

BANKBUSTERS

**A NATURE-BASED
SOLUTION FOR
RIVERBANK
MANAGEMENT**



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PREFACES

Matthias Diependaele
minister-president of the
Flemish government

As the Minister of Economy and Innovation of Flanders, it is my great pleasure to present the final report of the Bankbusters project, a remarkable initiative under the Blue Cluster for Nature Based Solutions (NBS). This project exemplifies our commitment to fostering innovation and sustainability within our maritime industries.

The Bankbusters project has been a beacon of collaboration, bringing together experts and researchers from various fields to address the pressing challenges facing our estuarine environments. Through innovative solutions and cutting-edge research, we have made significant strides in enhancing the resilience and sustainability of our blue economy and infrastructure.

The successful implementation of Nature Based Solutions proves vital and incredibly valuable for Flanders. By leveraging natural processes, we can protect our rivers and coastal areas but also promote the sustainable use of our natural resources. Nature Based Solutions provide us with

sustainable and cost-effective methods to address environmental challenges and biodiversity loss, ensuring the long-term health and vitality of our ecosystems.

I extend my heartfelt gratitude to all the partners, researchers, and stakeholders who have contributed to the success of this project. Your dedication and hard work have not only advanced our scientific understanding but also paved the way for practical applications that will benefit our communities and ecosystems for years to come.

As we look to the future, let us continue to build on the foundations laid by this project. Together, with research and knowledge institutes, we can drive forward the innovation that is essential for the prosperity of Flanders while we build our know-how and expertise and valorise our technology for the well-being of the Flemish people.

For centuries, the river Scheldt has been the unique and vital gateway to the port of Antwerp. Notwithstanding the enormous evolution of the shipping industry, it still is the robust lifeline for the port today. In fact the river Scheldt provides our unique selling proposition, namely the exceptional accessibility via water of a big port located far inland, close to the big production and consumption hotspots of North-West Europe. In short, the well-functioning of the river Scheldt is of utmost importance for Port of Antwerp-Bruges.

It is fair to say that Port of Antwerp-Bruges is one of the few major ports whose maritime access is provided by a resilient estuarine ecosystem. The substantial tidal influence

with its different salinity zones, the dynamic system of main channel and secondary channels, the range of subtidal and intertidal habitats along the river banks, ... are all building blocks of the unique ecosystem that has been protected under the European NATURE 2000 umbrella. The river Scheldt is indeed home to a complex set of chemical and biological processes, underpinning a range of ecosystem services and a level of biodiversity considered unique in North-West Europe.

In this context, it is important to monitor the anthropogenic impacts and to constantly strive for innovative ways to reconcile the economic and ecological functions of the Scheldt estuary. Resilience of the ecosystem is essential in a context of intensive use of the estuary. It requires innovative solutions developed by cross-sectoral partnerships. This is why Port of Antwerp-Bruges strongly supports the Bankbusters project that embraces the natural restoration of riverbanks, contributing to a healthier ecosystem and a sustainable future.

Jacques Vandermeiren
CEO of Port of Antwerp-Bruges



Piet Opstaele
CEO Blue Cluster

It is my pleasure to acknowledge the Bankbusters project, a pioneering initiative that embodies our commitment to innovation and economic growth with a positive impact. It is an important step forward in our mission to harness the potential of nature-based solutions within the blue economy.

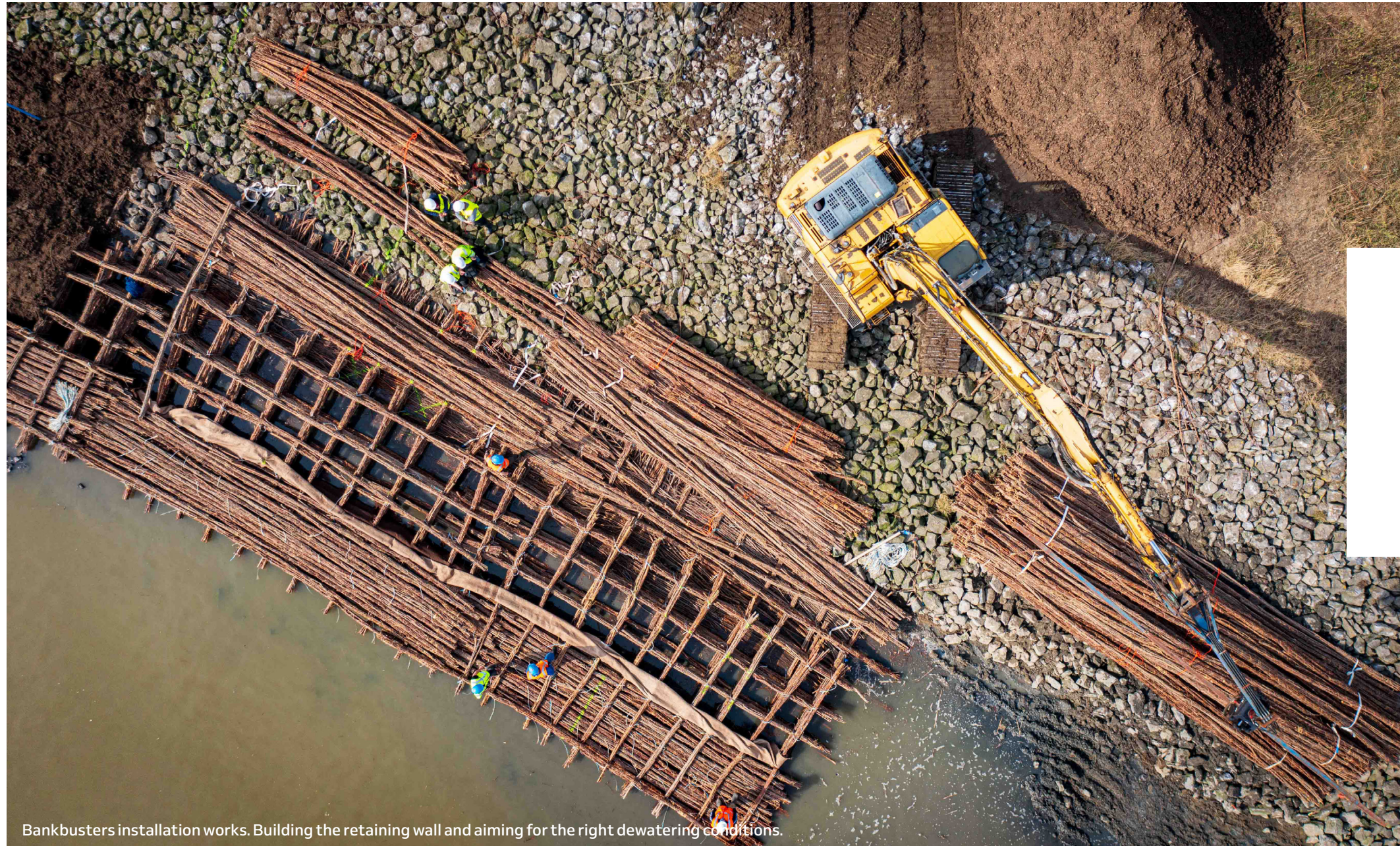
This project is not just about technological innovation; it is about creating a sustainable future for our oceans and rivers. By leveraging cutting-edge research and fostering collaboration between industry leaders, academic institutions and policymakers, we aim to develop long-term solutions that address some of the most pressing challenges facing our marine and estuarine environments. Build nature by using nature.

The success of the Bankbusters project is a demonstration to the dedication and expertise of our entire cluster. Together, we are paving the way for a more resilient and prosperous blue economy, one that balances economic development with care for the environment.

At Blue Cluster, we are convinced that Bankbusters is an important lever to make our companies and knowledge institutions frontrunners in nature based solutions, both nationally and internationally.

I would like to sincerely thank everyone involved in this project. Your hard work and commitment are the driving forces behind our achievements. I am convinced that the Bankbusters project will serve as a model for future initiatives and inspire continuous innovation and collaboration in the blue economy.

Thank you for your support and dedication.



Bankbusters installation works. Building the retaining wall and aiming for the right dewatering conditions.

INTRODUCTION

Estuarine tidal wetlands offer vital ecosystem services, including flood protection, erosion control and water purification. However, these tidal wetlands actually face significant pressures caused by both human activities and natural forces, leading to habitat and ecosystem degradation and loss. The Bankbusters project aims to address these issues by reusing soft dredged sediments to restore tidal marshes and mudflats as natural riverbank systems. As such, this initiative promotes biodiversity, enhances flood resilience and supports sustainable economic growth through innovative, eco-friendly and resilient solutions in the Scheldt estuary.

PARTNERS



DESIGNING A MARSHLAND

The project aimed to create a more sustainable and resilient integrated river management plan that addresses the diverse interests of all stakeholders involved. Such an ecosystem-based estuarine flood protection can only be brought into large-scale practice on condition that:

- sufficient space is made available in the estuary to accommodate the creation and development of (additional) ecosystems;
- relevant key species and their habitat conditions are identified to fully understand the complex and dynamic estuarine processes; and
- local stakeholders support the development of ecosystem services.

Once these conditions are met, solutions can be designed to translate the desired ecosystem engineering functionality into an integrated part of the estuarine flood protection management. On the one hand, such development requires a generic framework to select the appropriate measures based on the spatial and temporal scale of the overall estuary system. On the other, it requires knowledge on the ecology and ecosystem services delivered by the wetland (both marshland and mud flats) forming ecosystem. For these reasons, the design process integrates numerical modelling and experimentation,

adheres to legislation and emphasises the beneficial reuse of sediment and biosafe materials to achieve optimal groundwater dynamics. Controlled seeding in combination with optimized soil management are a crucial success factor for on-site application of ecological engineering.

The Bankbusters project aims to restore and create tidal marshland using dredged sediments and natural “biosafe” material.

Given the explicit multidisciplinary interaction, the success of the Bankbusters project relies on continuous interactive engagement with clients and stakeholders. Key stakeholders include the Port of Antwerp-Bruges, Vlaamse Waterweg and the Flemish Maritime Access Division, among others.



Seeds of target plants for the pilot site, collected at a reference site



Picture of a typical reference marsh

The Bankbusters consortium combines the operational excellence of the marine contractors DEME and Jan De Nul with the frontrunning knowledge and site experiences of the academic partners University of Antwerp and Ghent University as well as the dedicated expertise of iFLUX. The Bankbusters research project is facilitated under the Flemish spearhead cluster for Blue Growth (Blue Cluster) and supported by the Flemish agency for Innovation and Entrepreneurship (VLAIO).



Bankbusters consortium during seeding operation

MODELLING AND EXPERIMENTATION

As a first step, Bankbusters defined a series of ecosystem hydrodynamic and geomorphological boundary conditions to facilitate and enhance tidal wetland creation and development. Numerical modelling provided insight into potential (critical) riverbank erosion effects of structures being designed. Simulated (turbulent) flow impacts and erosive forces were taken into account in the design, engineering and installation procedures of the riverbank configuration. Some additional laboratory experiments were conducted to evaluate the proposed stepped river embankment configurations of mud flats and/or marshlands. These experiments were performed at the Mesodrome facility, a hydraulic laboratory test flume located at the “Drie Eiken” campus of the University of Antwerp. The Mesodrome facility and the adopted flow measurement techniques were crucial in assessing the performance of different schematised geometries inspiring both technical and ecological design ideas.

The experimental river, The Mesodrome, forms the hub of innovative aquatic research platforms that address converging issues, such as eutrophication, pollution and flooding. A standout feature is the flume – a 20-metre-long, 2-metre-wide experimental river. This facility enables precise manipulation of hydraulics, water quality, sediment characteristics and plants and animals, serving as a vital tool to study the interactive effects of anticipated changes on the functioning of river ecosystems.

Mesodrome facility



Pilot site showing vertical cliffs caused by erosion



BANK-BUSTERS SITE

The Bankbusters pilot site is located at the “Ketenisse” wetland spot along the left bank of the Scheldt estuary, next to the Waterbus stop at Kallo (Belgium). This area, just downstream from the Kallo sluice entrance, is known to be highly erosive and susceptible to both strong local tidal flow patterns and explicit ship induced wave impacts. Local riverbank profiles are currently protected from this excessive erosion by means of rock deposit on both the tidal water shoreline and higher at the toe of the existing hinterland SIGMA dyke. The pilot site currently shows very little vegetation due to the high erosive impacts. As a result, explicit vertical erosive cliffs are observed at the high water line. The soil of the pilot site is characterised partly by sandy sediments with areas of grey alluvial heavy clay. Further downstream of this erosive spot – just around the estuary corner – the Ketenisse natural wetland is used as a nearby natural reference riverbank profile site.

BENEFICIAL REUSE OF SEDIMENTS

The Bankbusters tidal marsh restoration project emphasises the beneficial reuse of sediments; both to promote a circular economy of building materials and to optimally enhance the ecosystem services as delivered by stable and healthy wetland riverbank systems along the estuary.

The choice of backfill material for the upper marshland soil massive is a critical determinant for the success of the wetland restoration scheme, as it directly impacts morphodynamic status, fine sediment retention, the groundwater dynamics, the gully system, organic content, pioneering vegetation and marsh habitat vegetation growth development. The key objectives for the fill material selection included:

- Ease of handling and positioning of the soil in the pilot test setup;
- Acceptable geotechnical stability of the upper marshland as part of the adapted river cross profile;
- Granulometry reflecting natural marsh conditions with fine sediments typical for tidal wetlands;
- Appropriate organic matter levels supporting vegetation growth and nutrient cycling; and
- Reusing locally available (dredged) materials to minimise environmental impact and promote circular economy principles.

Limited availability and complex environmental permitting, in the end, became the determining factors for fill material selection. Given strict boundary conditions and the existing operational constraints, available and fully compliant silty sandy material was chosen for the pilot setup of Ketenisse.



Aerial view of the Bankbusters site, first phase

Bankbusters during installation works



DRECO UNITS

Based on the initial assessment of the above-mentioned boundary conditions and the actual, updated intertidal observations and experiences along the river Scheldt, Bankbusters prioritised the marshland part of the intertidal cross profile restoration due to its technical feasibility and ecological value.

Bankbusters designed a Dredged Ecological Compartment (DRECO unit) system to stabilize soil, spread hydraulic loads and shelter vegetation developments under tidal influences. In close collaboration with Van Aalsburg BV, a containment bund configuration made from modular willow matrices was developed, addressing challenges like installation feasibility, groundwater flow, scour protection and sediment drainage.

BIOSAFE MATERIALS

Bankbusters materials are entirely natural and are able to withstand harsh environmental conditions to form tidal marshlands in a riverbank setup. They need to be biosafe, enhancing structural integrity, natural resilience and biodiversity. This means that only materials that do not harm the environment through weathering or leaching should be used. Furthermore, targeting a more sustainable riverbank ecosystem, a judicious material selection reduces the carbon footprint as well as the overall production impact.

The basis of the DRECO units are fascine mattress layers made up of wedges (i.e willow bundles). Fascines form an excellent foundation for nature inclusive engineering applications. They have been used for over 100 years to protect soils and banks against erosion by water and are a time-tested solution.



Installation works, 1st phase

LEGISLATION

The first Bankbusters field pilot project received a permit in the autumn of 2023. The application was examined taking into account the applicable legal provisions. Follow-up assessments were made as part of an integrated environmental and social impact evaluation.

As the project location is situated within the Habitat directive area "Scheldt and Durme estuary" between the Dutch border and Ghent (BE2300006) and the Bird directive area "Salt marshes and polders of the Lower Scheldt" (BE2301336), the permit required a specific legal status and falls under the provision of an intertidal site with "wet and dry infrastructure", nature conservation and the natural environment, and waterways and non-navigable watercourses within a certain category.



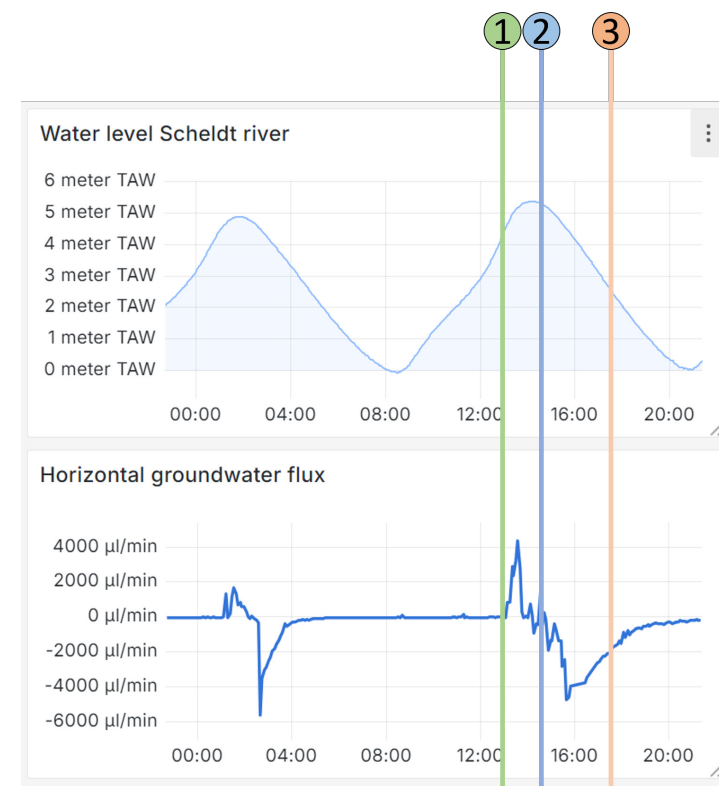
DEWATERING: KEY TO ENHANCE MARSHLAND DEVELOPMENT

Natural drainage of the soil massive is crucial for tidal marsh restoration and creation. Effective drainage is essential to assure overall stability at the start of the marshland development, to facilitate the settlement of the marshland soils, to grow pioneer vegetation and to maintaining the overall ecological integrity of the system towards a robust riverbank ecosystem. Proper drainage helps regulate both groundwater and surface water level, prevents waterlogging and allows for the natural movement of tidal and groundwater flows. Additionally, managing drainage in a way that mimics the natural processes of tidal marshes (for example, through dedicated gully systems) can promote vegetation growth, reduce erosion and support biodiversity.

iFLUX Horizontal flux sensor



Several drainage solutions can be implemented in saltwater marsh construction to mimic natural tidal flow. The selected silty sand material aids efficient marshland development. Our DRECO units act as containment bunds but with the specific aim to allow optimal groundwater drainage and rewetting of marshland. The Bankbusters structure ensures marsh sediments are kept in place and dynamically dewatered, supporting tidal marsh restoration and enhancing riverbank ecosystem services and biological value.



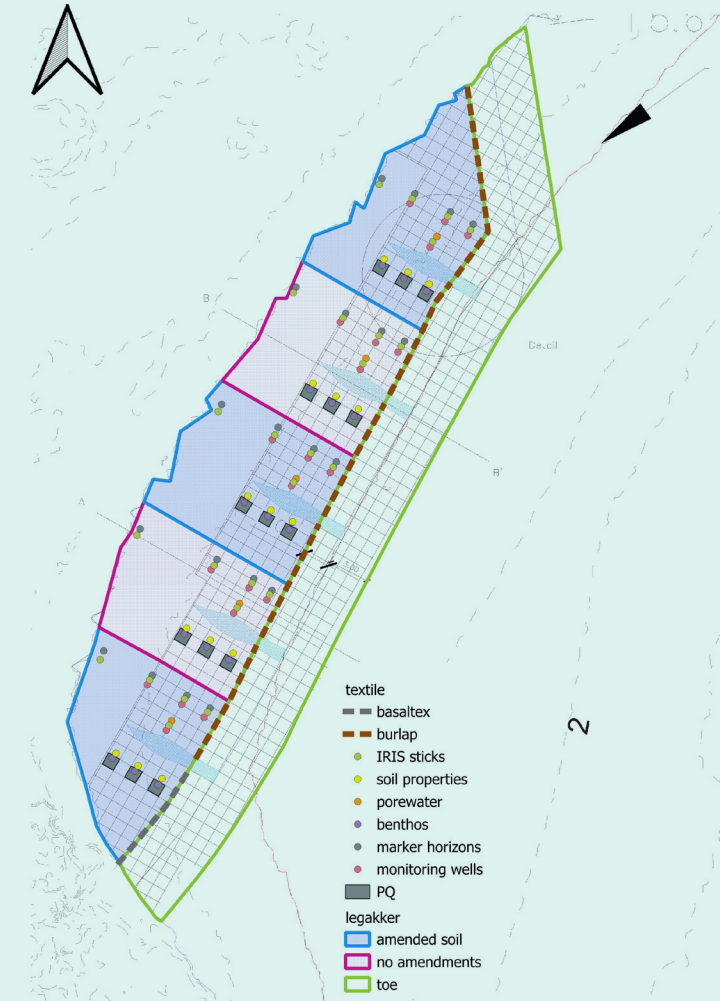
The iFLUX horizontal sensor clearly shows the varying groundwater flux with tidal stage and illustrates how operational camera system combined with real time groundwater sensor data provides insights into the highly dynamic nature of a tidal wetland. (1): The tide is rising and water infiltrates into the soil of the marsh. The sensor measures a flux towards the marsh. (2): high tide: the marsh is flooded and the groundwater flux stabilizes. (3): falling tide: surface water recedes from the marsh platform and groundwater seeps of the marsh soil, clearly visible as a groundwater flux towards the river. This outflow phase is generally longer compared to the inflow phase. Source water level: Waterinfo.be



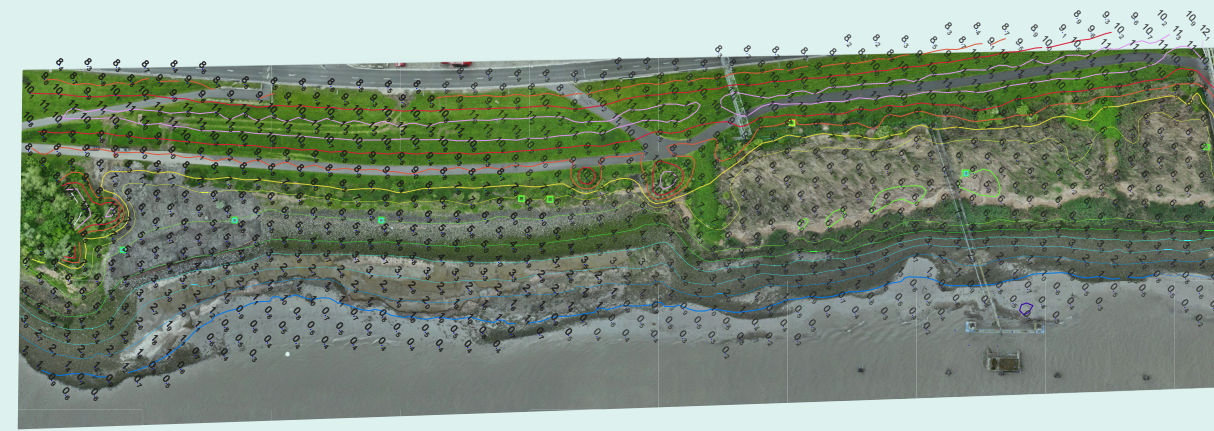
MONITORING

The marshland at the pilot site has a dynamic character. Short-term field monitoring records the pilot setup's performance during kick-off and initiation phase of marshland development, while long-term monitoring aids further operational management of the (nature-based solution) riverbank flood protection schemes. The monitoring setup was designed by iFLUX, a Belgian company specializing in real-time groundwater dynamics monitoring. The actual integrated monitoring approach includes a field measurement protocol to assess – in the initial development phase – the overall ecosystem status of the marshland and the level of flood risk protection as a riverbank system. Other ecosystem services will be observed as part of the further wetland riverbank environment development.

Key developments in the actual Bankbusters monitoring framework include a real-time groundwater flux sensor, modular telemetry data infrastructure and a monitoring protocol roadmap. DEME's drone observations and bathymetrical recordings provided insights into the marshland's morphodynamics, highlighting erosion, sedimentation and soil compaction. The permanent operational camera system adds value by visualising tidal processes and aiding flood frequency analysis. The monitoring programme aims to develop a scientifically underpinned strategy and detail the marsh's ecological and morphological evolution, ensuring the long-term success of tidal marsh restoration efforts.



Monitoring field site overview showing the project area divided into segments, with specific areas amended using organic snippets to increase permeability, create fertility by adding organic content and replicate natural marsh land conditions.



Orthophoto, drone survey of the project site after installation

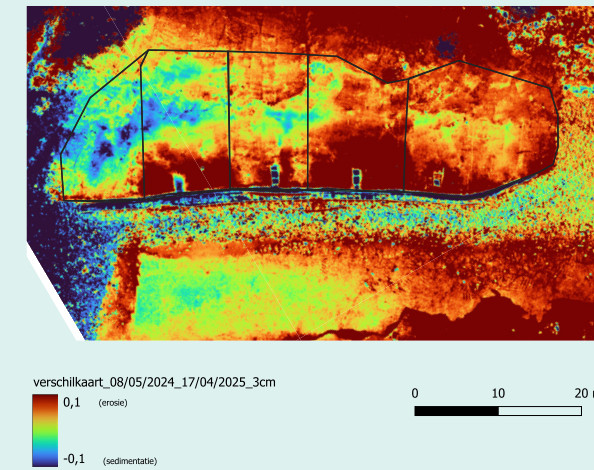


Chart for visualizing the differences between the surveys of May 2024 and April 2025. Variation in elevation between two discrete vector models is determined using a raster calculation, comparing the observed pixels - each with their own xyz coordinates in the Lambert 72 projection. The observations show a certain degree of erosion and subsidence of the marsh soil mass.



Picture of a survey drone flight

The valorisation paradox of nature-based solutions (NbS) lies in their complexity and long-term commitment, which deters investors seeking immediate returns. NbS benefits like biodiversity, carbon sequestration and water purification are hard to quantify. Traditional economic systems undervalue these ecosystems, underestimating risks to human welfare and economic growth. A paradigm shift is needed to recognise NbS as valuable, high-potential alternatives in decision-making processes.

ECOSYSTEM SERVICES BUSINESS MODEL

Tidal wetlands provide essential ecosystem services, acting as natural buffers against storm surges and floodings, improving water quality by filtering pollutants and supporting biodiversity. They also sequester carbon, helping mitigate climate change.

Tidal wetlands are indispensable for maintaining ecological balance, supporting fisheries and enhancing the resilience of waterborne communities along an estuarine river system.

These services are crucial for balancing economic activities, ecological values and flood protection. The Bankbusters brand, allied with Coastbusters, focuses on nature-based solutions (NbS) for more environmentally friendly riverbank systems. These projects aim to restore disturbed river cross-profiles, offering a new business model for estuarine river management.

CONCLUSION

Bankbusters, through its purpose-built “DRECO-units”, successfully upscaled a Nature-based experimental design to an advanced resilient estuarine flood protection for eroded riverbanks. The integration of in-depth modelling, maritime industry approach, operational expertise, and cutting-edge monitoring is key to ensure resilient Nature-based solutions. Adjusting traditional fascine mattress elements in an innovative modular concept, facilitated the natural processes involved in marshland restoration within estuarine wetland habitats. By selecting naturally occurring materials, Bankbusters reinforce their commitment to a circular economy and the beneficial reuse of resources—an approach especially relevant in the context of dredging and navigational management.

Amid growing demands for resilient, sustainable, and healthy estuarine ecosystems, Bankbusters demonstrates the success of a large-scale nature-based solution. The market for erosion-sensitive embankment protection and flood management is rapidly expanding, with future scenarios pointing to strong growth in nature-based solutions—driven by the rising awareness of the vital role biodiversity and ecosystem services play in a more adaptive socio-economic system.

FUTURE POTENTIAL

The Bankbusters project connected the growing need for more resilient and healthy estuarine ecosystems with a sustainable socio-economic development along the Scheldt estuary. Continued monitoring on the marshland riverbank development will quantify resulting ecosystem services - to valorise clear added values of this kind of nature-based solutions.

The market for this kind of ecosystem restoration is burgeoning: the ecosystem-based concepts of Bankbusters are ready to be applied in Scheldt-like estuaries all over the world!

Bankbusters marshland immediately after installation

Nature never deceives us;
it is we who deceive ourselves.

Jean-Jacques Rousseau



When you change the way you look at
things, the things you look at change.

Max Planck



