JDU

Journal of Delta Urbanism
Delft University of Technology

Issue #02 LONGUE DURÉE

Fall | Winter 2021

Building with Nature:

A Nineteenth Century Concept

Fransje L. Hooimeijer
Dennis Lambert

The concept of “Building with Nature” refers to a harmonious way of creating environments for new living, working and recreation spaces with respect to nature. It also builds resilience to natural events such as storm surges and thus involves the design of infrastructure., This is done with the intention of ensuring the preservation or expansion of environmental and ecological resources, nature, and landscape. Moreover, it considers climate change and sea level rise as well as more frequent and intense storms, resulting in floods and land subsidence. The concept of Building with Nature is strongly connected to an industrialized society. Before the Industrial Revolution, technological advances and engineering, people were forced to live and work according to the rules of nature. This paper seeks to discover what we can learn from 19th century concepts on Building with Nature that are rooted in the pre-industrial era.

The paper explores the history of the science of soil and water, in deltaic regions and focuses on the United States and the Netherlands during the nineteenth century. Within these contexts, two key historic figures are positioned, Joseph Raymond Thomassy and Willem Antonie Scholten. By reflecting on the communication between Thomassy and Scholten, the paradigm shift diverging from Building with Nature is exposed and takes on a new and compelling meaning of both an industrial approach and a natural solution to water management.

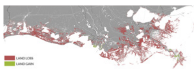
INTRODUCTION

Hurricane Ida (2021) was the second most damaging hurricane to hit the State of Louisiana since Hurricane Katrina. So far it is estimated to be the sixth costliest hurricane to hit the coastline of the United States and the cost of damage continues to rise. The strongest winds recorded in Louisiana are tied between Hurricane Laura (2020) and The 1856 Last Island Hurricane. Ida turned streets into rivers, ripped down power lines, uprooted trees, and cut off coastal communities. Hurricane Ida (2021) hit the Louisiana coast on August 29, the same date of landfall for Hurricane Katrina (2005), Hurricane Gustav (2008), Hurricane Isaac (2012) and Hurricane Harvey (2017).

In 2020, five named storms hit the Louisiana coast which included Tropical Storm Cristobal, Tropical Storm Marco, Hurricane Laura, Hurricane Delta, and Hurricane Zeta. In fact, a Category 4 or 5 hurricane has entered the Gulf of Mexico every 1.4 years since Hurricane Ivan (Charley (2004), Ivan (2004), Katrina (2005), Rita (2005), Wilma (2005), Gustav (2008), Ike (2008), Harvey (2017), Irma (2017), Michael (2018), Laura (2020) and Ida (2021)). The Mississippi River has seen some of its worst flooding in recent years. As a result, the Bonnet Carré Spillway, the location of a 19th century crevasse, has been opened spillway on average every 1.87 years since 2008, whereas it has only opened 13 times in the last 90 years. It was designed to open every 10 years.

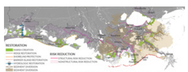
The recent spillway openings have included 2008, 2011, 2016, 2018, twice in 2019 and 2020 where the latter years decimated the oyster reefs in the Mississippi Sound with over 330 dolphins stranded, triggering an unusual mortality event declaration by the National Oceanic and Atmospheric Administration. The flooding of the estuaries also caused impairment to the shrimp and crab populations and higher mortality rates for the critically endangered Kemp's Ridley sea turtle. The flooding in the Mississippi River valley has become more and more intense as the river has been harnessed and confined within its banks by the largest levee project in the United States, called the Mississippi River & Tributary program, established following the 1927 flood.

figure 01 — page 32



Nevertheless, the connection of the river to the estuarine system was once a flourishing symbiosis for both water bodies. However, today, the disconnection and the nutrient pollution is clearly an impediment in building with nature in a proposed attempt to reconnect the two for delta management purposes. The river needs room to breathe within its once historic flood plain, though the impacts of opening it back up are severe which is why there is value in reviewing this "nineteenth century concept." The State of Louisiana has proposed to reconnect the river with the basins adjacent to it by building a sediment diversion structure at the river

figure 02 — page 32



with a gate allowing for flexibility and adaptive management practices as part of its operational plann. However, the projects have not included landscape mitigation measures such as dikes to minimize impacts to fisheries including oyster reefs, dolphins, fisheries, etc. within the receiving coastal estuaries.

This case illustrates how human urbanization is disturbing the natural systems, making humans especially vulnerable to natural disasters.

Urbanization requires more land for the population while climate-change (under expected scenarios) increases land loss. The Building with Nature concept offers a flexible integration of land-in-water and of water-in-land (working with nature), which could be profitable in tackling the issue described above because it is environmentally friendly and economically advantageous[1].

The essence of the concept "Building with Nature" within the hydraulic engineering field is the harmonious way of creating space for new living, working, and recreation space, and thus infrastructure, while ensuring the preservation or expansion of environmental resources, nature, and landscape[2]. Moreover, it considers climate change, resulting in general sea level rise and more frequent and intense storm surges, and thus floods, as well as land subsidence.

The concept of Building with Nature is applied in the Netherlands in the Delfland 'sand engine'. *figure 03 — page 34*  It is an experiment of concentrated nourishment on the Dutch coast to counter structural erosion. The idea is to deposit a large amount of sand in one location, which is then gradually redistributed across and along the shore by wind, waves, and currents. Making use of these natural processes to redistribute the sand aims to limit the disturbance of local ecosystems, while also providing new areas for nature and recreation.

Of course, the concept did not appear suddenly, and in other sectors there are comparable concepts such as Biomimicry in the chemical industry, and Nature Based Solutions in urban planning and design. These concepts share the goal of using natural processes to realize beneficial outcomes that improve human well-being[3]. They also all originate from the ecological movement that started in the 1970s with important figures like Rachel Carson (Silent Spring, 1962), Ian McHarg (Design with Nature, 1969) and the Club of Rome (Limits to growth, 1972). In particular, the role of ecology and ecologists has risen in environmental planning since then.

The traditional approaches focus on minimizing negative impacts and compensating for any residual negative effects or impacts of infrastructure projects. As a step beyond these reactive approaches, the concept of Building with Nature is quite innovative and is still in an early stage. Despite pilot projects having shown promising results, traditional approaches are often still favoured because uncertainties are perceived to be less[4]. Contextual learning about why pre-industrial Building with Nature practices have been abandoned can help in understanding how to implement the currently evolving concepts of Building with Nature in the 21st century.

The concept of Building with Nature is strongly connected to an industrialized society. Before the Industrial Revolution, before technology made everything possible and dominance of the engineering approach grew, people were accustomed to living and working within the rules of nature[5]. The 19th century is an interesting era in this respect because industrialization fostered the engineering approach until it came to full maturity after WWII. What we can also see in our fast-developing technological innovations today is that in technology, newcomers are overtaking the predecessors - considering that the nineteenth century ideas about working with nature were taken out of engineered solutions and did not

1 Waterman, 2011
2 Ecoshape, 2016
3 De Vriend et al., 2014; EC, 2015; Potschin et al., 2016
4 De Vriend et al., 2014
5 Hooimeijer, 2014

become mainstream. Maybe one of the reasons is that there was no such compelling term like ‘Building with Nature’ used but one engineer, Willem Antonie Scholten argued that technical solutions were a violation of the laws of nature while Joseph Raymond Thomassy claims: “The art of the engineer is then that much surer of itself as he is in line with nature, whether preceding it, or following it, but always moving in action and never retreating.” [6]

These two engineers, the Dutch Willem Antonie Scholten (1818-1861) and USA based French Marie Joseph Raymond Thomassy (1810 - 1863) are at the centre of discussing the question of this paper: “what can be learned from the 19th century concepts of Building with Nature which are rooted in the pre-industrial era?” This historical approach becomes relevant by directing thoughts to historic concepts, interventions, and approaches to present-day problems. Today, the proposed sediment diversions in Louisiana contain similar features of coupling and decoupling symbiosis between the river and the delta. The project attempts to align with nature, an historic connection, while at the same time adversely impacting the current state of nature in the system. The history of technological developments that diverted engineering from the natural context can help guide us back to future solutions in harmonizing with nature in order to address the impacts of climate change. The core example is called ‘Colmates’, which is a technique whereby dikes create the conditions for sediment diversion to happen naturally again. This is a nineteenth century concept of Building with Nature. This system would allow a symbiosis to be recoupled without detrimental impacts to marine and aquatic resources in coastal estuaries.

The paper first explores the pre-industrial history of the science of soil and water in deltas that show Building with Nature concepts and practices. To be able to show how technical knowledge development diverted the western world from working with nature, called the Industrial Revolution that, the developments of geo-sciences in the United States and water management in the Netherlands during the nineteenth century are explored. Within these two contexts Thomassy and Scholten are positioned within the field of water and land management and a paradigm shift, diverting from Building with Nature is discussed.

HISTORY OF THE SCIENCE OF SOIL AND WATER IN DELTAS

In order to be able to place the Building with Nature concept in an historical context, it is important to understand how the relationship between soil and water, as a science, evolved over time creating many branches of scientific study including, but not limited to, hydraulic engineering, hydrology, geology, geodesy, geomorphology, and oceanography. With this, it is important to note that before the Industrial Revolution these - today called - disciplines were not segregated as such. As shown in the professional segregation in the Royal Association of Engineers in the Netherlands, all these branches connected to coastal development segregated after the

figure 04 — page 35


Industrial Revolution changed the world[7].

The paradigm that came with the Industrial Revolution and is characterized by the idea that technology can make everything possible and therefore the engineered approach is more efficient and profitable,

6 Thomassy, 1858
7 De Ingenieur, 1960

removed centuries of dealing with the natural conditions following the rules of nature[8]. What are examples of this even much older paradigm of Building with Nature?

This paragraph sketches the historical context until the 20th century beginning before Menes, the founder of the first Egyptian dynasty in 3200 B.C. The earliest large-scale drainage and irrigation works are attributed to Menes, followed by many varied projects in the Mediterranean and Near East, including dams, canals, and aqueducts[9]. The greatest of human scenes have been near the shores of the Nile, the Euphrates, the Indus, and the Hoang Ho (Yellow River) and there we find the cradle of the first nations of the earth – the Egyptians, the Assyrians, the Hindus, and the Chinese[10]. Research revealed that a dam was built across the Nile around 4000 B.C. and later a canal was built from Cairo to Suez[11].

The Egyptians took a radically different mode of distribution of the waters of the Nile: they allowed the flooding river to spread freely over the land. They dug thousands of channels of irrigation, vehicles of muddy waters, intended to spread sediment over all parts of the country. Thanks to that general spreading of mud via these conveyances, a controlled sedimentary process of raising the territory prevented yearly catastrophic inundations of the Nile. The Nile delta is known to have a minimum depth of loam. Hence, for 3,000 to 4,000 years of known history, the Nile delta has undergone no radical change in the exterior aspects of its shoreline and has scarcely been modified but through the loamy deposits of its inner marshes[12].

Another noted project of the Ancient World is the ancient Dujiangyan irrigation system in Sichuan Province, China[13]. Constructed 2,500 years ago by the State of Qin as an irrigation and flood control project, it is still in use on the Min River (Minjiang), the longest tributary of the Yangtze. This natural watercourse would fill with silt, which made the nearby areas extremely prone to floods. The irrigation project however used a new method of channelling and dividing the water (sometimes referred to as a system of warping) rather than the old way of dam building.

During the Roman Empire, over 380 miles of aqueducts were constructed to bring water to Rome. Streamflow measurement techniques were first attempted in these water systems appearing in the written record around 97 A.D. and were based on the cross-sectional area of flow[14]. However, a huge gap in the state of knowledge persisted until the time of Leonardo di ser Piero da Vinci (Leonardo da Vinci) around 1500 A.D. when he proposed the idea that precipitation was the source of streamflow. Construction materials at the time also influenced early engineering works[15]. Leonardo da Vinci was credited with establishing the proper relationship between area, velocity and flow rate[16].

Other significant contributors to the science at the interface of water and soil before the 19th century include:

- Pierre Perrault on the comparison of rainfall and flow in the Seine River (1694).
- Edmond Halley on the estimation of evaporation from the Mediterranean Sea and concluded it was enough to account for tributary flows documenting the complete hydrologic cycle (1687).
- Edme Mariotte on the measured velocity of the Seine River which led to advances such as Daniel Bernoulli's equation, the development of Henri Pitot's tube and Antoine de Chézy's formula (1769).

8 Hooimeijer, 2014
9 Linsley et al., 1964
10 Thomassy, 1861
11 Bedient and Huber, 1992
12 Thomassy, 1861
13 Linsley et al., 1964
14 Bedient and Huber, 1992
15 Linsley et al., 1964
16 Bedient and Huber, 1992

The knowledge of the interface between soil and water continued to increase, including groundwater hydrology which took off in the 19th century with developments such as:

- Henry Darcy's law (1865) law in geology describing the rate at which a fluid flows through a permeable medium.
- Arsène Jules Étienne Juvenel Dupuit and Adolf Thiem's formula known as Dupuit-Thiem formula (1863) used to assess flow towards a pumping well in unconfined aquifers under steady-state conditions.
- Jean Léonard Marie Poiseuille and the Gotthilf Heinrich Ludwig Hagen equation (i.e., Poiseuille-Hagen equation) published by Poiseuille in 1840, 1841 and 1846, is a physical law that gives the pressure drop in an incompressible and Newtonian fluid in laminar flow flowing through a long cylindrical pipe of constant cross section.
- Claude-Louis Navier and George Gabriel Stokes equation known as Navier-Stokes equation (1822) is a partial differential equation which describes the motion of viscous fluid substances.

At that time, one of the older engineering schools in the world became more prominent, École des Ponts et Chaussées in Paris which was originally founded in 1747 as an organized centre of knowledge for engineering and science. This is where Dupuit and Navier were students and Chézy was a member of its faculty and served as director in 1798 upon his death[17]. The abundant knowledge resulting from these and other more recent practical applications are indispensable[18].

The contributions by the French in knowledge development and transference thereof of the science at the interface of soil and water affected both the Netherlands and the United States. In the following paragraphs, knowledge development in the Netherlands and United States in the 19th century is described to show how concepts of Building with Nature, or maybe better referred to as 'following the rules of nature', were overruled by explosive growth in the fields of geological sciences (the United States) and water management (the Netherlands) which is mostly represented in the building of embankments or dikes for flood protection.

KNOWLEDGE DEVELOPMENT IN THE UNITED STATES

As a preamble to the discussion about the development of water management in the United States, the development of the science in sediment transport and its origins with geology is needed to fully capture an understanding as it relates to Building with Nature in the Lower Mississippi River. This is, a build-up in part from geology to oceanography and mapmaking to hydrology and navigation.

Geology as an Emerging Science

When the United States was founded in 1776, several advances had been made in the area and the formulation of geology as a science which included directly challenging the Mosaic chronology, a paralleled movement of French Nationalism; the discovery of the origin of fossils and its linkages to stratigraphic geology; the establishment of geological dynamics; a deep awareness of the effects of volcanic action; the re-emergence of geomorphology; the classification of minerals establishing the role of chemistry in the formation of the earth; and the advent of cartographic techniques for the portrayal of geo-

17 Herschel, 1897
18 Hwang and Houghtalen, 1996

logic phenomena[19]. It was in the 19th century that the United States founded the U.S. Army Corp of Engineers (1802), the U.S. Coast Survey (1807), the U.S. Geological Survey (1879), the Weather Bureau (1891) and the Mississippi River Commission (1879) which were all critical in contributing to the written record of American knowledge development[20]. Until the establishment of the U.S. Geological Survey, the major burden of geological research was by the State surveys with the early exception of the Federal surveys of the western territories authorized under the leadership of then President Thomas Jefferson. In 1804, it was also President Jefferson who funded the expedition of Meriwether Lewis and William Clark shortly after he orchestrated the Louisiana Purchase in 1803. Later, the United States government funded the extensive geological reconnaissance of the western territories conducted by George William Featherstonhaugh, William Williams Mather and David Dale Owen. These surveys documented the much-needed cooperation between Federal and State surveys[21].

Oceanography and Mapmaking

While geology, as a science, was being formed, oceanography and geodesy, branches of geology, were also being formed, as shown in Benjamin Franklin's work of the North Atlantic currents, an example of early development in oceanography and geodesy. However, it was not until the publication of Physical Geography of the Sea by Matthew Fontaine Maury in 1855 that modern oceanography emerged as a distinct branch of geology. The U.S. Coast Survey was formed under the leadership of Ferdinand Hassler and his successor Alexander Bache, Benjamin Franklin's great grandson. Both Maury and Bache's contributions, though competitive with each other at the time, triumphed over the accomplishments of American geodesy. It was Bache's maps of Louisiana, based on extracts of Captain Andrew Talcott surveys and recommendations, published in 1837 and 1838, that provided the underpinning study of coastal geomorphology and landforms, a foundation of Building with Nature as proposed in 19th century Louisiana. By first depicting the changes and progress of the birdfoot delta of the Mississippi River, these landforms would shed light on nature's delta building capabilities. Incidentally, Captain Talcott was considered for Bache's position and responsible for modifying Peder Horrebow's method which is used to determine the maritime position at sea, by the location's latitude from the stars. This method, later, became known as the Horrebow-Talcott method. Mapmaking and navigation have played a major role in the important evolutionary concept of Building with Nature.

Hydrology and Navigation

Concurrently, other sciences were evolving such as the development of hydrology, an essential applied understanding needed in modern concepts of Building with Nature. Advancements included many flow formulas and measuring instruments developed for systematic stream gaging:

- Captain Andrew Humphreys and Henry Larcom Abbot published the first discharge measurements of the Mississippi River in 1861.
- The first systematic program of flow measurement was set up by the U.S. Geological Survey in 1888; Robert Manning's equation, as an alternate to Chézy's equation, was published in 1889[22].
- The current meter was invented by William Gunn Price in 1885[23].

19 Schneer, 1979
20 Bedient and Huber, 1992
21 Schneer, 1979
22 Bedient and Huber, 1992
23 Hager, 2015

These technological advances in data collection and measurement were occurring as part of the overarching water management practices of the United States. The Americans were attempting to establish navigable waterways within the Lower Mississippi River following European ownership of the territory previously under the French and Spanish monarchs. The natural tributaries of the Lower Mississippi River within the Plaquemines-Balize Delta (the birdsfoot) were modified as attempts to channelize them to render these waterways as navigable for commerce. These efforts had a profound impact on the state of knowledge of water management sciences in the United States.

In the 1850s, it was Marie Joseph Raymond Thomassy (1810 - 1863) that proposed the first U.S. recorded 19th century concept of Building with Nature founded on concepts and technological advances in geology, geography, hydrology, hydraulics, oceanography, geodesy, and a keen eye on historical knowledge development of mapmaking and coastal surveys. His work on Building with Nature followed his work on navigation and observation as recorded by the French explorer, René-Robert Cavelier, under the pseudonym de La Salle, which he found by happenstance. Thomassy discovered a manuscript of de La Salle on the discovery of the mouth of the Mississippi in 1682. In his work, Géologique practique de la Louisiane [Practical Geology of Louisiana], Thomassy discusses de La Salle and other explorations by Pierre Le Moyne d'Iberville and others[24] with the intention "to accurately depict the geology of the region"[25] and observes "revealing the complexity of the landscape that took shape through the subtle interplay of sediment, fresh andsaltwater, and vegeta

figures 05 and 06 — page 36

tion over millennia." The images   shown in Thomassy's work reveal actively shifting sediments through its coastal change maps in the passes relevant to navigation and the formation of natural levees.

While mechanical methods for channel maintenance were paramount to maintaining navigable waters within the birdsfoot, a more holistic approach was developed by Thomassy which pulled on the institutional knowledge of water management. Similar technologies included river training with wooden planks and jetties as developed by W. P. Craig and contracted to Craig with William Russell Rightor. This work was followed by others including Captain James B. Eads, civil engineer, inventor and shipbuilder from St. Louis. Eads implemented the necessary restrictions of outlets, upstream of the passes, in order to maintain water flow and velocity through the birdsfoot to order to induce self-scouring effects. The basic principle is the correlation between velocity and cross-sectional area, known as the continuity equation for flow (i.e., Qflow = Velocity x Cross-sectional Area).

Thomassy set out to prove his approach to the drainage commissions of New Orleans by seeking support for his proposal to establish a system of Colmates (sediment diversions) versus the chosen system of polders. Thomassy believed the diversion of sediment out of the riverbed of the Mississippi River would also benefit the management of sand shoals and bars in the passes of the birdfoot delta of the river mouth. In his argument, he professes the "gifts of nature" could be utilized to combat storms (surges) and inundations (river flooding). He travelled to the Netherlands in 1858, as it was referenced as "a model to follow" and, met with, as he

24 Schneer, 1979
25 Hindle, 2017

described in his manuscript, Géologie pratique de la Louisiane, the Director of Public Works of Rotterdam Willem Antonie Scholten (1818-1861) architect and son of Jan Arent Scholten (1793-1876) who worked as surveyor of the Schieland Water Control Board.

figure 07 — page 37


KNOWLEDGE DEVELOPMENT IN THE NETHERLANDS

The situation in the Netherlands at the beginning of the nineteenth century is different from the United States in the sense that since the fourteenth century there were Water Boards. Since the recognition of the 'Republic of Seven United Provinces' in 1579, followed by the installation of an organized army that surveyed and amassed knowledge by building fortifications, canals, and bridges, there was an institution where knowledge development concerning soil and water took place[26]. Due to the fact that the soil of the Dutch territory can be considered 'thick water', the emphasis has always been more on the water management dimension and the soil mechanics were part of national knowledge development well into the 19th century. In this paragraph, therefore these two dimensions are described separately and conclude with the establishment of the character of the engineering approach.

Water management

At the end of the eighteenth century there was a heterogeneous group of engineers specialized in water systems. There was no formal organization on a national level but there was an informal, fragmented civil service represented by the river inspectors in the Province of Holland[27]. During the French occupation (1795-1813) the French bureaucratic and centrally organized governmental structures were superimposed on the Dutch administration. Le Corps des Ponts et Chaussées (1716) and Ecole des ponts et Chaussées (1747) were models for the organization and schooling of engineers. In France these institutions trained expert engineers that were highly respected in society. National leaders were often engineers[28].

In the nineteenth century, the Netherlands was characterized by explosive population growth and industrialization. The first Industrial Revolution in the Netherlands took place between 1800 and 1850; principally in cotton-based technology (spinning, weaving, and so forth). The second Industrial Revolution took place from 1850 to 1900, and was characterized by railway, shipping, and heavy industrial development, producing iron and steel. Besides strongly altering the forces that shape the (urban) landscape, this was when industrialization arrived in the Netherlands. The Industrial Revolution also affected changes in hydraulic and hydrologic technology[29]. In the nineteenth century there were engineers working at the Water Boards who lost their autonomy because of the introduction of French bureaucracy. During the era of the Dutch Republic, water management was a decentralized activity and water was controlled by local citizens, where necessary and as they saw fit. After 1814, water management became of national importance and Water Boards were placed at the governmental level of the provinces. This special position is confirmed in Thorbecke's national constitution of 1848. The division of tasks and responsibilities have hardly changed to this day[30].

26 Bosch, 2000; van der Ham, 1999
27 Lintsen, 1980
28 Bosch & van der Ham, 2015; Lintsen, 1980; Freiherrn von Weber, 1887
29 Lonnquest et al., 2015
30 Brainich von Brainich-Felth, 1993

In 1815 the Ministry of Transport and Public Works was established and a year later the Body of Engineers of the Ministry of Transport, a department of the ministry, was given the name Department of Waterways and Public Works in 1820. In 1821 the River Committee was set up as a subdivision because since 1741, the rivers had caused the government concern[31]. Aside from the economic advantages, technological development was advanced by large scale projects undertaken in the Netherlands of the 19th century. In the field of general water management, theoretical models continue to be created; the use of Bernoulli work to measure the flow velocity of rivers made it possible to calculate how strong dikes and sluices needed to be. In dike building, the main transformation during this period occurred in 1840: boulders were replaced by basalt.

After work on the rivers in 1850, the riverine system was systematized under pressure of the danger of flooding. River traffic was not only disrupted by regular floods, but also by the drying up of the rivers (1857). After 1861 the Department of Waterways and Public Works had steam dredges at its disposal to keep rivers at a certain depth and in 1872 an independent Directorate of Rivers.

Under pressure of flood danger, various plans to close off the Zuiderzee followed each other: the Kloppenburg and Paddegon Plan (1848), engineer B.P.G. van Diggelen developed the Department of Waterways and Public Works Plan (1849), engineer J.A. Beyerinck (1866) and A. Huet (1862-1875 and 1870-1895). In 1886 the Zuiderzee Society was founded to study the feasibility of the plans. In October, Cornelis Lely took up his duties with the Society. In the following decades he devoted himself as Secretary of State for Transport to the execution of the plans[32].

The reclamation of the Haarlemmermeer (1848-1852) strengthened the position of technicians in relation to the government. Civil engineers proved that they could produce the interventions desired by the government, and the developments followed fast. What they could do was indeed impressive: control rivers, drain lakes, reclaim land, build railways and dig canals.

Soil mechanics

The development of soil mechanics took flight in the nineteenth century and matured as a science in the twentieth century. In the Netherlands, the first publication that considers Coulomb's work is an article by Brunings in the Verhandeling van het Bataafs Genootschap (1803): 'Over zijdelingsche drukking der aarde en de hier naar te regelen afmetingen der muuren' (About the sideways pressure of soil and the structural design of walls). Coulomb develops a purely theoretical model considering the balance of soil mass. He gives each type of soil a certain rating in moisture dependent cohesion, and introduces a new soil-specific characteristic, the angle of internal friction ϕ which measures the resistance of the soil type towards land sliding. When the cohesion between the soil particles is zero, the angle is the same as the angle of a natural gradient[33].

The article breathes of the Enlightenment because Brunings is convinced that the time has come when the distance between theory and practice is shrinking. This is due to the use of the same language and a greater understanding between the theory of observation and the practice of blind searching. The Enlightenment is representative of the justifica-

31 Van der Woud, 1987
31 Van der Woud, 1987
33 Verruit, 2001

tion of 'aware' humans and 'unaware' (or unconscious) nature[34]. This idea of understanding nature and controlling it inspired other Dutch scientists who contributed to the knowledge of soil mechanics like D. Mentz (1785-1847) and I.P. Delprat. The latter wrote the 'bible' of soil mechanics for the Military Academy in Breda (1837), and focused on the pressure of soil on stone walls in fortifications[35]. Coulomb's Law, used to calculate ground pressure, offers such a grasp of the matter, however, that the world of practice was, at that time, not eager to learn. Because of this as well as the developing science of that time, Bruning's idea of closing the gap between theory and practice is even less realistic. The gap is closed by Terzaghi in 1927, more than 100 years after Brunings book[36].

The continuous development of theory was supported by William John Macquorn Rankine (1820-1872) who published an article on the possible states of stress in soils in 1857. The principles of the mechanics of continua, including statics and strength of materials, are also well known in the nineteenth century, due to the work of Isaac Newton (1643-1727), Augustin Louis Cauchy (1789-1857), Claude Louis Marie Henri Navier (1785-1836), and Joseph Boussinesq (1842-1929). Around 1850, systematic soil research started by taking drilling samples. The development of soil mechanics needed large projects, like the building of the railway system in 1839[37].

The engineered approach

Considering these developments in water management and soil science, the triumph of being able to control nature and protect the Dutch people from suffering floods over and over became inherent to the engineering profession. Aside from their formal education, engineers organized themselves into the Royal Engineers Society (1847) and the Society of Civil Engineers (1853)[38]. Theory and the use of technology are closely interwoven with the Ministry of Transport and Water Management and civil engineering. Both disciplines were focused on technical planning according to an established pattern, with the difference being that the military way of thinking has always been strategic due to the inclusion of insecurities, while civil engineering is more about short term tactics and clear measures[39]. The many large-scale projects in the nineteenth century (railway, pumping lakes, and canals) caused engineers, who were mostly from the working class, to meet higher social classes. The prestige of these projects and the engineers' expertise in realizing them lifted their social status[40].

Two articles in De Ingenieur illustrate the position of the engineer in society, or in any case the journal's view of it. The first, written in 1887, sees the engineer in the front-line of the fight for modernization, proving that the powers of nature can be controlled. Engineers carry a large responsibility but are not appreciated for it. The articles describe how the fight for appreciation is difficult since the profession is so young and does not have a solid position in society[41]. The second article, written two years later, is about a visit of the Royal Society of Engineers to the Société des Ingénieurs: "That is the meaning of these visits, to ensure that we, as children of one spirit, get connected, so that we can make the nineteenth century a time of peaceful triumph of technical science. Believe me, signed, J. de Koning."[42]. The last quote is especially representative of the attitude towards nature and the role of the engineering approach.

34 Dupre, 2005
35 Lintsen, 1994c
36 Verruit, 2001
37 De Vet, 1994
38 Lintsen, 1980
39 Van der Woud, 1987
40 Lintsen 1980, 125
41 De Ingenieur, 1887
42 De Ingenieur, 1889

In the nineteenth century the approach towards the natural system, general water management prospered from the new forms of power, not only because of industrialization, but even more so due to the systematization of knowledge. Good organization transformed knowledge by experience into systematized building knowledge in hydrology and hydraulics. The force of the machine, the build-up of knowledge and the systematization of organization all led to a coherent engineering approach which was very well connected to the field of decision making.

INTERNATIONAL EXCHANGE OF BUILDING WITH NATURE CONCEPTS

Even though communication, until the introduction of the telegraph halfway the 19th century, was only through the written word, there was exchange of knowledge on a global scale through journals. It was this manuscript, Géologique practique de la Louisiane and the letters published in the L'Abeille de la Nouvell-Orleans (New Orleans Bee) that detail the historical knowledge Thomassy had gained about the Egyptians' and the Italians' concept of Building with Nature centuries before it was proposed in Louisiana. Due to Thomassy's training in mapmaking, acquired during his formal education of palaeography, philology and his continued studies in geography, geology and hydraulic engineering, he consulted the historical record illustrated in his work, "Les papes geographes et la cartographie du Vatican," in Rome and reported about it in the publication: Nouvelles Annales des voyages et de sciences geographiques[43]. Known today as the Gallery of Maps (Galleria delle carte geografiche) in the Vatican, the series of painted topographical maps of Italy by geographer Ignazio Danti show the Pontine Marshes as open water. Commissioned in 1580, Danti worked for by Pope Gregory XIII for three years. Nearly 200 years later, Pope Pius VI, commissioned the Bolognian engineer, Gaetano Rapini, to direct the rivers of Amezeno and of the Uffente to elevate the Pontine Marshes but was interrupted by the French Revolution[44]. Thomassy knew the marshes were no longer open water and were elevated by Rapine. When Napoleone di Buonaparte (Napoleon) proclaimed himself King of Italy in 1805 A.D., he commissioned Vittorio Fossombroni, an Italian engineer, and Gaspard de Prony, a French hydraulic engineer, to continue the work to reclaim the Pontine Marshes. Thomassy knew that the Pontine Marsh was intact and not open water as shown on Danti's maps. This is an important and ground-breaking observation to the knowledge development of Building with Nature because Thomassy was skilled in palaeography and philology from his formal education and developed his learned knowledge of hydrology, hydraulics, mapmaking, geology, and geography through his travels driven by the latter, was able to discern the features on this classical well-

figure 08 — page 37


known maps of the Vatican.

It is important to note that his affluent lifestyle afforded Thomassy the ability to acquire and accumulate the expertise needed for the formulation of working with nature. Regarding the efforts by Napoleon, Thomassy found that Fossombroni prevailed in the commission by Napoleon, citing his success for the works he performed for Leopod II, Duke of Tuscany, in the Val de la Chiana, an alluvial valley of Central Italy, lying on the territories of the

43 Thomassy, 1858
44 Thomassy, 1858

provinces of Arezzo and Siena in Tuscany. The Chiana was a tributary of the Tiber River. It was this relationship and also with the Arno River, which allowed Fossombroni to divert the sediment into a Colmate system to elevate 150,000 acres. After such an application of the Colmates system, Duke Leopold II asked Fossombroni for a new report for the reclamation of the coastal marshes known to be complicated by the presence of salt water. As the only serious problem to be resolved involved the swampy plains being on a lower level than that of the sea, the principle of the operation was that each of these vast expanses should be raised with the deposits of its own rivers. Thus, the marsh Grossetane should be raised with the deposits from the Ombrone; the Scarlinese with that from the Pecora; the Piombinese with that from the Cornia[45]. Thomassy's letters, lectures and manuscripts, particularly the Géologique practique de la Louisiane published in 1860, detail the method of the Colmate system and spread it further over the world.

45 Thomassy, 1858

There also have been many interventions from events that interrupted the transfer of knowledge developed in one country to another - that is from Italy to the Netherlands to the United States. In addition, the application of the technology is often semantically described in different ways for various reasons. Using sediment from rivers to elevate land goes back to the Ancients such as the Egyptians. The English described sediment diversions as a system of warping when diverting fluvial sediment from the rivers to the lands in which they would cultivate a crop, one of the agricultural tools in their toolbox, which was actively in place in the 18th and 19th centuries of the United Kingdom.

The Dutch Dialogue

Professor Thomassy travelled to the Netherlands in 1858 “in order to better understand and evaluate the objections (of natural hydraulics and sediment diversions) based upon the artificial hydraulics of the Dutch”. He further states “the supposed adversaries of the Colmate system (sediment diversions) declare themselves its most zealous partisans” of the Dutch polders. He describes Holland as “a European Louisiana, crested like ours (Louisiana) by fluvial alluviums, but retarded in its formation and its territorial rise through a fatal hydraulic error which has come to deprive it of the benefit of its alluvium. Yet it is the same mistake some would repeat once more upon the shores of the Mississippi (river), in spite of the almighty power of that river to form and to consolidate its shores and to dry all the riverside shallow bottoms by filling them.” He was determined to prove to the French-American and English-Americans living and governing the City of New Orleans that their proposed system of polders would be an error, referring to the unintended consequences of such a system in examples from Europe. Returning to New Orleans, he states “new experiences either confirm or correct former beliefs; and it is of that result of my voyage that I am going to entertain you with. After my letters upon the natural hydraulics of Italy, published in your newspaper (L’Abeille de la Nouvelle Orléans [The Bee of New Orleans]), there remained for me to evaluate in turn the purely artificial hydraulics which conquered an entire kingdom from the ocean in northern Europe. A glorious conquest, one all the more admirable that it is always threatened by the waves and seeing that created by the genius of man alone the latter must constantly be in fear of losing it, having to watch over it without stop or truce in order to insure its preservation.”

Finally, Thomassy says "These [Netherlands and Italy] countries teach us what should be done in Louisiana using the same system of Colmates. As to the objections made to us in the name of the Dutch polders, here is what Holland herself has answered in return. Note too that her testimony is all the more conclusive that she speaks contrary to her instinct of self-pride, and through her sole desire to prevent others from following paths wherein she herself became fatally lost." Thomassy, of course, is referring to Scholten's letter of support for the implementation of sediment diversions in Louisiana in order to elevate the soil naturally rather than artificially which requires constant maintenance and operations, an unforeseen cost to the Dutch. Scholten: The other system, that of the dikes (on the river itself), offers great difficulties because it's being unsuitable in itself, a regrettable error against the laws of nature. […] Although the dike system (on the river itself) is still in use here, and although various reasons may well still exist to prolong its existence, it is and has always been a dangerous system; I prefer by far your system of the Colmates myself, but what can be done now, it is much too late for anything else already!

Scholten also describes this by discussing the history of polders and how they became – in a bottom-up organization - threatened by the flow of the river. The number of dike failures led to a better, professionalized organization in the 19th century to a complete control in this century. The fact that Thomassy is French and the Dutch water governance system is set up after the French model when Napoleon ruled the Netherlands from 1795-1814, seems to be a common reaction that bridged the views of Thomassy and Scholten. They both considered the dike systems on the riverbanks as "a terrible mistake against the laws of nature," very comparable to the Building with Nature approach of the 21st century. Just before the Industrial Revolution, the effects of such a manipulative approach in water management already became evident[46]. Apparently, deltas have remained the same for over 100 years by the induction engine, or maybe the cooperation with nature has been blocked because of the induction engine.

Framework on water and soil

Building with Nature is described by Thomassy as a natural raising of the soil. Thomassy receives from Scholten a plan by a Commission of Dutch Engineers charged with looking into questions of the levees and the best way to help the natural flow of the river waters and prevent its overflows. He was attempting to mesh a water and soil management framework together by corresponding and then visiting Scholten about the Mississippi River and the unintended consequences of the system of embankments utilized in the Netherlands and elsewhere. He then followed up on subjects of soil and water published and archived up to the time of his proposal of sediment diversions to solve New Orleans' unique problems underpinned in the disciplines of geology and hydraulics.

Thomassy concludes[47]: "Why then could not we in turn revive the marvels of Egyptian hydraulics? The art of the Colmates (sediment diversions), moreover, is as old as civilization itself,[…]. That example, wholly classical as it is, is as good as any other and it helps to demonstrate once more that our system is also the best."

46 Van der Ham, 1999
47 Thomassy, 1860

Thomassy considers that for the Netherlands, the Colmate system was found proposed too late as a remedy for subsidence. He sees potential in a second line of dikes could work as colmatage: “when the rivers are highly charged with sediments, to whom they are specially muddy, the water could be allowed to enter these eyelets to the zone between the dikes and then be left to settle there. Once well clarified, it could be removed by means of pumping machinery and by repeating that operation year after year the eyelets would in the end become completely filled up. Now the recourse may be had to steam machinery these operations could easily be multiplied upon a large scale, and after having raised the soil extending between the two dikes a third line of these could be erected back of the second, and in that way the soil of Holland would be raised as a whole to a level equal to that of the highest tides''[48].

48 Thomassy, 1860

CONCLUSIONS

The notion that the dike system on the river itself was questioned as operating against the laws of nature, so one may ask, why was this argument so thoroughly ignored? The answer to this question is that in older European countries, many of the technicians who evaluated this phenomenon felt it was too late to implement the Colmate system of diverting sediment from rivers and raising up their land with controls such as containment dikes in second or third tier from the river. This is much like the second line of dikes tiered out as described by Thomassy, so the river can breathe and recapture part of its floodplain. However, many of these same distinguished citizens of Europe, mainly of France and the Netherlands, recommended Louisiana embark on this method as it was not too late. However, Thomassy received resistance from his French-American and English-American peers charged with the development of drainage systems for the City of New Orleans. Today, we know the unintended consequences as a result of pumping a bowl-shaped drainage landscape within the levee protection system of the city. Further, the significant land loss of coastal Louisiana (about 2,000 square miles) has occurred since the river levees were co structed in its lower reaches over the last 90 years.

Positioning the discourse of Thomassy and Scholten in the 19th century, the era in which the scientific and industrial revolution - ideas and concepts were born in the 18th century during the period of Enlightenment, came within reach. Since the Enlightenment, also known as the Age of Reason, a difference was made between conscious and unconsciousness that has placed humans outside of nature. We also must not deny the works of the Italians and their collaboration with the Vatican along with the recorded work of the Ancient Egyptian civilizations. Especially in the Netherlands, the ‘constructed land’, the relation of the people with nature is ambiguous and in the 19th century with the accelerating knowledge on water management and new responsibility of the Dutch state for safety was not the right time and place for concepts on Building with Nature to be embraced.

In the case of Louisiana, the concepts discussed in the paper appear disconnected because they were intercepted by events such as the Civil War. In the case of New Orleans, the concept of Building with Nature by diverting sediment out of the Mississippi River into the surrounding basins has only remerged in the 21st century and remained hidden since the Civil War upon Thomassy's death. To this day, Thomassy is still not well known in the field where engineers and scientists are proposing solutions that involve "working with nature". However, with the emergence of using the sediment in the river to rebuild the Louisiana wetlands, another uncoupling of symbiosis is about to take place. Due to the transition of the wetland from a riverine system to a more estuarine system where salinities are more desirable for both flora and fauna, the current balance could again be thrust out of balance. River water releases from the Mississippi River have been detrimental for oyster reefs, the foundation of a healthy estuary and fishery. Oyster reefs are a barometer for essential fish habitat where shrimp, crabs, oysters, dolphins, turtles and finfish forge, thrive and reproduce maturing juveniles. Combining both building with nature and maintaining the symbiotic relationship between species, the Colmate system provides a unique solution. It allows for the river to increase its floodplain it once inhabited while elevating the land and protecting marine life. This is the benefit of reviewing the nineteenth century concept.

Overseeing the historical development on both sides of the Atlantic Ocean the first remarkable insight is that knowledge development and innovation are apparently part of the timeframe in human technological development, even with limited communication channels. The key lesson learned is to preserve knowledge developed and the chronology of thought that birthed the concept.

Another similarity that can be detected is that all engineers who were part of the development of approaches with the natural system were interested in the environment as a space with quality. They were, as we would call them today, "integrated engineers" with the ability to place their technological field in the context. This is due to the fact that there was also not yet specialization as we know it today. Today, that is something we are consciously trying to redevelop, but we need to understand that it was quite normal for that time. It is important to recognize, for instance, in the current concept of diverting sediment from the river water of Mississippi River, projects are highly dependent on computer modelling. In reality, river water releases have been detrimental to all the marine resources on the receiving end of diverted water. Modelling projected out 50 years are weighted in scenarios that view the projects as less impactful. It is well known that marine life such as bottlenose dolphins in the Baratara Bay with a population of over 2,500 are at risk hence the State of Louisiana received a waiver the Marine Mammal Protection Act. The Colmate system is a real mitigation measure preventing the river water from entering these sensitive habitats of the estuary which would result in lowering risk significantly. Societal decisions must include lessons of overreliance on technology to reach a desired outcome and build with nature by first reviewing the historical record of knowledge development of that nineteenth century concept.

In fact, we can conclude that if you recognize that there was a path towards the hard-core technological approach and also that the contemporary concept of Building with Nature is returning to this path, it is obvious that we run into concepts that are very much the same. The reason why the concept never finds traction can be found in the diversion of humans from nature during the Enlightenment of the 18th century and the

Industrial Revolution enabling humans to control nature, which after suffering from many floods gained more carrying capacity amongst society. The trust in technology grew beyond the dependency on or relation to nature. We also must recognize the dominion of nature by man as believed from the beginning of the earliest Western civilizations. We must not make the same mistake twice.

Likewise, today, we empirically experience through disasters again that technology will not save us from nature and we need to go back and cooperate. The wording that Thomassy and Scholten use is directly applicable to the contemporary concept of Building with Nature in which we should work with nature, or work within the rules of nature, in line with nature as a paradigm change to the old: violation of the laws of nature, peaceful triumph of technical science and their terrible mistakes against the laws of nature.

The big question is of course to which nature we return to. Already in the 19th century it is recognized that with the new dike landscape, it is difficult to return to a natural system of Colmates. The challenge is to re-understand and re-define the natural landscape and see how we can cooperate as closely as possible to the natural state, again.

REFERENCE

Appleton, D (1864) 'The American Annual Cyclopaedia and Register of Important Events' Volume 3, 1864

Arguedas, J and Viosca, P (1936) 'Translation from French into English of Practical Geology of Louisiana' Works Progress Administration, 1936

Beauregard, P. G. T. (1853), 'Self-acting bar-excavator', US Patent 10147, 1853

Bedient, P and Huber, W (1992) 'Hydrology and Floodplain Analysis': Addison-Wesley, ISBN 0201120569, 9780201120561, 2nd Edition, 1992

Bishop, E. B. n(1858), 'Dredging-machine', US Patent 19908, 1858

Bosch A (2000) Om de macht over het water (Zaltbommel, 2000)

Bosch A and W. van der Ham (2015) Twee eeuwen Rijkswaterstaat (Asten, 2015)

Brainich von Brainich-Felth, C.H. (1993). Centralisatie en Waterschapswetgeving. In: J.C.N. Raadschelders and Th.A.J. Toonen, Waterschappen in Nederland, een bestuurskundige verkenning van de institutionele ontwikkeling. Hilversum: Verloren

Carson, R (1962) Silent Spring. New York: Houghton Mifflin

Club of Rome (1972) Limits to growth. Vermont: Chelsea Green Publishing

Corthell, E. L. (1880), 'A History of the Jetties at the Mouth of the Mississippi River', New York: J. Wiley & Sons, 1880

De Ingenieur (1888-2008) TUD Tresor University of Technology Delft Tresor

DeRussy, L (1858) 'Special Report Relative to the Cost of Draining the Swamp Lands bordering on Lake Pontchartrain to Honorable Henry St. Paul, Chairman of the Board of Drainage Commissioners: State of Louisiana, J.M. Taylor, State Printer, 1858

Design Council, (1870), 'Dredging the Mississippi, Long's Apparatus', Engineering, 1870.

Deventer, N van (1861), 'Dredger', US Patent 33460, 1861

Dupre, L (2005) Enlightenment and the Intellectual Foundations of. Yale University

EC. (2015). Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-naturing Cities. Potschin, M., Kretsch, C., Haines-Young, R., Furman, E., Berry, P., & Baró, F. (2016). Nature-based solutions. OpenNESS Ecosystem Services Reference Book.

Ecoshape (2012) Building with Nature – Thinking, acting and interacting differently, http://www.ecoshape.nl/files/paginas/ECOSHAPE_BwN_WEB.pdf

Ecoshape. (2016). Building with Nature Wiki. Retrieved from https://publicwiki.deltares.nl/display/BWN1

Freiherrn von Weber M.M. (1887). Die Stellung der Deutschen Techniker im staatlichen und socialen Leben. In: De Ingenieur 2E Jrg. 1887

H. M. Shreve, 'Improved machine for removing snags and sawyers from the beds of rivers', US Patent 913, published 12 September 1838

Hager, W (2015) 'Hydraulicians in the USA 1800-2000': A biographical dictionary of leaders in hydraulic engineering and fluid mechanics (IAHR Monographs), Taylor & Francis, ISBN 1317396243, 9781317396246, 1st Edition, 2015

Ham W. van der (1999) Heersen en beheersen (Zaltbommel, 1999)

Ham, W. van der (2002). De Historie. In: Buuren, M. van a.o. (red.) WaterLandschappen, de cultuurhistorie van de toekomst als opgave voor het waterbeheer. Lelystad: Ministerie V&W, RIZA

Herschel, A (1897) '115 Experiments on the Carrying Capacity of Large, Riveted, Metal Conduits, Up to Six Feet Per Second of Velocity of Flow': Wiley, 1897

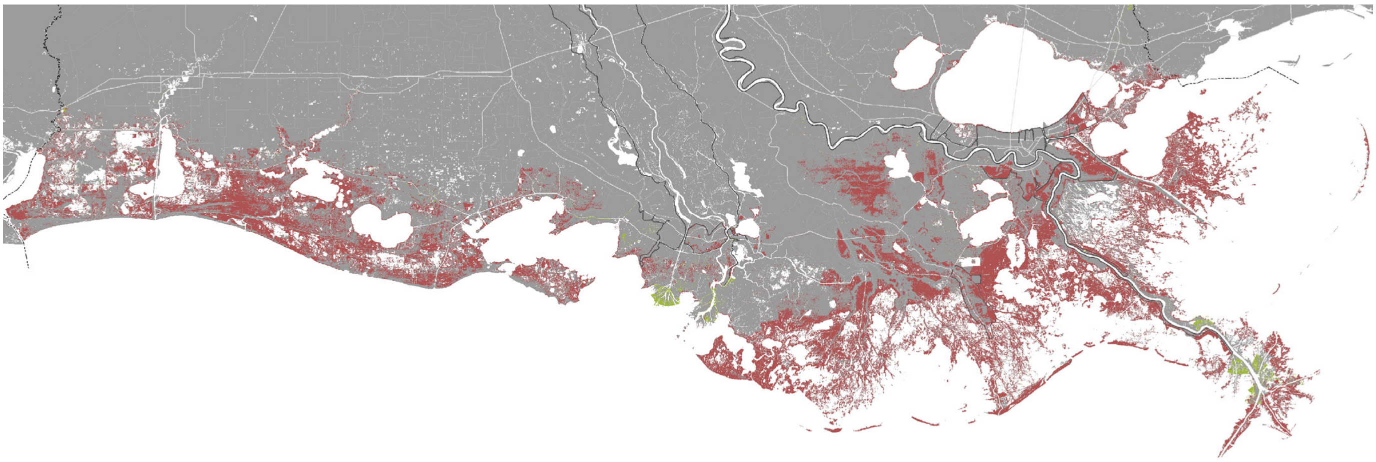
Hindle, R (2017) 'Prototyping the Mississippi Delta: Patents, alternative futures, and the design of complex environmental systems' Journal of Landscape Architecture, Volume 12, 2017 - Issue 2, 2017

Hooimeijer, F.L. (2014) The making of polder cities: a fine Dutch Tradition. Rotterdam: Jap Sam Publishers

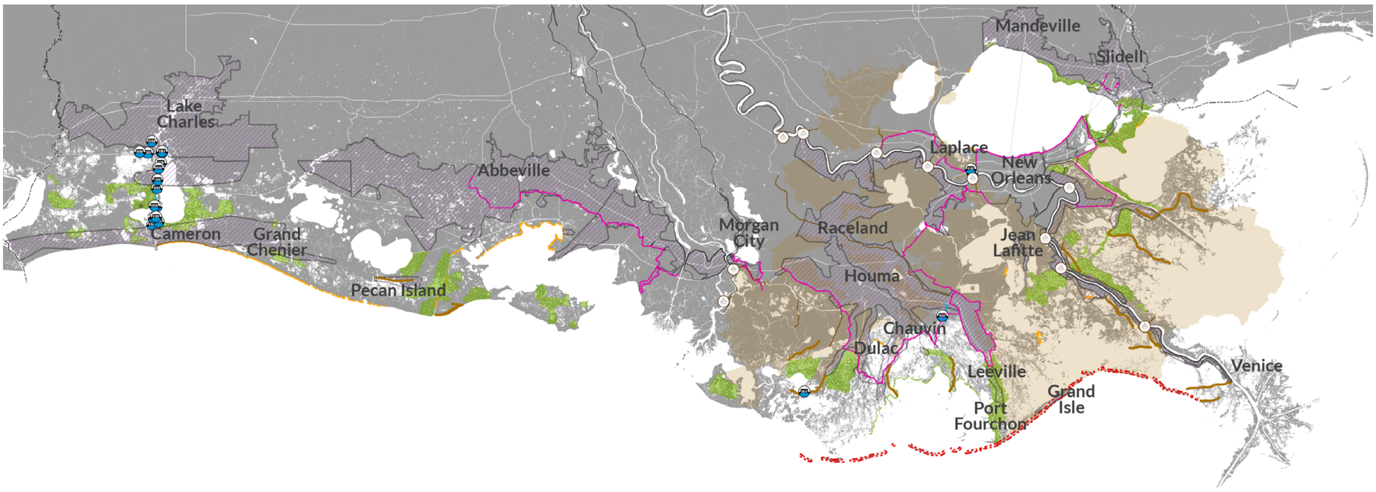
Hwang, N; Houghtalen, R (1996) 'Fundamentals of Hydraulic Engineering Systems', Prentice Hall, ISBN 0131766031, 9780131766037, 1996

Jones, A. C. (1842) 'Dredging the Bars of

Rivers', The Civil Engineer and Architect's Journal, 1842
Lambert, D (2016) 'Géologique practique de la Louisiane – An Early 19th Century Proposed Sediment Diversion' Louisiana Civil Engineer, Volume 24, No. 2 – February Issue, 2016
Linsley, R; Franzini, J; Freyberg, D; Tchobanoglous, G (1964) 'Water Resources Engineering': McGraw-Hill Series in Water Resources and Environmental Engineering, ISBN 0070380104, 9780070380103, 4th Edition, 1964
Lintsen, H.W. (1980). Ingenieurs in Nederland in de negentiende eeuw. Een streven naar erkenning en macht. Den Haag: Stichting Historie der Techniek
Lintsen, H.W. (1994c). Geschiedenis van de techniek in Nederland. De wording van een moderne samenleving 1800-1890. Deel V. Den Haag/Zutphen: Stichting Historie der Techniek/Walburg Pers
Littell, E (1861) 'Littell's Living Age': Littell, Son and Company; Cowles and Company; and Geo. C. Rand & Avery, Volume 69, April, May, June, ISBN 0260302902, 9780260302908, 1861
Long, S. H. (1861) 'Dredging-machine', US Patent 31811, 1861
Lonnquest, J & H.C. Toussaint, J. Manous and M. Ertsen (eds.) (2014) Two Centuries of Experience in Water Resources Management (Alexandria,2014)
Lottman E B (1983) 'De bijdrage van de Rotterdamse en Schiedamse "tekenscholen" aan het bouwkundig onderwijs circa 1750-1850' in: Rotterdams Jaarboekje (1983), pp. 254
Louisiana Coastal Protection and Restoration Authority, Louisiana Comprehensive Master Plan for a Sustainable Coast (2007 Coastal Master Plan, 2012 Coastal Master Plan, 2017 Coastal Master Plan)
McHarg, I (1969) Design with Nature. New Jersey: Wil
Miller, J. B. (2013), 'Principles of Public and Private Infrastructure Delivery', New York: Springer, 2013
Mumford, L. (1961). The City in History. New York: Routledge
Putnam, J. R. (1841 [1]), 'Dredger and machinery for removing bars or other obstructions from harbors and rivers and for forming and cleaning out docks', patent published, 1841
Putnam, J. R. (1841 [2]), 'J. R. Putnam's Plan for Removing Bars at the Mouth of the Mississippi River and Other Harbors on the American Coast and Interior. With a Full Description of His Patent Ploughing and Dredging Machine, Invented by Him for That Purpose, with Drawings, Etc.', New Orleans: Printed at the Bulletin Office, 1841
Roachanakanan, T. (2012) Floodways and Flood Prevention in Thailand. Reflections of the great flood in 2011. Paper prepared for "World Flood Protection, Response, Recovery & Drawing up of Flood Risk Management Conference" 12-13 September 2012, Bangkok.
Schneer, C (1979) 'Two Hundred Years of Geology in America': Proceedings of the New Hampshire Bicentennial Conference on the History of Geology, University of New Hampshire, ISBN 0874511607, 9780874511604, 1979
Scholten, W.A. 'Overzigt van de geschiedenis en de ontwikkeling der denkbeelden op technisch gebied, op het einde der achttiende eeuw, en blik op de gevolgen dier ontwikkeling voor de bouwkunst,' in: Bouwkundige bijdragen, Volume 8, Deel 1862. p. 169—196.
Thomassy, R (1852) 'Les papes géographes et la cartographie du Vatican': A. Bertrand, ISBN 97812771987441852, 1852
Thomassy, R (1858) 'Lettres sur le dessèchement de la Louisiane': New Orleans Academy of Sciences on March 1, 1858, Reprinted from L'Abeille de la Nouvelle Orléans (The Bee of New Orleans), 1858
Thomassy, R (1859) 'De La Salle et ses relations inédites de la découverte du Mississipi': Extrait de la Géologie pratique de la Louisiane, Librairie de Charles Douniol, 29 rue de Tournon, Paris, 1859
Thomassy, R (1860) 'Géologique practique de la Louisiane' Arno Press, Chex L'Auteur, A La Nouvelle-Orleans; et a Paris, E Lacquoix, Librairie Scientifique, Industrielle et Agricole, 15 Quai Malaquais, ISBN 0405104618, 9780405104619, 1860
Thomassy, R (1861) 'The Mississippi River is the Father of Fluvial Deposits': Hydrology of the Mississippi River, De Bow's Review, Volume XXX, Edited by J.D.B. De Bow, 1861
Tinker, E (1923) 'Les écrits de langue française en Louisiane au XIXe siècle': essais biographiques et bibliographiques, Volume 85 of Bibliothèque de la revue de littérature compare, Slatkine Reproductions, 1923
Verruijt, A. (2001). Soil Mechanics. Delft: University of Technology
Vet, W.J.M. de (1994). Geotechnische apparatuur in Nederland 1850-1975. Een inventarisatie-onderzoek van industrieel erfgoed uit de branche grondmechanica en funderingstechniek. Den Haag: Stichting Historie der Techniek
Viroli, M. (1998). Machiavelli. New York: Oxford University Press Mumford 1961, 11)
Vriend H (2014) 'Building with Nature': The new Dutch approach to coastal and river works. Proceedings of the ICE, Civil Engineering, 167 (CE1), 2014
Vriend, H. J. de, van Koningsveld, M., Aarninkhof, S. G. J., de Vries, M. B., & Baptist, M. J. (2014). Sustainable hydraulic engineering through Building with Nature. Journal of Hydroenvironment Research, 9, 159-171.
Waterman R (2011) 'Building with Nature': principles and examples, http://www.coastalcooperation.net/part-III/III-3-3-1.pdf
Waterman, R.E. (2011) 'Building with Nature': principles and examples,
Woud, A. van der (1987). Het lege land, de ruimtelijke orde van Nederland 1798-1848. Amsterdam: Meulenhof



01



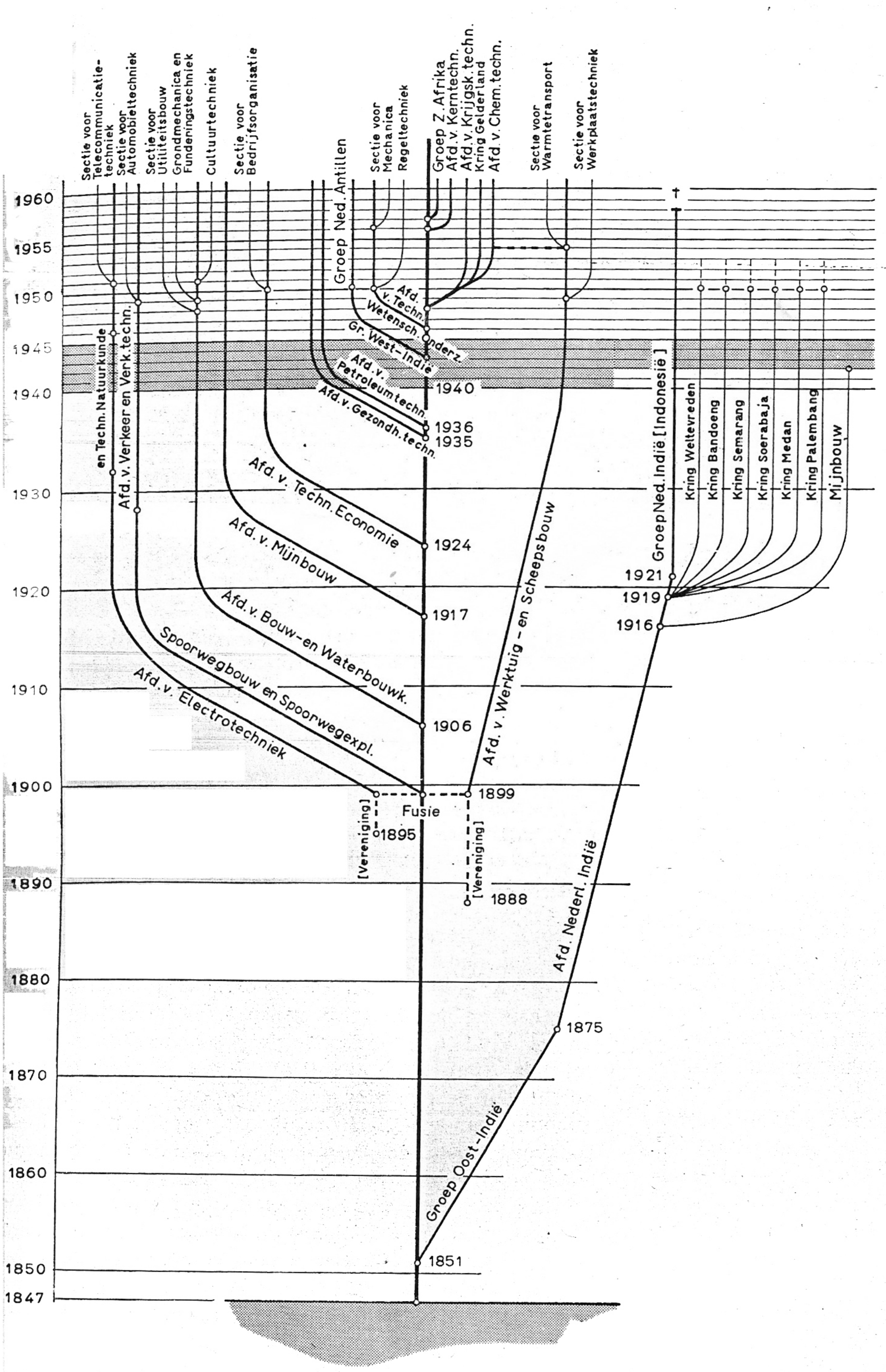
02

01 2017 Louisiana Coastal Change Map Future Without Action by CPRA (Coastal Protection and Restoration Authority)

02 2017 Louisiana Master Plan Projects with Sediment Diversions by CPRA

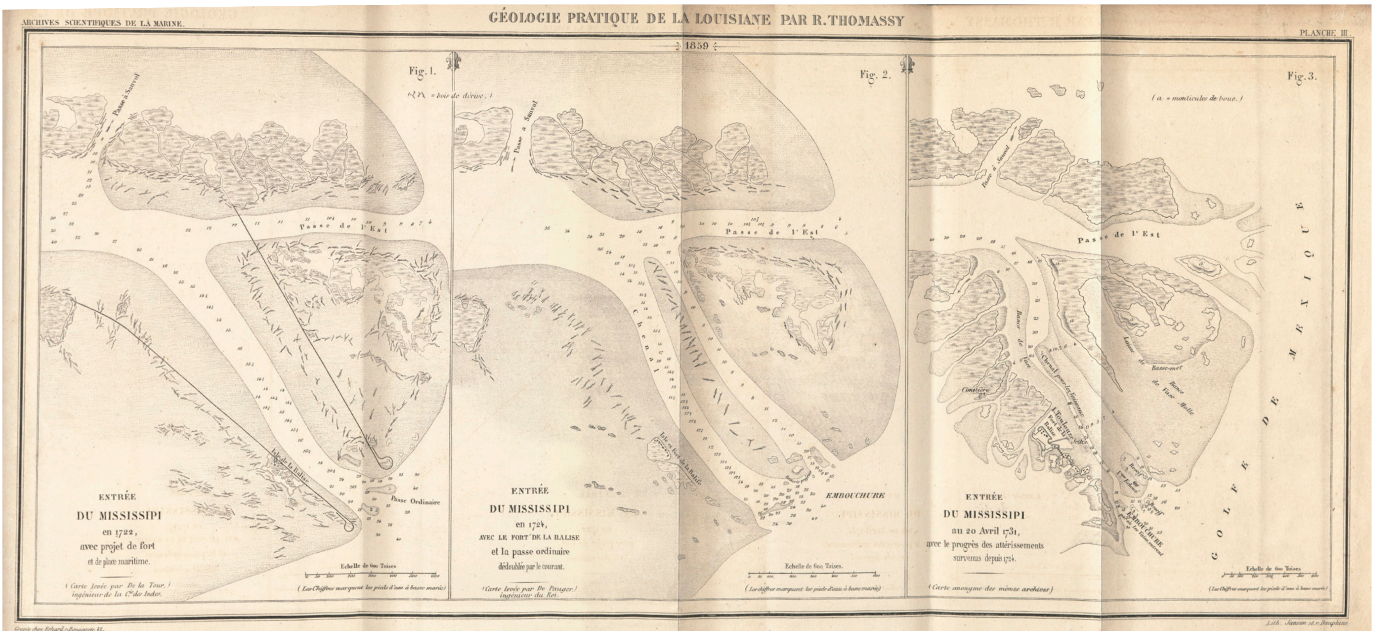

03

03 The Sand Engine. Rijkswaterstaat.

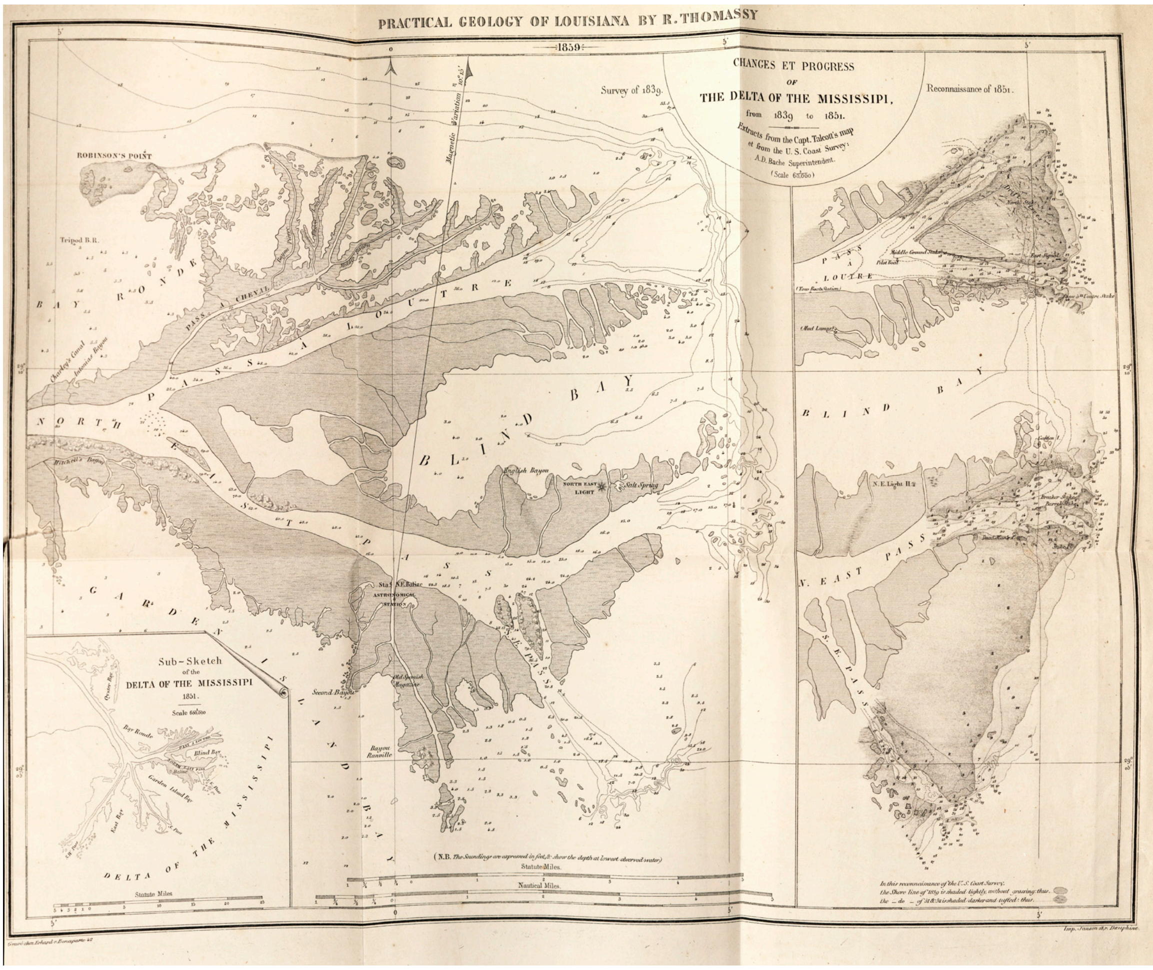


04

04 Royal Institute of Engineers, division of branches over time (De Ingenieur, 1960)



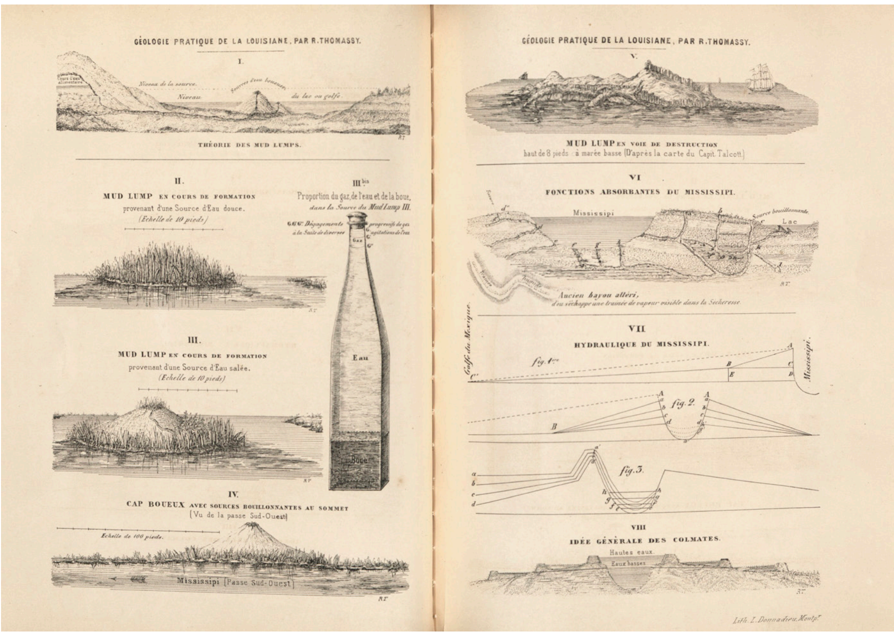
05



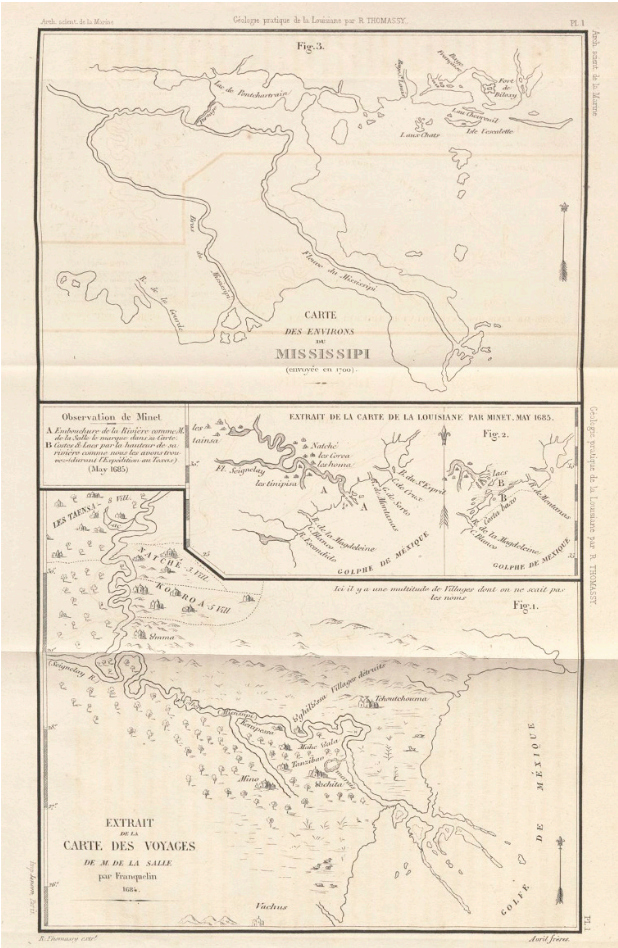
06

05 19th Century Louisiana Coastal Change Map by Thomassy

06 19th Century Louisiana Coastal change map by Thomassy



07



08

07 19th Century Proposed Louisiana Sediment Diversions by Thomassy

08 19th Century Louisiana Maps from Voyages of De la Salle by Thomassy

JDU
Journal of Delta Urbanism

JDU is a project by Delta Urbanism Research Group
and DIMI Delft Deltas, Infrastructure and Mobility Initiative
Delft University of Technology

Graphic Layout
bruno, Venice (Italy)

Typefaces
Union, Radim Peško, 2006
JJannon, François Rappo, 2019

Publisher
TU Delft OPEN
https://www.tudelft.nl/library/openpublishing

Subscription and Printing on Demand
Open access journal: available subscription on the journal website
For subscriptions and any further information: JDU-BK@tudelft.nl
Printing on demand will be available from January 2021

Frequency: 1 volume per year

Publication Funding
TUDelft Delta, Infrastructure and Mobility Initiative

Contacts
For any further information:
JDU-BK@tudelft.nl
https://journals.open.tudelft.nl/jdu/
www.deltaurbanism.org

N.2 | Longue Durée | Paper | 01
Fall | Winter 2021

Authors
Fransje L. Hooimeijer, *Delft University of Technology, the Netherlands*
Dennis Lambert, *IEM, USA*

Citation
Hooimeijer, F. L. and Lambert, D, Building with Nature:
"A Nineteenth Century Concept", J. Delta Urbanism 2(2021),
doi.org/-10.7480/jdu.2.2021.6223

All published contributions are submitted to a Blind Peer
Review process except for the sections Dialogues and Dictionary.

ISSN: 2666-7851
p-ISSN 2667-3487