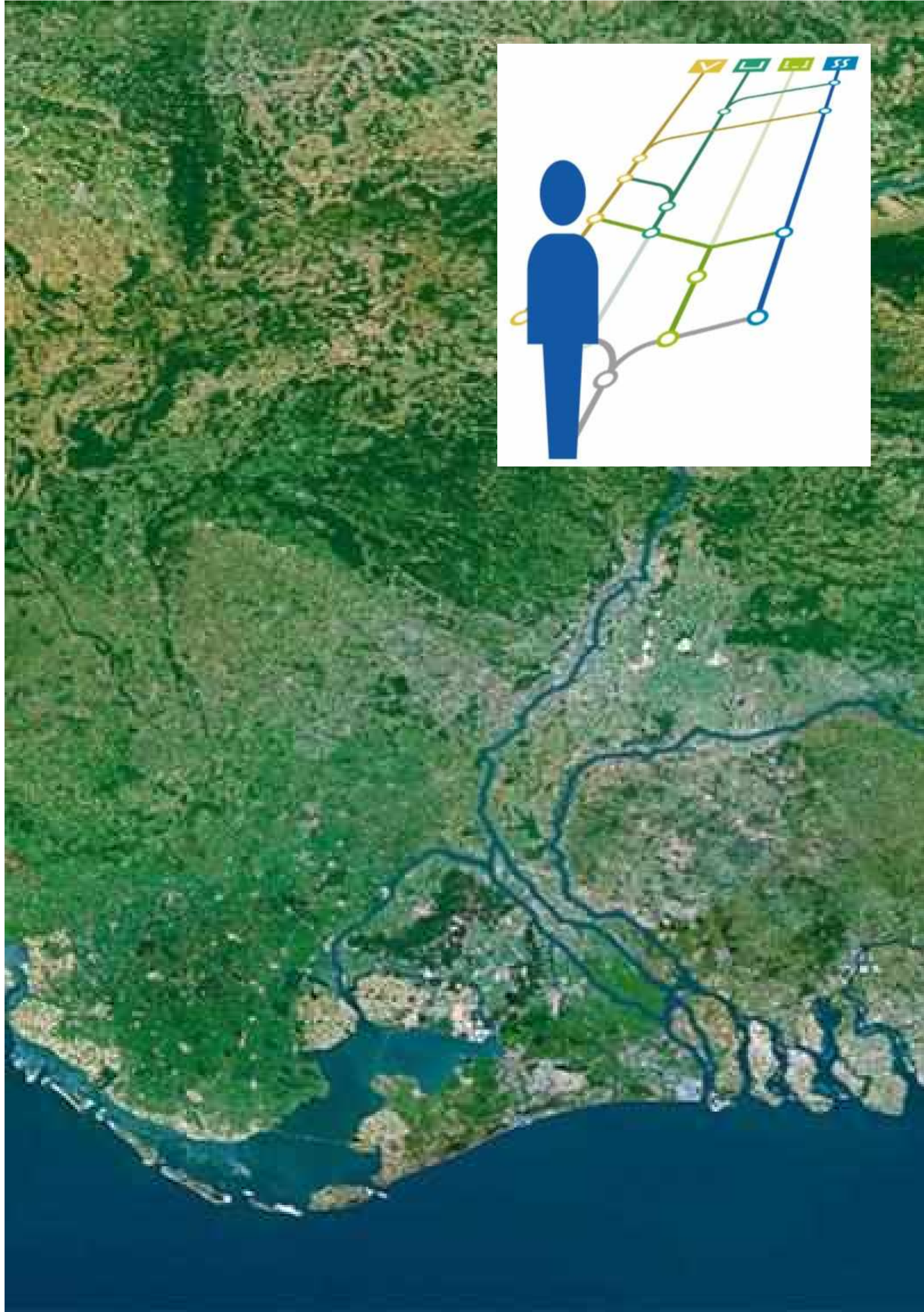
- Biodiversity loss
- Need for housing
- Energy transition
- Agriculture transition



Deltares

Summary

- Current crisis challenge long-term thinking which is needed for a climate robust and climate neutral delta for all.
- Anticipating change through exploring pathways help to identify path-dependencies, limits and opportunities, at national and river basin scale.
- Near term choices (of others) can determine future adaptation needs and possibilities
- Climate-nature-human balance is important. Nature based solutions offer untapped potential. Engineering measures will also be necessary.



Deltares

Liu Kunyi

——气候变化时代的水系统与港口经济：以莱茵河、长江和密西西比河为例

——Water system and port economy under climate change: examples of the Rhine, the Yangtze and the Mississippi rivers

长江下游地区岸线可持续利用的思考

Considerations on the Sustainable Utilization of the shoreline in the Lower Reaches of the Yangtze River

中国城市规划设计研究院 刘昆轶

Liu Kunyi, China Academy of Urban Planning & Design

2022年10月

Oct. 2022

研究背景 Study background

- **参与国合会2021-2022年《低碳韧性城市发展与适应气候变化》课题**
- **In 2022 CCICED *Development of low-carbon and resilient cities and adaptation to climate change***

1.气候变化背景下全球大河流域的多重风险与挑战

1. Risks and challenges of global river basins under climate change

2.面向2050年长江流域治理的理念、愿景与行动

2. 2050 idea, vision and action of the Yangtze River Basin governance

3.长江流域气候变化的现象和灾害影响的风险分析

3. Climate change and risk analysis of disaster impact of the Yangtze River Basin

4.国际流域治理经验借鉴

4. Experience from global river basins governance

5.长江流域气候变化韧性（适应力/韧性）策略

5. Climate change resilience (adaptability/resilience) strategy in the Yangtze River Basin

6.生态低碳民生导向的长江下游岸线优化利用策略

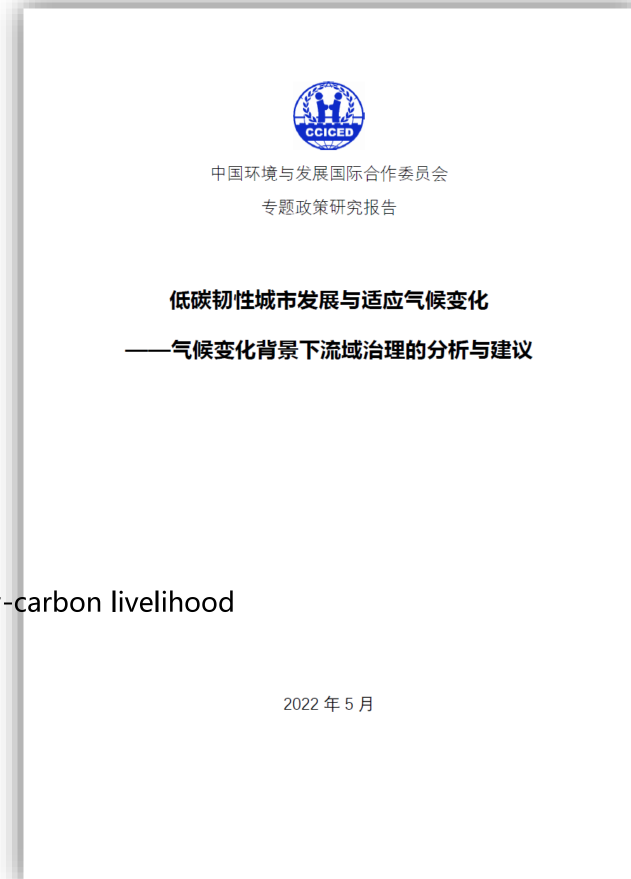
6. Optimal utilization strategy of the lower Yangtze River shoreline based on ecological low-carbon livelihood

7.流域应对气候变化的性别公平与社会包容问题

7. Gender equity and social inclusion of river basins to cope with climate change

8.政策与工作建议

8. Policies and recommendations



中国环境与发展国际合作委员会

专题政策研究报告

低碳韧性城市发展与适应气候变化

——气候变化背景下流域治理的分析与建议

2022 年 5 月

交流框架 Exchange framework

1. 长江下游地区岸线现状特征

1. Status quo of shoreline in the lower reaches of the Yangtze River

2. 快速增长时期产生的问题

2. Issues occurred during rapid growth

3. 气候变化时代面临的挑战

3. Challenges under climate change

4. 生态大保护下的新趋势和思考

4. New trends and thoughts under ecological conservation

研究范围：长江下游地区Scope: the lower reaches of the Yangtze River

- 长江干流南京以下至长江入海口段岸线，包括主江和洲岛岸线；
- shoreline from the main stream of the Yangtze River below Nanjing to the estuary of the Yangtze River, including the shoreline of the main river and islands;
- 行政范围涵盖南京、镇江、扬州、常州、无锡、泰州、苏州、南通、上海九座城市。
- The administrative scope covers Nanjing, Zhenjiang, Yangzhou, Changzhou, Wuxi, Taizhou, Suzhou, Nantong and Shanghai.

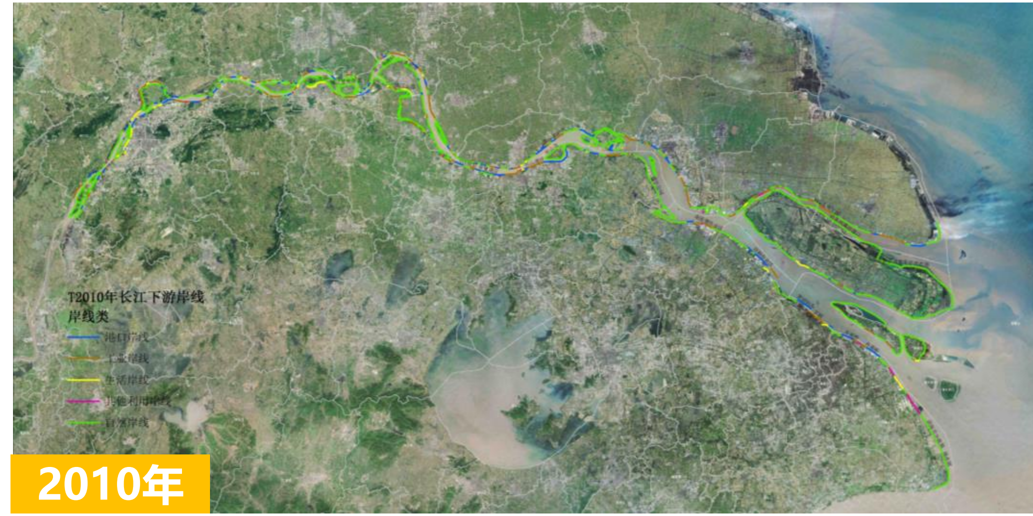
长江流域示意图
Schematic Diagram of the Yangtze River Basin

1.长江下游岸线总体情况 Overall situation of shoreline

2010年岸线总长度1978KM
2010 total length: 1,978KM

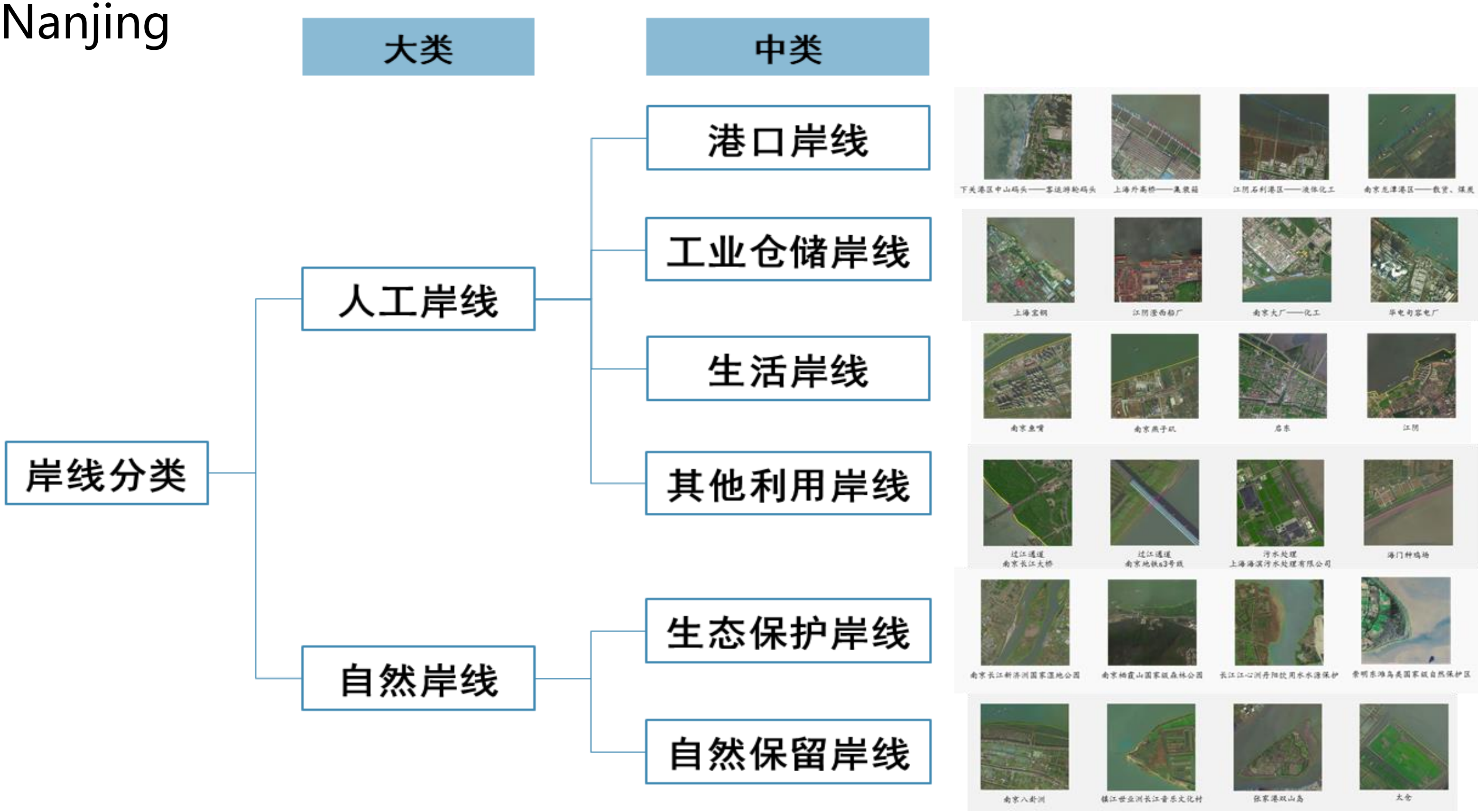
十年间增加42KM
42KM increase in ten years

2020年岸线总长度2020KM
2020 total length: 2,020KM



长江下游岸线现状分类 Status quo of shoreline in the lower reaches of the Yangtze River

- **基础工作：开展长江南京以下岸线利用情况的识别**
- Basic work: Map the current shoreline utilization of the Yangtze River below Nanjing

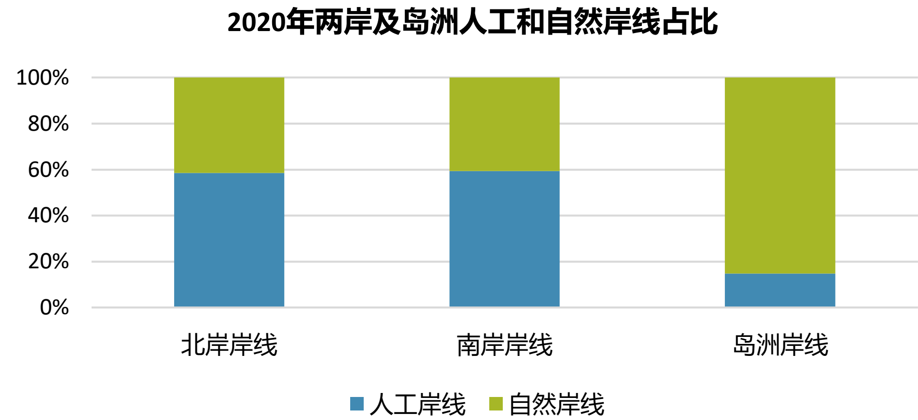


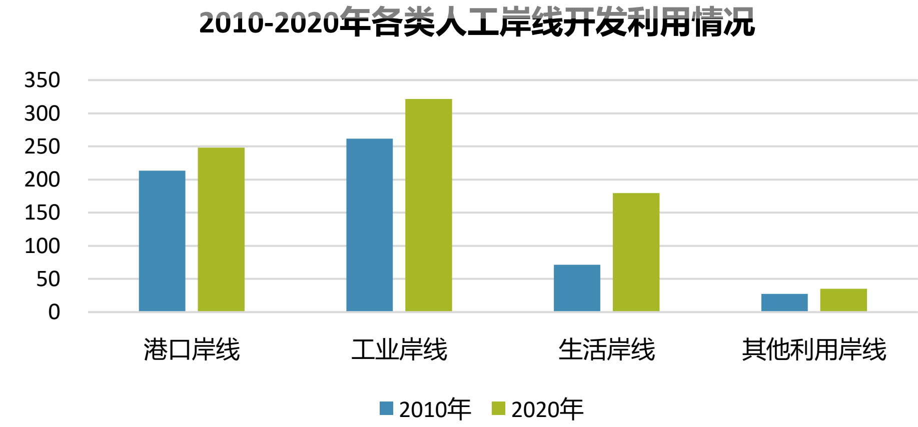
2. 高速增长时期产生的问题 Issues occurred during rapid growth

2.1 岸线利用粗放、低效，缺乏统筹安排

Extensive, inefficient shoreline utilization, without overall arrangement

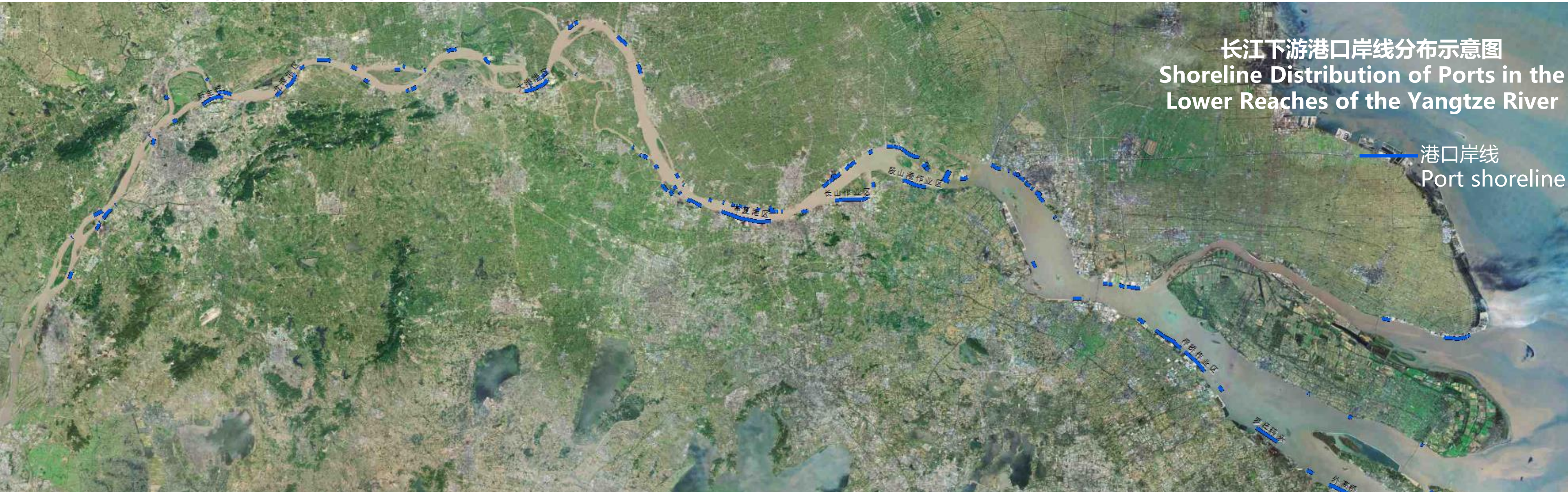
- **人工岸线开发利用强度高**
- Intensive artificial shoreline exploitation and utilization
- **十年间生活、工业港口岸线增加最快，工业港口岸线占人工岸线73%**
- **Fastest shoreline growth of domestic and industrial ports in the past decade, the shoreline of industrial ports accounting for 73% of the artificial shoreline**





■ 以港口岸线为例：开发缺乏统筹，导致重复建设、低效竞争
■ Port shoreline: no overall exploitation plans causing repeated construction and inefficient competition

- ➢ **岸线规模大，使用效率差距巨大**
- ➢ Long shoreline, huge gap in use efficiency
- ➢ **业务分散和同质化现象非常严重**
- ➢ Severe business decentralization and homogenization
- ➢ **优质岸线被企业占用，岸线闲置浪费情况普遍**
- ➢ Occupied quality shorelines by enterprises, large idle and wasted shorelines



■ 相邻城市在大开发时期都形成了完整的泊位类型，难以形成规模效应

■ Complete berth types by adjacent cities during big exploitation，difficult scale effect

太仓港 Taicang Port

名称	类型	规模
荡茜作业区	散货	
新泾作业区	件杂货、集装箱	
浮桥作业区	集装箱	
太仓太海汽渡	汽渡	
埃克森美孚、中石油华东润滑油厂等	液体化工	
鹿河作业区	装备制造	
茜泾作业区	液体散货	

常熟港 Changshu Port

名称	类型	规模
兴华作业区	件杂货、集装箱	
金泾塘作业区	化工	
白茆小沙作业区	预留区（临港工业服务）	
华润电力有限公司	电力	

图例

- 散货
- 件杂货
- 油气
- 化工
- 集装箱
- 电力
- 钢铁
- 其他

张家港港 Zhangjiagang Port

名称	类型	规模
东沙作业区	件杂货	
段山港作业区	散货、件杂货、油气等	
长山作业区	散货、件杂货、集装箱、化工	
化学工业园作业区	化工、集装箱、粮油运输	
冶金工业园作业区	钢铁	

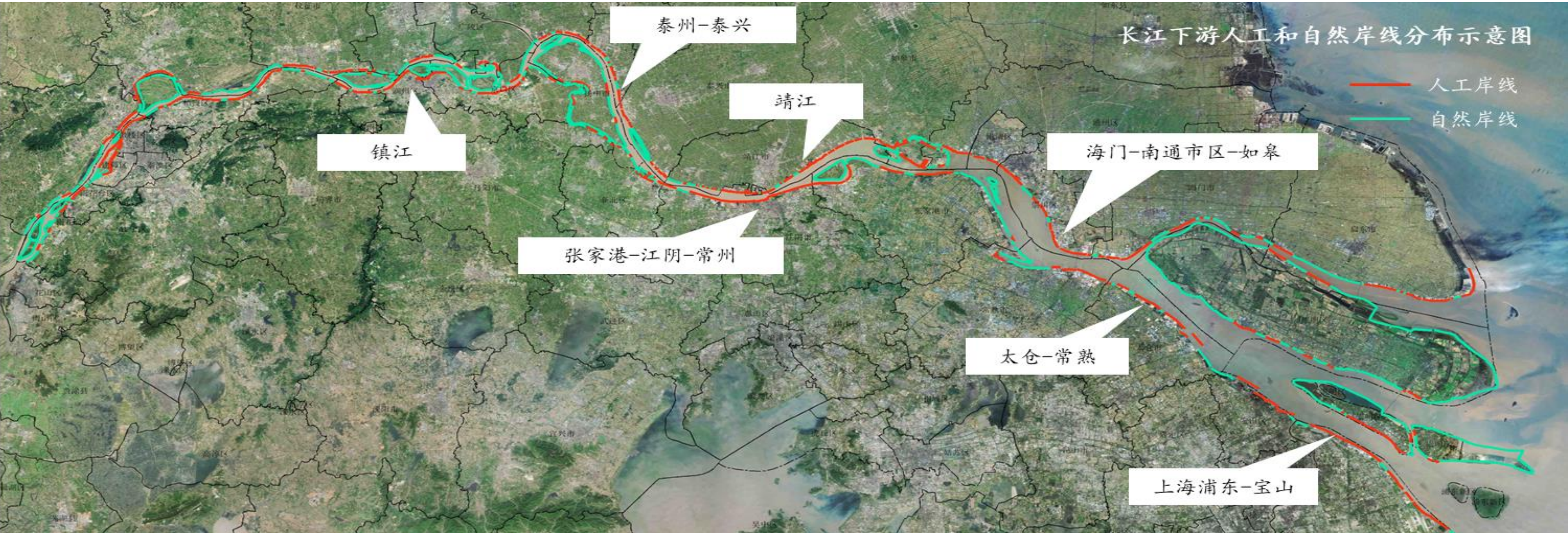
2.2 沿江重化工产业集聚，节能降碳压力大，面临安全隐患

Heavy chemical industry cluster along the river, with great pressure on energy conservation, carbon reduction, and potential safety hazards

- **长江下游是中国乃至世界上化工、钢铁、能源等重化工产业分布最密集的地区；**
- The lower reaches of the Yangtze River has the most heavy chemical industries like chemical industry, steel industry and energy industry in China and even the world;
- **化工园区分布密集；**
- Densely distributed chemical parks in the lower reaches of the Yangtze River;
- **港口、城市岸带、城市内河入江口以及入海口氮磷含量高；**
- High nitrogen and phosphorus in ports, urban shorelines, urban inland river inlets and sea inlets;

2.3 沿江高强度连绵开发压缩水陆生态空间 Intensive and continuous exploitation along the river reduces the aquatic and terrestrial ecological space

- **近十年自然岸线减少了约170千米，自然岸线与人工岸线之比由2010年7：3转变为2020年6：4；**
- **人工岸线高强度连绵开发，城市间缺乏生态安全的缓冲空间；**
- Intensive and continuous exploitation of artificial shorelines, without buffer spaces for ecological security in cities;
- **人工岸线开发利用对水源地、生物栖息地等生态敏感区域的占用影响；**
- Exploitation and utilization of artificial shorelines undermine ecologically sensitive areas such as water sources and biological habitats



3. 气候变化时代面临的挑战 Challenges under climate change

■ 河口地区面临海平面上升和台风风暴潮的风险
Sea level rise and typhoon storm surge in estuary areas

- **我国海岸线上升速率略高于全球平均水平，台风风暴潮频次和强度增大，对河口地区影响严重**
- China’s shoreline rising rate is slightly higher than the global average, with more and severer typhoon storm surges, impacting estuary areas
- **气候影响下，围绕河口地区的研究，主要集中两个方面：海岸带湿地侵蚀和综合脆弱性评估**
- Under climate change, studies on estuary areas focus on coastal wetland erosion and comprehensive vulnerability assessment

- **1980-2014我国海平面上升趋势**
- **1980-2014 China rising trend of sea level**

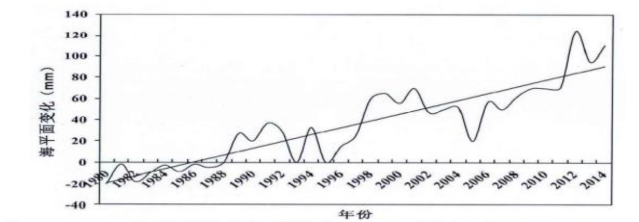


图 1-1 1980-2014 年中国沿海海平面较常年（0 mm）的变化（国家海洋局，2015）

Fig.1-1 The sea level change of China Coast from 1980-2014

- **国家海洋局（2012-2014）：**
- **State Oceanic Administration 2012-2014）：**
- 我国沿海海平面至2050年，升高约0.145米-0.2米
- China's coastal sea level will rise by about 0.145m-0.2m by 2050
- **IPCC-AR6 WGI发布的报告：**
- **Report by IPCC-AR6 WGI:**
- 至2100年，升高约0.28米-1.01米
- Rise by about 0.28m - 1.01m by 2100
- 至2150年，升高约0.37米-1.88米
- Rise by 0.37m - 1.88m by 2150

- **1949-2016影响上海地区的台风风暴潮受灾统计**
- **1949-2016 statistics of typhoon storm surges affecting Shanghai**

表 2-1 1949~2016 年影响上海地区的台风风暴潮灾害事件统计

Table 2-1 Typhoon storm disasters in Shanghai from 1949 to 2016

台风编号	台风名称	最低气压（hPa）	最大风力（级）	最大增水（cm）	死亡人数（人）	经济损失（万元）
4906	Gloria	960	10	150	1670	/
5116	Amy	960	12	/	35	/
5612	Wanda	905	12	250	12	2000
6207	Nora	971	12	203	49	300000
6312	Gloria	918	/	/	11	/
7413	Mary	958	11	160	10	3200
7708	Babe	906	11	125	2	2200
7909	Irving	955	10	99	/	2774
7910	Judy	908	10	142	5	2802
8114	Agnes	949	12	170	6	44813
8310	Forrest	876	12	192	/	200
8506	Jeff	965	10	/	26	/
8615	Vera	923	12	147	9	6303
8913	Ken	980	9	122	/	1497
8923	Vera	980	10	101	/	395
9015	Abe	955	10	89	3	3857
9216	Polly	975	9	134	/	530
9417	Fred	935	9	117	/	51
9507	Janis	980	11	87	/	167
9608	Herb	935	9	119	/	4261
9711	Winnie	920	12	235	7	63490
0012	Prapiroon	965	11	165	1	12200
0014	Saomai	920	10	147	/	1500
0102	Chebi	960	12	120	/	200
0205	Rammasun	950	12	171	6	/
0216	Sinlaku	950	/	/	/	210
0407	Mindule	950	9	142	1	1180
0414	Rananim	950	12	107	/	240
0417	Chaba	920	/	79	/	/
0509	Matsa	950	13	132	7	135800
0515	Khanun	945	10	/	/	36950
0608	Saomai	915	/	/	/	/
0713	Wipha	935	10	83	/	100
0716	Krosa	935	12	122	/	15700
0808	Fungwong	955	7	38	/	/
0908	Morakot	950	12	100	/	33200
1109	Muifa	915	13	60	/	1200
1211	Haikui	960	14	117	2	600
1323	Fitow	945	14	125	1	9300
1416	Fungwong	982	10	/	/	/
1509	Chan-hom	935	18	/	/	500
1616	Malakas	940	15	112	/	/

注：在胡德宝等（2005）整理的基础上进行补充，"/"为暂未收集到数据。

资料来源：《海平面上升与可能最大风暴潮复合作用的风险评估及其适应策略研究——以上海地区为例》，易思

Data source: ***Risk Assessment of the Combined Effects of Sea Level Rise and Possible Maximum Storm Surge and Its Adaptation Strategies - A Study of Shanghai Region as an Example, Yi Si***

■ 台风和风暴潮影响下 岸线淹没风险和防洪排涝压力升高

■ Higher shoreline inundation risk and flood control and drainage pressure under typhoon and storm surge

- **风暴潮下的海岸淹没：** 由于上海堤防水平相对较高，可以抵御中、低强度的风暴潮，但极端天气下的高强度风暴潮仍有很大风险
- **Shoreline inundation under storm surge:** it can withstand moderate and low-intensity storm surges due to Shanghai's high levee level, but with a high risk of high-intensity storm surges in extreme weather
- **风暴潮带来的洪水：** 上海城市不透水面率高，需进一步提升防洪排涝的措施和标准
- **Flood caused by storm surg**e: measures and standards for flood control and drainage need to be further improved due to Shanghai's high impermeable surface ratio

- **2030和2050上海土地利用预测**
- 2030, 2050 Shanghai land use prediction

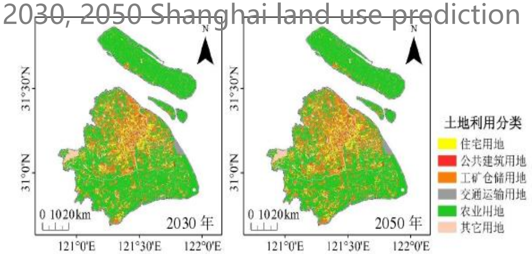


图 5-2 2030 年和 2050 年上海市土地利用预测图

- **6种不同强度（V1-V6）及两种登陆角度（32°/75°）风暴潮影响下上海市淹没地区分布**
- **Distribution of Shanghai's inundated areas under storm surges with six intensities (V1-V6) and two landing angles (32 °/75 °)**

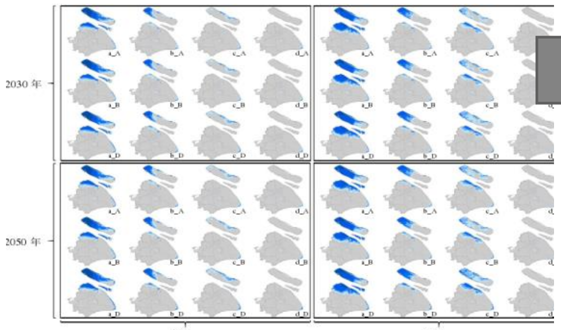


图 4-12 上海地区海平面上升-可能最大风暴潮复合情景的淹没分布

Fig.4-12 Inundation distribution under the compound scenarios of SLR-PMSS in Shanghai

- **2030和2050上海受最高强度风暴潮影响下的经济损失情况**
- Shanghai economic losses in 2030 and 2050 under the strongest storm surge

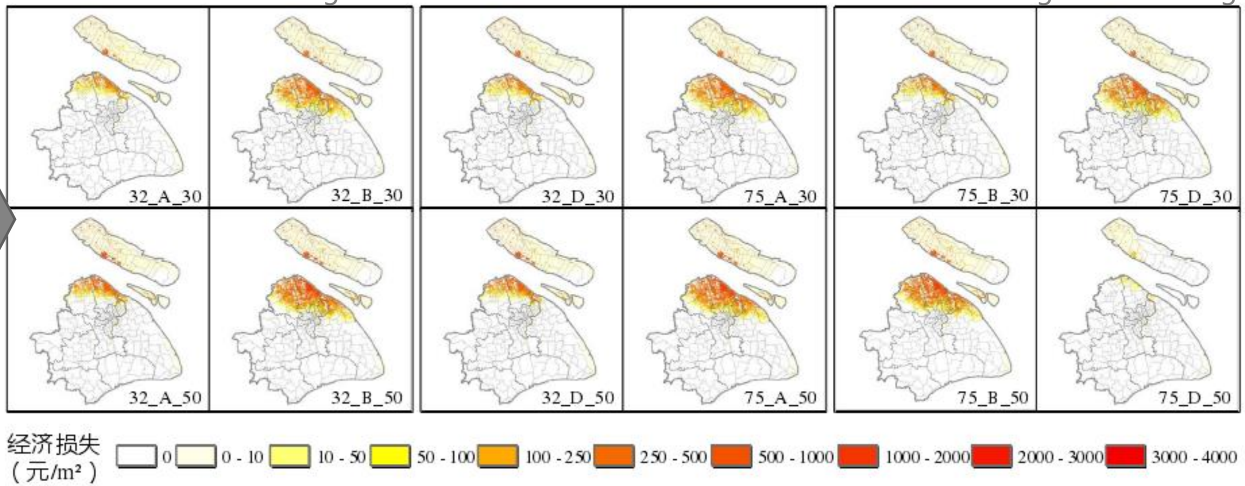


图 5-6 最高强度可能最大风暴潮情景的海平面上升-可能最大风暴潮复合情景的经济损失分布

资料来源：《海平面上升与可能最大风暴潮复合作用的风险评估及其适应策略研究——以上海地区为例》，易思

■ 经模拟，气候影响下河口地区湿地脆弱性不断增大

■ More vulnerable estuary wetlands under climate change by simulation

➢ **5个维度的气候变化影响**

➢ **Impact under climate change in five dimensions**

①海平面上升速率、②地面沉降/抬升速率

③现状湿地高程、 ④日均淹水时间、 ⑤沉积速率

① Sea level rise rate ② Land subsidence/lifting rate

③ Current wetland elevation ④ Average daily flooding time ⑤ Deposition rate

（数据基于：IPCC 第五次评估温室气体排放情景中的RCP8.5情景）

Data: RCP8.5 scenario in the 5th IPCC assessment of greenhouse gas emission sce

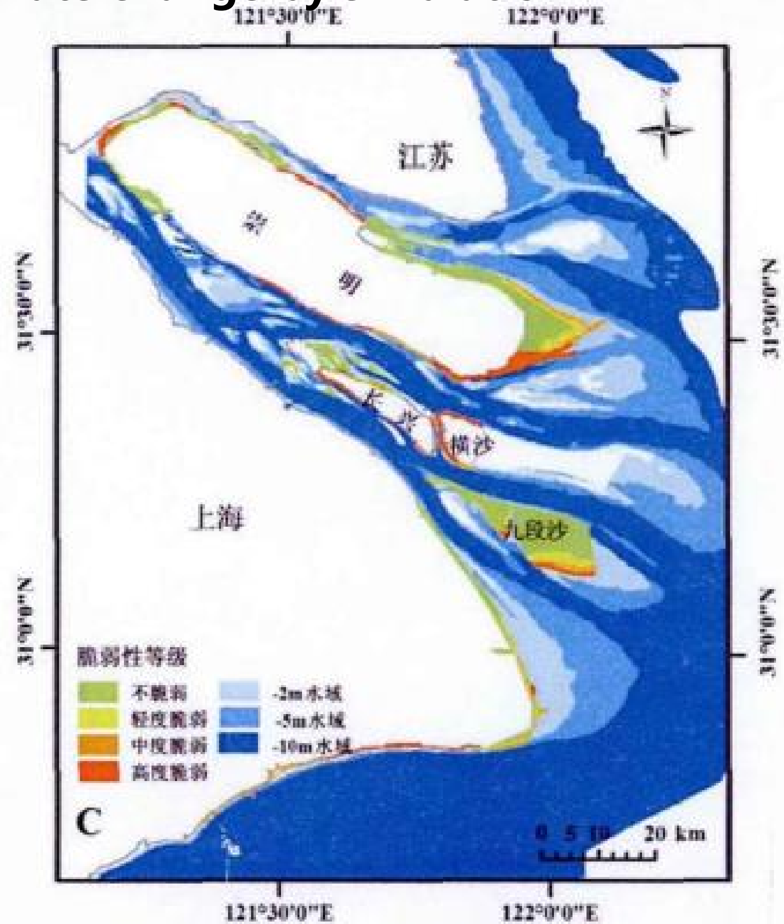
表 6-4 RCP8.5 情景下长江口滨海湿地脆弱性等级百分比（%）

Table6-4 The percentage of vulnerability for the coastal wetlands in the Yangtze Estuary in the 2030s, 2050s and 2100s under RCP8.5 scenario (%)

海平面上升情景	时间尺度	脆弱性等级			
		无	低	中	高
RCP8.5	2010-2030	85.3	12.7	2.0	0.0
	2010-2050	74.3	14.6	8.9	2.2
	2010-2100	65.1	10.2	11.5	13.2

➢ **长期来看（2100年），高脆弱度的地区主要分布在：崇明南岸和东海沿岸、横沙岛西岸和金山边滩沿岸、九段沙南岸**

➢ In the long run (2100), highly vulnerable areas are mainly along Chongming south coast and East China Sea coast, Hengsha island west coast and Jinshan beach coast, Jiuduansha south coast



RCP8.5情境下长期（2010-2100）长江口滨海湿地脆弱性空间分布

资料来源：《海平面上升影响下长江口滨海湿地脆弱性评价》，崔利芳

4. 生态大保护下的新趋势和思考

New trends and thoughts under ecological conservation

■ 国家层面政策 National policies

- 1980S：陆大道提出T形发展战略
- 1990S：沿海开放战略
- 2000S：西部大开发战略；中部崛起战略
- 2005：《长江经济带合作协议》（交通运输部）
- 2009：七省二市希望将长江经济带列为国家战略
- 2010,12：《全国主体功能区规划》两横三纵 一级开发轴
- 2012：《长江流域综合规划》（长江水利委）
- 2013：**习总书记考察湖北 把长江全流域打造黄金水道**
- 2014,3：《政府工作报告》提出依托黄金水道建设长江经济带
- 2014,9：《依托环境水道推动长江经济带发展的指导意见》
- 2016,1：习总书记重庆座谈 提出 生态优先 绿色发展
- 2016,9：《长江经济带发展规划纲要》提出共抓大保护，不搞大开发
- 2018：习总书记长江考察 提出统筹五个关系 推动高质量发展
- 2021：《中华人民共和国长江保护法》

■ 地方层面行动 Local actions

■ 江西相关工作

- 《江西（九江）沿江岸线资源评价和综合开发利用规划》
- 沿江产业布局规划

■ 湖南相关工作

- 《湖南（岳阳）沿江岸线资源评价与总体开发规划》
- 《湖南省临港（城陵矶）经济发展战略研究》

■ 江苏相关工作

- 《江苏省长江岸线开发利用布局总体规划纲要》
- 《江苏省沿江开发总体规划》
- 《南京长江岸线资源综合利用总体规划》
- 《南京段长江文化旅游融合发展概念规划》
- 沿江工业园区选址和岸线开发规划方案

■ 安徽相关工作

- 《安徽省长江岸线保护和开发利用总体规划》
- 《芜湖市长江岸线保护与利用规划》
- 《池州市长江岸线资源开发总体规划》
- 安徽沿江沿江区域规划、皖江城市带规划
- 马鞍山、芜湖、巢湖、安庆等地沿江开发详细规划和岸线综合开发利用规划

■ 上海相关工作

- 《上海市“一江一河”发展“十四五”规划》

■ 举措：工业退、港口移、生态保、生活进

Measures: industrial removal, port relocation, ecological protection and city introduction

案例分类 Case classification		工业码头岸线转型 Shoreline transformation of industrial wharf		自然岸线生态修复 Ecological restoration of natural shoreline
		转型为生态岸线 Transform into ecological shoreline	转型为生活岸线 Transform into life shoreline	
长江岸线 Yangtze River shoreline	城市段 Urban section	南通五山地区和滨江生态修复 Nantong five mountains and riverside ecological restoration	上海杨浦滨江、徐汇滨江等 Riversides of Shanghai Yangpu, Xuhui, etc	南京江北新区绿水湾湿地 Lvshuiwan Wetland of Nanjing Jiangbei New Area
		运河三湾生态文化园 Yunhe Sanwan Ecological Culture Park	南京下关、浦口滨江更新 Riverside renewal of Nanjing Xiaguan and Pukou	江都南水北调源头公园 Jiangdu South Water to North Source Park
			江阴滨江公园建设 Jiangyin Riverside Park Construction	
	郊野段 Suburb section	桥林“春江十里长江”线 Qiaolin "Chunjiang Shili Changjiang River" Line		南京龙袍湿地 Nanjing Longpao Wetland
重要洲岛 Key islands		如皋长青沙生态修复 Rugao Changqingsha ecological restoration		崇明东滩湿地、九段沙湿地 Chongming Dongtan Wetland and Jiuduansha Wetland
				镇江豚类保护区整治修复 Restoration of Zhenjiang Porpoise Reserve
				南京新济洲国家湿地公园 Nanjing New Jeju National Wetland Park
				张江港长江第一湾双山岛生态修复 Ecological restoration of Zhangjiagang Shuangshan Island of No.1 Bay of the Yangtze River

案例1：上海黄浦江全线贯通
Case 1: Full opening of Shanghai Huangpu River

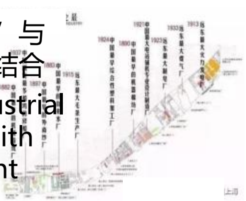
- 2017年，黄浦江两岸45公里岸线公共空间实现全线贯通，成为上海重要的开放空间
- 2017 saw the full opening of the public space along the 45km shoreline on both sides of the Huangpu River, as a key open space in Shanghai
- 从“工业锈带”到“生活秀带”
- From "Industrial Rust Belt" to "Life Show Belt"

智慧型滨江空间
Smart riverside space

从“制造”走向“智造”
From "manufacturing" to "smart manufacturing"

历史感滨江空间
Historic riverside space

将“工业元素”与“后续设计”结合
Combine "industrial elements" with "subsequent design"

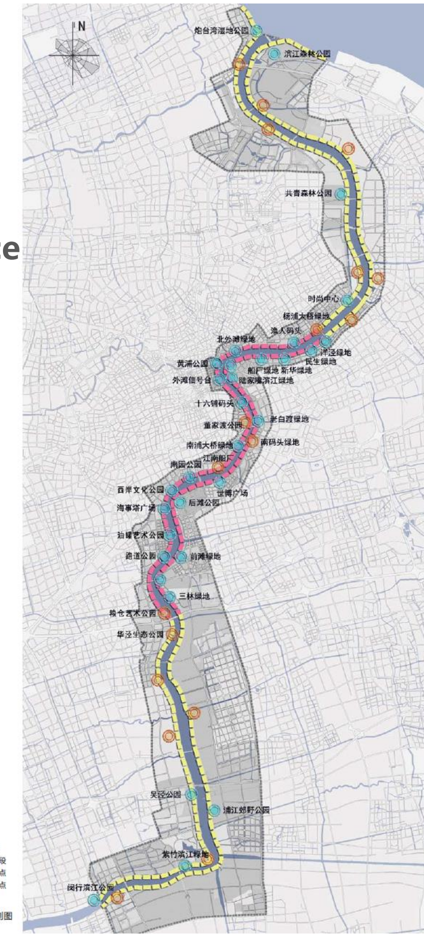


多样性滨江空间
Diversified riverside space

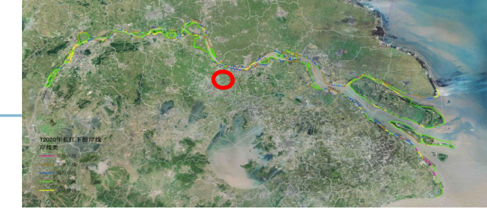
将生活推向水岸
Move the life to the shore

原杨浦滨江
Former Yangpu Riverside

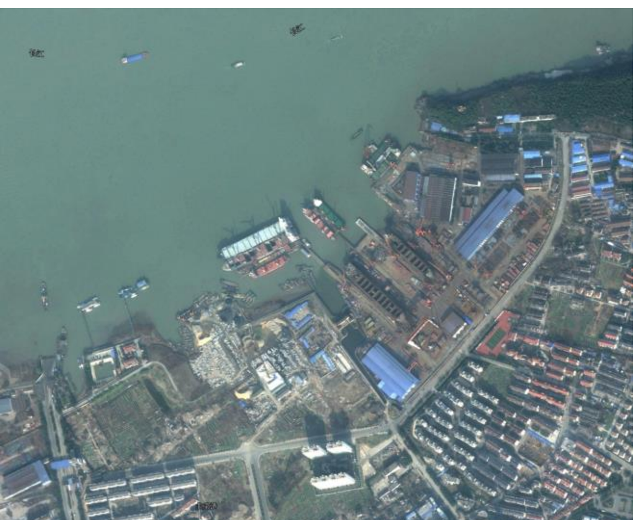
现杨浦滨江公共空间
Current Yangpu Riverside Public Space



案例2：江阴滨江公园片区更新
Case 4: Renewal of Jiangyin Riverside Park



- 2012年前为造船工场和企业码头
- Shipyard and enterprise dock before 2012
- 2013年造船工厂与企业码头退出，向城市生活功能转型
- From shipyards and enterprise dock to urban living functions in 2013
- 开发建设：长江游船码头+城市滨江公园+滨江生活功能区
- Exploitation: Yangtze River cruise dock+urban riverside park+riverside living area



2012年影像图
2012 image

2014年影像图
2014 image

建成实景
Real view after completion

案例3：南京江北新区桥林街道

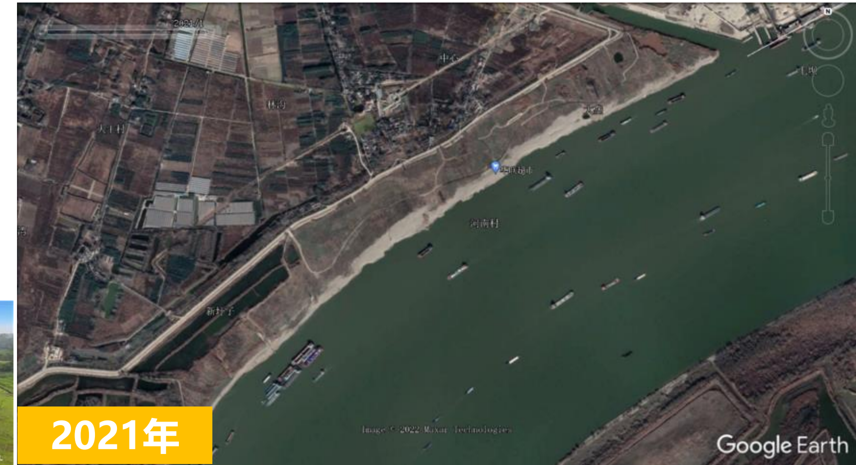
Case 5: Qiaolin sub-district, Nanjing Jiangbei New Area

从“十里造船带”到“春江十里长江”线

From "Shili shipbuilding belt" to "Chunjiang Shili Yangtze River" Line

- 18.9公里长江岸线一度聚集多达47家大小船厂；
- 47 big and small shipyards gathered along the Yangtze River of 18.9km;
- 环境隐忧逐渐显现：最直观的感受是看不到江豚了；
- Emerging environmental worries: disappearing finless porpoise is the most intuitive
- 2018年浦口区启动十里造船带整治工作，拆除造船厂岸线全面生态修复；
- Pukou District renovated the Shili Shipbuilding Belt and demolished shipyards for comprehensive ecological restoration of the shoreline in 2018;

- 累计拆除龙门吊等机械设备300余套,建筑物13万平方米
- Removed more than 300 gantry cranes, mechanical equipment and buildings of 130,000 m²
- 清除水泥、砂石地坪等150万平方米
- Removed cement, sand and gravel floors of 1.5 million m²
- 复绿面积约150万平方米，恢复生态岸线约11公里
- Recovered greening area of about 1.5 million m² and the ecological shoreline of about 11 km



■ 思考与建议 Considerations and recommendations

河流沿线空间组织十分关键，具有持久的重要性。倡导河流岸线沿线土地留白，为未来的适用性举措提供战略灵活性，提升流域安全水平。

Spatial organization along river lines is critical and of lasting importance. We should advocate for non-use of land along river shorelines to provide strategic flexibility for future applicability measures and improve the security level of the River Basin.

树立"水陆共治"理念，加强岸线整体管控和水陆域协同管理。系统开展岸线资源评价，统筹岸线资源配置，建立"水域-岸线-陆域空间"的协同管理机制；加强涉水部门的统筹协调，探索实行岸线资源开发利用部门联审，避免水陆分割。

Establish the concept of "co-management of water and land", and strengthen the overall management and control of the shoreline and the coordinated management of water and land areas. Carry out shoreline resource evaluation systematically, coordinate the allocation of shoreline resources, and establish a collaborative management mechanism of "water-shoreline-land space"; strengthen the overall coordination of water-related departments, and explore the implementation of joint review of shoreline resource development and utilization departments to avoid separation of land and water development and utilization.

制定政策推动岸线保护与更新，提高生态与城市生活岸线比例。建立综合效益评估机制，退出低效污染岸线；建立自然岸线和生态空间保护修复鼓励机制；建立推动滨水城市更新增加公共空间的机制。

Formulate policies to promote shoreline protection and renewal, and increase the proportion of ecological and urban life shorelines. Establish a comprehensive benefit assessment mechanism to withdraw from low-efficiency polluted shorelines; establish an incentive mechanism for the protection and restoration of natural shorelines and ecological spaces; and establish a mechanism to promote the renewal of waterfront cities and the increase of public space.

Derek Hoeferlin

This presentation is a preview of a forthcoming book:

Way Beyond Bigness: The Need for a Watershed Architecture, ORO Editions.

http://watershed-architecture.com/home

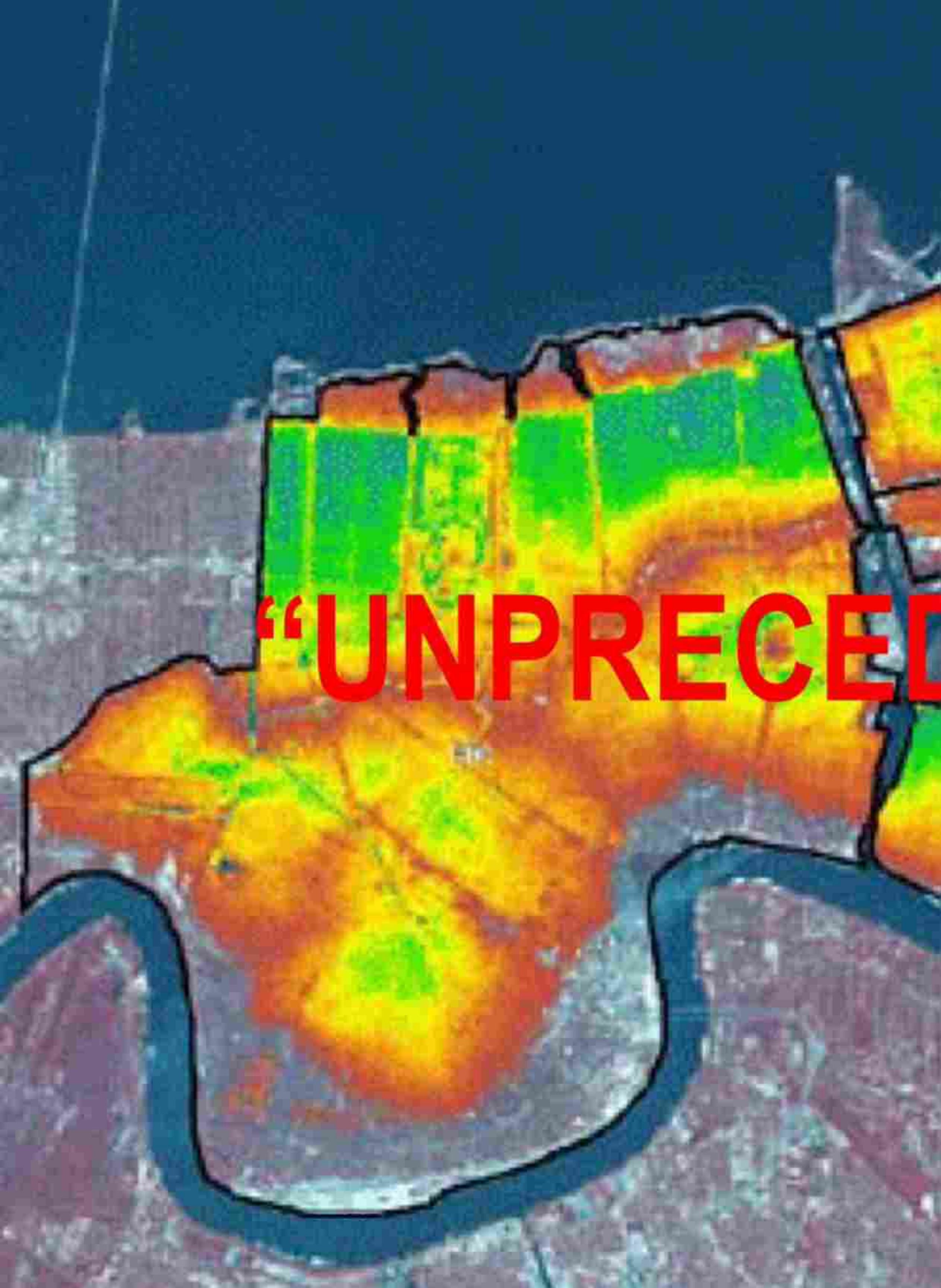
Water Systems and Port Economies in Times of Climate Change: Rhine, Yangtze and Mississippi

Derek Hoeferlin
Washington University in St. Louis
[dhd] derek hoeferlin design

"Mississippi River Basin & Delta"
12 October 2022
Rotterdam, Netherlands

IT TOOK A “NATURAL” DISASTER TO BUILD A $14.5 BILLION WALL

IHNC Lake Borgne Surge Barrier, Louisiana (Image courtesy Waggonner & Ball)


“UNPRECED

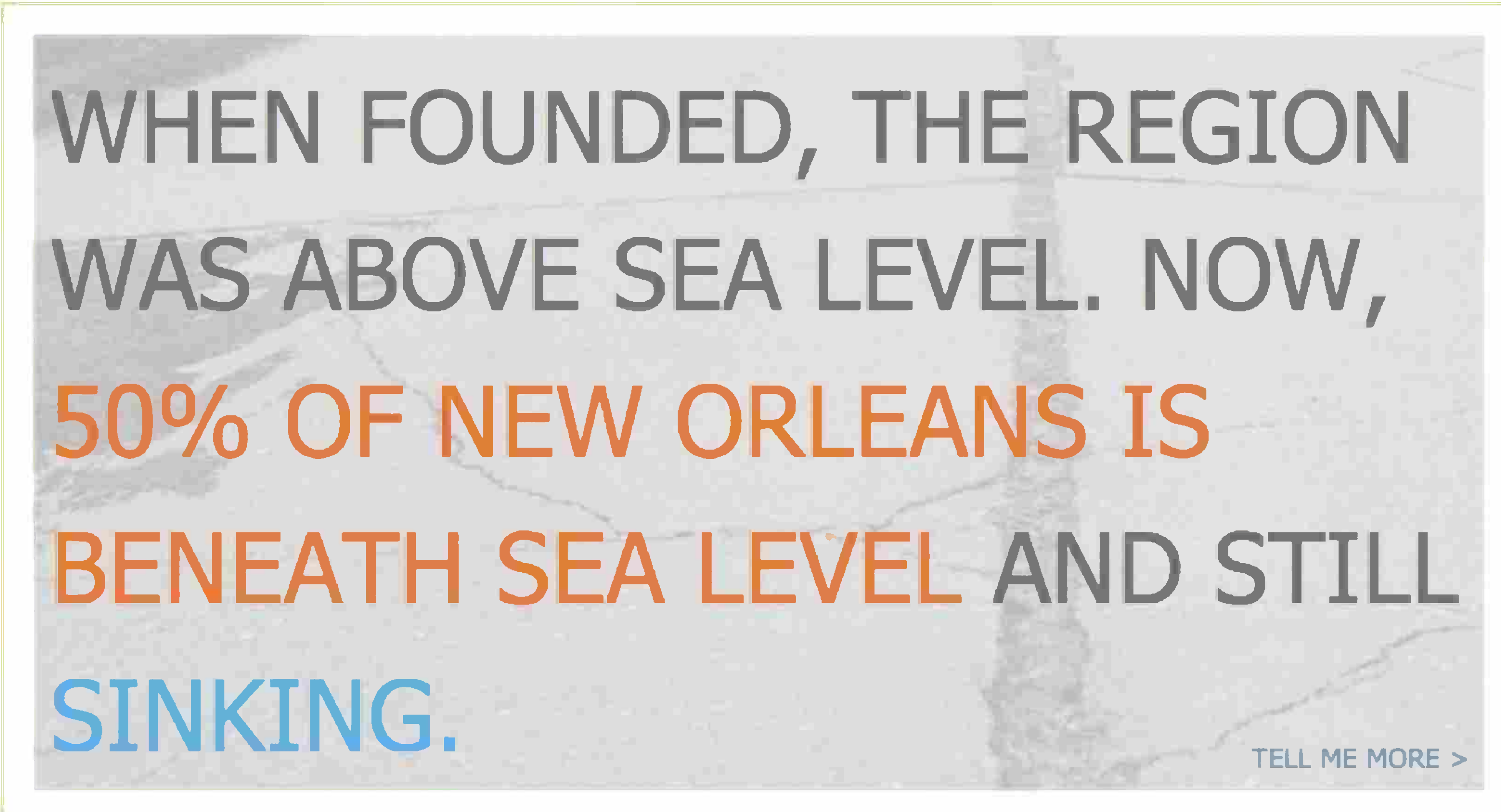

DENTED"
Image courtesy NOAA

Image courtesy H3 Studio, Inc.

New Orleans, Louisiana, 2005

New Orleans, Louisiana, 2005

New Orleans, Louisiana, 2005



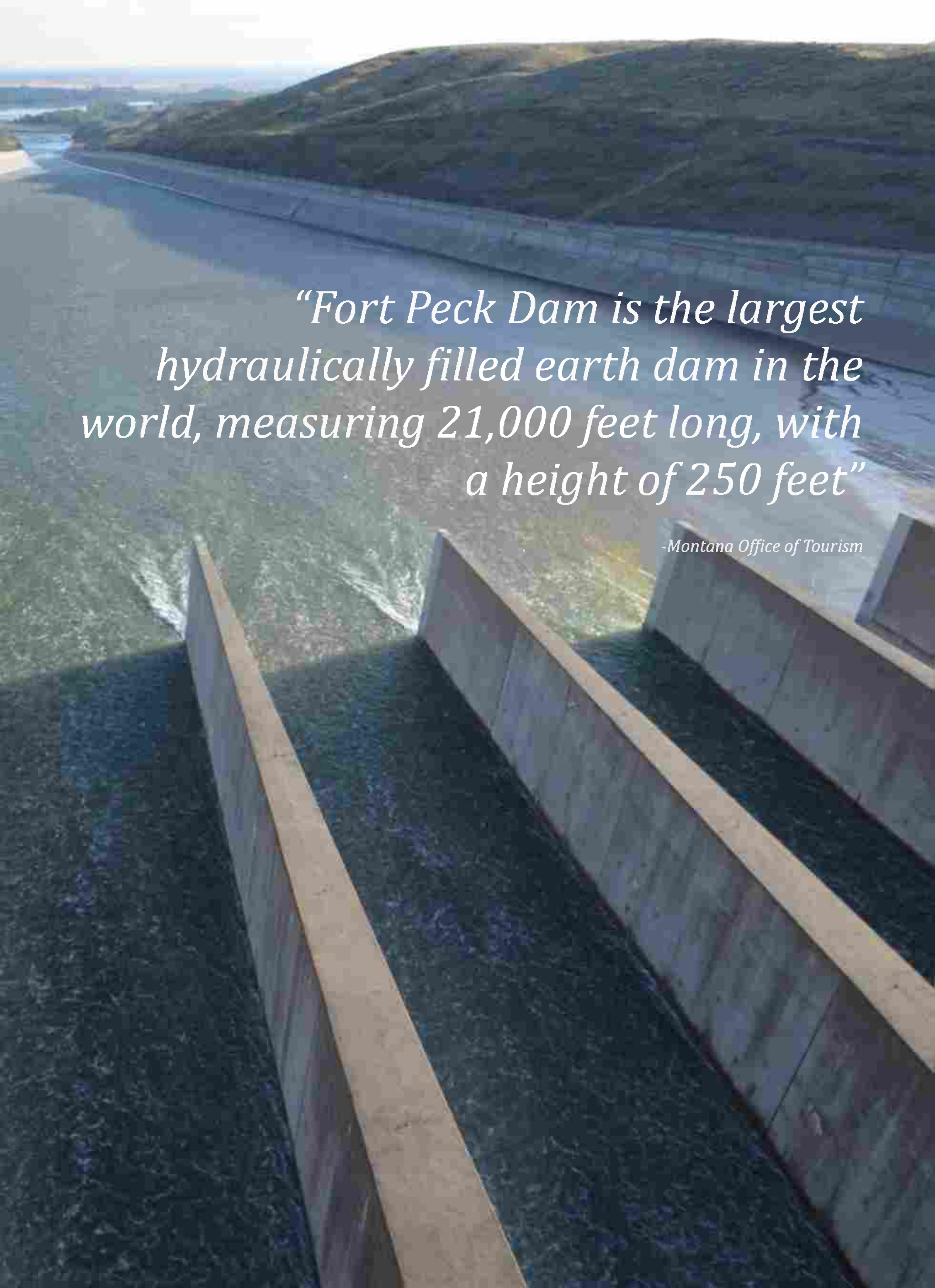
Gutter to Gulf, Washington University in St. Louis/University of Toronto, 2010

St. Bernard Parish, Louisiana, 2012

~ sea level
(wild boars, pelicans, alligators)

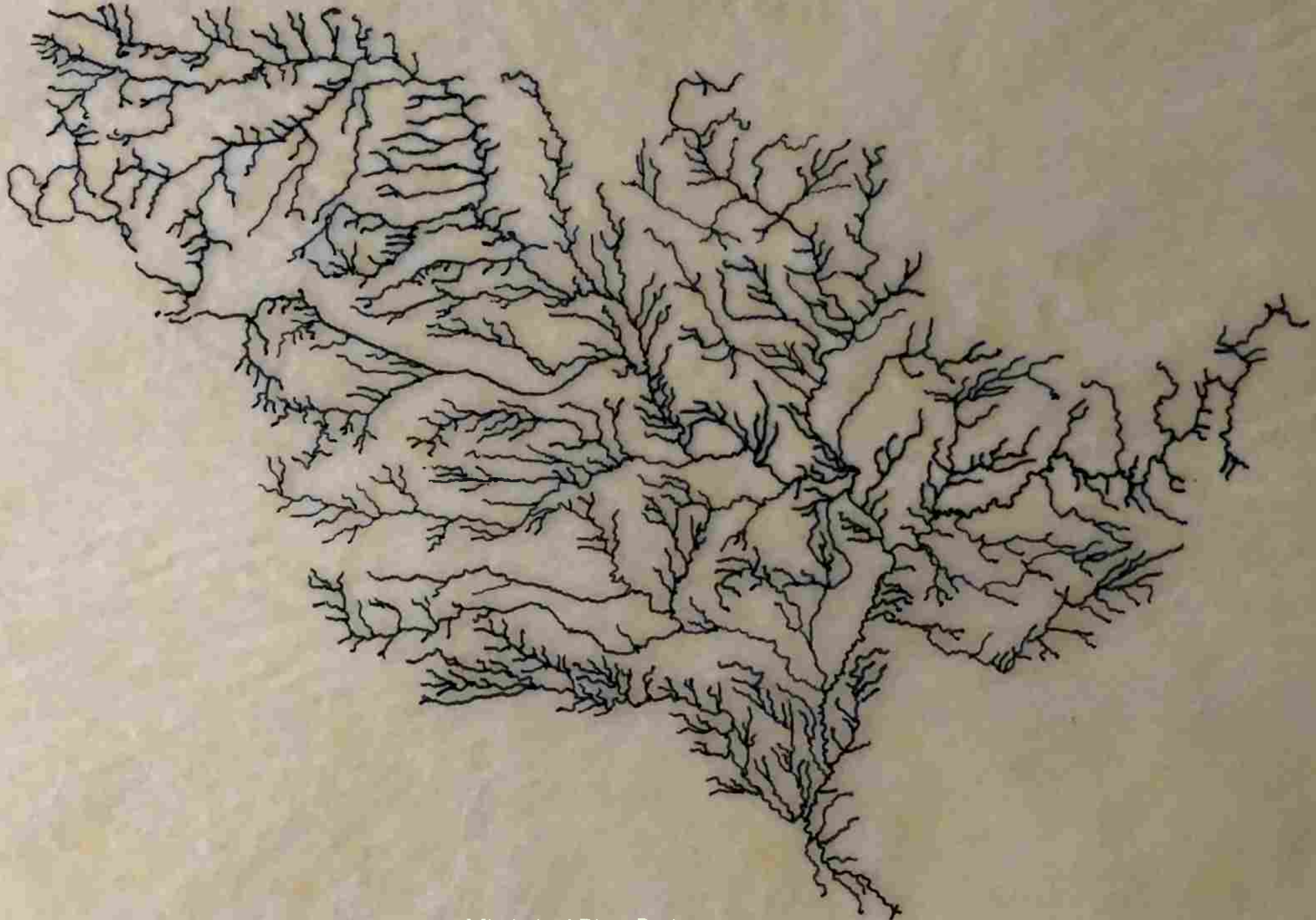
- 6 feet below sea level
(humans, cars)

St. Bernard Parish, Louisiana, 2012



"Fort Peck Dam is the largest hydraulically filled earth dam in the world, measuring 21,000 feet long, with a height of 250 feet"

-Montana Office of Tourism



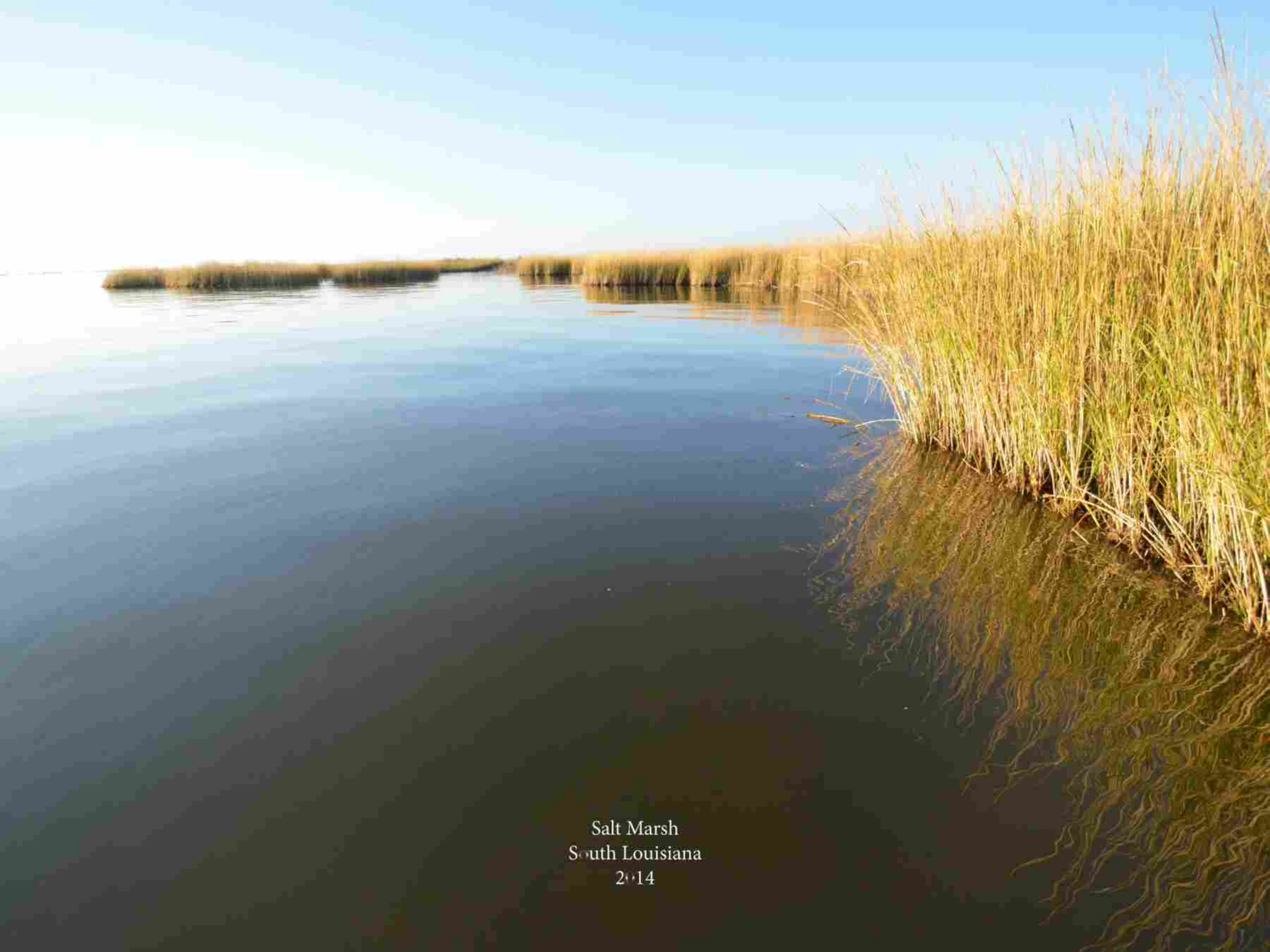
Mississippi River Basin
rivers + streams
2000

Mobile Oil Drilling Platform
Louisiana Delta
2014

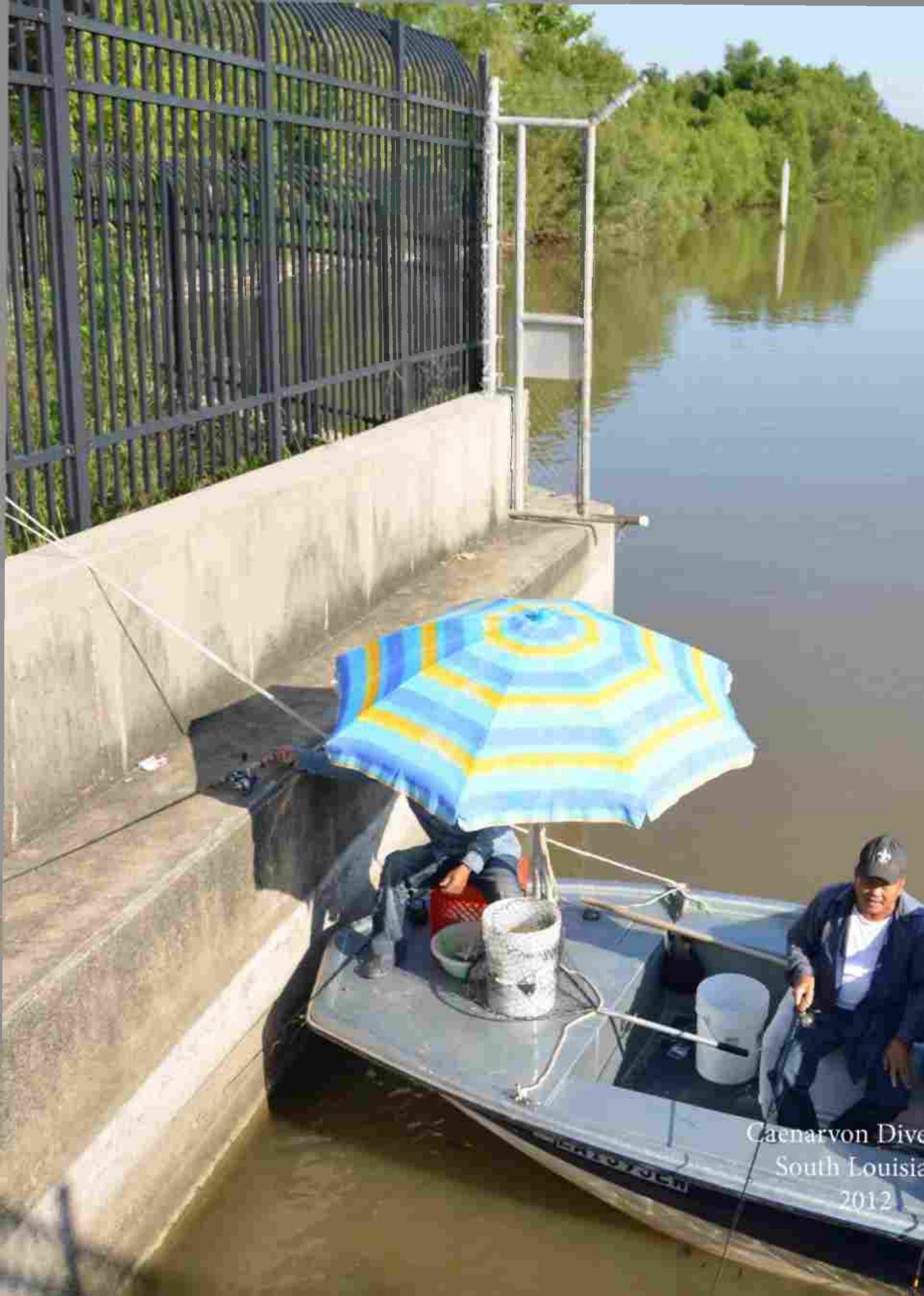

BP Oil Spill Cleanup
Grand Isle, Louisiana
2010


BP Oil
Grand

Spill Cleanup
sle, Louisiana
2010



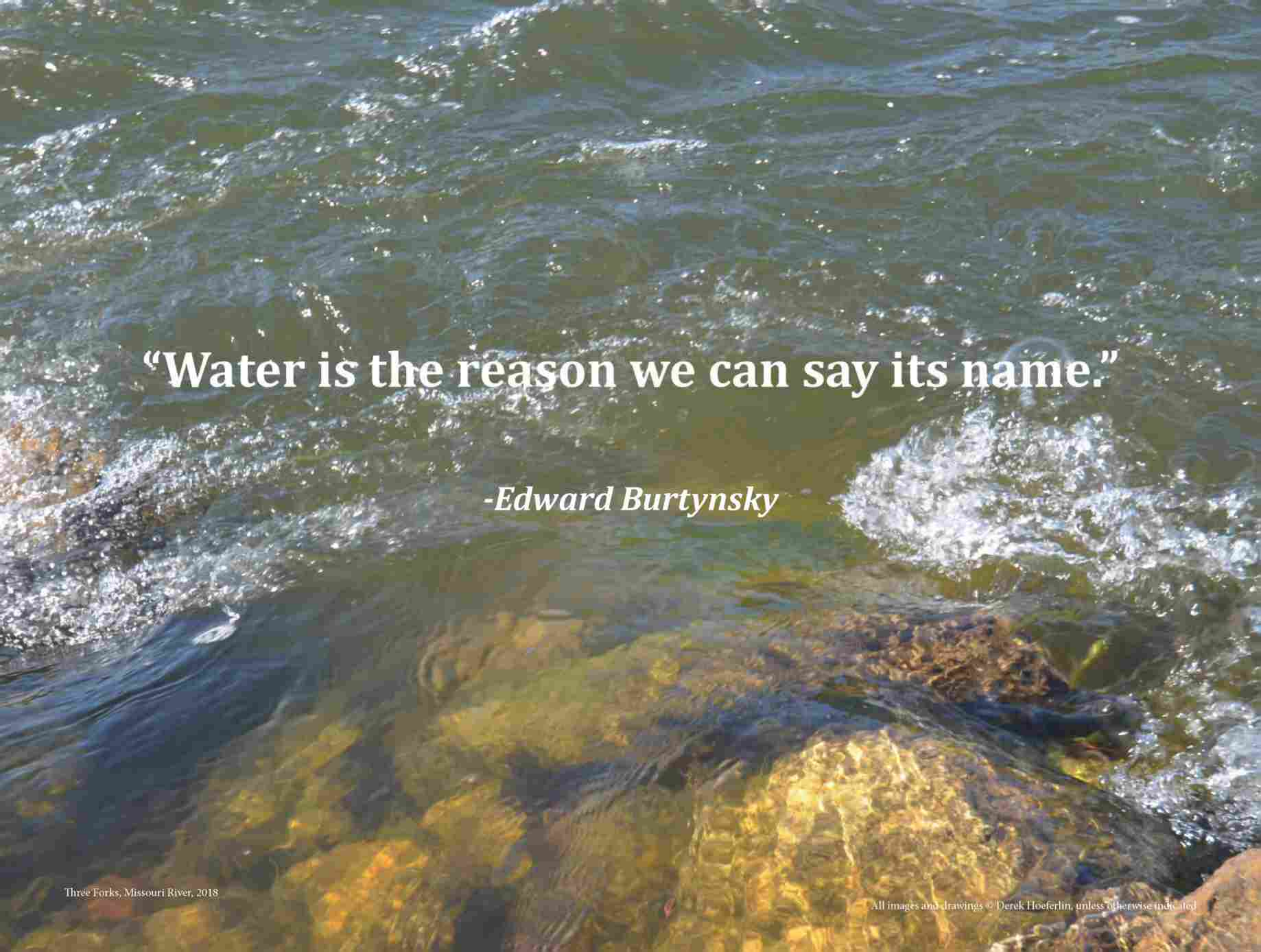
Salt Marsh
South Louisiana
2014



Caenarvon Dive
South Louisia
2012

ersion
ına

Shell Beach
St. Bernard Parish, Louisiana
2011

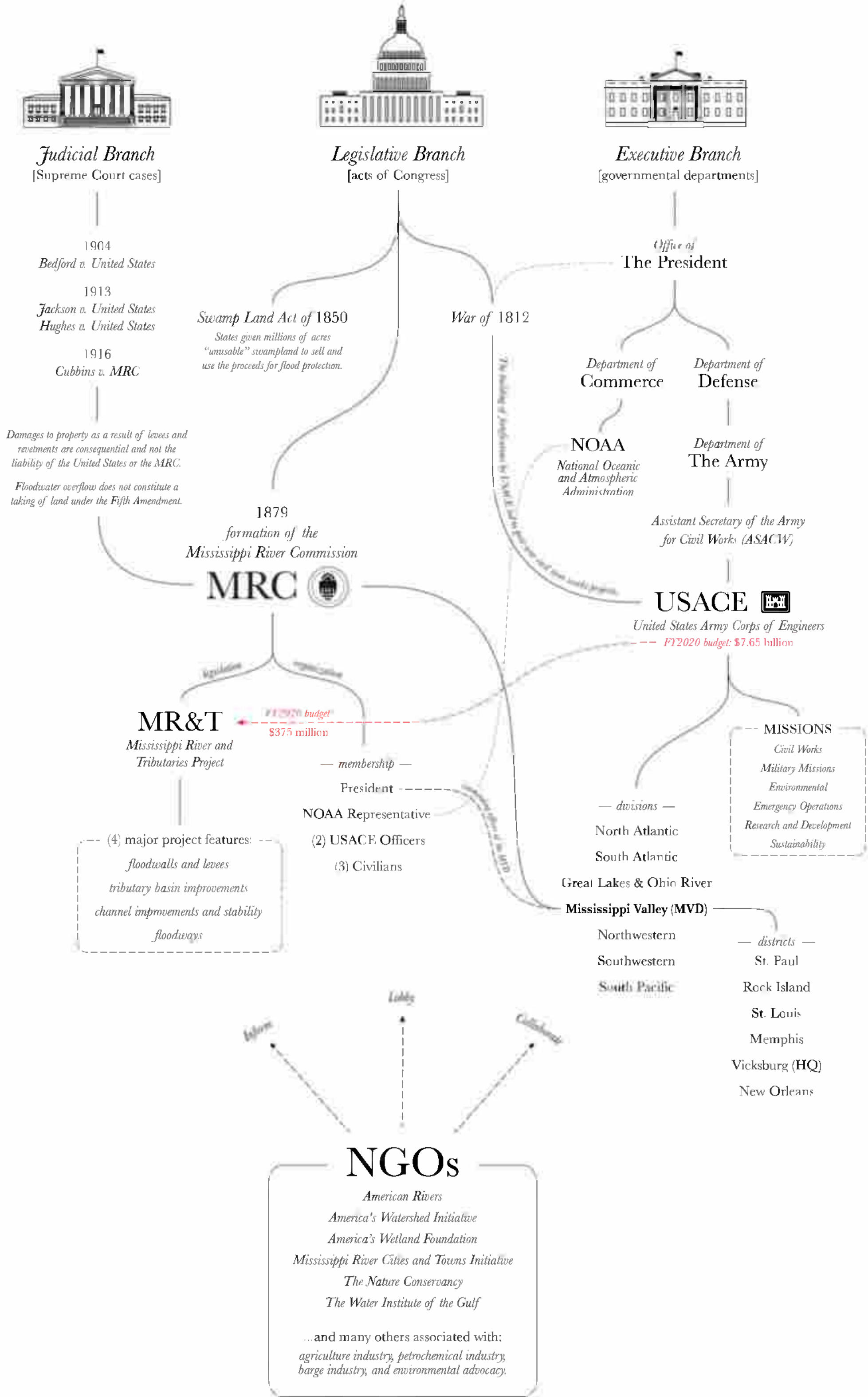


Three Forks, Missouri River, 2018

Mississippi River Flood
St. Louis, Missouri
2011


US Army Corps
of Engineers

elvin Price Locks & Dam
Alton, Illinois
2017



Judicial Branch
[Supreme Court cases]
1904
Bedford v. United States
1913
Jackson v. United States
Hughes v. United States
1916
Cubbins v. MRC
Damages to property as a result of levees and revetments are consequential and not the liability of the United States or the MRC.
Floodwater overflow does not constitute a taking of land under the Fifth Amendment.
Legislative Branch
[acts of Congress]
Swamp Land Act of 1850
States given millions of acres "unusable" swampland to sell and use the proceeds for flood protection.
War of 1812
1879
formation of the
Mississippi River Commission
MRC
Executive Branch
[governmental departments]
Office of
The President
Department of
Commerce
Department of
Defense
NOAA
National Oceanic and Atmospheric Administration
Department of
The Army
Assistant Secretary of the Army for Civil Works (ASACW)
USACE
United States Army Corps of Engineers
FY2020 budget: $7.65 billion
MR&T
Mississippi River and Tributaries Project
budget
$375 million
— membership —
President
NOAA Representative
(2) USACE Officers
(3) Civilians
(4) major project features:
floodwalls and levees
tributary basin improvements
channel improvements and stability
floodways
MISSIONS
Civil Works
Military Missions
Environmental
Emergency Operations
Research and Development
Sustainability
— divisions —
North Atlantic
South Atlantic
Great Lakes & Ohio River
Mississippi Valley (MVD)
Northwestern
Southwestern
South Pacific
— districts —
St. Paul
Rock Island
St. Louis
Memphis
Vicksburg (HQ)
New Orleans
NGOs
American Rivers
America's Watershed Initiative
America's Wetland Foundation
Mississippi River Cities and Towns Initiative
The Nature Conservancy
The Water Institute of the Gulf
...and many others associated with:
agriculture industry, petrochemical industry, barge industry, and environmental advocacy.

USACE
United States Army Corps of Engineers

DIVISIONS & DISTRICTS

Divisions —— *Districts*

NORTH ATLANTIC

New England District
New York District
Philadelphia District
Baltimore District
Norfolk District

SOUTH ATLANTIC

Charleston District
Wilmington District
Savannah District
Mobile District
Jacksonville District

GREAT LAKES & OHIO RIVER

Detroit District
Chicago District
Buffalo District
Pittsburgh District
Huntington District
Louisville District
Nashville District

MISSISSIPPI VALLEY

St. Paul District
Rock Island District
St. Louis District
Memphis District
Vicksburg District (HQ)
New Orleans District

NORTHWESTERN

Seattle District
Portland District
Walla Walla District
Omaha District
Kansas City District

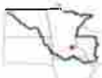
SOUTHWESTERN

Little Rock District
Tulsa District
Fort Worth District
Galveston District

SOUTH PACIFIC

San Francisco District
Sacramento District
Los Angeles District
Albuquerque District

MISSISSIPPI VALLEY DIVISION → MRC
Mississippi River Commission



ST. PAUL DISTRICT
5 states
139,000 square land miles
243.6 miles of Mississippi River navigation channel
13 locks & dams (on the Mississippi)

ROCK ISLAND DISTRICT
5 states
78,000 square land miles
314 miles of Mississippi River navigation channel
12 locks & dams (on the Mississippi)

ST. LOUIS DISTRICT
2 states
28,000 square land miles
300 miles of Mississippi River navigation channel
4 locks & dams (on the Mississippi)

MEMPHIS DISTRICT
6 states
25,000 square land miles
355 miles of Mississippi River navigation channel
1 spillway (on the Mississippi)

VICKSBURG DISTRICT (HQ)
3 states
68,000 square land miles
278 miles of Mississippi River navigation channel

NEW ORLEANS DISTRICT
1 state
~20,000 square land miles (delta ever-changing)
400 miles of Mississippi River navigation channel
2 spillways (on the Mississippi)

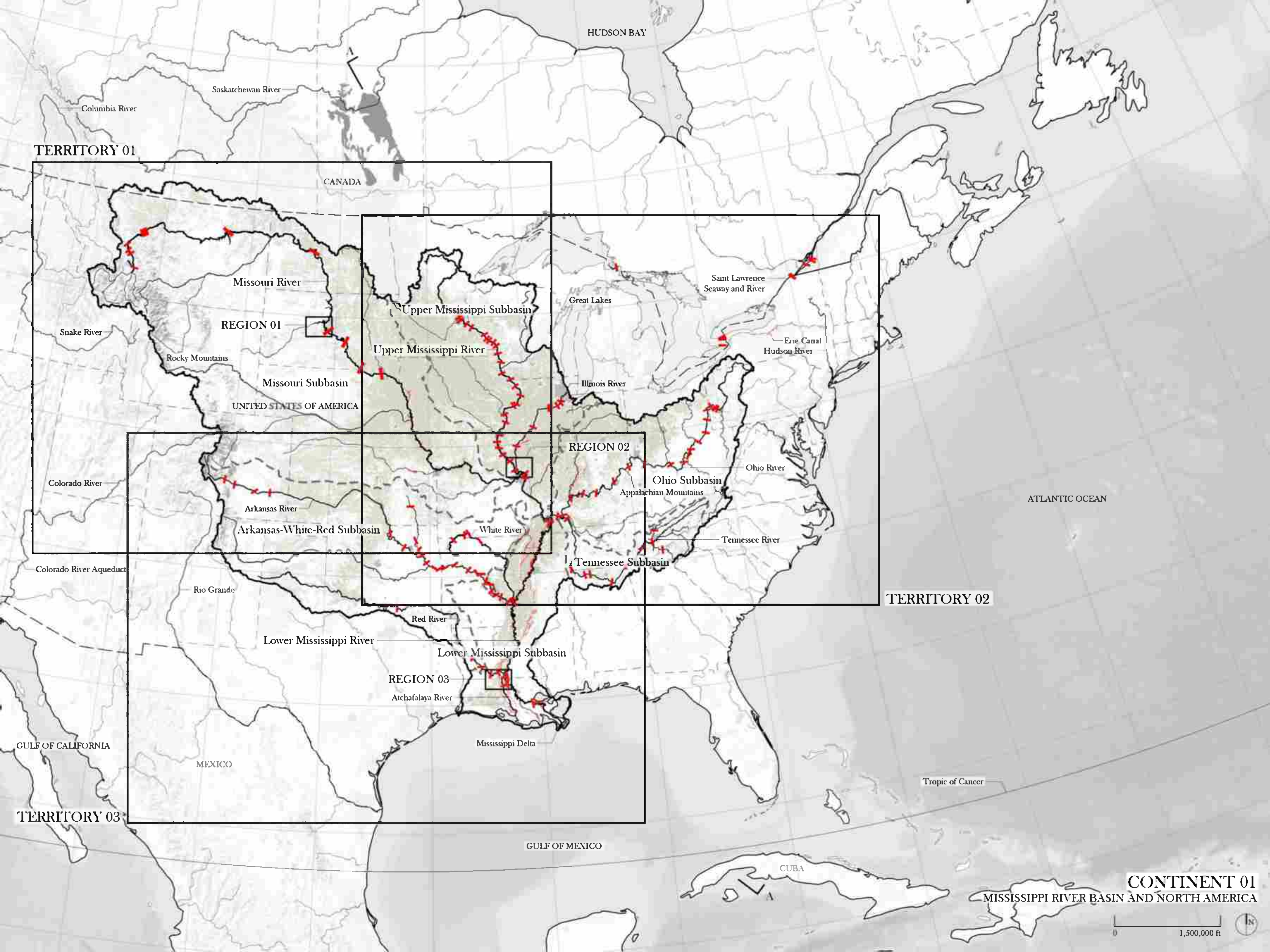
Mississippi River Basin & the World

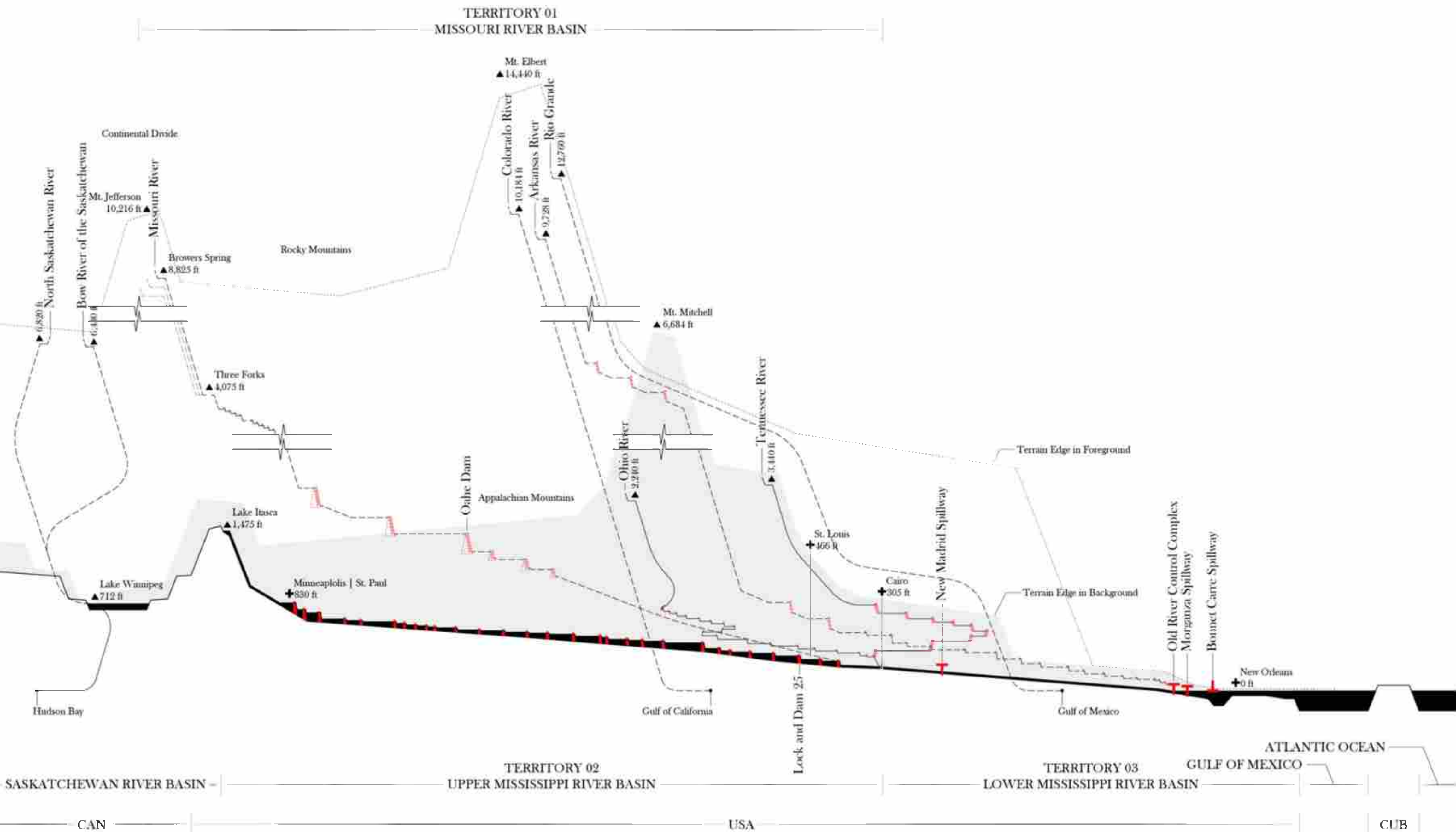
Quoting Colin Wellenkamp, the executive director of the Mississippi River Cities and Towns Initiative:

"Forty percent of the world's food supply comes out of the Mississippi River Basin. An additional forty percent of all United States agricultural output from coast to coast moves up and down the river. One in every twelve human beings on Earth ingests commodities made in the Mississippi River Basin. Eighty percent of what is grown in the Mississippi River Basin goes overseas. If you wanted to destroy or otherwise compromise the globe's food web, shut down the Mississippi River and it could collapse."

Continent 01: Mississippi River Basin & North America

Water Intake Towers, Mississippi River at flood stage at Chain of Rocks, St. Louis, Missouri, 2013

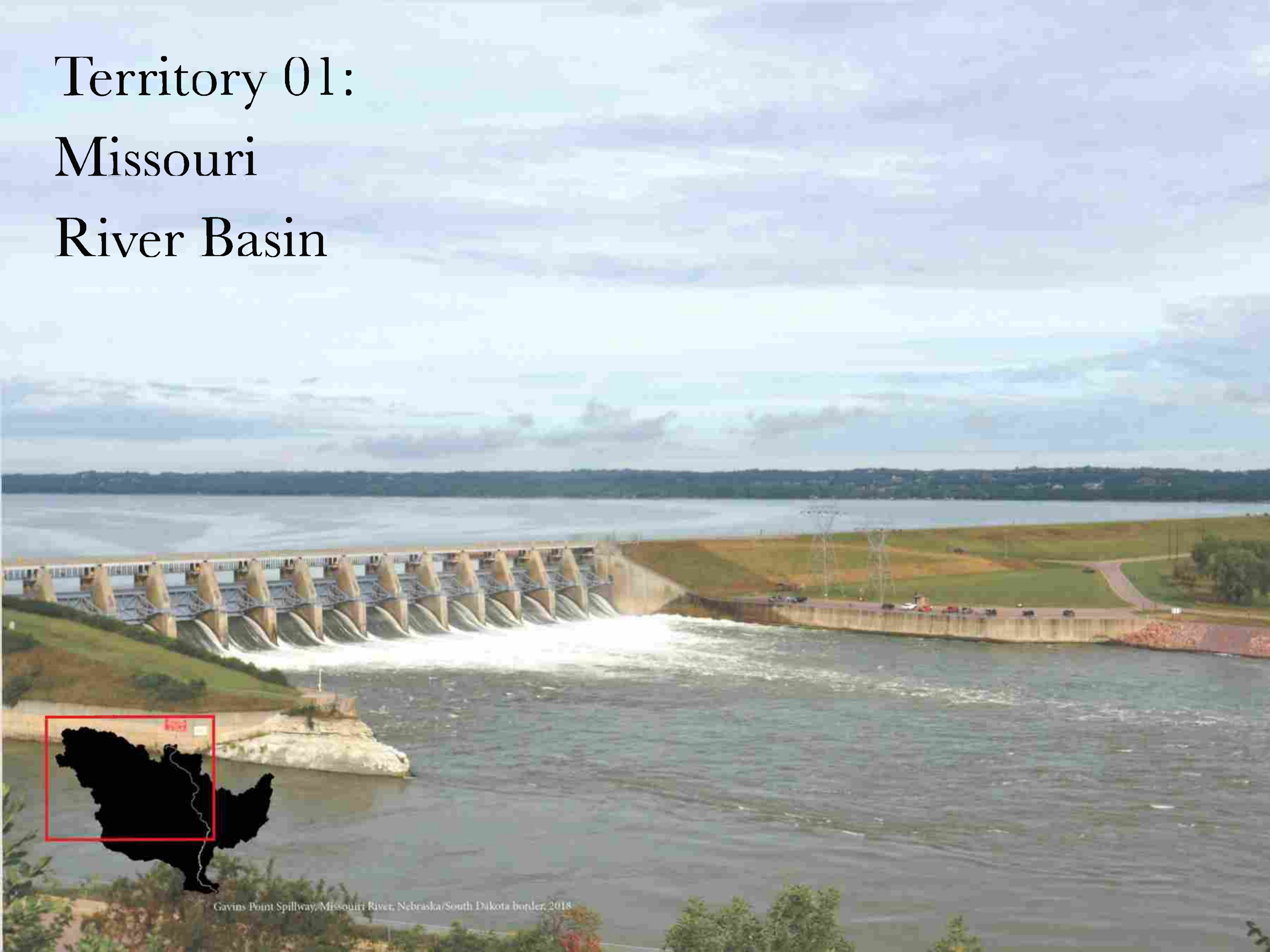

HUDSON BAY
Saskatchewan River
Columbia River
TERRITORY 01
CANADA
Missouri River
REGION 01
Snake River
Rocky Mountains
Missouri Subbasin
UNITED STATES OF AMERICA
Upper Mississippi Subbasin
Upper Mississippi River
Great Lakes
Saint Lawrence Seaway and River
Erie Canal
Hudson River
Illinois River
REGION 02
Ohio River
Ohio Subbasin
Appalachian Mountains
ATLANTIC OCEAN
Colorado River
Arkansas River
Arkansas-White-Red Subbasin
White River
Tennessee River
Tennessee Subbasin
TERRITORY 02
Colorado River Aqueduct
Rio Grande
Red River
Lower Mississippi River
Lower Mississippi Subbasin
REGION 03
Atchafalaya River
Mississippi Delta
GULF OF CALIFORNIA
MEXICO
Tropic of Cancer
TERRITORY 03
GULF OF MEXICO
CUBA
A
CONTINENT 01
MISSISSIPPI RIVER BASIN AND NORTH AMERICA
0
1,500,000 ft
N



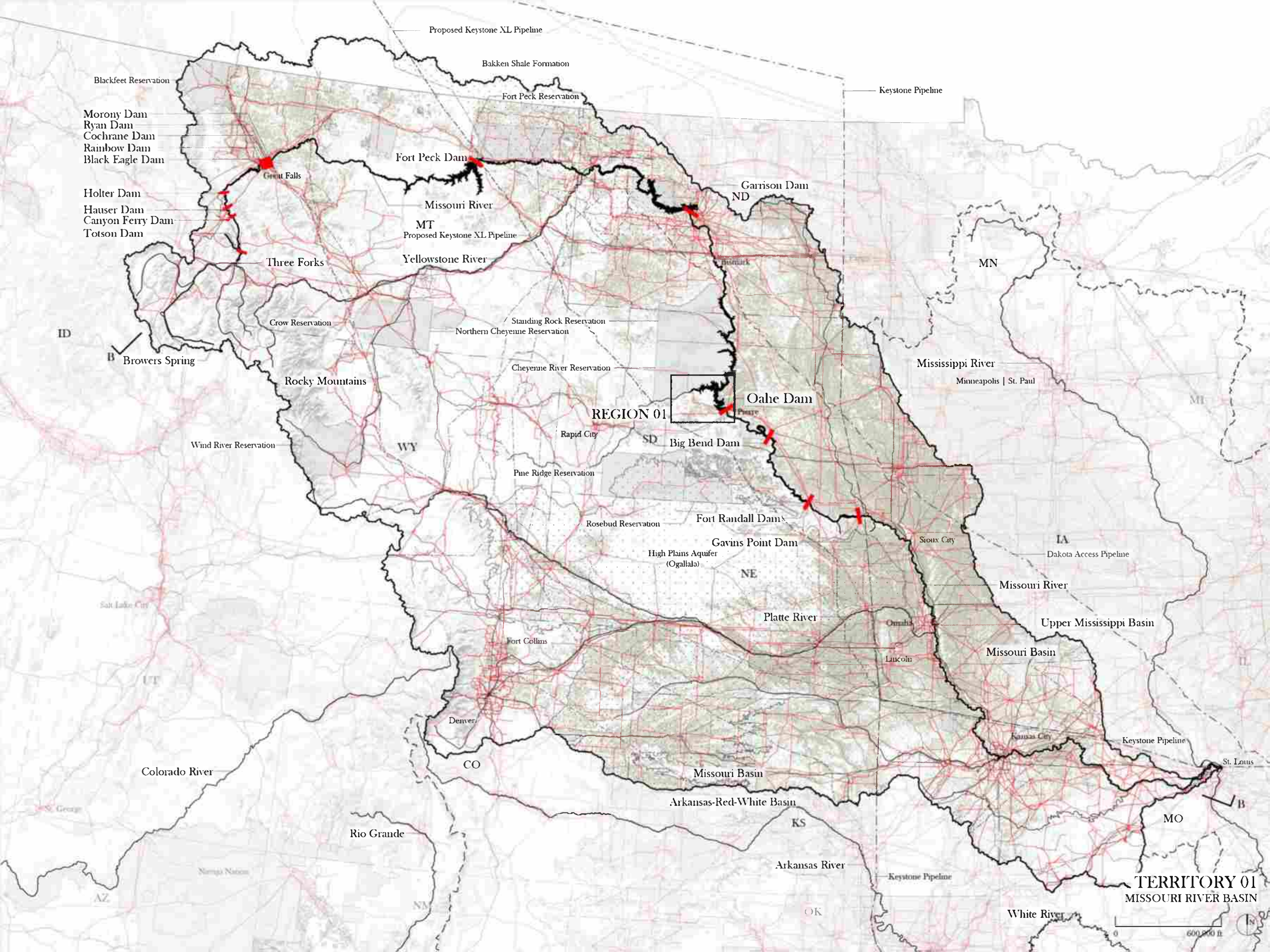
SECTION A-A

FOLLOWING THE PATH OF THE MISSISSIPPI RIVER

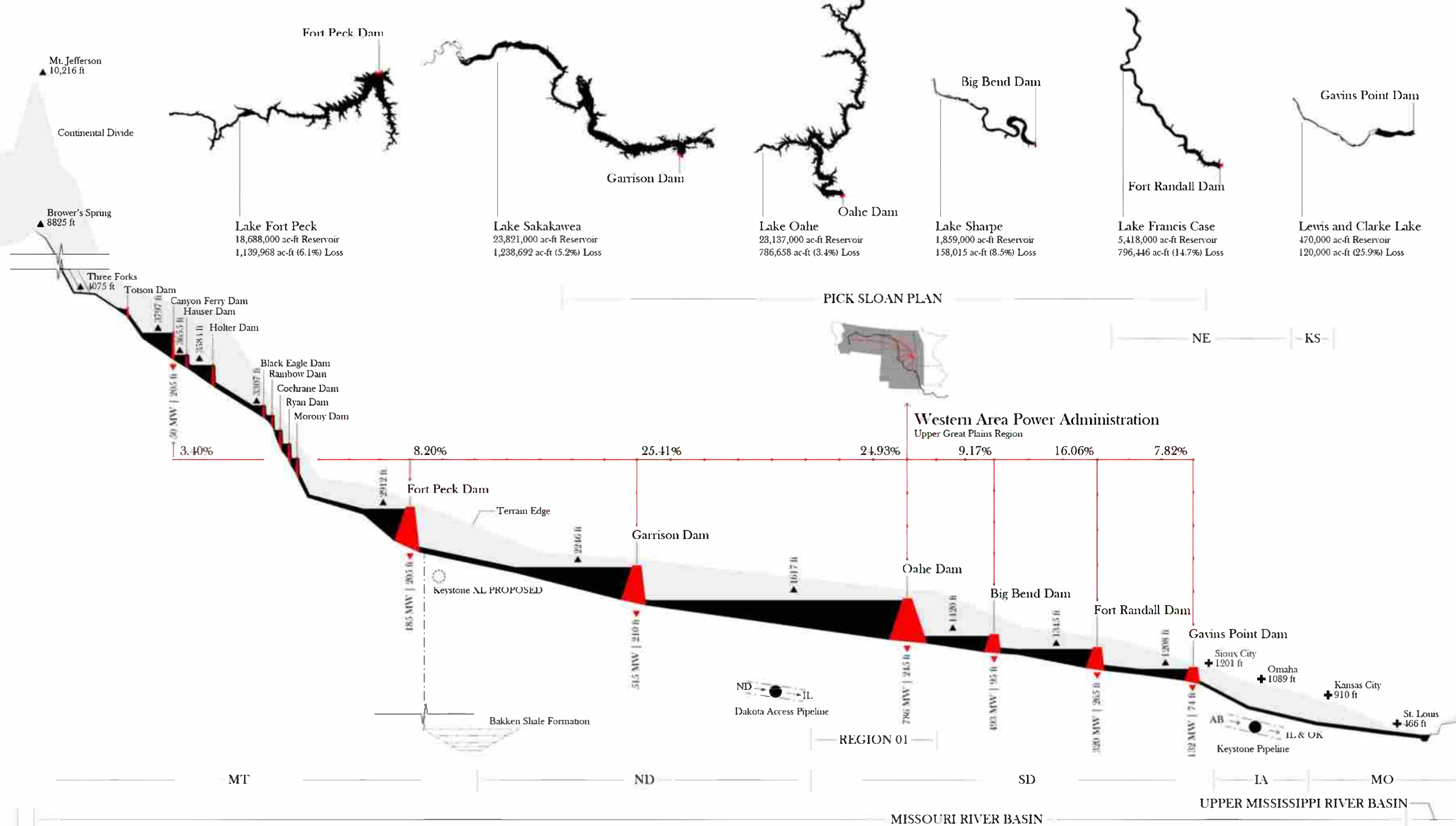
Territory 01: Missouri River Basin



Gavins Point Spillway, Missouri River, Nebraska/South Dakota border, 2018

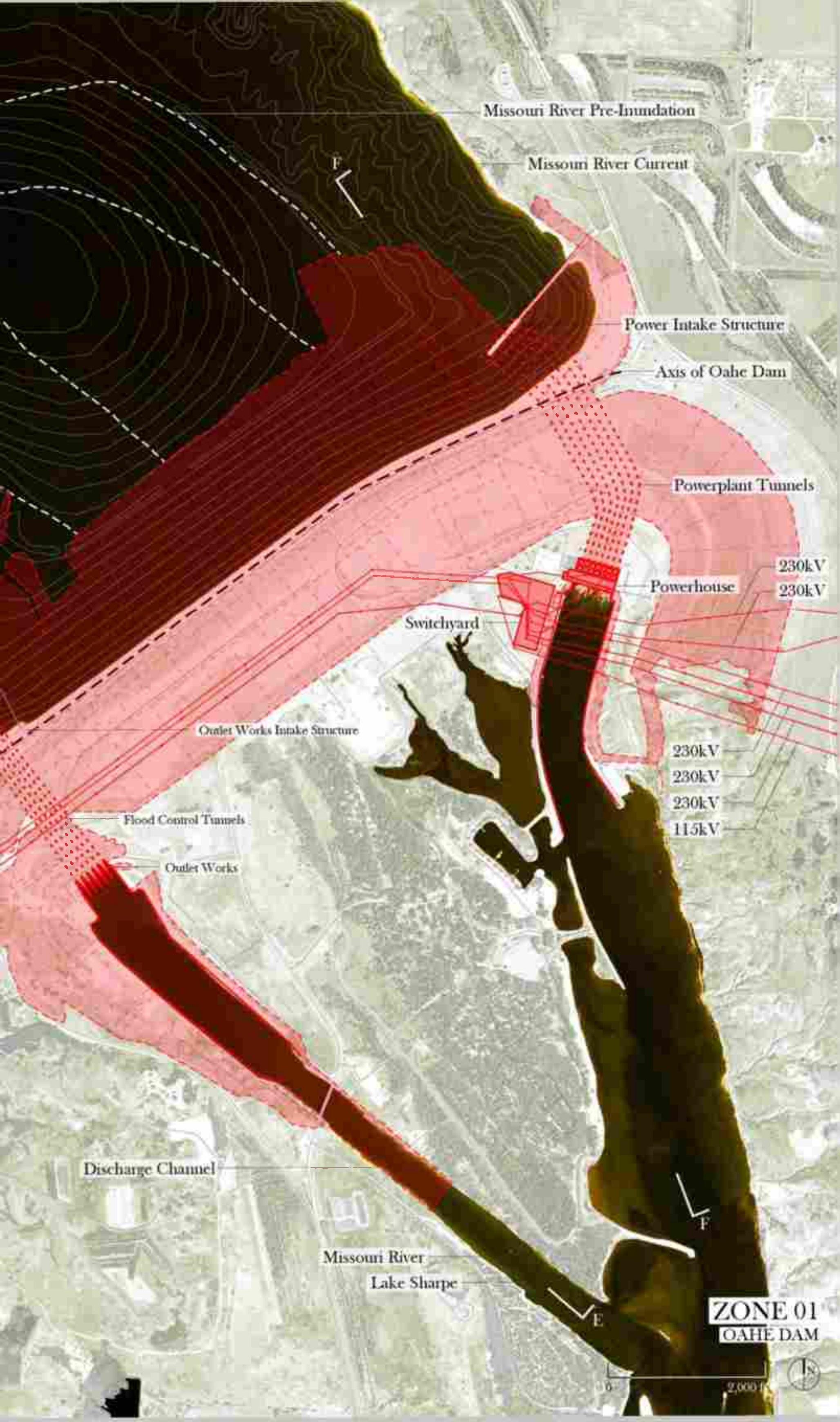


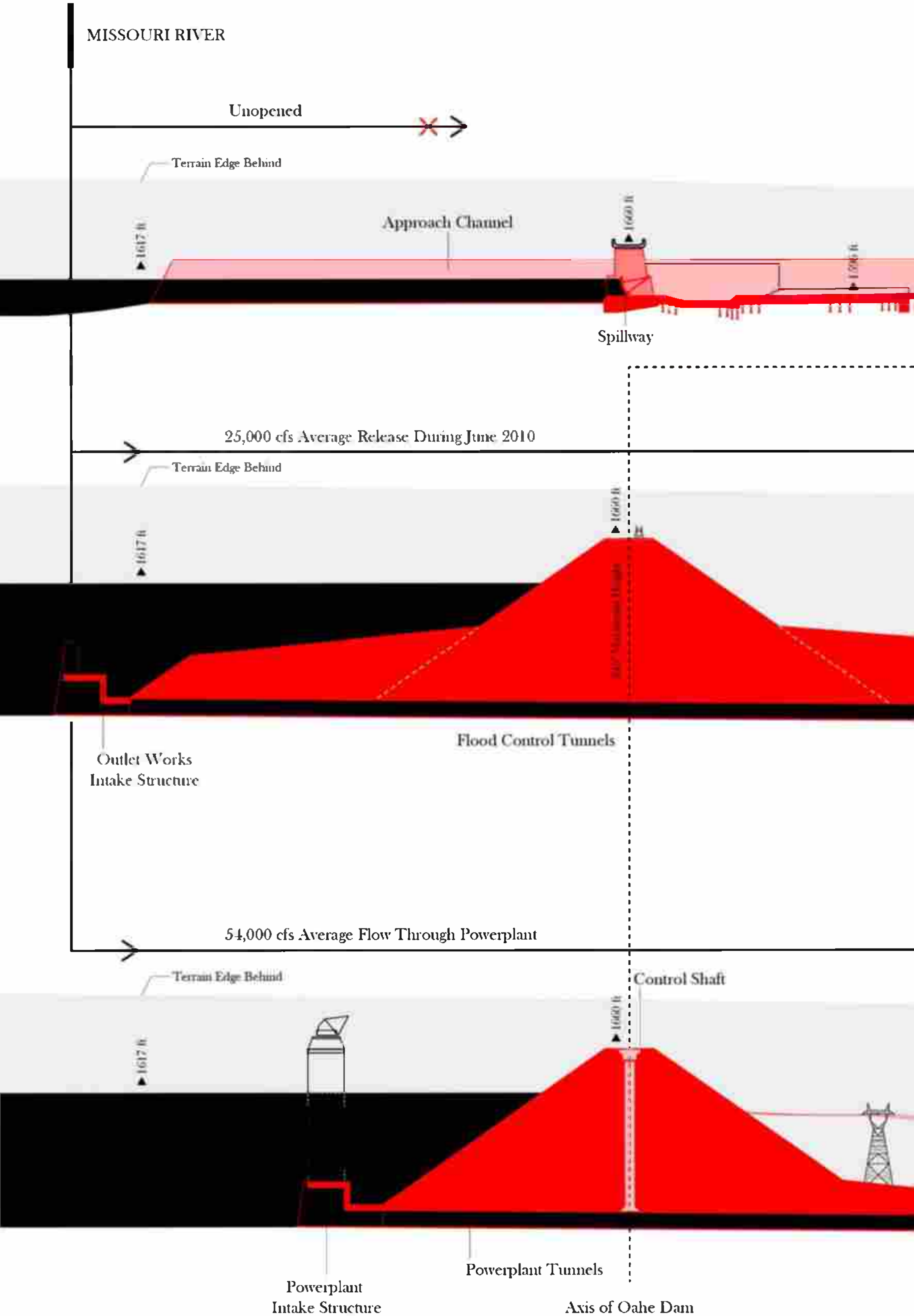
Proposed Keystone XL Pipeline
Bakken Shale Formation
Blackfeet Reservation
Fort Peck Reservation
Keystone Pipeline
Morony Dam
Ryan Dam
Cochrane Dam
Rainbow Dam
Black Eagle Dam
Great Falls
Fort Peck Dam
Garrison Dam
ND
Holter Dam
Hauser Dam
Canyon Ferry Dam
Totson Dam
Missouri River
MT
Proposed Keystone XL Pipeline
Three Forks
Yellowstone River
Bismark
MN
Crow Reservation
Standing Rock Reservation
Northern Cheyenne Reservation
ID
B
Browers Spring
Mississippi River
Cheyenne River Reservation
Minneapolis | St. Paul
Rocky Mountains
Oahe Dam
REGION 01
Pierre
Wind River Reservation
Rapid City
SD
Big Bend Dam
WY
Pine Ridge Reservation
Rosebud Reservation
Fort Randall Dams
Sioux City
IA
Gavins Point Dam
High Plains Aquifer (Ogallala)
Dakota Access Pipeline
NE
Missouri River
Platte River
Omaha
Upper Mississippi Basin
Salt Lake City
Fort Collins
Missouri Basin
Lincoln
UT
Denver
Kansas City
Keystone Pipeline
Colorado River
CO
Missouri Basin
St. Louis
Arkansas-Red-White Basin
B
KS
MO
Rio Grande
Arkansas River
Keystone Pipeline
TERRITORY 01
MISSOURI RIVER BASIN
AZ
NM
OK
White River
0
600,000 ft

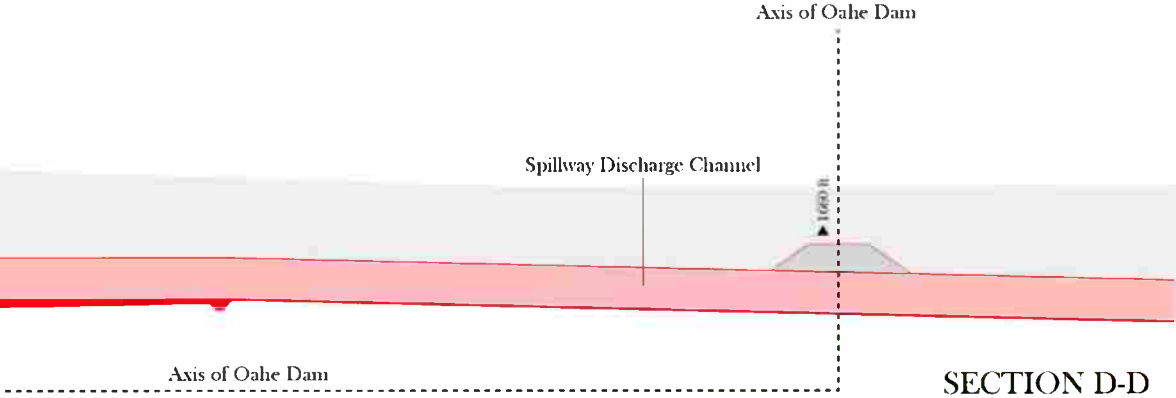


SECTION B-B
FOLLOWING THE PATH OF THE MISSOURI RIVER

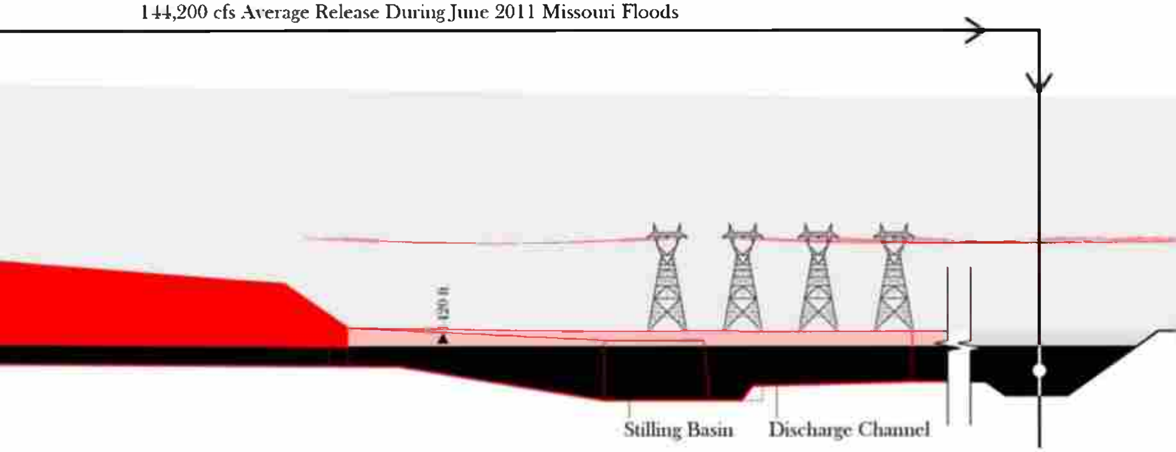
D
Lake Oahe
E
Approach Channel
Spillway
115kV
115kV
Spillway Discharge Channel
230kV
D


Missouri River Pre-Inundation
Missouri River Current
F
Power Intake Structure
Axis of Oahe Dam
Powerplant Tunnels
230kV
230kV
Powerhouse
Switchyard
Outlet Works Intake Structure
230kV
230kV
230kV
115kV
Flood Control Tunnels
Outlet Works
Discharge Channel
F
Missouri River
Lake Sharpe
E
ZONE 01
OAHE DAM
0
2,000

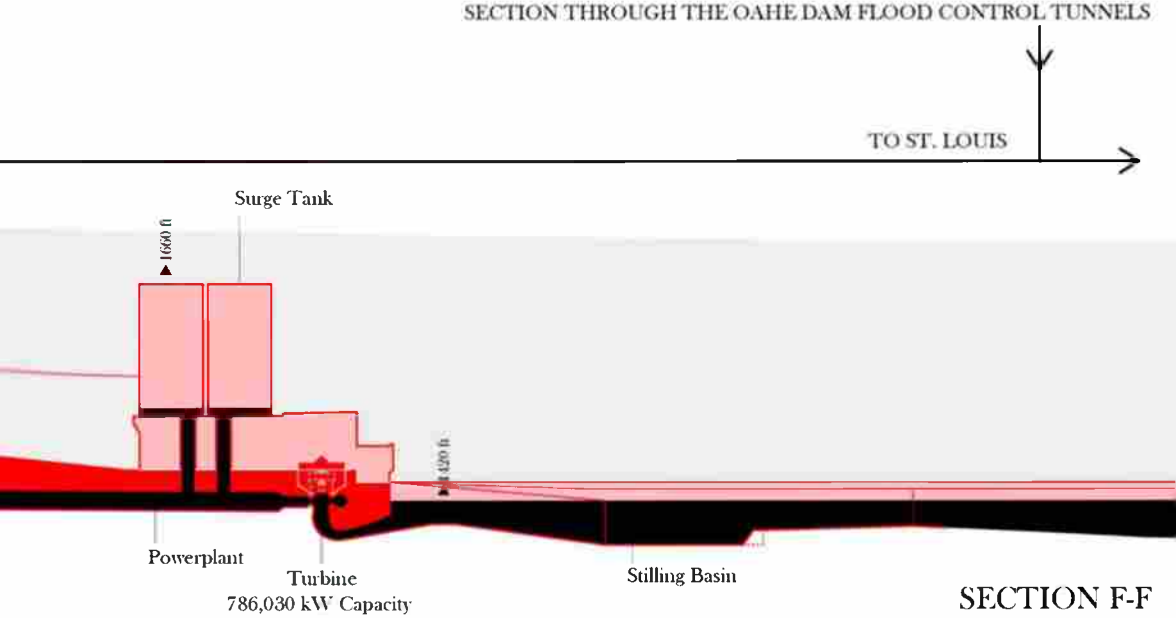

MISSOURI RIVER
Unopened
Terrain Edge Behind
Approach Channel
Spillway
25,000 cfs Average Release During June 2010
Terrain Edge Behind
Outlet Works
Intake Structure
Flood Control Tunnels
54,000 cfs Average Flow Through Powerplant
Terrain Edge Behind
Control Shaft
Powerplant
Intake Structure
Powerplant Tunnels
Axis of Oahe Dam



SECTION D-D
SECTION THROUGH THE OAHE DAM SPILLWAY



SECTION E-E
SECTION THROUGH THE OAHE DAM FLOOD CONTROL TUNNELS



SECTION F-F
SECTION THROUGH THE OAHE DAM POWERPLANT

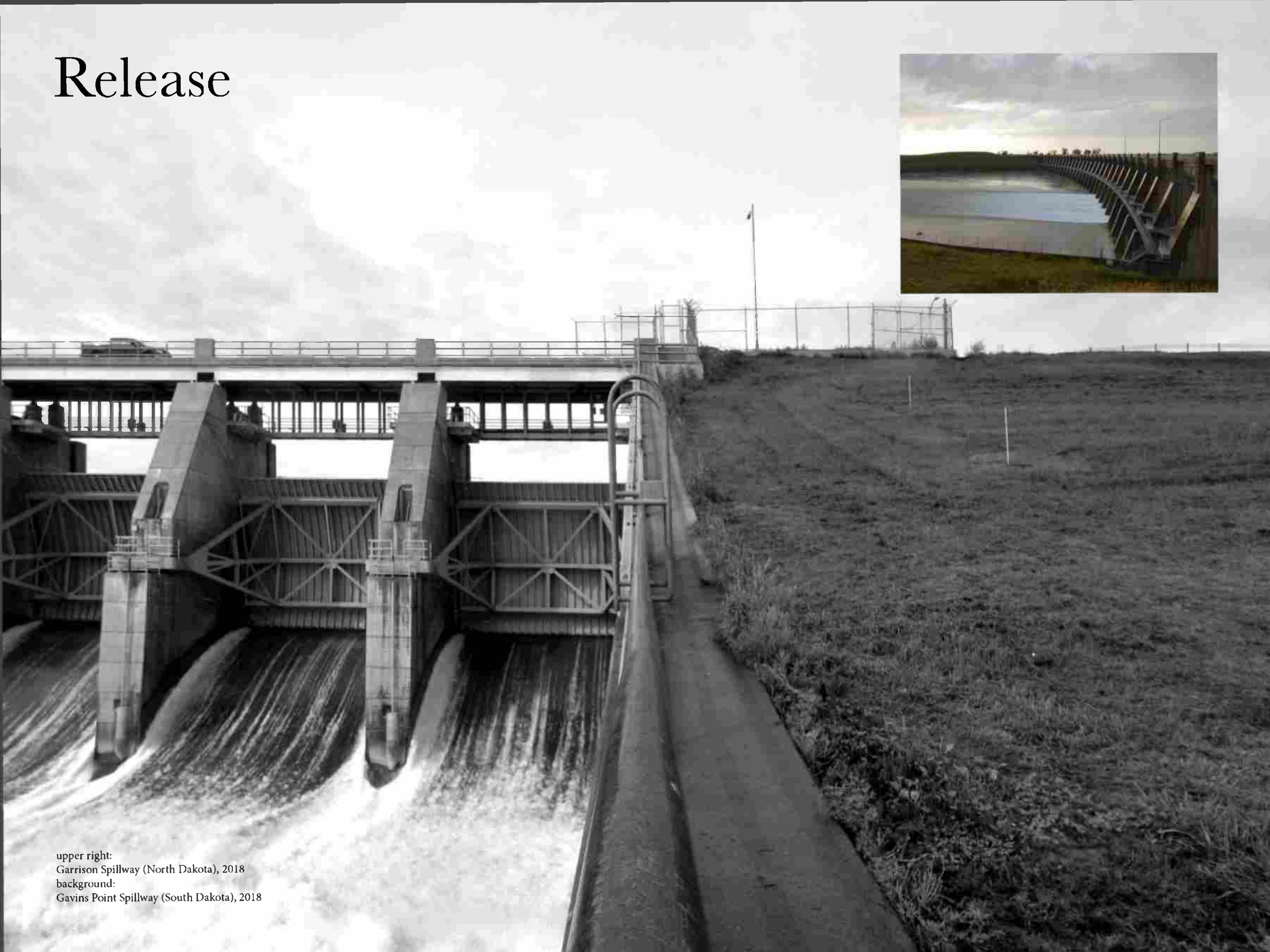
Generate

upper right:
Fort Peck Powerplant, Montana (2018)
background:
Garrison Powerplant, South Dakota (2018)

Extract

upper right:
Civeo Killdeer Lodge "pre-fabricated workforce accommodation facility," (Killdeer, North Dakota)
background:
typical Bakken Shale Formation oil and natural gas drilling site, (Killdeer, North Dakota), 2018

Release



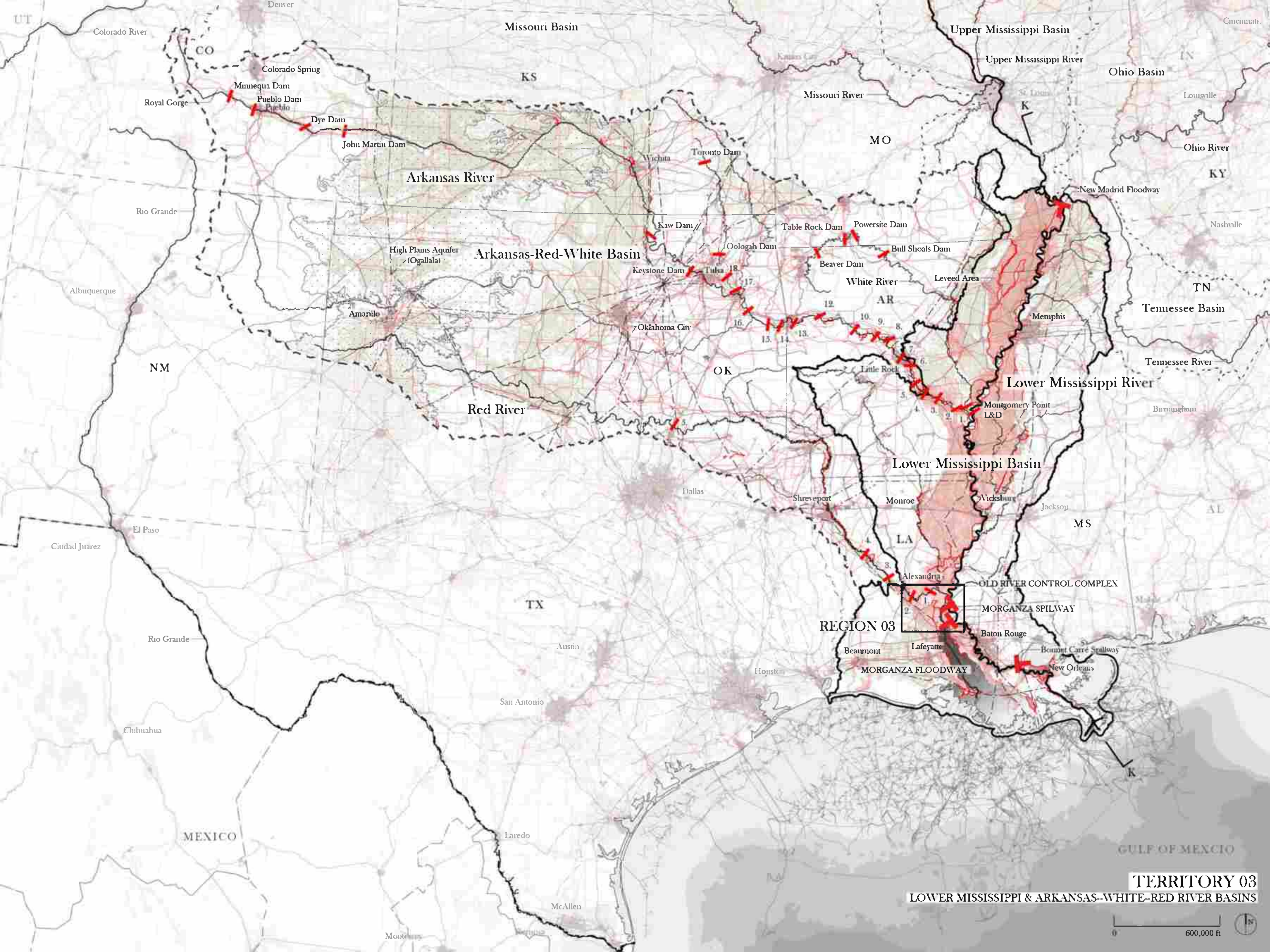
upper right:
Garrison Spillway (North Dakota), 2018
background:
Gavins Point Spillway (South Dakota), 2018

Inundate

upper right:
Cannonball River and view towards former site of Oceti Sakowin protest camp (North Dakota) 2018
background:
View towards Lake Oahe and Standing Rock Reservation, (Mobridge, South Dakota) 2018

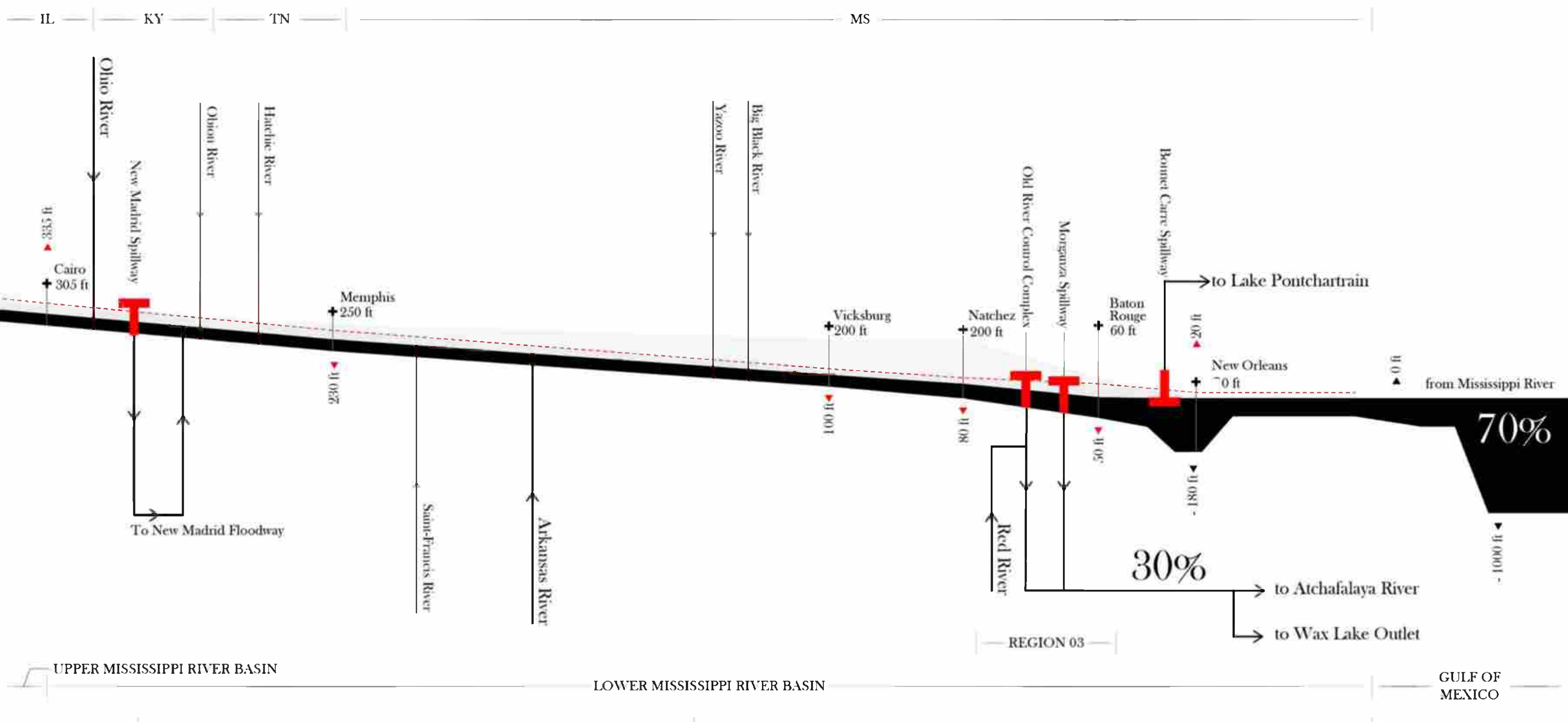

Possible Resting Place of Sitting Bull
Fort Yates, South Dakota
2018

Territory 03: Lower Mississippi & Arkansas-White-Red River Basins



TERRITORY 03

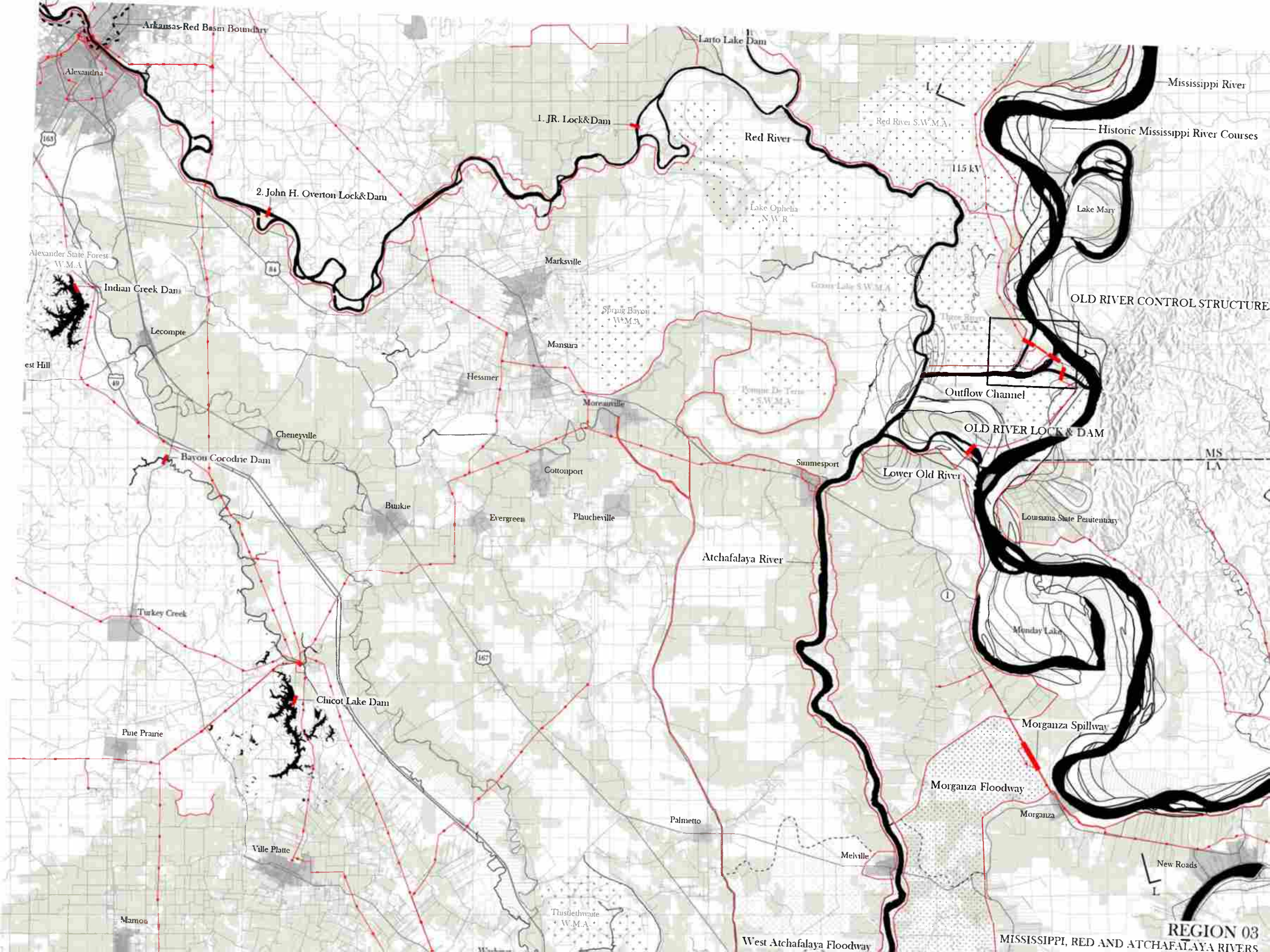
LOWER MISSISSIPPI & ARKANSAS–WHITE–RED RIVER BASINS



SECTION K-K

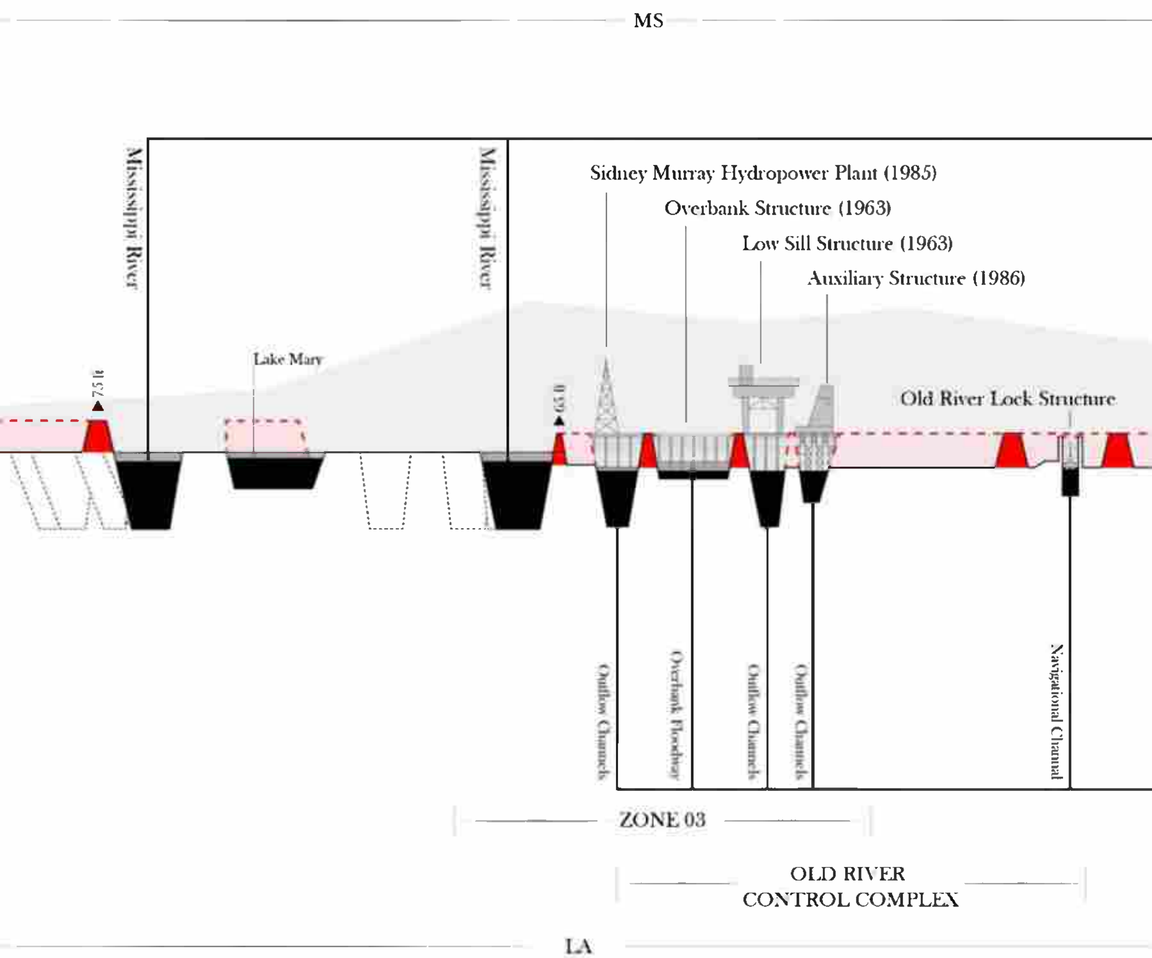
FOLLOWING THE PATH OF THE LOWER MISSISSIPPI RIVER

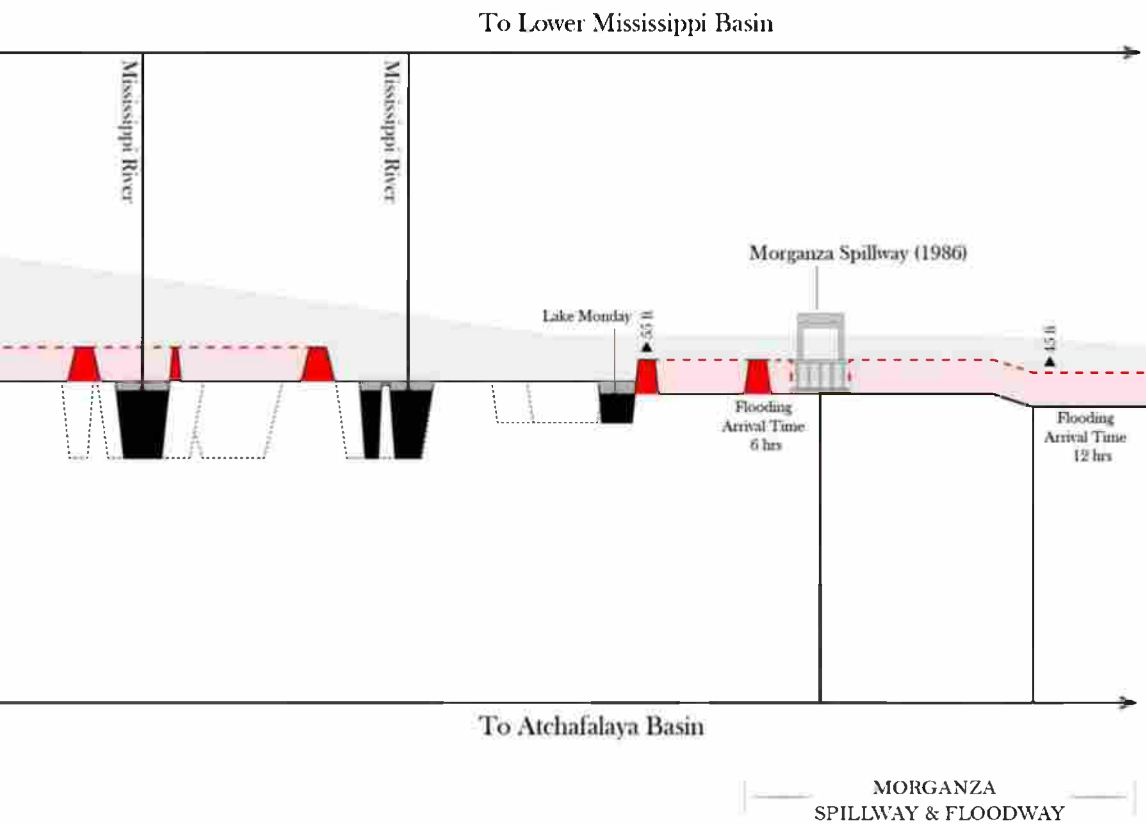
Region 03: Mississippi, Red & Atchafalaya Rivers


Arkansas-Red Basin Boundary
Larto Lake Dam
Mississippi River
Alexandria
1. JR. Lock&Dam
Red River S.W.M.A
Historic Mississippi River Courses
Red River
115 kV
2. John H. Overton Lock&Dam
Lake Ophelia N.W.R
Lake Mary
Alexander State Forest W.M.A
Marksville
Indian Creek Dam
Grassy Lake S.W.M.A
OLD RIVER CONTROL STRUCTURE
Spring Bayou W.M.A
Three Rivers W.M.A
Lecompte
Mansura
Hessmer
Pomme De Terre S.W.M.A
Outflow Channel
Moreauville
OLD RIVER LOCK & DAM
Cheneyville
MS
LA
Bayou Cocodrie Dam
Simmesport
Lower Old River
Cottonport
Bunkie
Evergreen
Plaucheville
Louisiana State Penitentiary
Atchafalaya River
Turkey Creek
Monday Lake
Chicot Lake Dam
Morganza Spillway
Pine Prairie
Morganza Floodway
Morganza
Palmetto
Ville Platte
Melville
New Roads
Mamou
Thistlethwaite W.M.A
REGION 03
West Atchafalaya Floodway
MISSISSIPPI, RED AND ATCHAFALAYA RIVERS


Hydropower Plant


Overbank Structure

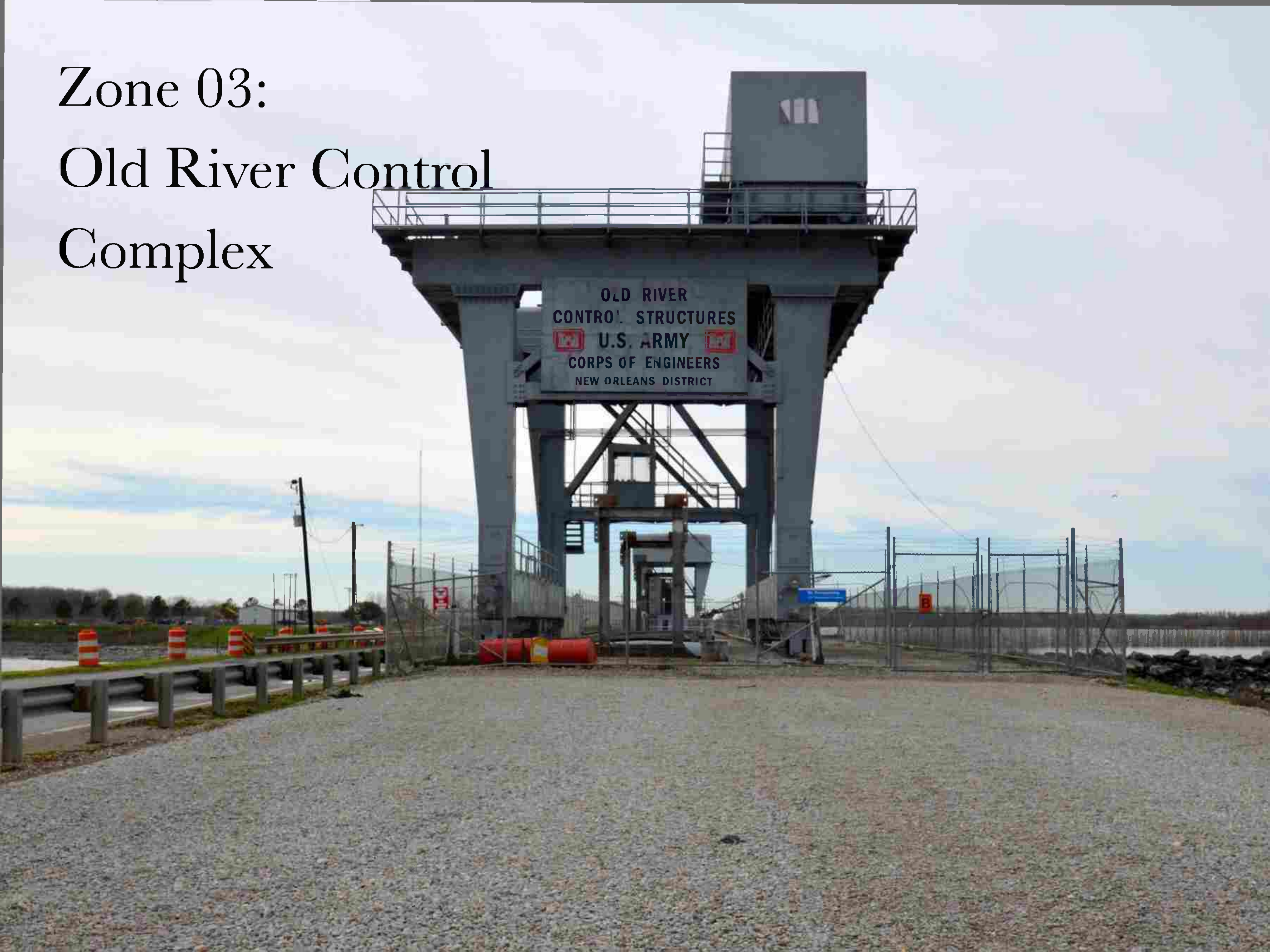

MS
Mississippi River
Mississippi River
Sidney Murray Hydropower Plant (1985)
Overbank Structure (1963)
Low Sill Structure (1963)
Auxiliary Structure (1986)
Lake Mary
Old River Lock Structure
Outflow Channels
Overbank Floodway
Outflow Channels
Outflow Channels
Navigational Channal
ZONE 03
OLD RIVER
CONTROL COMPLEX
LA



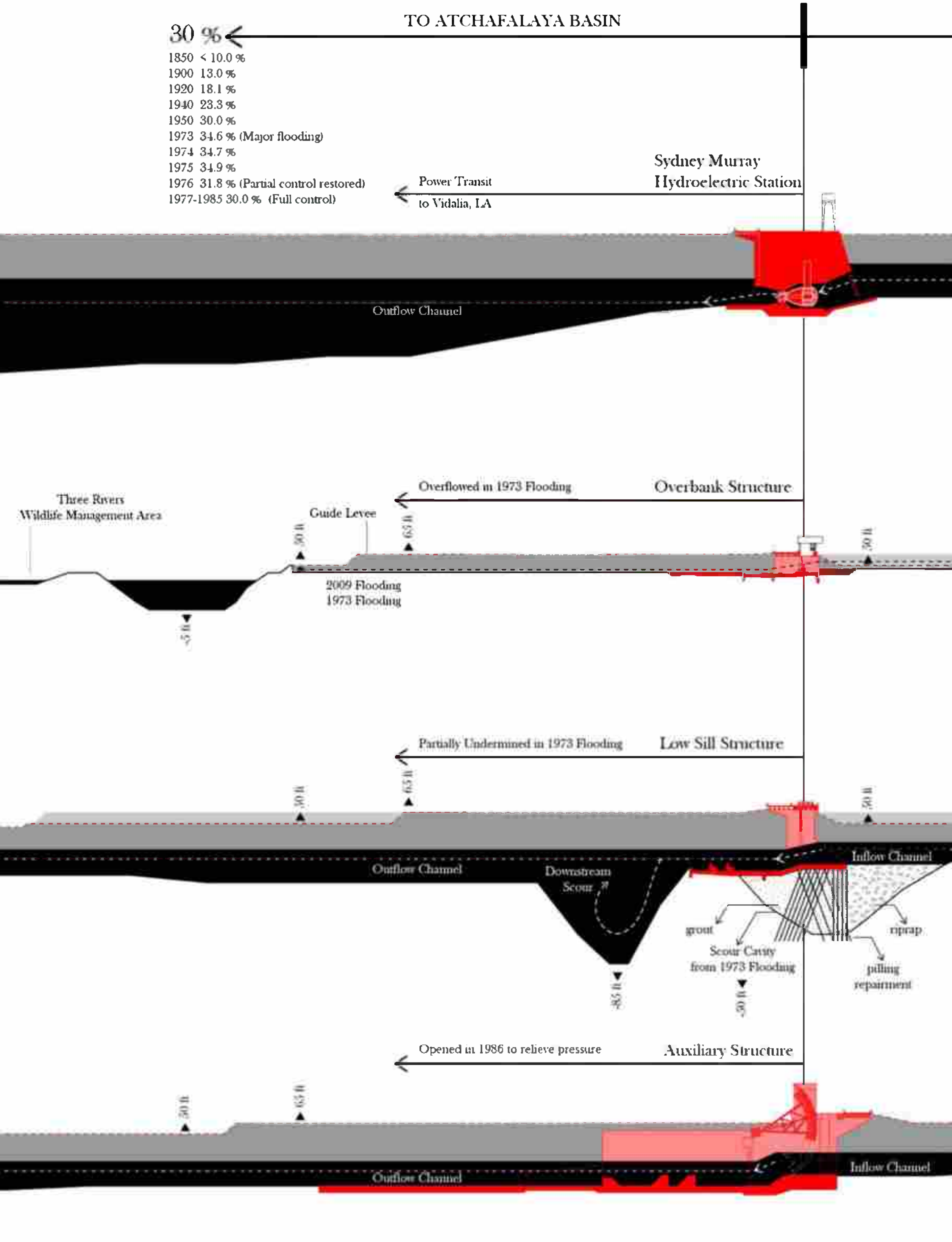
SECTION L-L

SECTION THROUGH THE MISSISSIPPI, RED AND ATCHAFALAYA RIVERS

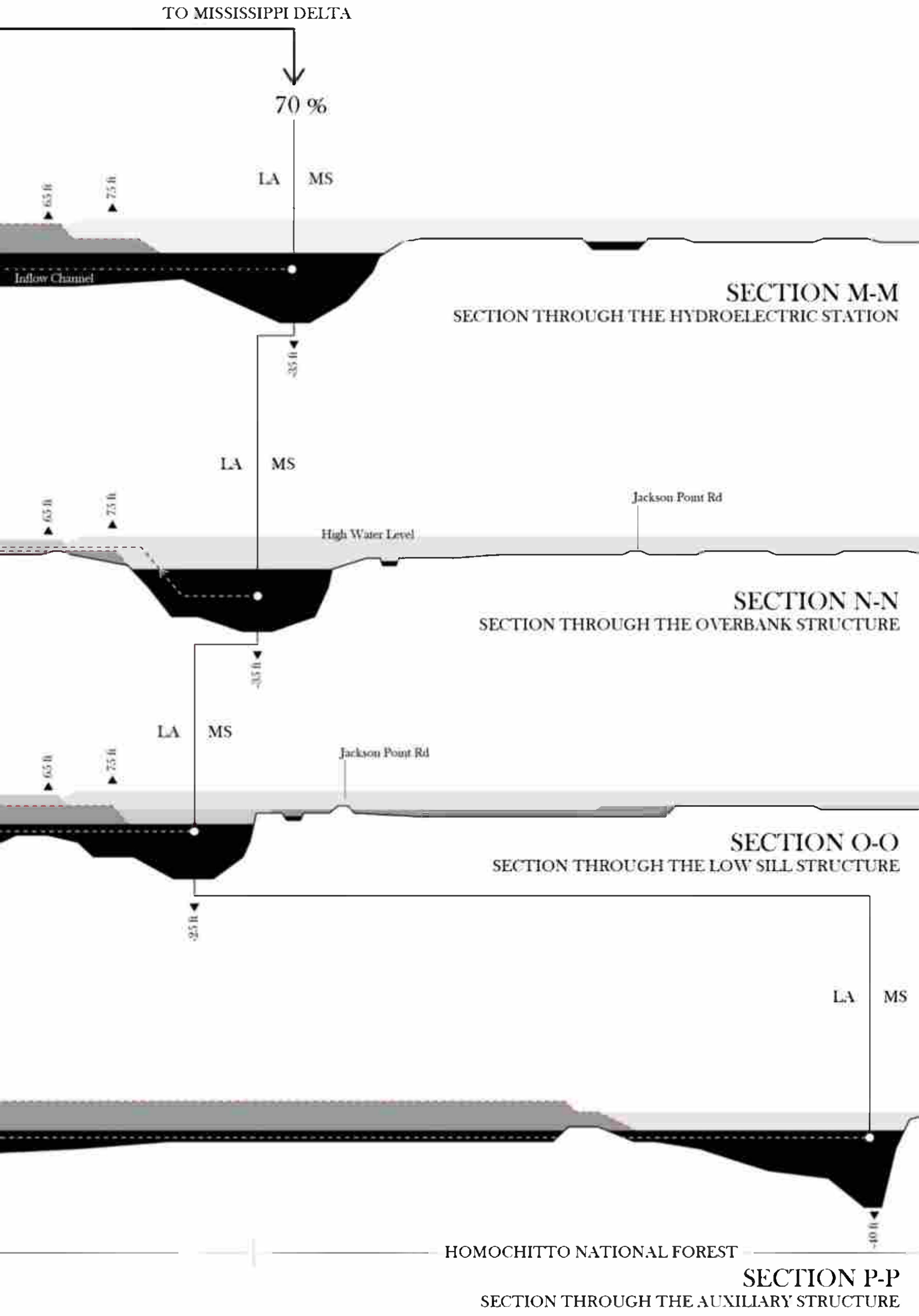
Zone 03: Old River Control Complex




115kV Transmission Lines
500 Year Levee
Sidney Murray Hydroelectric Station
Mississippi River
Overbank Structure
Guided Levee
Low Sill Structure
Outflow Channel
Auxilary Structure
ZONE 03
OLD RIVER CONTROL COMPLEX
0
2,000 ft
N



OLD RIVER CONTROL COMPLEX



TO MISSISSIPPI DELTA
70 %
LA
MS
65 ft
75 ft
Inflow Channel
-35 ft
SECTION M-M
SECTION THROUGH THE HYDROELECTRIC STATION
LA
MS
65 ft
75 ft
Jackson Point Rd
High Water Level
-35 ft
SECTION N-N
SECTION THROUGH THE OVERBANK STRUCTURE
LA
MS
65 ft
75 ft
Jackson Point Rd
-25 ft
SECTION O-O
SECTION THROUGH THE LOW SILL STRUCTURE
LA
MS
HOMOCHITTO NATIONAL FOREST
SECTION P-P
SECTION THROUGH THE AUXILIARY STRUCTURE

Navigate

Refine

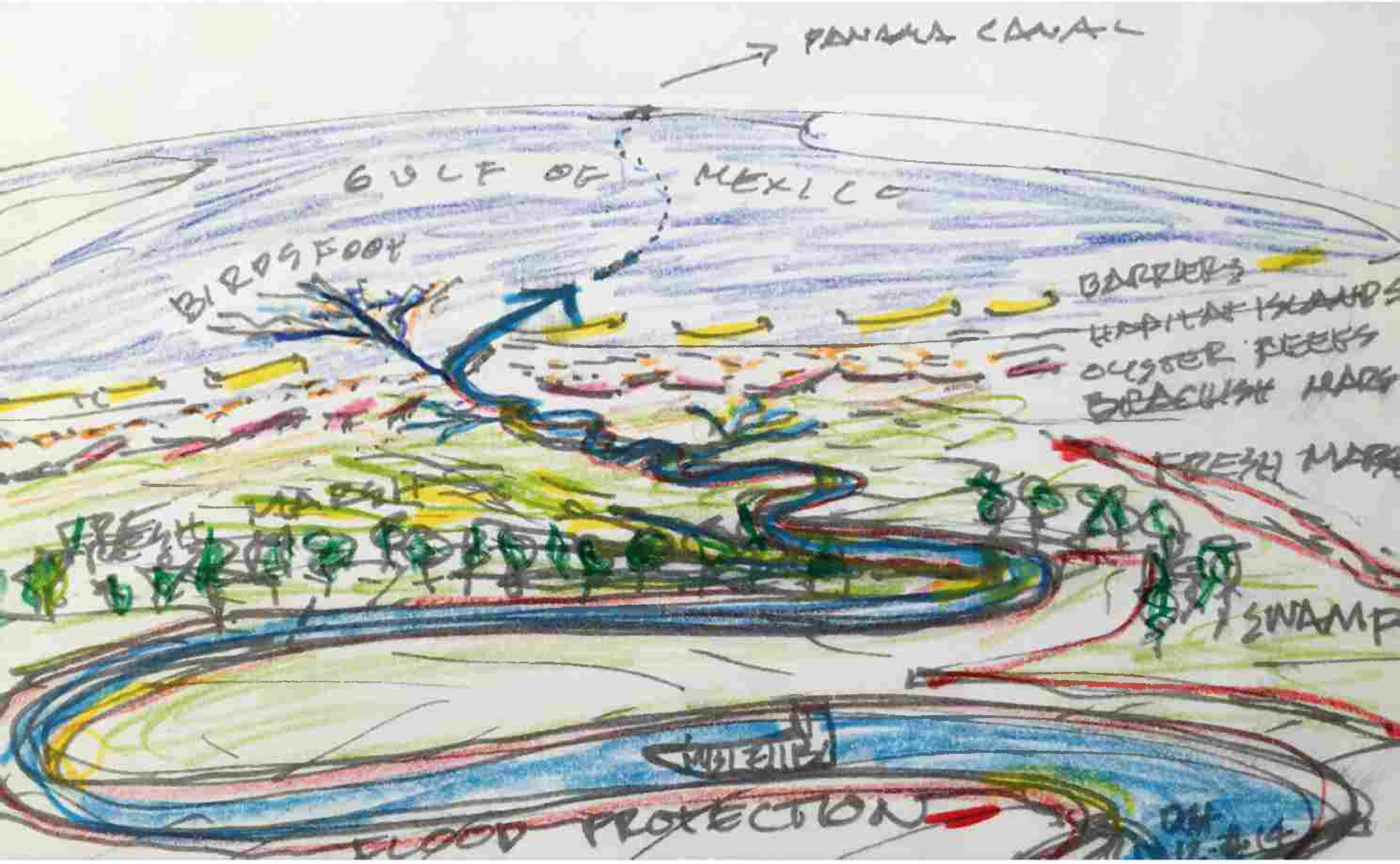
Divert

Erase

But…there are clues…there are possibilities…

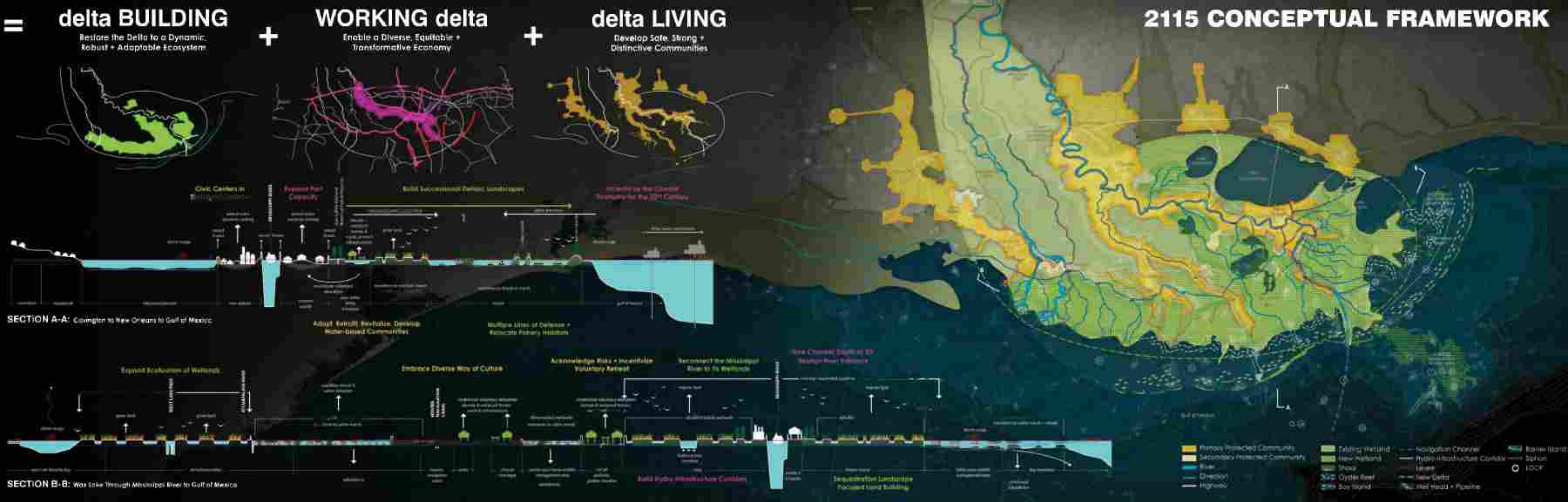
...to Replinish...to Redistribute...to Reboot...

Atchafalaya Delta, 2010



PANAMA CANAL
GULF OF MEXICO
BIRDSFOOT
BARRIERS
HABITAT ISLANDS
OYSTER REEFS
FRESH MARSH
SWAMP
FRESH
MARSH
FLOOD PROTECTION

"The New MISI-ZIIBI Living Delta"
with STUDIO MISI-ZIIBI
2014



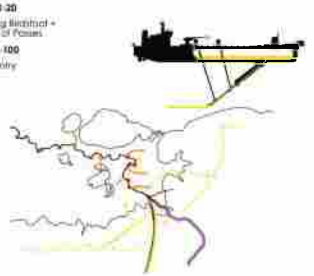
INTERVENTIONS IN THE DELTA

1. New Mississippi River Enhance Channel
2. New Head of Passes
3. 8 Sediment Diversions on Mississippi River
4. 6 Dredge Siphons
5. 4 Sediment Diversions on the Atchafalaya River
6. Adjust the 70/30 + 80/20 split at Old River Control
7. Birdsfoot + Biloxi Marsh Shoals
8. Evolve MRGO into Natural Wetland
9. Major Distribution Areas for Dredge Material
10. Major Source Areas for Dredge Material
11. Rebuilt Wetlands
12. Cypress Swamps
13. Barrier Islands
14. Sand Engines
15. Bay Islands
16. Oyster Reefs
17. Mississippi River Channel, 50ft Minimum Depth
18. Port facilities along entire length of Mississippi River
19. New Port Facility
20. Anchorage
21. Inland Waterways
22. 2 Shallow Draft Channels at New River Mouth
23. Deep Water Energy Infrastructure
24. LOOP

ECO-3D STRATEGY - LAND BUILDING

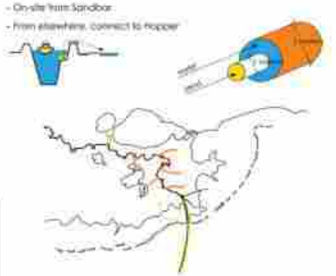
DREDGE + DUMP

year 0-20
Existing Birdsfoot + Head of Passes
year 0-100
New Entry



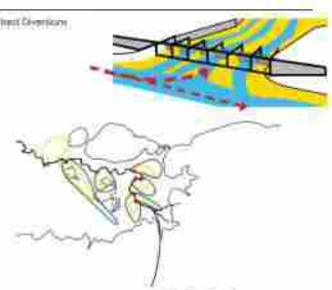
DREDGE - SIPHON

- On-site from Sandbar
- From elsewhere, connect to Hopper



DIVERT

- 8 Pulsed Diversions



DIVERSION SETTINGS

Diversions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A. Maurepas	3k cfs	30k cfs	46 km²	82 km²	0.9/- km²
B. Des Allemands **	3k cfs	150k cfs	251 km²	277 km²	3.1-3.5 km²
C. Davis Pond **	3k cfs	150k cfs	250 km²	276 km²	3.1-3.5 km²
D. Central Wetlands	3k cfs	30k cfs	107 km²	116 km²	1.3-1.5 km²
E. Caernarvon	3k cfs	10k cfs	35 km²	33 km²	0.4 km²
F. Upper Breton **	3k cfs	150k cfs	225 km²	251 km²	2.8-3.1 km²
G. Mid Breton	3k cfs	100k cfs	224 km²	250 km²	2.8-3.1 km²
H. Myrtle Grove	4k cfs	60k cfs	229 km²	260 km²	2.9-3.3 km²

* always operate each at minimum for flow/vegetation
** 150k max. design capacity

2,860 km² from diversions over 100 yrs.

DIVERT

+

1,200 km² from beneficial dredge + construction material over 100 yrs.

DREDGE

=

MAXIMUM POTENTIAL
5,000 km² from Mississippi River over 100 years

TOTAL LAND BUILDING POTENTIAL

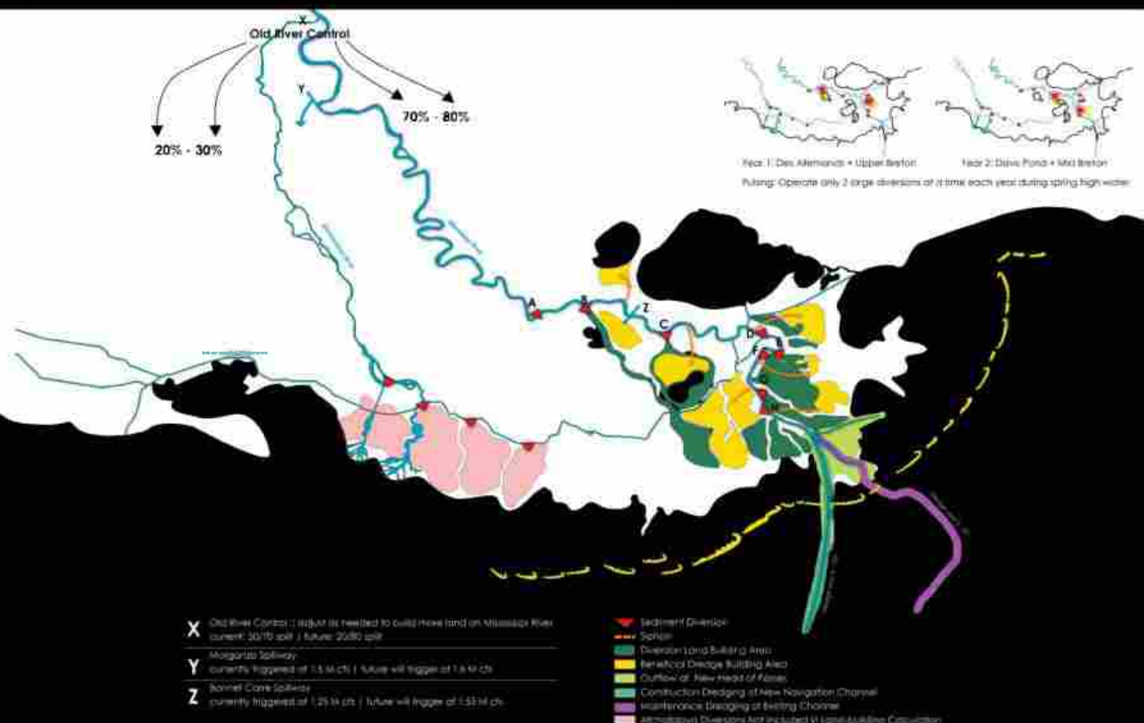


Image Courtesy STUDIO MISI-ZIIBI/H3 Studio, Inc.

LOWER MISI-ZIIBI VISION 2115

DELTA BUILDING

successional ecologies

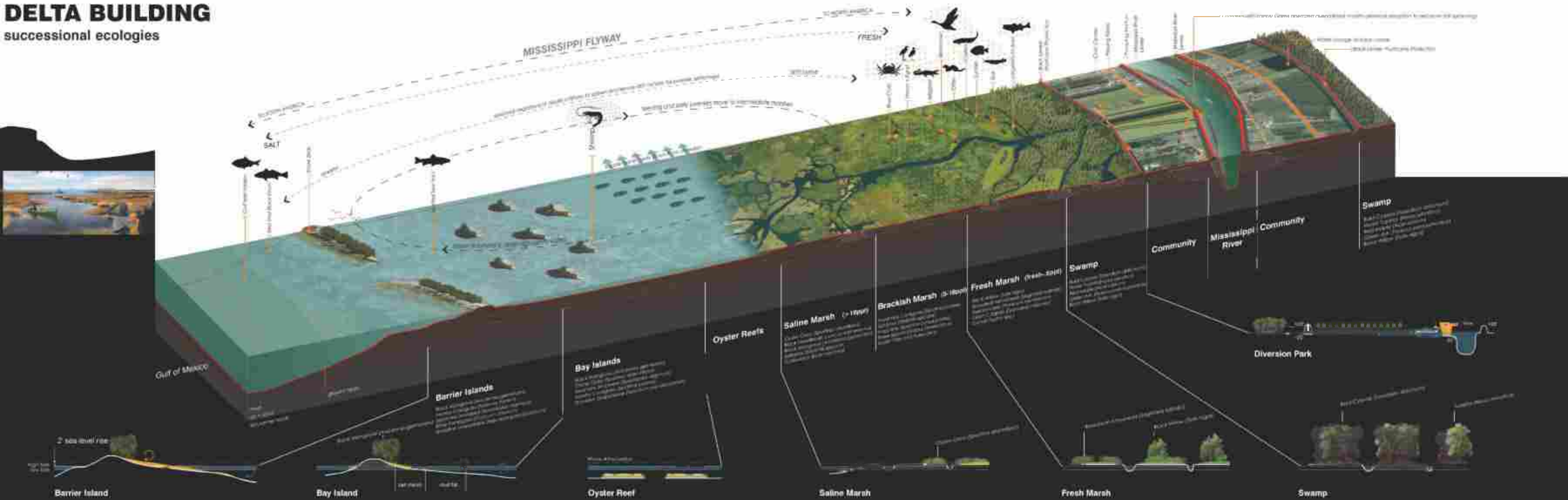
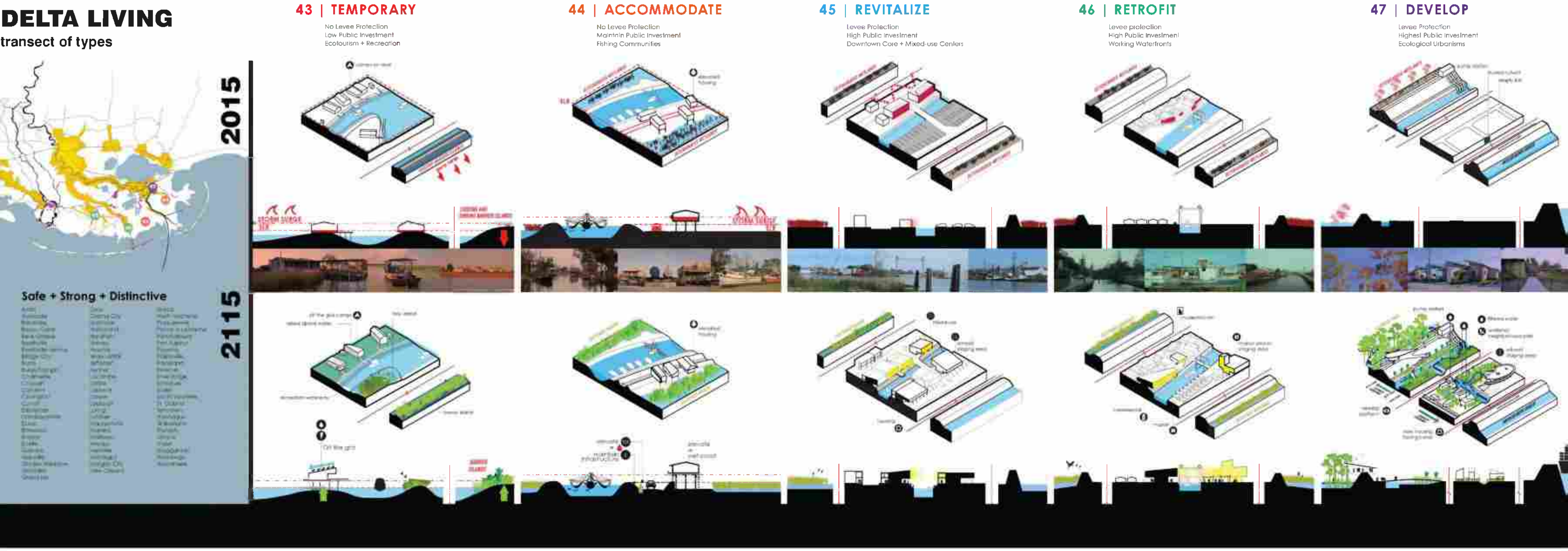


Image Courtesy STUDIO MISI-ZIIBI/H3 Studio, Inc.

DELTA LIVING
transect of types



WORKING DELTA
hydro-infrastructure corridor + sequestration landscape

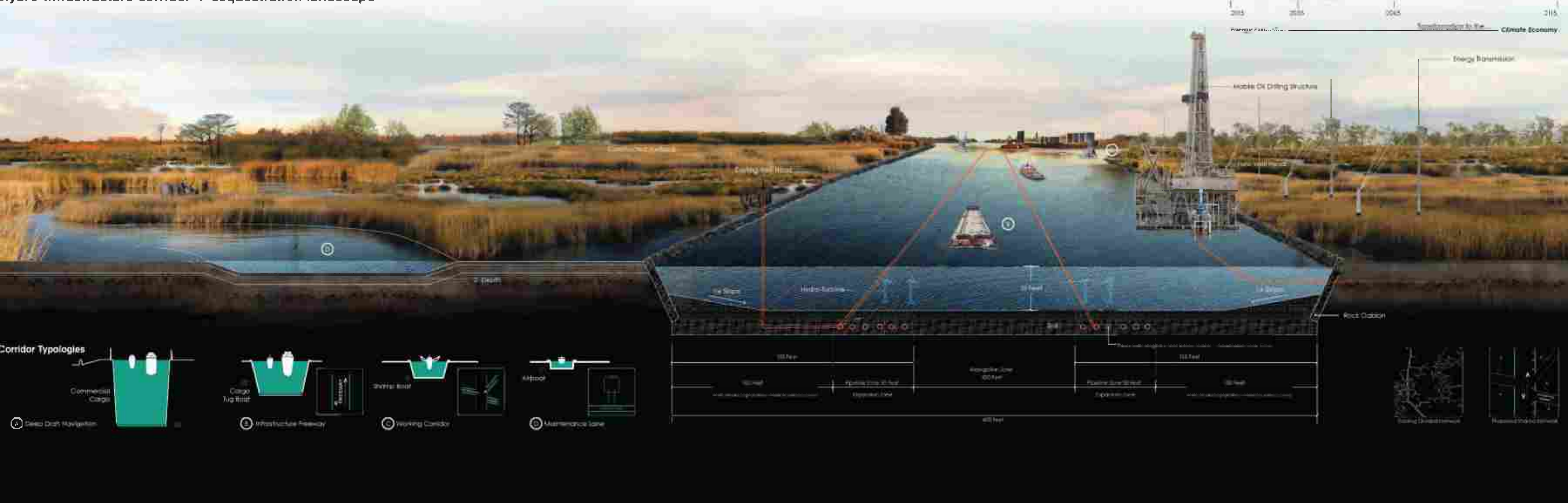
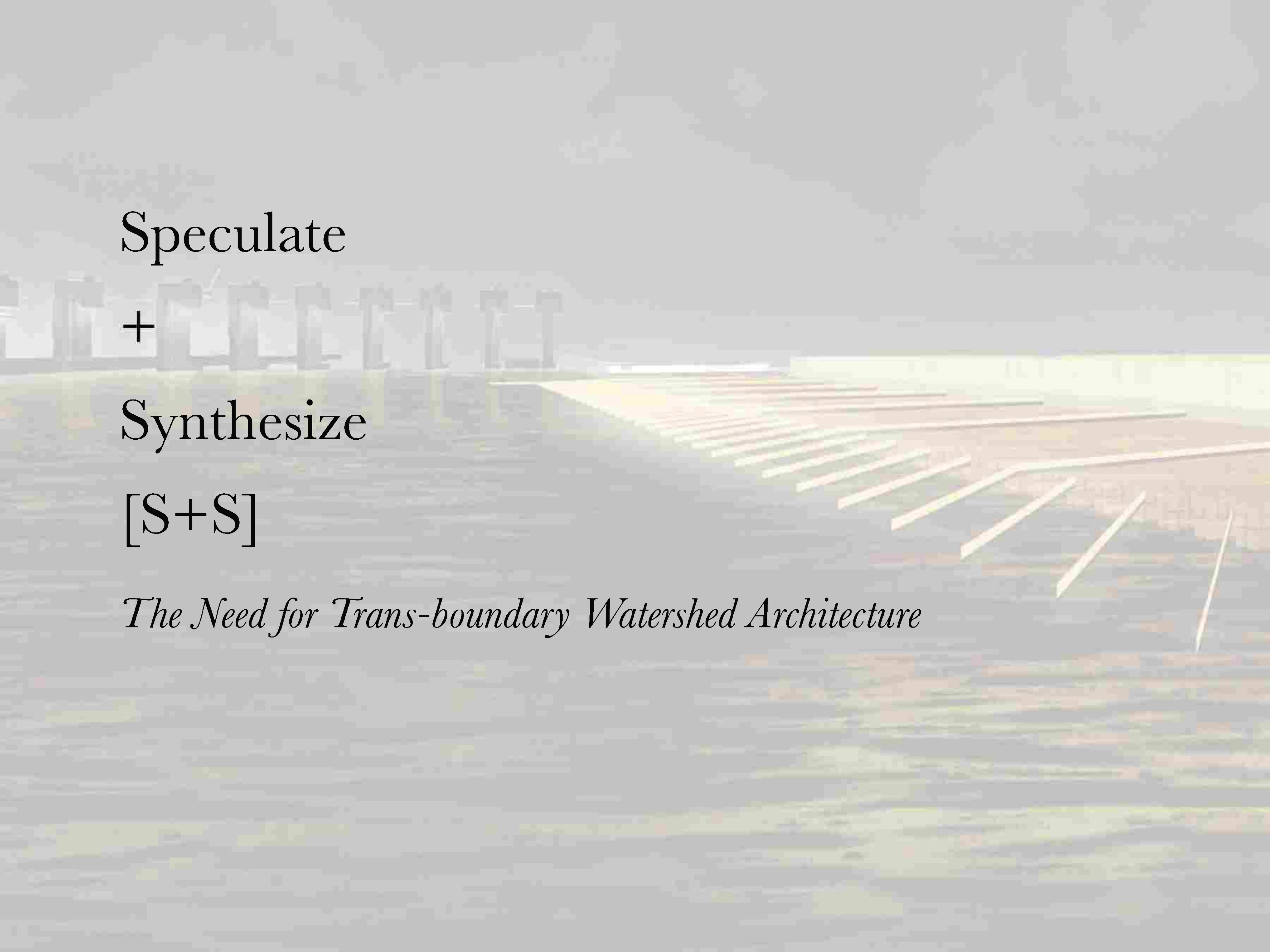


Image Courtesy STUDIO MISI-ZIIBI/H3 Studio, Inc.



Speculate

+

Synthesize

[S+S]

The Need for Trans-boundary Watershed Architecture

The Continental Compact

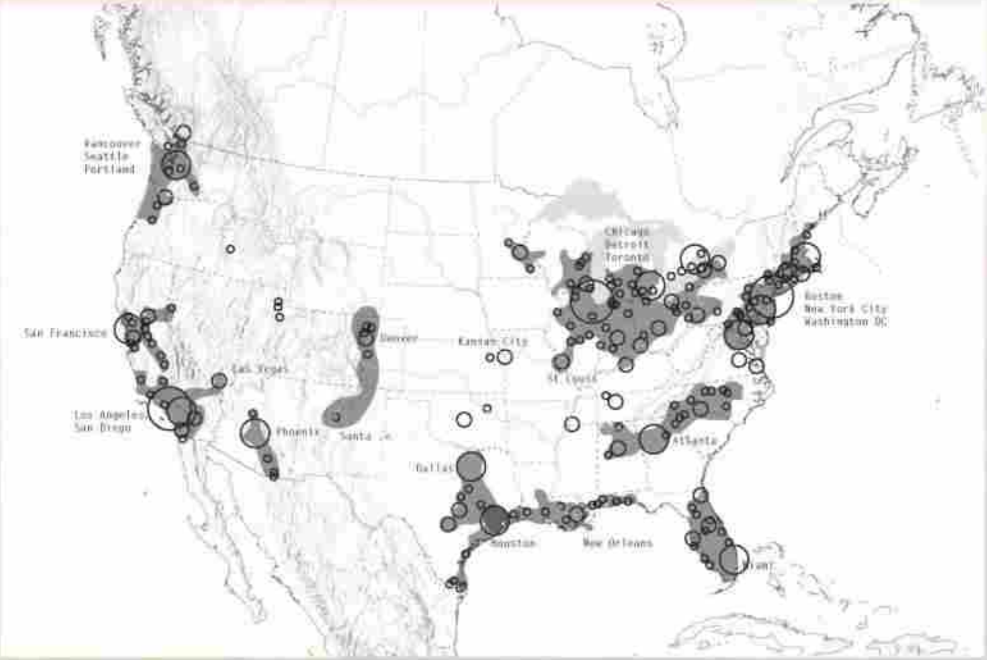
eastward migration in a

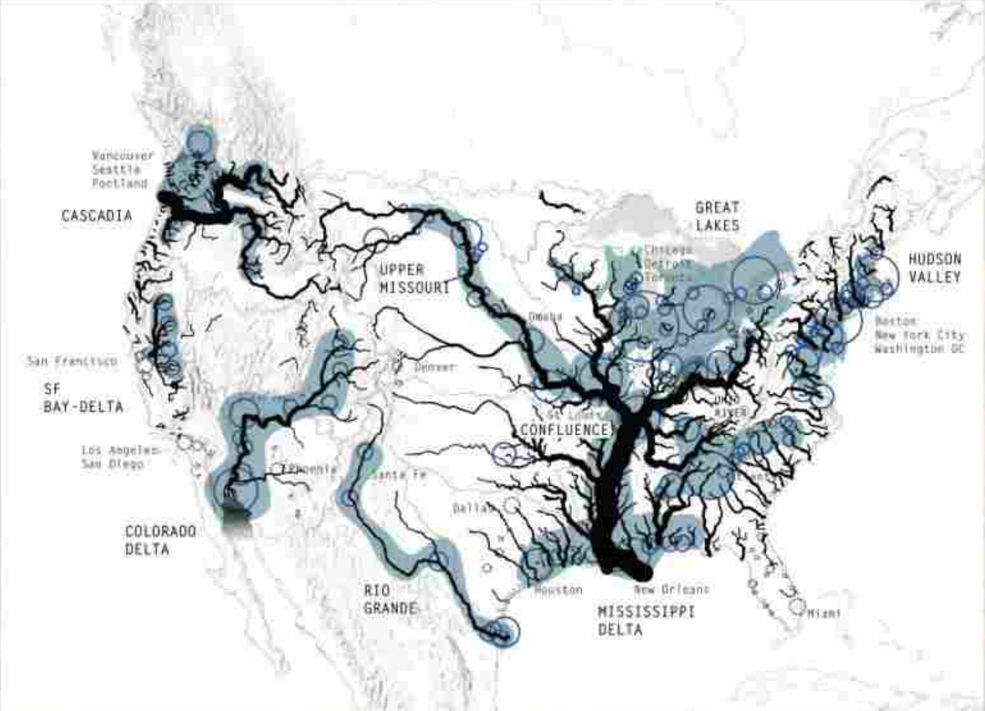
(new) new world

...or the case for hydro-regions

in the Mississippi River

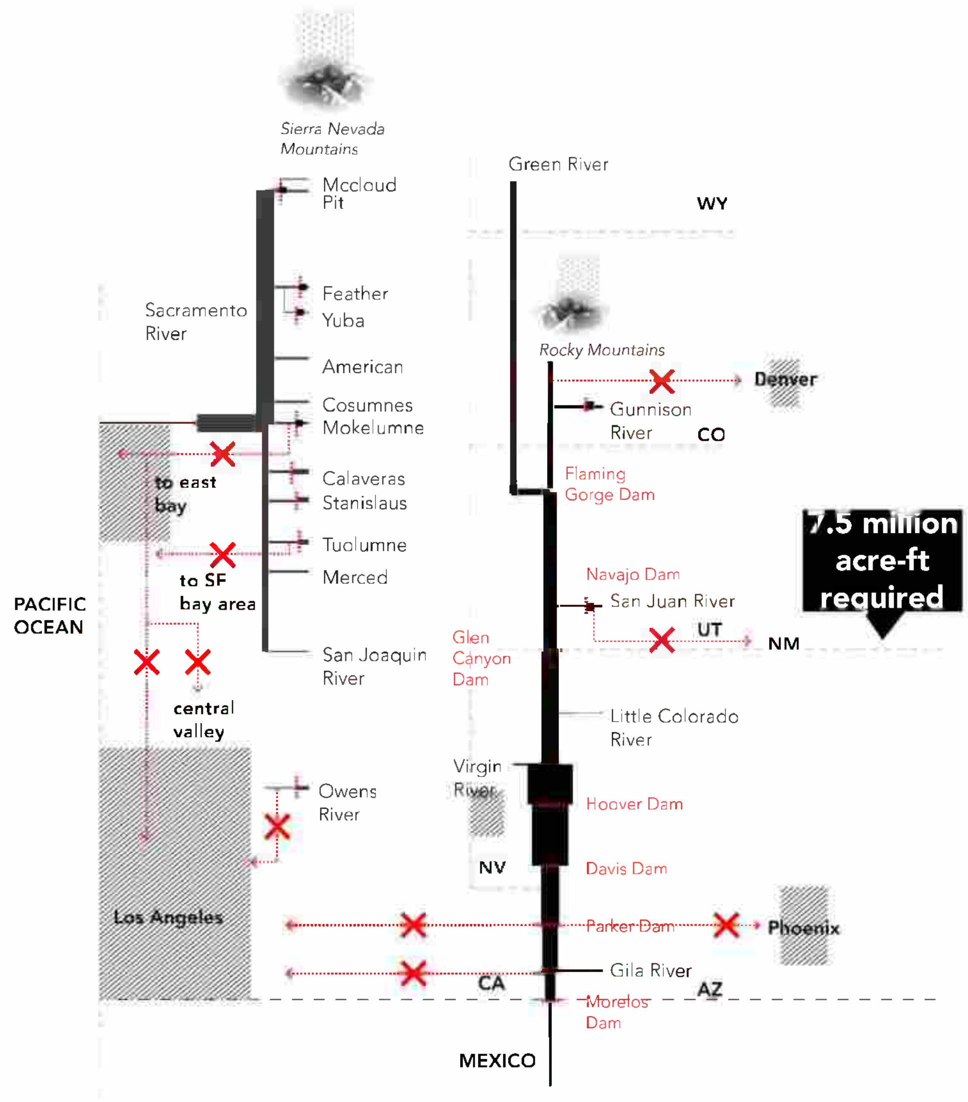
Basin...





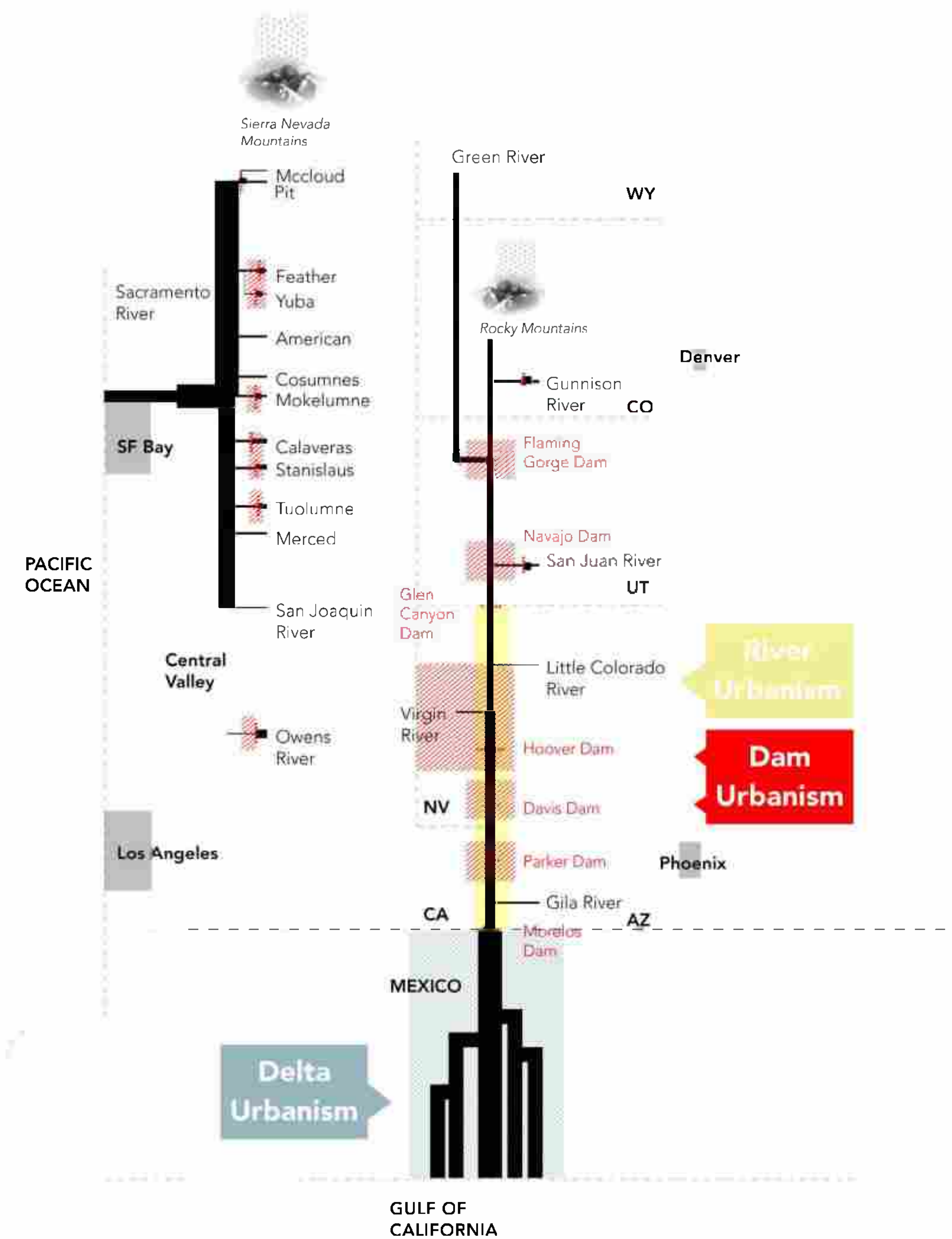
Design Team: Derek Hoeferlin, AIA, Ian Caine, RA (co-design leads)
Emily Chen, Tiffin Thompson, Pablo Chavez (assistants)
2017

HYDRAULIC URBANISM



"The Continental Compact"
with Ian Caine
2015

HYDROLOGIC URBANISM



from the

Big Dams

to the

Birds Foot

transforming the Nutrients, the Sediments, and the Industries in the Mississippi River Basin

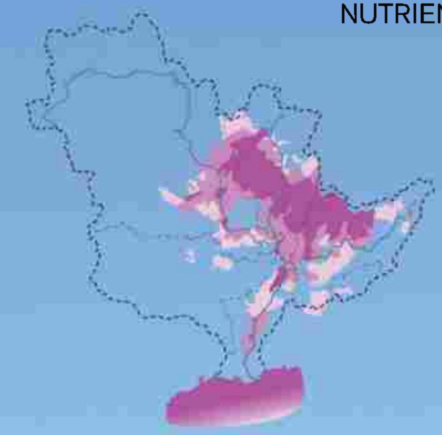
Design Team: Derek Hoeferlin, AIA (design lead, principal [dhd])
Irene Compadre, Allison Mendez, Jonathan Stitelman (assistants)
2012

Wastes as Resources

Excess Nutrients

The DEAD ZONE primarily is caused by excess levels of nitrogen and phosphorus nutrients discharged into the Mississippi river basin via run-off. According to the USGS, 70% of the nitrogen and phosphorus is the result of large-scale agricultural processes in the Lower Mississippi, Upper Mississippi and Ohio sub-basins. And 75% of all nitrogen and phosphorus discharged into the river basin originates from only 9 of the 31 states drained by the river basin—Illinois, Iowa, Indiana, Missouri, Arkansas, Kentucky, Tennessee, Ohio and Mississippi. As these nutrients make their way unmitigated through the river basin, they significantly contribute to the DEAD ZONE phenomena in the Gulf of Mexico off the coast of Louisiana. The dead zone is a hypoxic area caused by algae blooms that develop from the excess nutrients nitrogen and phosphorus. The algae blooms, coupled with the large amounts of fresh water at the surface of the Gulf, starve oxygen from reaching important marine life in the lower, heavier, saltier areas of the Gulf.

EXCESS
NUTRIENTS



Wastes as Resources

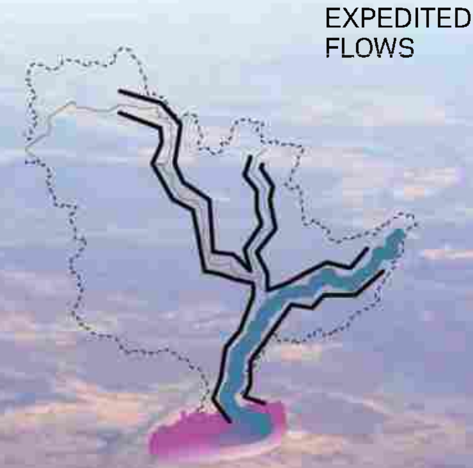
Suppressed Sediments

In current form, two of the main negative environmental and economic impacts from development of the Mississippi river basin ultimately manifest in south Louisiana and the Gulf of Mexico: WETLAND LOSS and the DEAD ZONE . WETLAND LOSS is caused by a number of factors, but the two significant contributors from the river basin are sediment suppression and expedited flows. Due to the damming of the sediment rich Missouri River far up-river basin, a large portion of the sediment never makes its way to south Louisiana to help grow the land with seasonal flooding.

Wastes as Resources

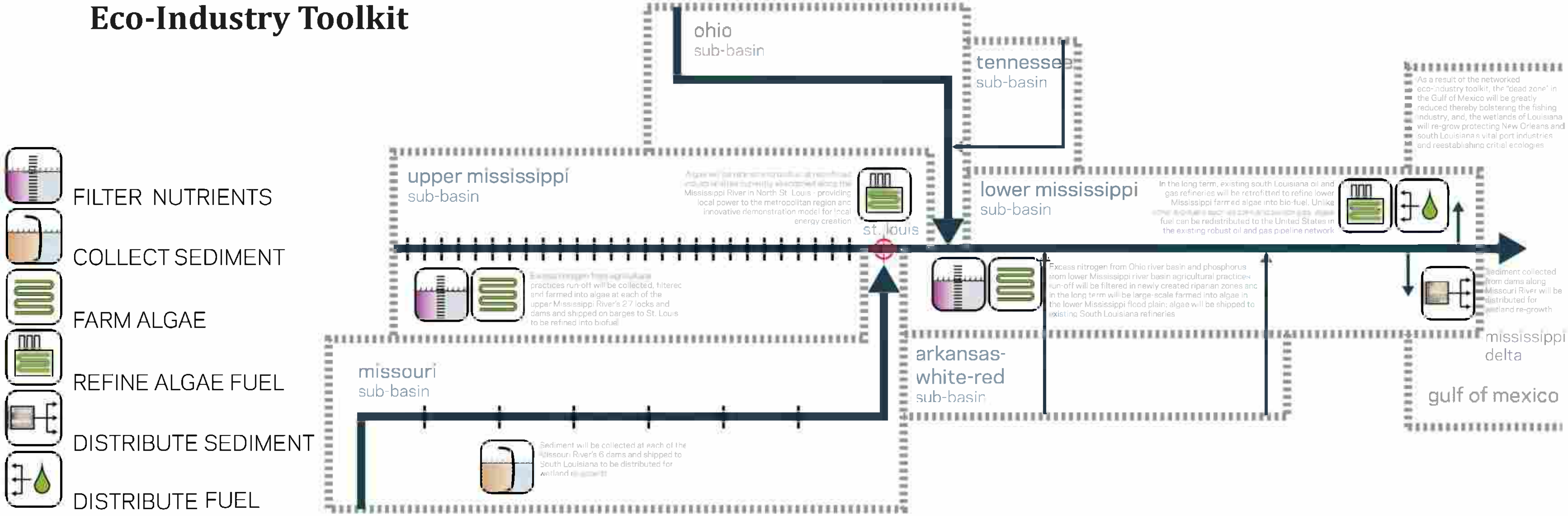
Expedited Flows

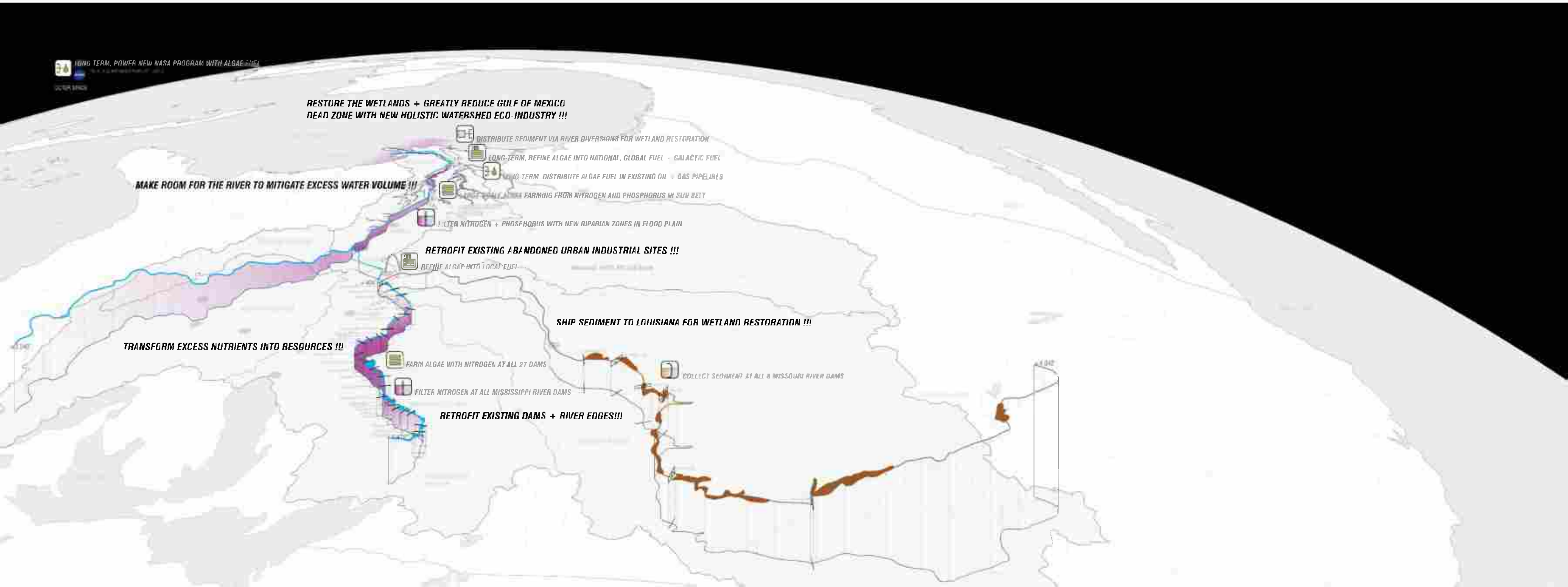
Coupling this wetland loss is the extreme leveeing of the majority of the river basin that expedites the flow of the waters and does not allow the river to flood to distribute the sediment. What little sediment resource is left is forced out to the Gulf of Mexico, off the continental shelf, as if going through a hose spigot. Some say coastal Louisiana loses the equivalent of one football field of wetlands every 30 minutes.




20th Century Industries

Eco-Industry Toolkit





Sub Basin Retrofit Zones + Sites

MISSOURI SUB-BASIN ZONE

BEFORE: DAMS TRAP SEDIMENT FROM FLOWING DOWN-RIVER

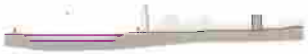
AFTER: COLLECT SEDIMENT AT DAMS AND TRANSPORT DOWNRIVER

UPPER MISSISSIPPI SUB-BASIN ZONE

BEFORE: EXCESS NUTRIENTS + UNDERUTILIZED DAM SITES

AFTER: NUTRIENT FILTERS + ALGAE FARMS AT DAM SITES

URBANIZED ZONE (ST. LOUIS, MO)



BEFORE: ABANDONED INDUSTRIAL SITES ALONG RIVER

AFTER: URBAN ALGAE REFINERY FOR LOCAL POWER

LOWER MISSISSIPPI SUB-BASIN ZONE

BEFORE: CHANNELIZED RIVER EXPEDITING WATER + NUTRIENT FLOWS

AFTER: SLOW WATER, ALGAE FARMS + RIPARIAN ZONES

SOUTH LOUISIANA / GULF COAST ZONE

BEFORE: GULF COAST OIL/GAS REFINERIES, WETLAND LOSS, DEAD ZONE

AFTER: GULF COAST ALGAE REFINERIES + RE-STORED WETLANDS

transport site

farm site

refine site

filter site

restore site

Cultivate Foods

(UPPER RIGHT) Agricultural equipment, St. Charles County, Missouri, 2013
(BACKGROUND) Agriculture levee and farmland between the Mississippi and Missouri Rivers, St. Charles County, Missouri, 2013 (image credit: Derek Hoeferlin)

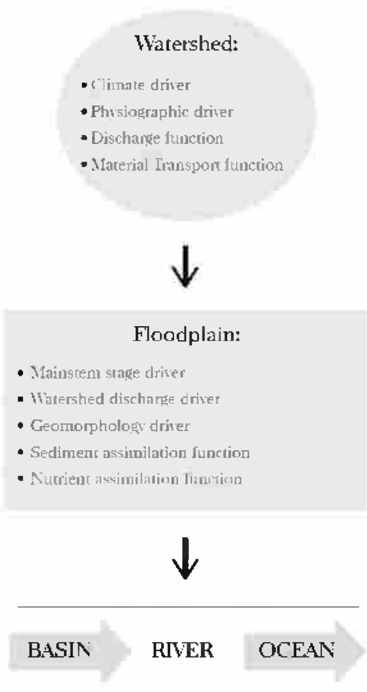
Transport Cargos

(UPPER RIGHT) Barges at Bellerive Park, St. Louis, Missouri, 2012
(BACKGROUND) Barge tow transporting petrochemicals upriver on the Mississippi River, St. Louis, Missouri, 2019 (image credit: Derek Hoeferlin)

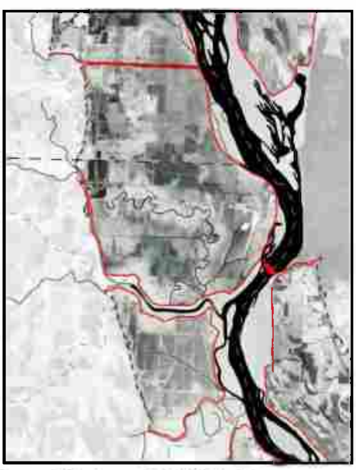
Reconnection

Adaptive Management for Levee and Drainage Districts

Chuck Theiling

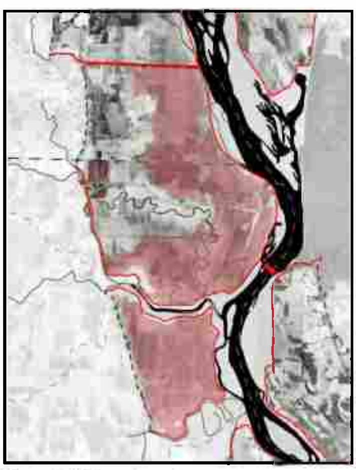


[Figure 1] Hydrologic Cycle (image credit: Chuck Theiling, re-drawn by Chenyu Zhang)



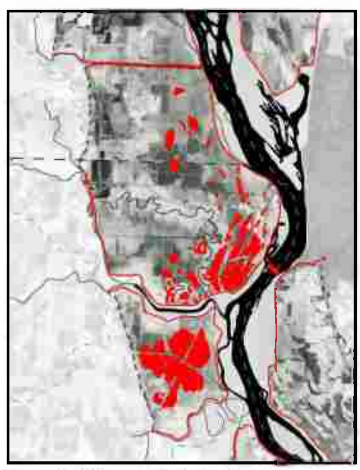
Levee Districts at L & D No.21

(a.)



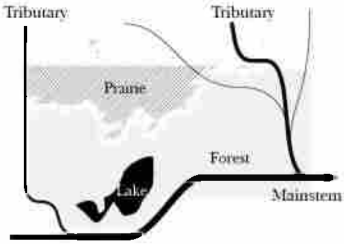
Potential Detention Areas

(b.)

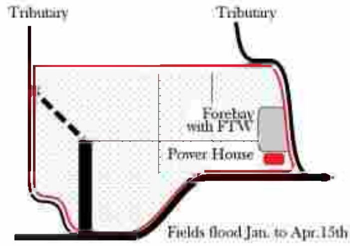


Potential Managed Wetlands

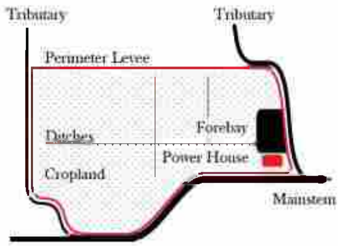
(c.)



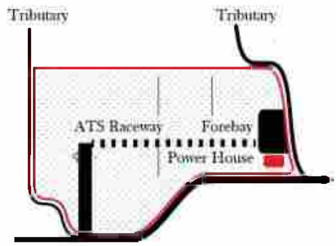
Pre-Development Condition



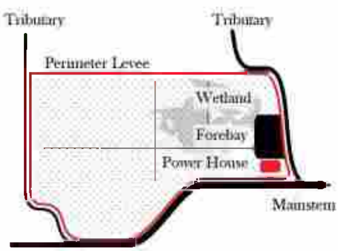
(f.) Hydroponic System
FTW (Floating Treatment Wetlands)



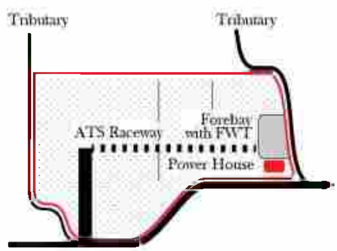
Post-Development Condition



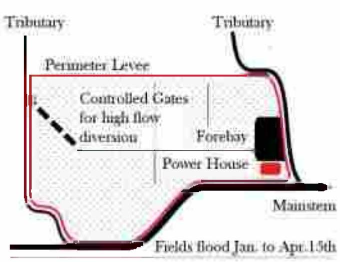
Mainstem Inlet
ATS (Algal Turf Scrubber)



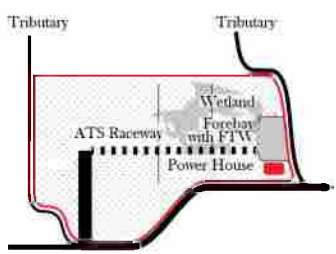
Reduved Pumping Wetland
Formation



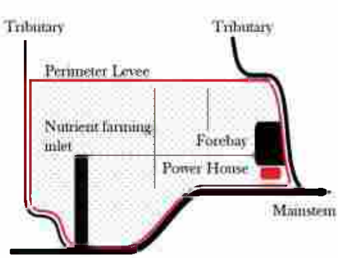
Mainstem Inlet
ATS (Algal Turf Scrubber)



Seasonal Tributary Diversions



Strategic Integration



Mainstem Inlet Nutrient
Assimilation

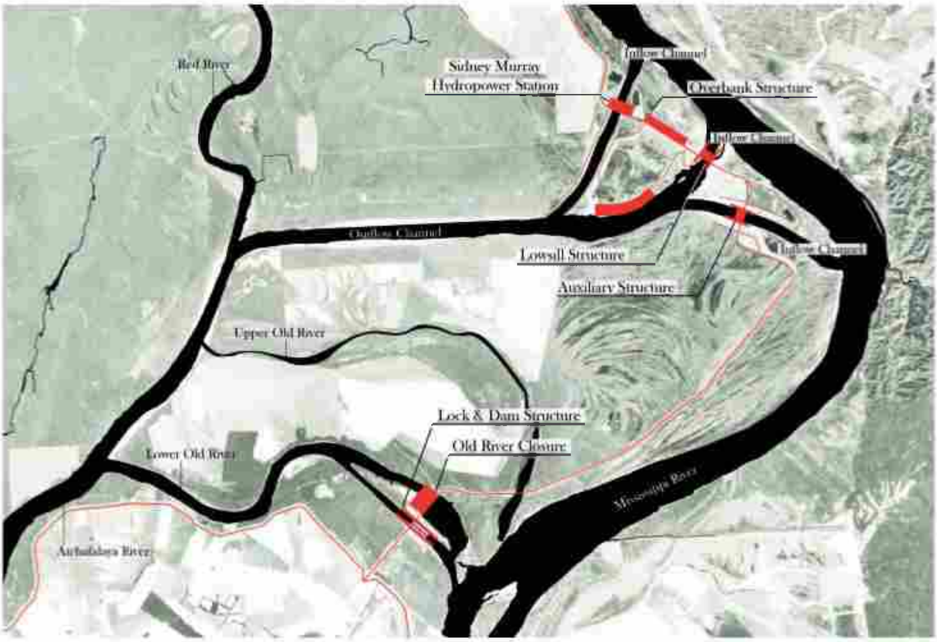
Mississippi Catfish Ponds," *Proceedings of Southeastern Association of Fish and Wildlife Agencies* 46 (1992): 10–17.
10. Sarah E. Lehnen and David G. Krementz, "Use of Aquaculture Ponds and Other Habitats by Autumn Migrating Shorebirds Along the Lower Mississippi River," *Environmental Management* 52, no. 2 (2013): 417–426.
11. Bruce A. Wagner, "The Epidemiology of Bacterial Diseases in Food-Size Channel Catfish," *Journal of Aquatic Animal Health* 14 (2002): 263–272.
12. Justine Holzman and Sandra Cook, "Wet Lands: Agroecological Experimentation in Essex County," in *Fresh Water*, eds. Mary Pat McGuire and Jessica M. Henson (San Francisco: Applied Research + Design Publishing, 2019), 162–171; Forbes Lipschitz, "From Drain to Delta: Green Infrastructure for Working Landscapes," in *Fresh Water*, eds. Mary Pat McGuire and Jessica M. Henson (San Francisco: Applied Research + Design Publishing, 2019), 71–81.
13. R.L. Stanton, C.A. Morrissey, and R.G. Clark, "Analysis of Trends and Agricultural Drivers of Farmland Bird Declines in North America: A Review," *Agriculture, Ecosystems & Environment* 254 (2018): 244–254; T. Tscharntke et al., "Landscape Perspectives on Agricultural Intensification and Biodiversity Ecosystem Service Management," *Ecology Letters* 8, no. 8 (2005): 857–874; Tim G. Benton et al., "Linking Agricultural Practice to Insect and Bird Populations: A Historical Study over Three Decades," *Journal of Applied Ecology* 39, no. 4 (2002): 673–687.
14. Joan Iverson Nassauer, Mary V. Santelmann, and Donald Scavia, eds., *From the Corn Belt to the Gulf: Societal and Environmental Implications of Alternative Agricultural Futures* (Washington, DC: Resources for the Future, 2007); Michael Ezban, *Aquaculture Landscapes: Fish Farms and the Public Realm* (New York: Routledge, 2020).
15. Billy Fleming speaks to this specifically, using the Army Corps as the governmental organization and "singular force" determining the form and future of water infrastructure in the U.S. despite the work of early and contemporary landscape architects who have advised otherwise. Billy Fleming, "Boxed In, Boxed Out: Water, Policy, and Design in Landscape Architecture" in *Fresh Water*, 20–25. Rob Holmes attributes this to a fixation on solutionism, while offering a number of hopeful pathways for landscape architecture to engage in landscape infrastructure: Rob Holmes, "The Problem with Solutions," *Places* (July 2020), accessed September 14, 2020, https://doi.org/10.22269/200714.

Shifting

Adjustments & Weak Spots in the Mississippi River Delta

Alexander S. Kolker

[Figure 1] Map of southeast Louisiana, featuring the Atchafalaya Basin Floodway in gray; delineating major river control structures such as Old River Control, Morganza, West Atchafalaya and Bonnet Carré Spillways and the overall levee systems, which includes "Morganza to the Gulf," in red; and, locating Mardi Gras Pass and Fort St. Philip crevasse downriver from New Orleans (image credit: Alex Kolker, Derek Hoeferlin, Chenyu Zhang)



[Figure 2] Plan of Old River Control Complex, comprised of multiple structures, Louisiana (image credit: Alex Kolker, Derek Hoeferlin, Chenyu Zhang)

People who study the Mississippi River will often say that the river is likely to jump down the Atchafalaya River, switching course near the Old River Control Structure in northeastern Louisiana. If this happened, that change to the region would be dramatic. The main stem of the Mississippi River would transform into a tidal, saltwater channel, which would likely silt up, impacting shipping conditions along this heavily industrialized corridor, mostly between the urbanized areas of Baton Rouge and New Orleans. As saltwater moved up the Mississippi River, the drinking water supply for New Orleans would be impacted, likely requiring intensive desalinization efforts. The increased salinities would change the ecology of the region, transforming many freshwater and brackish systems into high salinity ones. And the lack of sediment carried by the river would make restoration in many parts of Louisiana more difficult. At the same time, such a shift would raise water levels and river flood threats in Morgan City in the Atchafalaya Basin. It would also increase the amount of sediment moving through the Atchafalaya Basin, resulting in large quantities of new land developing in southwest Louisiana. **[Figure 1]**

The idea that the Mississippi River will change course down the Atchafalaya is backed by important historical studies. Starting in the mid-19th century, the Atchafalaya started receiving an increasing amount of water from the Mississippi River. By the early 1950s, between 20 and 30 percent of the flow of the Mississippi River flowed through the Atchafalaya.[1] Seeing that a channel switch was likely, the U.S. Army Corps of Engineers (USACE) at the direction of the U.S. Congress constructed a water control structure at Old River.

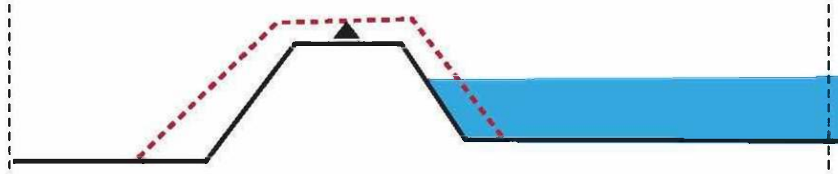
Anne Loes Nillesen

Explore directions

1) EXPANDING TECHNICAL SYSTEM

FLOOD RISK MANAGEMENT

1 Reducing the risk by strengthening the dike

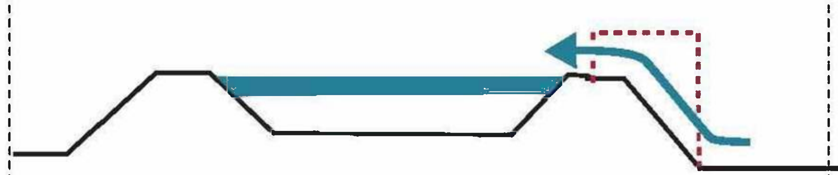


WATER AVAILABILITY

1 Supply extra water

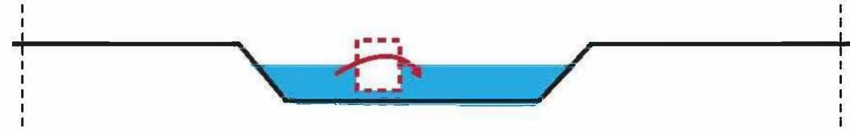
WATER DISCHARGE

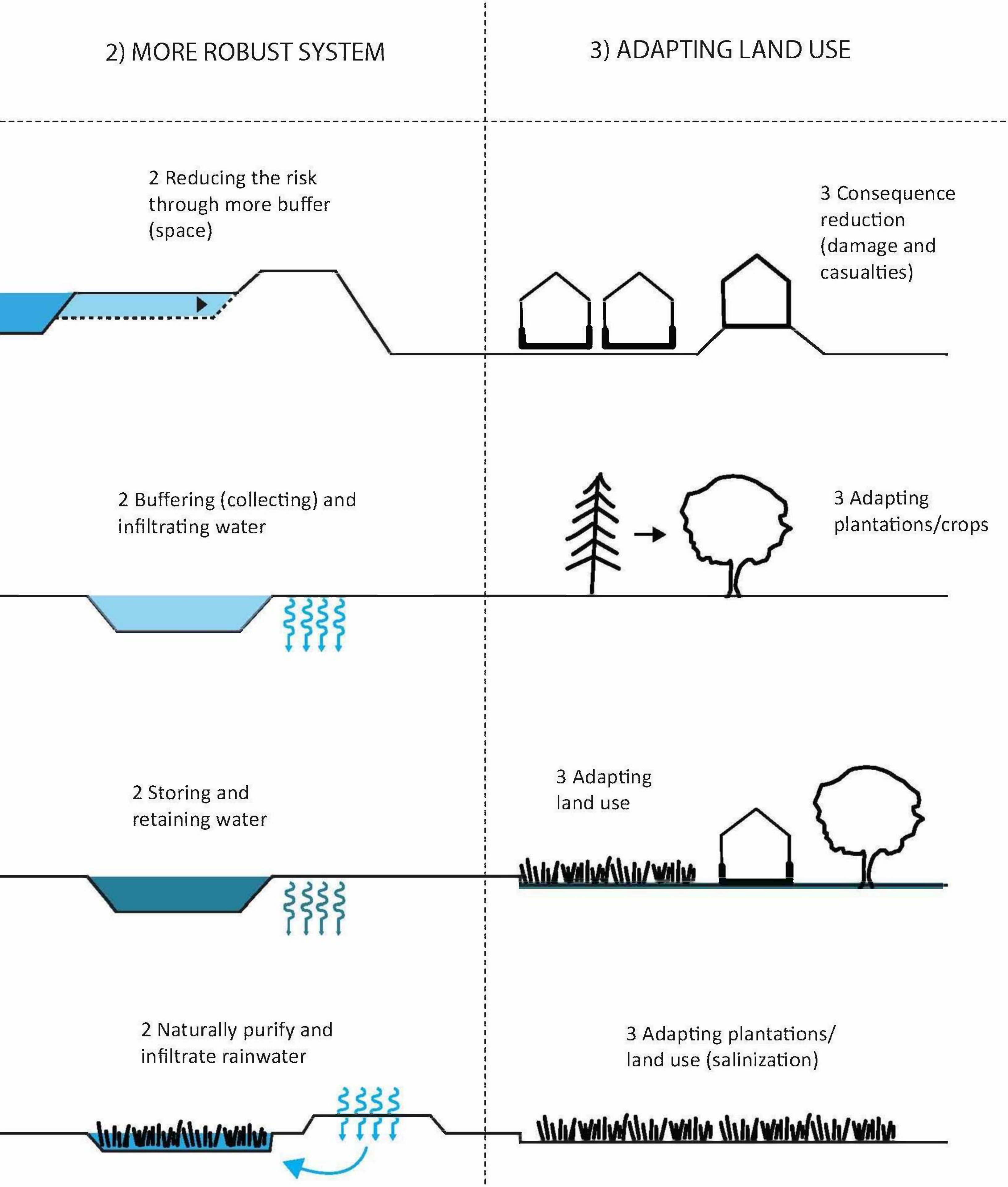
1 Discharge extra water



WATER QUALITY

1 Purification plant

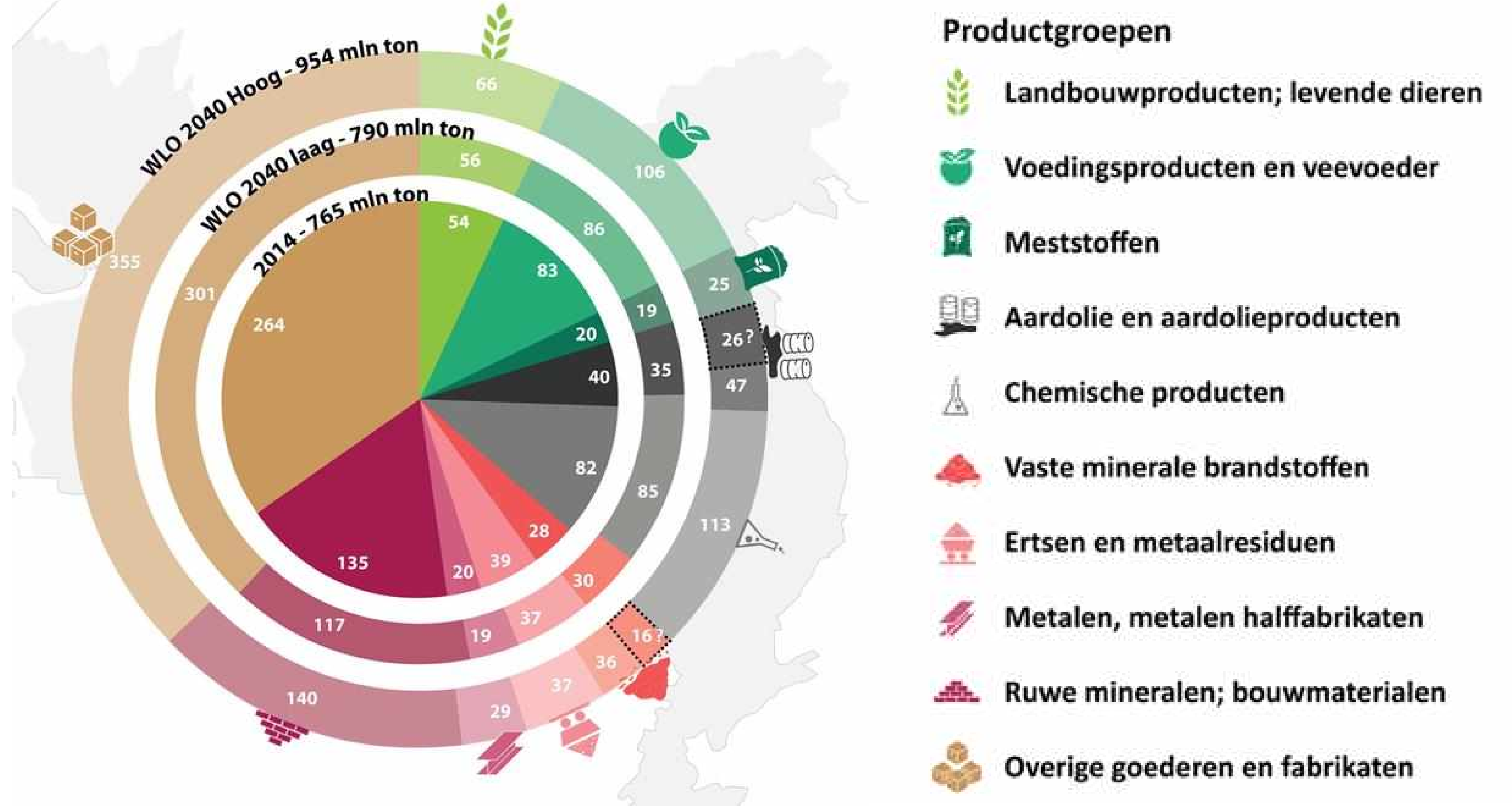



2) MORE ROBUST SYSTEM
3) ADAPTING LAND USE
2 Reducing the risk through more buffer (space)
3 Consequence reduction (damage and casualties)
2 Buffering (collecting) and infiltrating water
3 Adapting plantations/crops
2 Storing and retaining water
3 Adapting land use
2 Naturally purify and infiltrate rainwater
3 Adapting plantations/ land use (salinization)

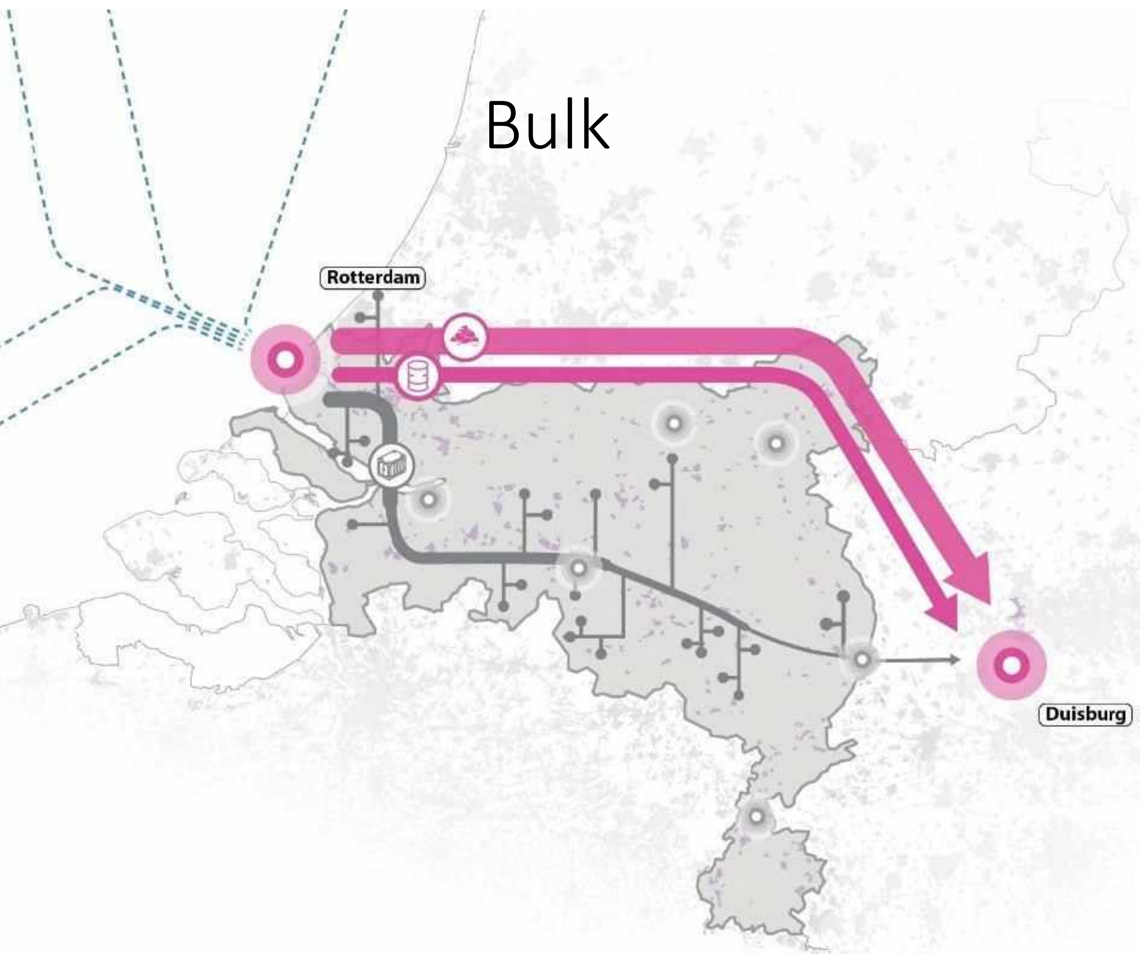

Integrated perspectives
that include sectoral transitions

Integrated perspectives

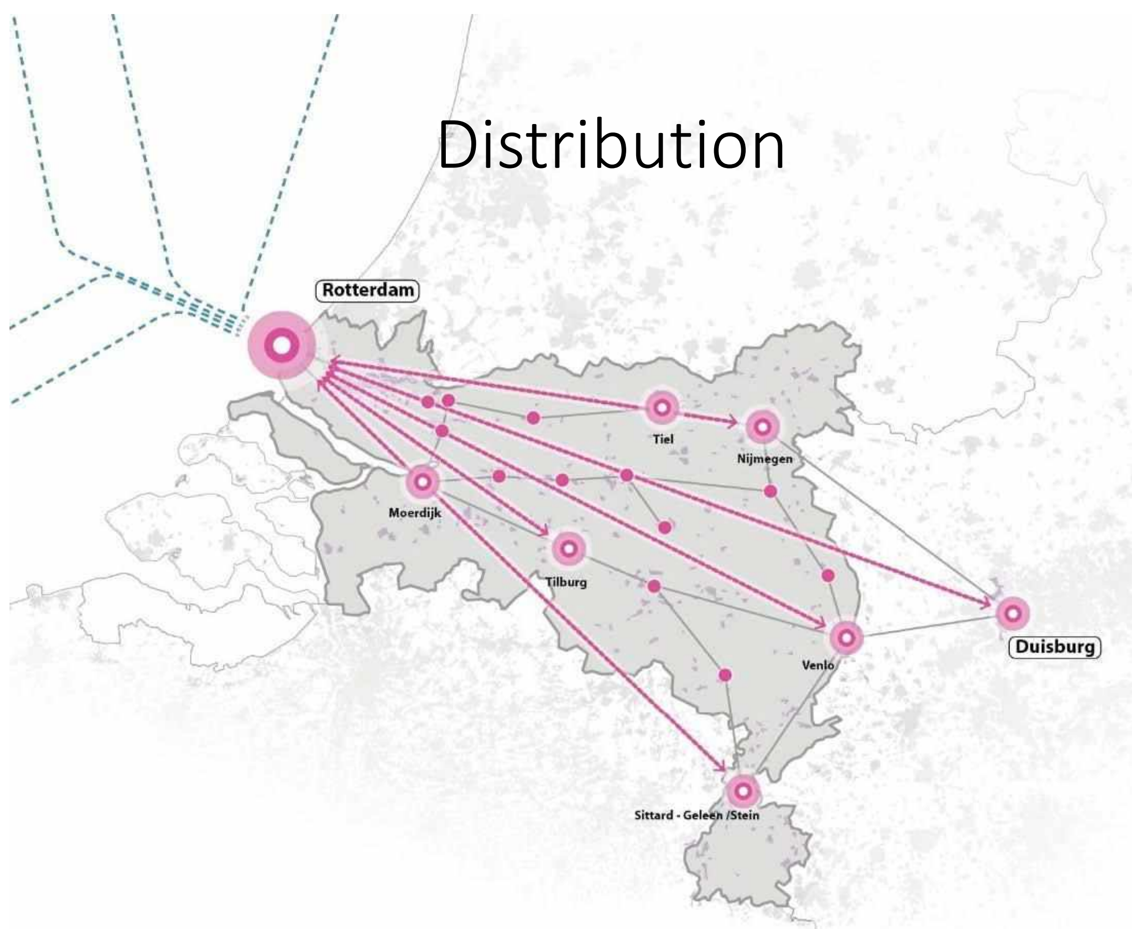
that include sectoral transitions



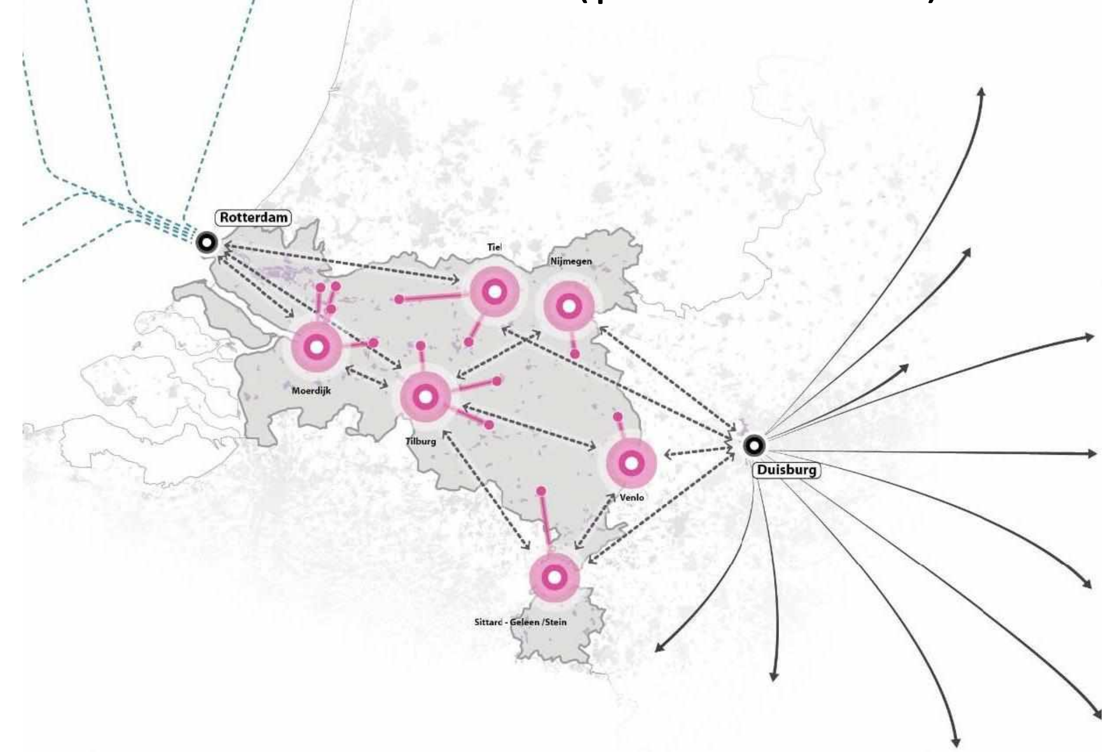
Bulk



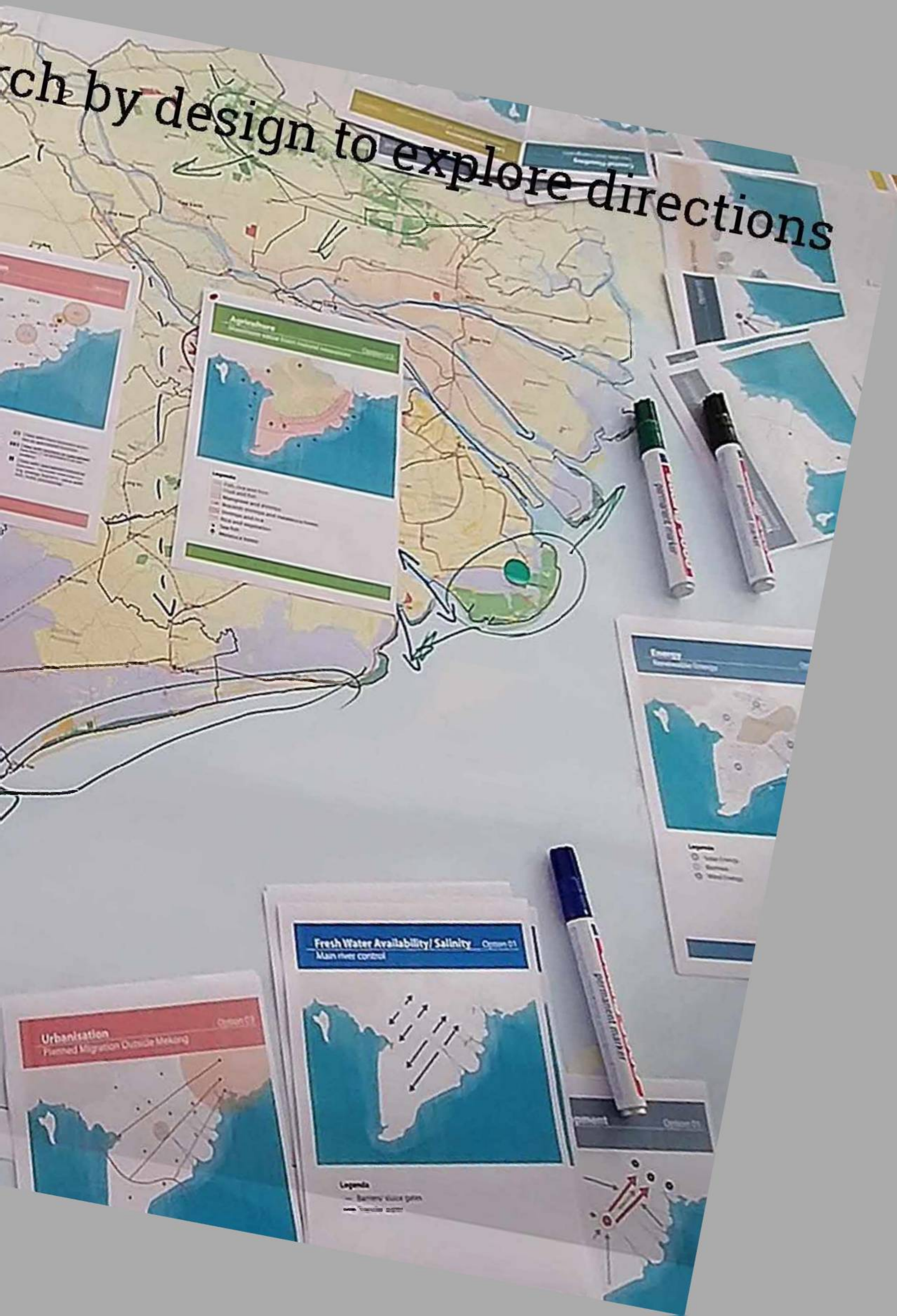
Distribution



Added value (production)




Use resea
Ecology
Title :
Slogan :
Let it go!
Legend
Natural Resources
permanent marker

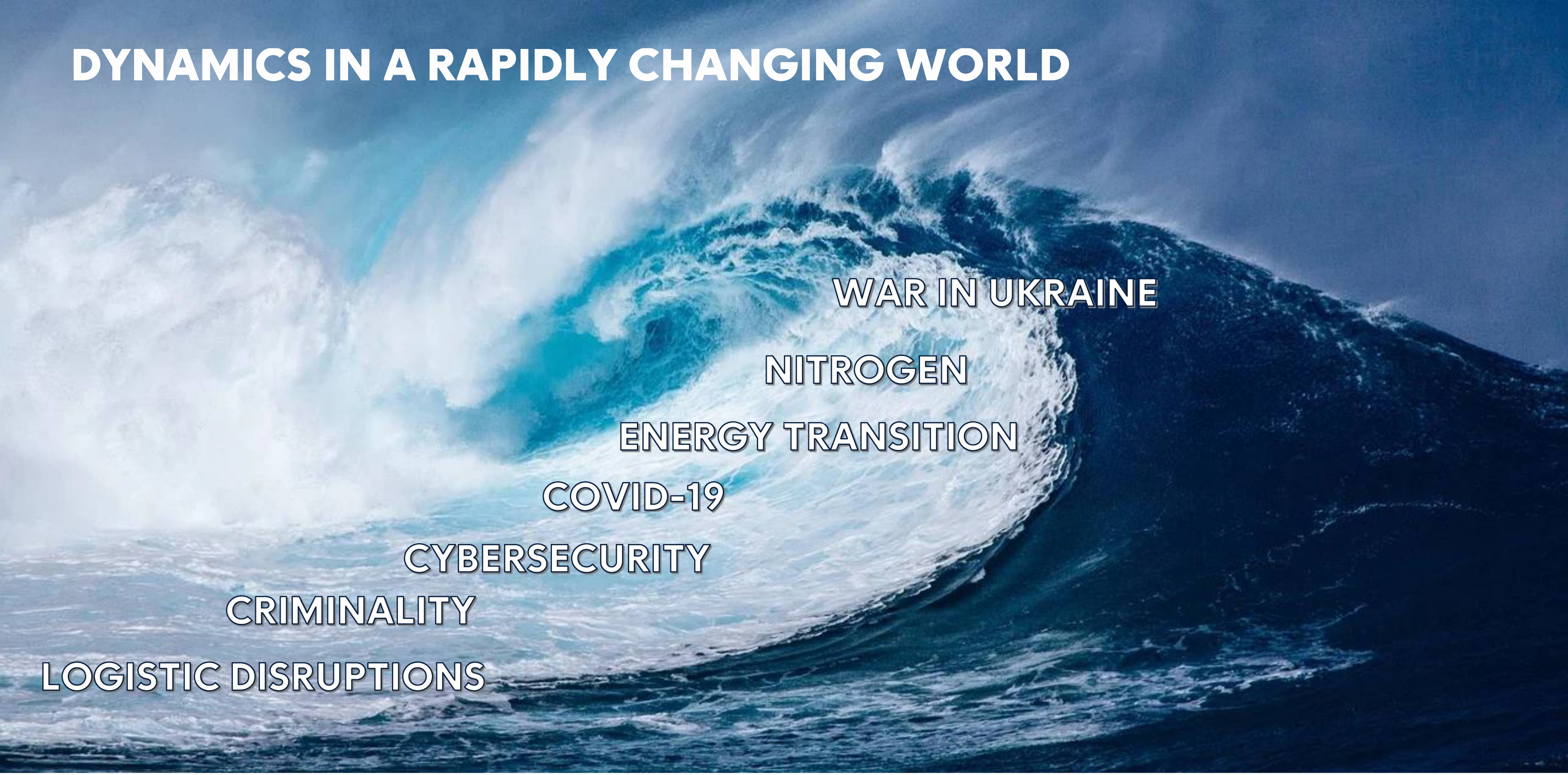

rch by design to explore directions
Agriculture
Energy
Fresh Water Availability / Salinity
Option 01
Main river control
Legenda
Urbanisation
Option 01
Planned Migration Outside Mekong
permanent marker

Carline Borest

THE PORT AS A GATEWAY FOR 350 MILLION PEOPLE

Port of Rotterdam

DYNAMICS IN A RAPIDLY CHANGING WORLD



Port of Rotterdam

ENERGY TRANSITION: STRATEGY BASED ON 4 PILLARS

PILLAR 1
EFFICIENCY AND INFRASTRUCTURE

PILLAR 2
A NEW ENERGY SYSTEM

PILLAR 3
A NEW RAW MATERIAL AND FUEL SYSTEM

PILLAR 4
SUSTAINABLE TRANSPORT (-20% BY 2030)

-55% CO_2 BY 2030

CO_2-NEUTRAL BY 2050

End of report