PROJECT

FROM IDEA TO REALITY:

THE UK'S FIRST SANDSCAPING PROJECT

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The Bacton Sandscaping scheme is a large-scale beach nourishment designed to protect the Bacton Gas Terminal from cliff and beach erosion while also reducing flood and erosion risk to the communities of Bacton and Walcott, buying the time needed for adaptation to coastal change. The scheme was inspired by the Sand Engine project in The Netherlands but has translated the concept to the different geography and governance setting of the UK. It can be seen as the Sand Engine's 'little nephew'.

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The northeast Norfolk coast has been subject to long-term coastal change. It is likely that the cliffs have been eroding at around the present rate for the last 5,000 years. The cliffs are made of soft deposits – mainly sand and soft clays – which are very vulnerable to erosion. This long-term coastal change puts pressure on communities, infrastructure and business in the coastal zone.

FIGURE 1

Defences at Bacton Gas Terminal prior to Sandscaping.

The Bacton Gas Terminal is situated on the North Norfolk coast, approximately 30 kilometres north of Great Yarmouth. The Terminal has infrastructure near the cliff edge, within the cliff and under the beach. It is a piece of nationally important critical infrastructure supplying up to one third of the UK's gas demand from the North Sea extraction fields and to and from the continent. The Terminal is owned by Shell, Perenco as well as other oil and gas businesses. The Gas Terminal requires protection from cliff erosion and beach lowering for as long as the Terminal is needed to avoid national impacts in the event of the gas supply being interrupted.

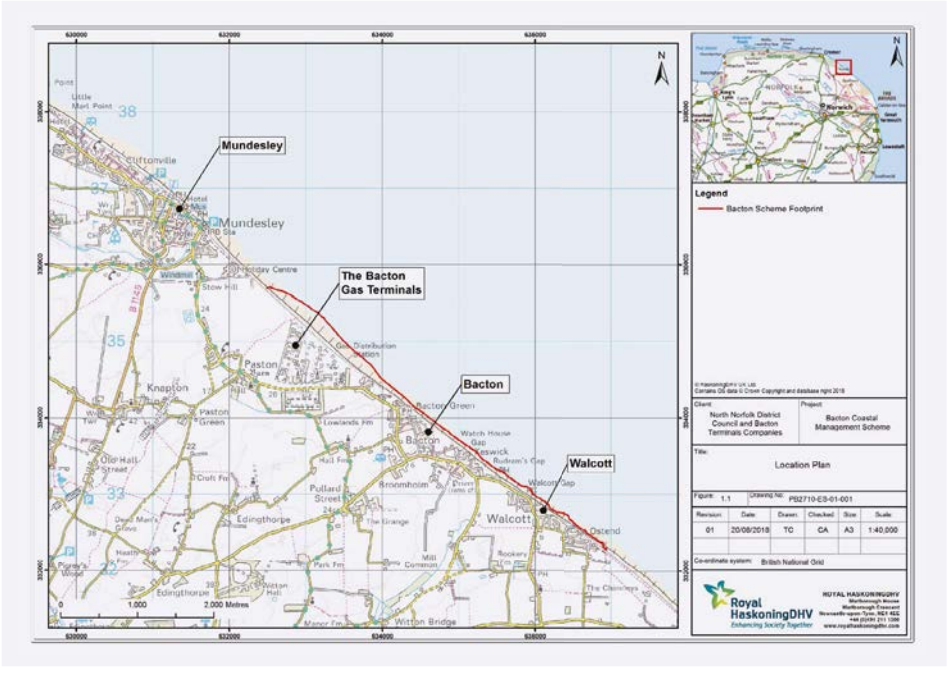
The Terminal was defended by a series of timber groynes which sought to manage beach levels and a timber revetment to reduce cliff erosion (see Figure 1). These structures were more exposed due to beach lowering, suffered damage during storm events and only provided protection against 10% Annual Exceedance Probability (1:10 per year) storms.

Despite these defences, cliff erosion at the Terminal had progressed rapidly over the years, notably during storm surges in November 2007 and December 2013. Following the December 2013 storm it became clear that erosion was starting to threaten the infrastructure at the Terminal. This included the cliff top infrastructure itself and pipelines buried within the cliffs and beach. There was therefore an urgent need to provide protection against further erosion. In January 2017, due to the immediate risk, Shell constructed a temporary coast protection solution along critical lengths of their section of the Terminal frontage. This temporary solution consisted of rock-filled gabion baskets placed at the toe of the cliffs on a gabion mattress and backfilled with sand. The temporary solution was designed to provide intermediate protection and assumed construction of a full permanent scheme would be performed in the near future. The vulnerability of the Gas Terminal infrastructure to erosion was highlighted again in the storm surge event of January 2017 which caused significant lowering of the beach and damage to the existing timber revetment and the temporary coast protection solution which was in the process of being constructed.

Southeast of the Bacton Gas Terminal, continued coastal protection of the villages of Bacton and Walcott (referred to as 'the Villages' within this article) was only likely to be economically viable in the short-term under current UK treasury rules. The Villages form an integral element of the community and socio-economic structure of northeast Norfolk, providing residential areas supporting the population and overall housing stock of the area. They contribute to the important tourism potential to the area and sustain small

FIGURE 2

Location Plan with red line denoting Sandscaping placement (Royal HaskoningDHV, 2018).



businesses that also form part of the support structure to the wider rural hinterland. The Villages are protected from coastal erosion and flooding by a concrete seawall along most of their length, flanked by timber revetment. These defences were supported by a timber groyne field which, due to falling beach levels preventing access, were in varying states of repair. All the defences relied on the beach as the first line of defence to reduce water depth and, therefore, the height of the waves that can reach the defences, as well as protecting the lower part of the seawall from direct exposure to waves while also providing structural support. The beach had eroded significantly since the construction of the seawall in the 1950s and 60s to a point where the seawall was predicted to have a residual life of only 5 to 15 years. The erosion of the beach also increases flood risk: the storms of 2007, 2013 and 2017 caused significant flooding of the coastal road and properties due to waves.

The challenges

As the coastline changed, parties were faced with complicated decisions about how and where to defend. Economics, communities, the environment and physical geography all played a part in these decisions. Full 'hard' defences along the entire coast were not an option because they were not affordable, environmentally acceptable or sustainable and can exacerbate erosion.

Bacton Gas Terminal urgently needed to be protected against coastal erosion. The Shoreline Management Plan (SMP), adopted in August 2012, set out the agreed intent of management of the coast for the short, medium and long term. The SMP states that protection of the Terminal is acceptable but only if it does not increase erosion at the neighbouring villages of Bacton and Walcott. For the Villages, the SMP states that the sea defences should be maintained as long as economically viable. This is only expected to be possible in the short term, but before the sea defences fail, measures will be required to manage the risk and mitigate the displacement of people and loss of property and facilities in the medium term.

This means that any 'hard' solutions could only work if complemented by significant beach nourishment to counteract the negative impact to the Villages due to wave overtopping. 'Hybrid' solutions were also considered, including the placement of rock armour with additional sand. However, these were discounted. Initial appraisal subsequently determined that these 'hybrid' solutions would be less attractive than sand-only solutions.

In 2013, Royal HaskoningDHV had already identified that a large-scale sandy solution could work for the northeast Norfolk coast through a study for North Norfolk District Council and The Crown Estate. This was part of the UK-wide sandscaping initiative which aims to explore application of coastal management approaches inspired by the Dutch Sand Engine project. Sandscaping solutions are large-scale beach nourishments that are designed to work with natural processes and with the intention of achieving multiple objectives. However, the Bacton-specific study still had to confirm the preferred concept (in terms of scale and shape) for the sandy solution, ranging from a traditional regular nourishment to a sandscaping solution with its larger scale, intent to work with natural processes and intent to generate multiple benefits. In particular, the Dutch Sand Engine project has demonstrated major recreational benefits and would be ideally replicated by the scheme.

Development of the solution

From terminal-only to a combined solution

The North Sea tidal surge of 5 December 2013 was the key event which spawned the project, leading to the UK's inaugural sandscaping scheme. In this event, several metres of soft cliff in front of the Gas Terminal were lost to the concern of the terminal's operators. Similarly, at Bacton and Walcott there was infrastructure and housing damage caused by the storm waves and flooding. The terminal's operators immediately secured the services of engineering consultants Royal HaskoningDHV to assess options to eliminate erosion risk to the Terminal.

While the team was developing solutions for the Terminal, meetings were held with North Norfolk District Council and Environment Agency to share initial findings and explore the possibilities around joint development of a project with North Norfolk District Council. These meetings and discussions led to an option being explored of a public/

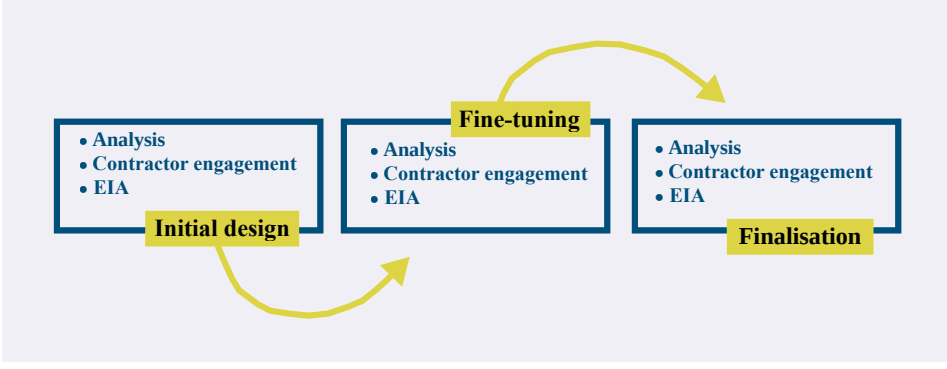


FIGURE 3

Design process.

private sector collaboration to deliver a collective solution to address erosion risk at the Terminal and flood and erosion risk at the villages of Bacton and Walcott. The work for the terminal companies had confirmed that a sandy solution could be designed to prevent downdrift impacts; now the challenge was to develop this to a sustainable and affordable solution that would improve the beach at the Villages, thereby extending the life of the Villages and reducing their risk.

Design process

The aim of the subsequent stage was to refine the design of the sandy solution (in terms of volume, shape, renourishment interval and sediment size) while initiating the process toward the statutory consents, in particular

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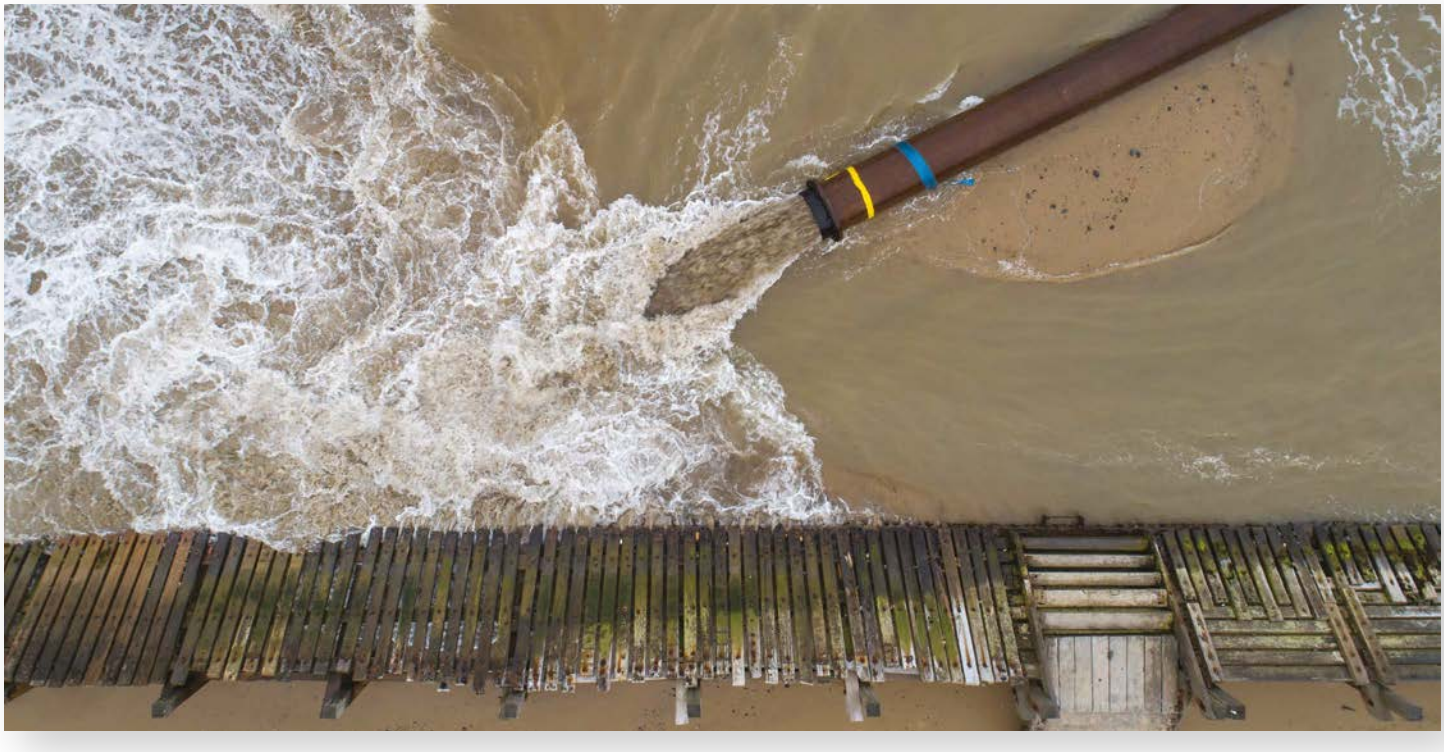


FIGURE 4

Sand extracted from the seabed is pumped onshore through a pipeline.

The team made a special effort to engage closely with all contractors on the Environment Agency framework throughout the design process.

the Marine License and Planning Permission. The team followed an iterative approach with three parallel tracks:

1. analysis (including modelling),
2. environmental study, and
3. engagement with contractors (see Figure 3).

The iterations concerned sediment volume, various configurations and shapes, distribution between Terminals and Villages, sediment size. The process converged gradually toward the finally chosen selection, informed by insights derived from each of the three workstreams.

Modelling and analysis

To assess the technical performance, a conceptual model was used that combined the strengths of a one-dimensional (Litline) and a two-dimensional area model (coupled wave, TOMAWAC, flow, TELEMAC-2D and sediment transport, SISYPHE, models within the TELEMAC-MASCARET modelling system; run by HR Wallingford) with appropriate use of expert knowledge and judgement and local information (in particular from the Coastal Monitoring Programme). The resulting conceptual model was agile enough for optioneering while fully representing the beach processes. The conceptual model uses the one dimensional Litline model as the central engine and uses the other tools to add cross sectional processes which cannot be captured by the one-dimensional model on its own. This relates specifically to the loss of sediment toward deep water and the development of the cross-sectional shape of the beach (i.e. the long-term balance between offshore losses and onshore recovery). The overall shape and volume of nourishment at the Terminal was technically assessed and optimised using cross-sectional modelling. The Terminal element was designed to provide protection against cliff erosion in storms up to a 0.01% Annual Exceedance Probability (1:10,000 per year) event. The team developed an innovative approach using hydrodynamic wave modelling with AMAZON to compare design wave loading on the cliff face with known historic storms that did not cause erosion. In addition, plume modelling was carried out to inform the Environmental Impact Assessment (EIA) and for wind-blown sand, a research model developed for the Dutch Sand Engine

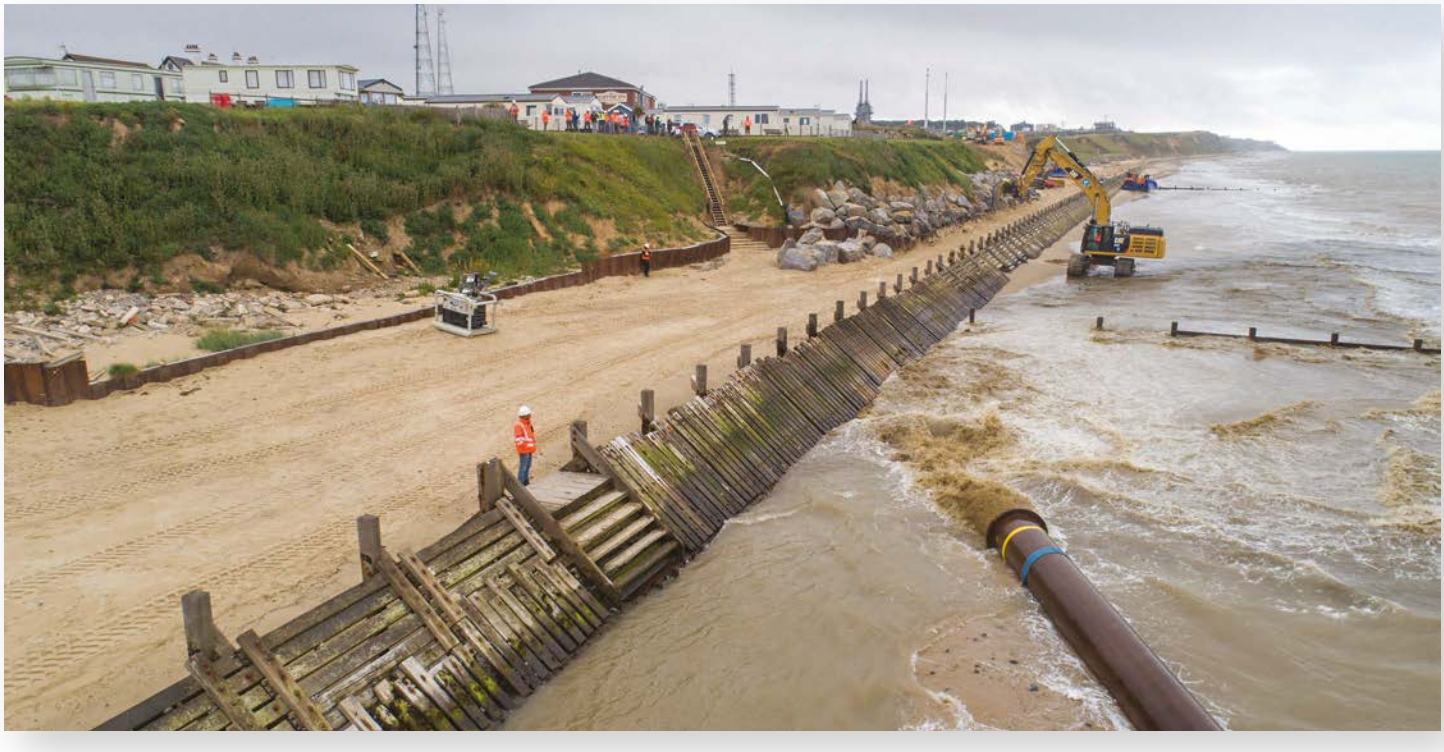


FIGURE 5

View of shoreline nourishment with various equipment at work.

FIGURE 6

Schematic overview looking from north to south along the coast, before (A) and after (B).

was used to test impacts on the terminals and community as well as inform the design of mitigating measures. Modelling studies considered placing greater volumes of sand around the Terminal in a hemispheric shape, similar to the Dutch Sand Engine. However, limited benefit was offered by the additional volumes. Modelling showed that tidal currents in the area washed the additional volume away very rapidly.

Environmental study

The environmental study was not only carried out to meet statutory requirements (EIA, Habitats Regulations, Marine Conservation Zone Assessment, Water Framework Directive) but played a strong and driving role through the design process, both in terms of designing out negative impacts and incorporating mitigation as well as in terms of incorporating opportunities for enhancement. The project identified a chalk bed near the coast within the Marine Conservation Zone and this influenced the design to minimise the risk that the chalk bed would be impacted by the scheme. The environmental study also influenced the grain size and spawned the idea of stimulating dune growth on the nourishment with the added benefit of limiting wind-blown sand.

Contractor engagement

The team made a special effort to engage closely with all contractors on the Environment Agency framework throughout the design process. All potential contractors were invited and all became very positively involved, helping to optimise scheme design and increasing confidence in the cost estimates to the benefit of the clients. This is particularly important for a scheme like this – which was dominated by dredging and nourishment operations – because operations depend on the specific (often commercially sensitive) characteristics of the contractors' equipment. The team initially considered engaging with a single selected contractor but the chosen approach of working with multiple contractors in parallel has proven to work well, also because it helped sustain a level playing field for contractor procurement. This process has influenced size, shape and grain size of the nourishment.

What was proposed?

The Sandscaping scheme consisted of the placement of sand along the coastal stretch between the Terminal and the south-eastern end of Walcott. This is a stretch of coast of 5.7 kilometres. The scheme comprises two distinct but connecting elements: the nourishments in front of the terminals and in front of the Villages (as shown in Figure 2).

Element 1: Terminals

This element aims to prevent significant cliff erosion up to a storm event with a 0.01% Annual Exceedance Probability (1:10,000 per year). The initial placement of sand is expected to last approximately 15 to 20 years from first placement with the intention to potentially re-nourish after that period. The terminals element covers the terminals frontage down to the adjacent Holiday Park and contains approximately 1 million cubic metres of sand. The nourishment here is at its widest and highest: 3.5 to 5 metres higher than the current beach at the cliff toe (7 metres Above Ordnance Datum (AOD)), with a crest width up to 80 metres, and then sloping down to the existing sea bed. The existing outfall pipes were replaced with a new single buried pipe.

Element 2: Villages

This element provides additional protection in front of the Villages from Bacton to Walcott for which the proposed scheme is considered the only viable solution. The initial sand placement improves beach levels which in turn increases the life of the existing sea defences. Over time, tide and waves will transport sand from the Terminals nourishment to feed the beaches of the villages. The higher and wider beach will also reduce wave overtopping and therefore flood risk for the Villages. The Villages element runs from the south-eastern end of the Terminals down to the end of the scheme at Ostend, Walcott and contains approximately 0.8 million cubic metres of sand. The initial beach level covered the exposed sea wall toe, at 4 to 5 metres AOD with a crest width up to about 25 metres, and then sloped down to the existing seabed. The crest at 4 metres AOD means that there would (at least) initially be a beach at high water. The coast would still erode, including temporary rapid losses during storm events. However, the scheme would have 'turned back the clock' by several decades and the extra sand would make the beach more robust with the ability, under the right conditions, to naturally recover.

Overall

The total sand volume of 1.8 million cubic metres was extracted from the seabed, from an existing licensed site, off Great Yarmouth. The extraction sites are approximately 20-25 nautical miles from Bacton. The sand grains

will be similar to the current beach (D50 of 0.35mm), or slightly coarser (D50 up to 1.2mm). Generally, coarser sand is more stable so will create a more stable beach but it is also more expensive to place, and if too coarse, it could have impacts on amenity use or habitats. The sand placement in front of the Terminal provides immediate protection and narrows towards the villages (see Figure 6). Modelling has shown that this alignment is the most favourable.

The placed beaches will adapt rapidly to the natural conditions. The sand will spread out along the coast in both directions. The scheme is expected to provide the required level of protection at the Terminal's coast for approximately 15–20 years (with the exact timing dependent on weather conditions and to be confirmed through ongoing monitoring and review). A future placement may be designed to continue to protect the Terminals – probably without future placements in front of the Villages – depending on considerations at that time. The improved beach in front of the villages of Bacton and Walcott is expected to enhance the lifespan of the

FIGURE 7

Total sand volume of 1.8 million cubic metres was extracted from the seabed, from an existing licensed site, off Great Yarmouth.

The beach plays an important role of absorbing the energy from the sea before it reaches the cliff and defences while also providing support and protection to the defence foundations.

existing sea defences. The sandscaping scheme could delay sea defence failure by 15 to 50 years depending on the state of the seawall and beach development over time. This significantly delays the loss to erosion of nearly 300 households. It is also predicted to reduce flood risk due to overtopping to the coast road and over 100 households. Therefore, the scheme is delivering approximately 400 OMs (Outcome Measures) under current UK Government funding criteria.

Benefits

The scheme will have very large benefits to the Gas Terminal, extending its functional life as a piece of nationally critical infrastructure, preventing potential (very expensive) national disruption of supply and its consequential damages, and the direct damages to the Terminal facilities.

For the Villages, the scheme is expected to delay the loss of the seawall, and thereby delay the loss to erosion of the coast road and nearly 300 households. In addition to these measurable benefits, the scheme is expected to provide time to the communities to adapt to

coastal change, for which they currently have very little time and opportunity.

Following discussion with DEFRA and the Environment Agency the village element of the scheme is eligible for government Flood and Coastal Erosion Risk Management (FCERM) Grant in Aid (GiA) funding as set out in the following list:

- Properties protected from erosion, determined by applying the standard methods from the Environment Agency approved Economic Appraisal Manual. Essentially, the benefits are generated by the delay of the loss to erosion of properties in Bacton and Walcott, using appropriate property values to calculate the damage. The year of loss of individual properties and their respective access roads was estimated for each option. For the initial situation this was based on the estimated year of seawall failure. For each option, the extensive modelling carried out for scheme design was used to determine how the enhanced beach would delay this year of failure. This was combined into a Present Value Damage (PVD) amount for each option. Note that this leads to a 'duration of benefits' that varies along the frontage, which has been incorporated in the calculation of GiA,
- Properties protected from flooding. Bacton and particularly Walcott were vulnerable to flooding from wave overtopping over a coastal seawall. Reflecting the relatively low importance compared to erosion, the team took a pragmatic approach to calculating the benefits. First, the economic flooding damages for Walcott Gap calculated in previous studies, updated to the current date, were used to estimate how the scheme options would generate benefits. In addition, the number of households for which the scheme options reduce the probability of flooding, was estimated on the basis of data from the Environment Agency's coastal modelling study. These two results were combined to determine the scheme options' economic benefits and their contribution to Outcome Measure 2 (households moved from a high flood risk category to a comparatively lower category).
- Highways protected. The benefits concern the delayed need to reconstruct the B1159 road at Walcott on a more inland alignment. In practice, it is more likely that the road would not be repaired, and calculations confirmed that the economic impact of the resulting delays would be higher. However, in line with UK Treasury rules the lowest damage scenario is used as part of the calculation.
- Loss of recreational value. This was calculated as the loss of visitor spend, based on available economic data. Alternative analysis based on reduced value of enjoyment produced higher impacts, but was considered less reliable. Therefore, the lower value has been applied.

Additional benefits

There are also be additional benefits further downdrift from the Villages frontage. The scheme is expected to provide additional sediment which will, over time, also generate benefits downdrift from Walcott: first at Happisburgh and then also at Eccles and Sea Palling. Due to the significant uncertainty regarding these possible benefits, and the fact that its inclusion is outside of current policy guidance, these additional benefits have not been calculated within the approved business case submitted to LPRG.

The scheme is expected to create other benefits which are not eligible for GiA because they do not relate to reduction of flood and erosion risk. This concerns the enhancement of the communities' capacity to adapt to coastal change (likely to improve

Royal HaskoningDHV has been working with The Crown Estate and other partners since 2011 to explore the application of sandscaping solutions in the UK.

FIGURE 8

Coastal nourishment looking southward from the Terminals toward the Villages.

economic productivity and reduce the burden on the UK's health care system) and the improvement of tourism facilities (in addition to prevention of losses, which is potentially eligible for in GiA). These benefits are relevant for alternative sources of funding.

Local stakeholders showed overwhelming support for the scheme and were keen to see the sandscaping solution implemented. Initial concerns regarding potential negative impacts during construction, either to tourism or fishing, were largely overcome through active engagement and consultation.

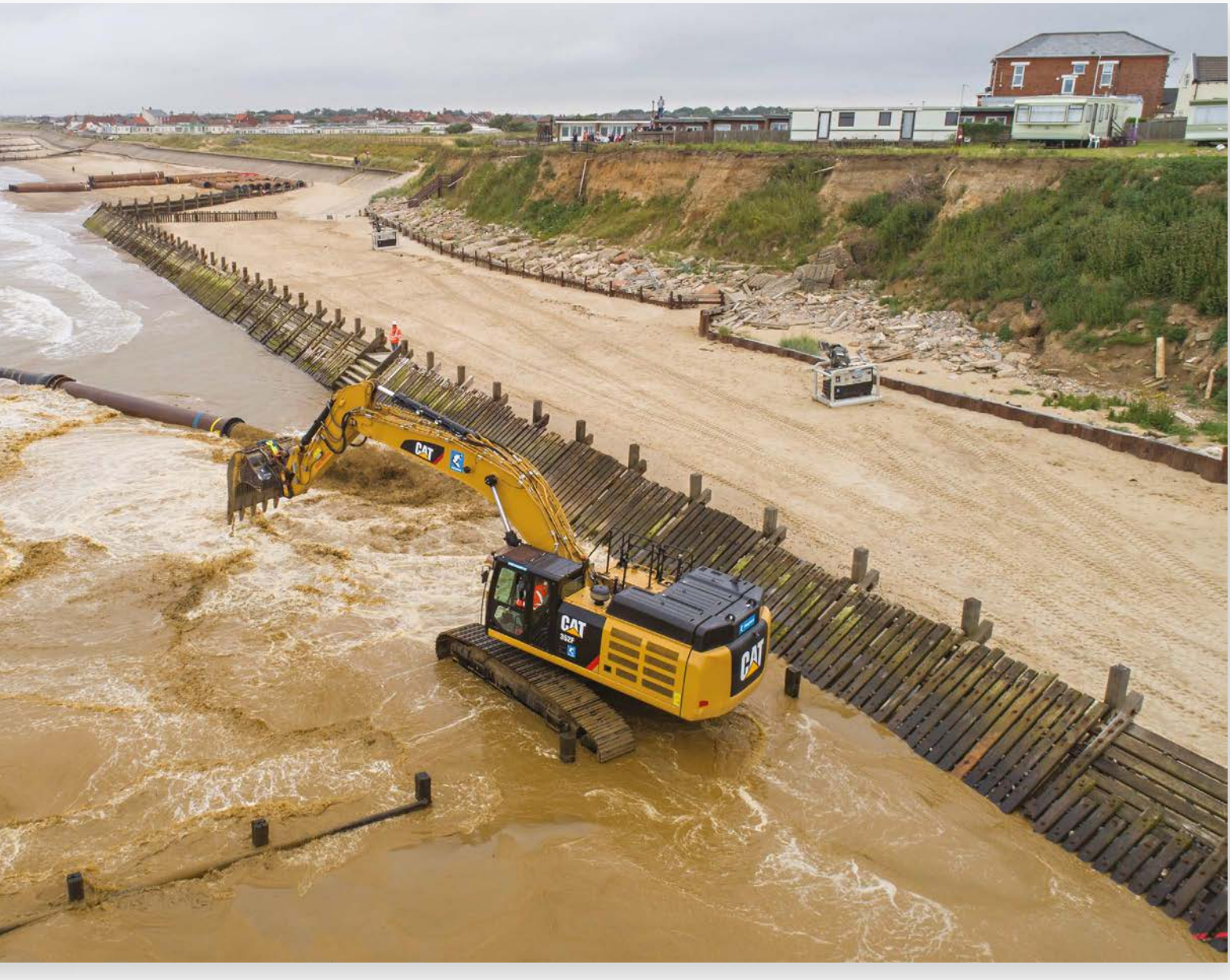
The loss of existing recreational value described above is eligible for FCERM GiA. In contrast, the improvement of tourism economy concerns the positive impact on the local tourism economy of the options, for example by improving the beach.

The scheme is also likely to improve the adaptive capacity of the communities. The understanding that a large number of households were expected to be lost in the coming 20 years has far-reaching impacts on people. One key aspect is the loss of mobility (i.e. the reduction in house prices restricting ability to move elsewhere and therefore find work). In addition, the loss of households puts an additional burden on health and social care.

These non-financial benefits are challenging to report quantitatively, but were considered within the choice of the preferred Sandscaping option.

How it will work

The beach plays an important role of absorbing the energy from the sea before it reaches the cliff and defences while also providing support and protection to the defence foundations. The larger beach will absorb more energy and supports the defences. Detailed studies have



The Bacton scheme will be a very useful case study for other coastal managers in the UK and elsewhere to consider sandscaping solutions for their area.

been done to assess how coastal processes along this dynamic stretch of coast will work with the scheme, and this provides confidence that the scheme will perform. Over time, the bulk of sediment protecting the Terminal is expected to feed the beaches in front of Bacton, Walcott and beyond, sustaining the initial sand placement in front of those villages.

Experience with the Dutch Sand Engine shows that (mainly in the 12 months following construction), the shape of the sediment placements will change and this is to be expected. With a new 'dry beach' above mean high water, there is a risk of windblown sand, particularly in the first 18 months. This will need to be monitored and managed.

Funding

The funding for the Bacton to Walcott Coastal Management Scheme came from a number of private and public sources. The FCERM GiA was a critical element of the project to enable the joint Terminal and villages scheme to proceed but did not form the primary funding source. The private funding was led by Shell UK and Perenco UK who oversaw an umbrella of other infrastructure provider contributions. Opportunities for external funding were comprehensively explored with the Terminal and UK Government. The total cost of the project was approximately £21 million including the re-provision of a surface water outfall for the gas terminal. The following funds were intended to be made available to the project.

- Terminal's contribution to the cost of the Terminal protection and new surface water outfall, totalling two thirds of the overall funding.
- FCERM GiA capital funding allocated from the Environment Agency's Flood and Coastal Erosion Risk Management Investment Programme;
- North Norfolk District Council contribution;
- Local Levy agreed allocation from the Anglian Eastern Regional Flood and Coastal Committee (RFCC);
- Environment Agency's agreed allocation from the Natural Flood Management (NFM) funding stream;
- Norfolk Business Rates Pool contribution from Norfolk Local Government sources;
- New Anglia Local Enterprise Partnership Growth Funds contribution; and,
- Contributions from the local community and other beneficiaries collected through the JustGiving account set up by North Norfolk District Council.

With regards to the NFM funding stream, as part of the original application for funding, the importance of post construction monitoring was emphasised. As such, and in order to maximise the learning from this project, there is an expectation that a proportion of the NFM allocation will be attributed to such monitoring. Post-construction monitoring in beach nourishment projects is covered by FCERM GiA monies elsewhere (for example the Eccles to Winterton scheme).

The capital funding requirement for the Bacton to Walcott scheme is included in the Environment Agency's flood and coastal risk management investment programme (2015-2021), Terminal investment programmes and North Norfolk District Council capital investment programme. The revenue for future maintenance is limited and will be shared as identified in the Development Agreement.

Ongoing costs with regards to maintenance are expected to be low as the scheme will naturally decommission over time. Monitoring costs are to be shared and it is expected that a significant proportion of the costs can be captured in the Environment Agency's Anglian Coastal Monitoring programme. Monitoring is likely to include several fields, including: ecological, bathymetric, geomorphological and social science aspects. In addition, further research will be supported and encouraged.

Sandscaping and wider applicability in the UK

Royal HaskoningDHV has been working with The Crown Estate and other partners since 2011 to explore the application of sandscaping solutions in the UK. This consisted of technical work to develop the concept, carry out a UK-wide assessment of potential sites and location specific feasibility studies. In addition, the sandscaping partnership has engaged with decision makers and influencers at various levels in order to understand the constraints for and opportunities around this innovative solution in the UK. The approach was strongly driven by the clear realisation that sandscaping schemes will only happen if it is the right solution locally, and is 'consentable' and affordable. As a result, a key aim has been to convince coastal managers to include sandscaping on longlists for projects and to create a level playing field so that it can be appraised against more traditional options.

There have been a number of specific engagement initiatives in the UK. In April 2015, a workshop was held in London hosted by The Crown Estate. During this workshop, which encompassed coastal practitioners and community representatives from across the country, the advantages and disadvantages of such an approach were explored for a number of coastal locations from around the country. Concurrent to this, consultants Royal HaskoningDHV funded by The Crown Estate, undertook a technical assessment of coastal locations. More recently (April 2018), an event was held at the Dutch Embassy to explore sand engine/sandscaping approaches in the UK environment. The technical audience included coastal practitioners from Environment Agency, Coastal Risk Management authorities, DEFRA, Natural England and Marine Management Organisation. Part of the afternoon discussion centred on the potential for a sandscaping approach to be taken at other locations in the UK. There was consensus that there were other specific locations in the UK where such an approach could be valid. However, other factors such as already planned interventions could affect timings.

Clearly, after completion of the Bacton to Walcott Sandscaping scheme, the monitoring

FIGURE 9

Floating pipeline delivering sand to the shore from an offshore site.

and sharing of results more widely is possible. At this point, coastal practitioners will be in a good position to consider the merits of this approach for other locations.

Conclusions

The Bacton to Walcott Sandscaping scheme shows that it is possible to design, fund and gain consent for a sandscaping scheme in the UK – a large-scale nourishment that is designed to work with natural processes and with the intention to achieve multiple benefits.

Such an approach not only provides erosion and flood risk benefits but also has the potential to improve tourism income and adaptive capacity of communities, while working with natural processes. The higher and wider beaches will delay failure of the defences, reducing uncertainty and providing more time for adaptation. Future engagement around coastal adaptation will be critical, North Norfolk District Council continues to engage locally while also lobbying national for wider inclusion of adaption in the national approach.

By taking a coastal zone approach, considering longshore interactions and taking partnership opportunities, the Bacton scheme has created a solution to not only protect nationally important infrastructure but to support the communities of Bacton and Walcott where this would otherwise not be possible.

The success of this collaborative project development has been due to all parties, private and public, playing their part. In simple terms, having the 'right' people doing the 'right' things at the 'right' time. This concerns both personalities and organisational remits.

The Bacton scheme will be a very useful case study for other coastal managers in the UK and elsewhere to consider sandscaping solutions for their area.

It can be seen as the Sand Engine's 'little nephew'.

Summary

The Bacton Sandscaping scheme is a large-scale beach nourishment designed to protect the Bacton Gas Terminal from cliff and beach erosion while also reducing flood and erosion risk to the communities of Bacton and Walcott, buying the time needed for adaptation to coastal change. The scheme was inspired by the Zandmotor project in The Netherlands but has translated the concept to the different geography and governance setting of the UK. It can be seen as the Zandmotor's 'little nephew'.

This article describes the context of the challenge, how the sandscaping approach works and tells the story of how the first project of this type outside the Netherlands has developed from the seed of an idea to reality. Technical expertise, passion, trust, flexibility and lateral thinking have all been to the fore in a truly unique collaboration between multiple private and public sector organisations.

This article was presented as a paper at an Institution of Civil Engineers Conference in 2019. It is updated here and published with permission.

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The success of this collaborative project development has been due to all parties, private and public, playing their part.

Mark Johnson

Mark has worked for 35 years in various roles for the Environment Agency and its predecessor organisations. For the majority of this time he has been focused on the East Anglian Coast.
During the last 14 years he has overseen delivery of many large flood and coastal erosion risk management projects, many of which have realised multiple benefits for the protection of people and property, important wildlife sites and rural land. Mark has been actively working with various groups on the East Anglian coast to help progress projects where partnership approaches are pivotal in helping to address the challenges of the UK coast. He has been the Chairman of the East Anglia Coastal Group (EACG) since 2012 and chaired elected members during the development phase of the Shoreline Management Plans.

Robert J.W. Goodliffe

Rob is a Coastal Manager for North Norfolk District Council/Coastal Partnership East working across local authorities on the Norfolk and Suffolk coasts. Rob works with communities and organisations to deliver practical coastal management approaches for business and communities including traditional coast protection and pioneering coastal change adaptation projects. Rob entered the coastal management field to deliver innovative adaptation projects, such as the relocation of business and community assets and purchase and relocation of at risk homes. He has since developed opportunities and funding packages for coastal protection and maintenance schemes and, more recently, has lead North Norfolk District Councils role in the development and delivery of a UK first Sandscaping scheme to protect communities and major national gas infrastructure. Rob holds a BSc honours degree from Wye College/Imperial College London, Institute of Leadership and Management certificate alongside a breath of experiences ranging from tourism, environmental management, public open space management, planning policy and coastal management.

Gökhan Doygun

Gökhan is a Senior Commercial Advisor at Shell and is currently working as Opportunity Lead/ Commercial Lead on Energy Transition projects in the Netherlands and in the UK Southern North Sea. He played a key leading role, as the Business Opportunity Manager(BOM) acting on behalf of Shell UK, in the success of the public and private collaboration for the joint protection of the nationally critical infrastructure Bacton Gas Terminal and the adjacent Bacton & Walcott villages – UK's first 'Sandscaping' solution for Bacton to Walcott Coastal Management Scheme.

Jaap Flikweert

Jaap is a flood and coastal management advisor and a Leading Professional with Royal HaskoningDHV, and a Fellow of CIWEM. He has twenty-five years of experience in flood and coastal management, in the Netherlands, the UK and worldwide. Jaap's career started in 1994, working from the Netherlands until 2004 and based in the United Kingdom since then. His expertise covers flood and coastal management: from detailed design to strategy and policy level, as well as planning, preparation, protection and response. He produced the guidance for the statutory flood defence assessment in the Netherlands; led three of the 20 Shoreline Management Plans for England and the review of flood defence performance after several of the recent floods in the UK (including Winter 2015/16); and established the method that the US Army Corps of Engineers applied to incorporate resilience in New Orleans' levees after Katrina. Jaap is the technical lead for the Sandscaping initiative that aims to introduce Dutch Building with Nature concepts into the UK. He led the RHDHV team that developed the design, Environmental Impact Assessment, business case and monitoring plan for the Bacton to Walcott Sandscaping scheme.

Gerard Spaan

Gerard is a Senior Civil Marine Engineer at Shell Projects & Technology and is currently working on the development of LNG import terminals globally, from their early definition to the actual execution. For the Bacton Sandscaping Project, Gerard was the Technical Lead on behalf of Shell, providing technical assurance and guidance for the design and execution of the works, including concept selection as well as procurement for the different work packages. Gerard holds an MSc degree in Civil Engineering from Delft University of Technology in the Netherlands. Prior to joining Shell in 2009, Gerard worked as a Civil and Coastal Engineer at Deltares, an independent institute for applied research in the field of water and subsurface, and at Van Oord Dredging and Marine Contractors.