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Department
for Environment
Food & Rural Affairs

Report on the coastal management practices at Pagham

January 2015



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Introduction

This report has been produced for the Secretary of State for Environment, Food and Rural Affairs following the accelerated coastal erosion at Pagham Beach, West Sussex. It sets out the background to the situation and summarises the conclusions of the three main approaches for future management of the Pagham coastline. The funding of the different management practices is not considered in the report.

It considers evidence relating to coastal management practices at Pagham submitted by the Environment Agency, Natural England, Arun District Council and Pagham Parish Council. A list of the evidence submitted is available in Annex A.

Further information on Pagham, including responsibility for management of Pagham, environmental status and recent coastal changes, is provided separately in annexes.

Background

Pagham Beach has had a long history of coastal change. The dynamic nature of the coastal processes at Pagham means that future changes to the coastline are difficult to accurately predict.

Pagham Beach has undergone significant erosion recently due to the growth of the Church Norton Spit. Arun District Council (Arun DC) has undertaken defence works to better protect properties from erosion. No properties have been flooded or lost from erosion at Pagham Beach. The Environment Agency and Natural England have also been active in the management of the Pagham coastline.

The environmental status of Pagham is recognised with international, national and local environmental designations and any changes that could adversely impact the environment in the area need to be carefully considered.

Arun DC is responsible for the coastal management of Pagham under the Coast Protection Act 1949. Further information is provided in Annex C.

Approaches for managing the Pagham Coastline

Three main management approaches are set out below. The approaches have been previously considered in several reports listed in Annex A. The suitability of each approach has been set out in relation to six main factors, including impact on the Shoreline Management Plan (SMP) policy. Annex C provides further information on the SMP policy. The impacts on both Pagham Beach and Pagham Harbour are detailed.

Approach 1: No intervention

One management approach for Pagham is to not intervene. This would involve no further defence works to protect Pagham Beach.

1. **Short term impacts** - In the short term this could lead to a significant increase in erosion and flood risk to the properties located along the frontage at Pagham Beach. However, the extent of the impact and location of the erosion would be difficult to project due to the complex geomorphological processes. If the spit continues to cause erosion, then under this approach it is likely that properties would have to be removed.
2. **Long term viability** - The outcome of this approach in the long term is that the risk and impact of erosion and flooding would likely decrease, as properties would be removed from vulnerable areas.
3. **Flood risk in Pagham Harbour** - This approach could lead to further erosion and an increase in flood risk to properties in Pagham.
4. **Impacts on the wider coastline** - This approach would allow the natural movement of shingle along the coastline.
5. **Environmental impacts** - This approach would allow the area to return to a more naturally functioning system.
6. **SMP policy** - This approach would be more in line with an SMP 'no active intervention' policy, rather than the current SMP policy of adaptive management for the Pagham unit.

Approach 2: Management of Pagham Beach frontage

This involves the management of the frontage at Pagham Beach through, for example, the construction and maintenance of coastal defences and beach re-nourishment or recycling.

1. **Short term impacts** - In the short term it is likely that this approach would meet the objective to better protect the properties at Pagham Beach from coastal erosion, as suggested in a number of reports. The rock revetment constructed in December 2013 is effectively reducing the risk to the 15 properties from erosion. The additional urgent revetment and beach recycling, completed November 2014, are also reducing the risk of erosion at present to a further 10 properties.

The Decision Framework for Adaptive Management at Pagham Harbour (2011) supported a beach management approach as it met the objective to protect properties with minimal environmental impacts. The Consultation on Concept Options (2014), produced on behalf of Pagham Parish Council concluded that a beach management should prevent erosion along Pagham Beach.

If the Church Norton spit continues to grow then further defence works are likely to be required at other areas along Pagham Beach. A key reason for the use of rock in the revetments was that it could be moved to other areas of the beach when necessary.

It is suggested in the Environment Agency technical advice to Arun DC (2014) that the urgent revetment, constructed in November 2014, could need to be altered to provide a higher level of protection.

2. **Long term viability** - In the longer term, the suitability of a beach management approach is linked to future changes in the spit. If the movement of sediment

contributing to the growth of the Church Norton spit is reduced then erosion rates caused by the scour will likely decrease in the future. This will mean Pagham Beach will not be subject to the present scour erosion.

3. **Flood risk in Pagham Harbour** - An increase in flood risk in Pagham Harbour is unlikely as the aim of beach management is to reduce flood risk. This was set out in the Royal Haskoning DHV Environmental Scoping Report (2013).
4. **Impacts on the wider coastline** - The impact of beach management on the wider coastline was set out in the Environmental Report (2013) and suggested that impacts on the wider coastline from a beach management approach is minimal.
5. **Environmental impacts** - The Environmental Statement (2009) and Environmental Report (2013) concluded that environmental impacts on the SPA and SSSI would be minimal and a Habitat Regulations Assessment would not be required. It is likely that a beach management approach, similar in scale and scope to what has already occurred, would not require significant additional permissions and could be implemented within a short timeframe.
6. **SMP policy** - This approach would be in line with the SMP policy of adaptive management.

Approach 3: Intervention with Church Norton spit or the inlet channel

This approach involves cutting and maintaining a channel through the Church Norton spit or closing the inlet channel. Pagham Parish Council supports this approach.

Intervention with the spit and closing the channel has recently been set out in the Consultation on Concept Options (2014). The report set out the options, presented as Option 2a and 2b (cutting a channel through the spit) and Option 3a and 3b (closing the channel inlet). The location of the channel cut through the spit is the main difference between option 2a and 2b. Both options could require the construction of a structure protruding seaward. It is expected that this would also require a high level of ongoing maintenance, due to the constant natural movement of shingle. Annex G shows the options.

The location of the channel cut through the spit will also affect whether Arun DC or Chichester District Council is the local planning authority. Chichester District Council is the responsible authority for the west of the harbour at Church Norton.

1. **Short term impacts** - It was suggested in a report and letter to Pagham Parish Council from Anthony Cowey of Patrick Parsons (2010) and (2014), and in the Consultation on Concept Options (2014) that cutting a channel through the spit would decrease erosion at Pagham Beach. The Royal Haskoning DHV Consultation on Concept Options (2014) appreciated that there was uncertainty that this would occur and stated that detailed geomorphological assessments would be required to know the impact with an acceptable level of confidence.

The Environment Agency and Natural England has suggested that the position of the channel cut through the spit (option 2a or Option 2b) would have an effect on the

mitigation of short term erosion at Pagham Beach. There is uncertainty that cutting the spit too close to its end would not cause a large enough volume of shingle to move onto Pagham Beach to provide adequate protection in the short term. If the shingle does migrate, there is limited evidence at present to state how long it would remain at Pagham Beach without further erosion from wave action.

The Consultation on Concept Options (2014) also suggested that closing the inlet channel would limit the localised scour and enable the movement of sediment from the spit to Pagham Beach. However, it appreciated that this approach could have major direct and indirect impacts on the spit and may face many challenges.

2. **Long term viability and impact on wider coastline** – The long term suitability of this approach is dependent on the future changes of the spit system. It is suggested by both Natural England and Environment Agency that the structures built in Option 2a or 2b, or Option 3a and 3b, could disrupt the movement of sediment further along the coast. This could lead to an increase in the risk of erosion to other properties further east along the coast at Pagham and further down the coast, potentially requiring further defence work.
3. **Flood risk in Pagham Harbour** - The impact on flood risk in Pagham Harbour from cutting a channel through the spit or closing the channel is dependent on the location and orientation of the new channel cut through the spit. The Environment Agency would assess the impact on flood risk after the technical design of an approach is finalised.
4. **Environmental impacts** - Adverse impacts on the natural environment are expected, but there has been not yet been a formal assessment of the impacts on the environment of cutting the spit or closing the inlet. The Environmental Statement (2009) and Environment Report (2013) assessed only the environmental impact of the beach nourishment and the rock revetment, respectively. Cutting the spit and closing the inlet channel were considered in the Environmental Statement (2009) as alternative options only. They were not considered appropriate options to meet the objective of protecting the properties on Pagham Beach from erosion. Impacts on the environment from intervention with the spit or closing the channel, such as impacts on the Water Framework Directive and SSSI, will need to be assessed in an Environmental Impact Assessment.

If an adverse effect on the environment from cutting the spit or closing the channel is initially identified during an environmental scoping report, then a fuller assessment of the environment impacts, known as a 'Habitat Regulations Assessment', would be required in line with 'The Conservation of Habitats and Species Regulations (2010)'. This would assess the environmental impacts of cutting the spit and closing the channel on the SPA and Ramsar site.

If it is shown that the SPA or Ramsar site would be adversely affected then exceptions can be granted, as stated in Annex D. The requirement to show that there is no less environmentally damaging alternative approach that would also protect properties on Pagham Beach from erosion will need to be considered in the 'Habitat Regulations Assessment', This was set out to Pagham Parish Council by Royal Haskoning DHV in the Consultation on Concept Options document (2014).

Natural England has advised the environmental impacts of cutting the spit closer to the end of the spit (option 2b) would be less adverse, in comparison to cutting the spit further west (option 2a). The width of the channel cut through the spit would also have significant differences.

ABPmer, on behalf of the Pagham Parish Council, are progressing with a planning application into cutting the spit as an approach. This is being taken forward and financed by Pagham Parish Council. Pagham Parish Council is the organisation pursuing the planned works and is responsible for supplying information required by the local planning authority (Arun DC). A letter by ABPmer (2014), submitted as evidence, states that there is a need for an initial options review and details the various assessments required before permissions can be provided. The Royal Haskoning DHV Consultation on Concept Options (2014) was only an initial setting out of the options and was not a thorough assessment of suitable alternatives.

5. SMP policy

Interference with the spit and channel approach is more in line with a hold the line SMP policy, rather than adaptive management.

Conclusions for future management

The evidence submitted has demonstrated the complexities and uncertainties of the situation. This report concludes:

1. A no intervention approach could result in a loss or damage to property at Pagham Beach.
2. A beach management approach would help reduce the risk of erosion at Pagham Beach.
3. Intervention with the spit has many uncertainties, especially on the natural environment and impact on the wider coastline. The complex coastal processes in place means a precise geomorphological assessment is difficult to undertake and the outcomes would be difficult to predict with a high degree of confidence.

Next steps

1. Arun DC continues to monitor the performance of the urgent revetment and the erosion along Pagham Beach. Arun DC plans how the risk of erosion along Pagham Beach can be managed, with continued support from the Environment Agency and Natural England.
2. Pagham Parish Council reviews the outcome of the Environmental Scoping Report in March 2015, after it has been considered by Arun DC planning department. The Habitats Regulations Assessment and Environmental Impact Assessment to be completed by May 2015 will enable the environmental impacts to be known with greater certainty and inform further steps.

Annexes

Annex A - List of documents submitted as evidence

Name	Year
Beachy Head to Selsey Bill Shoreline Management Plan - Final Report	2006
Arun District Council Policy Scrutiny Committee meeting note	2007
Pagham to East Head Coastal Defence Strategy - Final Report	2009
Pagham to East Head Coastal Defence Strategy - Consultation document	2009
Pagham Beach Coastal Defence - Environmental Statement	2009
Pagham Coastal Defence Study - Geomorphological assessment	2009
Geomorphological Advice in respect of Pagham spit 2009	2009
Patrick Parsons Report - Coastal defences and flooding report Pagham	2010
Decision Framework for Adaptive Management at Pagham Harbour - Final Report	2011
Pagham Harbour - Managing the risk of coastal change	2011
Habitats and Wild Birds Directives: guidance on the application of article 6(4)	2012
Arun District Council - Mutli agency meeting notes 10 Jan 2013	2013
Pagham Beach Coastal Defence Project - Environmental Report	2013
RSPB Pagham Harbour local nature reserve management plan 2013-2018	2013
Geomorphological Advice in respect of Pagham spit 2013	2013
Initial estimate of costs for cutting the spit - Environment Agency	2014
Technical discussion note for Arun District Council: Potential future development of the Church Norton spit at Pagham	2014
Letter from ABPmer to Steve Woodgate - Providing advice to support planning application for Pagham spit intervention	2014
Letter from Anthony Cowey (Patrick Parsons) to Ray Radmall	2014
Pagham Beach and Harbour Entrance Potential Intervention Measures Consultation on Concept Options – Monday 6th October 2014	2014
Pagham Beach and Harbour Entrance Potential Intervention Measures Report on Workshop Meeting held on 7 May 201	2014
Letter from Rosebay Services Ltd to Ray Radmall	2014
Arun District Council - Multi agency meeting notes 10 Jan 2014	2014
Natural England Environmental Impact Assessment Scoping Letter	2014
Number of Breeding terns in Pagham (1945-2014)	2014
Geomorphological Briefing notes: Changes in Pagham Spit Jan-Feb 2014	2014
Pagham Harbour: Geological Conservation Review	2014

Annex B: Background to Pagham

History of coastal change at Pagham

There has been a long history of coastal change at Pagham. The Pagham Harbour double-spit system is highly dynamic, and the positions of the Church Norton spit and the Pagham spit have undergone significant change in recent history. As a result, the location of the harbour inlet and the coastline of Pagham Beach have changed significantly in the past and are likely to continue to change into the future.

A consequence of the dynamic nature is that coastal processes along the coast at Pagham are complex and future changes are difficult to accurately predict. This has been confirmed by a number of coastal geomorphological assessments.

Flood and coastal erosion risk at Pagham

The majority of the properties at Pagham Beach were predominately built in the 1920s and 1930s, after the Pagham spit had undergone a period of growth. It is important to note that the area currently occupied by the properties was located either seaward of, or on the Mean High Water line, during 1890s.

Of the properties at risk of coastal erosion at Pagham Beach, 15 properties are protected by a coastal defence constructed in 2013. A further 10 properties are now better protected by further defence work completed by Arun District Council (Arun DC) in November 2014. An additional 25 (approx.) properties located along the frontage are also at risk of erosion.

There are 83 properties in Pagham village at risk of flooding from Pagham Harbour. The main source of flooding is from the tidal inlet through the harbour mouth. The Environment Agency is currently constructing a flood defence scheme to better protect properties in Pagham village. The scheme is planned to be completed in September 2015.

Annex C: Management of the Pagham coastline

Responsibility for coastal management at Pagham

Under the Coast Protection Act 1949 Arun DC is the responsible coastal authority and leads on coastal risk management for the Pagham coast. Arun DC has the powers to undertake coastal erosion schemes and is responsible for managing third party activities on the coast.

The Environment Agency has a strategic overview of all flood and coastal erosion risk management as set out in 'The Flood and Water Management Act 2010'. This strategic overview makes sure that decisions on coastal management are made in a joined-up manner and that works in one part of the coast take account of the impacts on another part. Defences are provided under permissive powers and there is no legal obligation on the Government or local authority to protect property. The Environment Agency is also a statutory consultee on flood risk and assesses any project or development which is likely to have an impact on flood risk.

Natural England is a statutory adviser to the Government on the natural environment.

Arun DC is responsible for promoting coastal schemes and submitting these to the Environment Agency. The Environment Agency scrutinises the Project Appraisal Report to assess the technical feasibility, financial aspects according to the Partnership Funding approach, and the environmental sustainability of the scheme. This includes an assessment of the potential impacts of the scheme on flooding and erosion downdrift. Arun DC, as the local planning authority, would have to provide consent for a scheme which is planned within their area.

Coastal authorities are responsible for developing Shoreline Management Plans (SMPs) in consultation with the Coastal Groups, local authorities and other interested parties. The Environment Agency has strategic oversight for the production and quality control of SMPs under its coastal strategic overview role. Any change in an SMP policy is handled through the Environment Agency SMP Change Process and follows clear procedural guidance. Arun DC would have to consult the relevant SMP partners, which include local authorities and the South East Coastal Group, the local community, the Environment Agency and other interested parties. The Environment Agency approves all changes to SMPs.

Beachy Head to Selsey Bill Shoreline Management Plan

SMPs provide a long term policy framework to manage the risk of coastal change in a sustainable and holistic manner. SMPs are not statutory documents, but through significant consultation with interested parties, set the direction of travel for coastal flood and erosion risk management over three time epochs: short (20 years), medium (50 years) and long (100 years).

The Beachy Head to Selsey Bill Shoreline Management Plan (SMP) includes the stretch of coastline at Pagham and was finalised in 2006. Arun DC is the lead authority for the SMP. There are two SMP policy units relevant to Pagham. The SMP unit 4d24 (Aldwick to Pagham), which includes all the residential properties on Pagham Beach, recommended a

policy of 'hold the line' at the time for the short, medium and long term. This meant maintaining the standard of protection of existing defence along the frontage.

The SMP unit 4d25 (Pagham to Church Norton) is also relevant as it covers Pagham Harbour, the Church Norton spit and the western end of the Pagham spit. This unit recommended a policy of 'managed realignment' in order to achieve a more naturally functioning coastline. This would be achieved by adjusting the line of defence to control erosion.

The Pagham to East Head Coastal Defence Strategy

The Environment Agency, Arun DC and Chichester District Council developed 'The Pagham to East Head Coastal Defence Strategy', which was approved in 2009. The aim of the strategy was to identify a sustainable coastal and flood management approach for the next 100 years that builds on the SMP recommendations.

The Strategy responded to the dynamic changes to the Pagham coastline at the time, and the uncertainty of how the coastline at Pagham would change in the future, by recommending that the preferred option for the SMP policy unit 4d25 (Aldwick to Pagham) should be 'adaptive management'. The strategy appreciated that as further knowledge is acquired it could be possible to have more defined actions for Pagham.

The aim of the adaptive management policy was to work with natural processes and *"manage complex coastal areas by monitoring changes and acting on them in a planned but flexible way, increasing understanding over time"* (EA, 2011).

A key outcome of the adaptive management approach was to promote community involvement and awareness of the options to the rapidly changing coastline. The majority of stakeholders agreed with the adaptive management policy during the public consultation. Pagham Parish Council requested further clarity of 'adaptive management' and was concerned at the time that the policy commitment was not clear. The EA and Arun DC responded by the production of an adaptive management plan.

The Strategy suggested that a review of the adaptive management policy would be undertaken by the Environment Agency in 2019. However, it was appreciated that the timing of the review might be influenced by other factors and the strategy could be reviewed sooner if issues arose.

Decision Framework for Adaptive Management at Pagham Harbour

A major recommendation of the Strategy was the development of an adaptive management plan, which was finalised in 2011. The plan evaluated the appropriateness of future management options for the Pagham coast for potential coastal scenarios. The plan took account of the rapidly changing coast and was based on a geomorphological assessment of the Pagham coast to gain a greater understanding of the coastal process at Pagham to help develop management approaches.

A key outcome of the plan was the development of trigger levels. Any changes to the coastline of Pagham would be regularly monitored; when the beach width (the distance between the properties and the sea) was reduced under a specified length then Arun DC would respond. The rates of reduction were based on the historic erosion rate of approximately 1m/year.

Annex D: Environmental status of Pagham

Environmental designations

Pagham is a nationally and internationally important environmental site. Pagham Harbour is important for its range of coastal and wetland habitats which support overwintering wildfowl and waders, and summer breeding birds, such as little terns. The site also supports nationally important communities of plants and invertebrates. The coastal geomorphology of the area is also of key importance. The Church Norton spit is dynamic in nature and supports important vegetated shingle habitats which little terns currently nest on.

The harbour is also a Local Nature Reserve managed by the Royal Society for the Protection of Birds (RSPB). It attracts tens of thousands of visitors each year, bringing economic benefit to the local area. The area is also important for social, cultural and educational values.

This environmental importance has been recognised and the area has been provided with the following designations. The designations provide a legal protection against damaging activities to make sure the environmental integrity of the UK and Europe is maintained.

- Special Protection Area (SPA)
- Ramsar site
- Site of Special Scientific Interest (SSSI)
- Marine Conservation Zone (MCZ)
- Local Nature Reserve (managed by RSPB)

The dynamic nature of the spit system is a main reason why the landform was designated a 'geomorphological SSSI'. The boundaries of the SSSI and SPA designations follow the Mean Low Water line and are liable to change, to account for natural changes to the spit system.

Potential adverse environmental impacts on Pagham

Any changes that could adversely impact the environment in the area need to be carefully considered. The local planning authority (Arun DC) would be responsible for ensuring that any planned works comply with the relevant environmental legislation when evaluating whether permission can be granted. The organisation pursuing the planned works is responsible for supplying information required by the local planning authority.

Under 'The Conservation of Habitats and Species Regulations (2010)', which transposes the 'Habitats Directive (1992)', any planned works likely to have a significant effect on the status of a SPA or Ramsar site will first need to undergo an appropriate assessment, known as a Habitat Regulations Assessment. Normally a plan or project may not proceed where an adverse effect has been identified. Exceptions can however be granted via a derogation process where: (i) there is no alternative solution that meets the objective; (ii) the works are considered to be of an imperative overriding public interest to justify the environmental damage it will cause; and (iii) sufficient compensatory measures, such as the creation of the alternative habitats, are provided.

The precautionary principle applies here. This means that if there is an absence of sufficient knowledge to confirm that planned works will not have adverse impacts, then the works should be subjected to the above principles.

Section 118 of the National Planning Policy Framework (NPPF) would also apply to works likely to have an adverse effect on a SSSI. It states that if a development is likely to have an adverse effect on a SSSI, it should not normally be permitted and works should only go ahead if the benefits should clearly outweigh the costs posed to the environment. SSSIs are also protected under the Countryside and Wildlife Act (2000) through a duty on public bodies to conserve and enhance them.

MCZs have the same level of protection as SSSIs under the Marine and Coastal Access Act 2009. Any works below Mean High Water would also require a Marine Licence. The Marine Management Organisation (MMO) would assess the impact on the marine environment and any MCZ when providing the Marine Licence.

Any potential changes to Pagham Harbour would need to be assessed in relation to the status of the water body under the Water Framework Directive and a Water Framework Directive Compliance Assessment would need to be completed.

Annex E: Changes to the Pagham coastline

Several expert assessments of the geomorphological process on the Pagham coast have been undertaken by or on behalf of Arun DC, the Environment Agency and Natural England, as well as independent assessments.

Migration of the Church Norton spit and resulting erosion

The coastline at Pagham Beach has been subject to coastal erosion from wave actions since the Pagham spit was formed in the early 1900s. Four groynes were constructed in the 1960s to protect against this erosion and were further strengthened in the 1980s. The situation at Pagham Beach has recently been made worse by the growth of the Church Norton spit in an easterly direction towards Pagham Beach.

As suggested by several geomorphological assessments, the reason for the growth of the spit is the arrival of a natural supply of shingle coming onshore around 2001 from nearshore shingle banks, known as the Inner Owers, and subsequently moving eastward along the coastline. The recent growth of this spit is unprecedented in recent history and has been difficult to predict. Recorded growth levels show the spit grew at levels of around 80-100m/year. Geomorphological assessments are unable to accurately predict how the natural supply of shingle will change in the future. At present, the rate of growth of the Church Norton spit is highly variable and likely to remain so.

Before the increase in the natural supply of shingle moving along the coast, the Environment Agency used to strengthen the hinge of the Church Norton spit by recycling shingle, as a means to protect Pagham Harbour from flooding. When the hinge of the spit was sufficiently maintained naturally, due to the increased natural supply of shingle, the routine work stopped in 2003.

The Church Norton spit has historically developed on a cyclical basis where it was naturally breached and overtopped by wave action. However, the most recent geomorphological assessment by the Environment Agency (2014) suggests that the current height and position of the spit has reduced the likelihood of a natural breach occurring, when compared to previous years.

This rapid growth of the spit has resulted in coastal erosion at Pagham Beach, as suggested by a number of the geomorphological assessments. As the end of the spit has grown eastwards, the speed of the water flowing through the channel has increased and been deflected towards Pagham Beach, causing localised scour at Pagham Beach. As the spit has grown in length, and the end of the spit has moved more landward, the point of the localised erosion has migrated eastwards along the coastline. Additionally, the growth of the spit has disrupted the natural replenishment of Pagham Beach from shingle moving along the coast. Both these factors have resulted in a decrease in the width of Pagham Beach through erosion. It is important to note here that no properties at Pagham Beach have been flooded or lost due to erosion.

Response to the erosion of Pagham Beach

Arun DC undertook a re-nourishment of Pagham Beach in 2009, by placing shingle from other sources on the beach to strengthen it. This increased the level of protection for properties situated along Pagham Beach east of the Yacht Club, but not to the properties currently affected by the localised scour. An Environmental Statement (2009) was produced by Royal Haskoning DHV on behalf of Arun DC. This looked at the appropriate alternatives and concluded that the beach re-nourishment would not have a significant effect on the status of the natural environment.

During the winter 2012/13 the trigger levels were reached for properties located furthest west and, under the adaptive management approach, Arun DC responded with the planned construction of a rock revetment and stabilisation of the most westerly groyne. Rock was used because it is mobile and could be used again on different parts of Pagham Beach if required. This work was completed in December 2013 and reduced the risk to 15 properties. However, it was significantly delayed from September 2013, owing to procurement issues, and during this time significant erosion of this section of Pagham Beach occurred. These works cost approximately £550k and were predominately funded through Flood and Coastal Erosion Risk Management Grant in Aid, with other funds from Arun DC and other private contributions, including Pagham Parish Council.

The revetment met the objective of protecting the 15 properties from erosion over the severe winter 2013/14 storms, despite sustaining some damage which Arun DC repaired.

A further Environmental Report (2013) was completed by Royal Haskoning DHV on behalf of Arun DC to assess the impact of the rock revetment. It concluded that the revetment and extension of the most westerly groyne would not have adverse environmental impacts and a Habitat Regulations Assessment in line with 'The Conservation of Habitats and Species Regulations (2010)' would not be required.

Since then the Church Norton spit has grown further eastwards resulting in the focus of the localised scour erosion shifting further eastwards and causing a further 4 properties, not protected by the revetment built in 2013, to be within the required trigger levels. Under the adaptive management approach, Arun DC responded by recycling shingle onto the beach and planning the construction of a further rock revetment, which is now complete. This would reduce the risk to 10 properties in total to account for future changes to the coast and the likely increased risk to other properties along the frontage.

The construction of the revetment and shingle recycling was planned for August 2014; however the supply of the rock, to be imported from Norway, was delayed. The 2014 rock revetment shingle recycling was constructed and finalised at the end of November 2014 using rock imported from France instead. This delay was significant as during this time period high tides and storms led to significant erosion at Pagham Beach reducing the beach width to within 5 metres in front of the 4 properties. Arun DC carried out a number of urgent works, supported by the Environment Agency and Natural England, to protect the coast until the revetment was completed. This revetment was urgently completed for around £100k, protecting 10 properties, but does not provide the same level of protection as the revetment built in 2013.

The rapid migration of the spit and the resulting erosion meant the warning levels were reached sooner than geomorphological assessments projected. The aim of the adaptive management policy was to monitor and respond appropriately when the warning levels were reached, but delays impacted the timing of the response.

Future changes to the Pagham coastline

The recent geomorphological assessments of the Pagham coastline have concluded that the growth of the spit is still uncertain. At present, the natural supply of shingle from the Inner Owers is still moving along the coast, causing the growth of the spit to continue. This uncertainty has significant implications on the future management approach for Pagham.

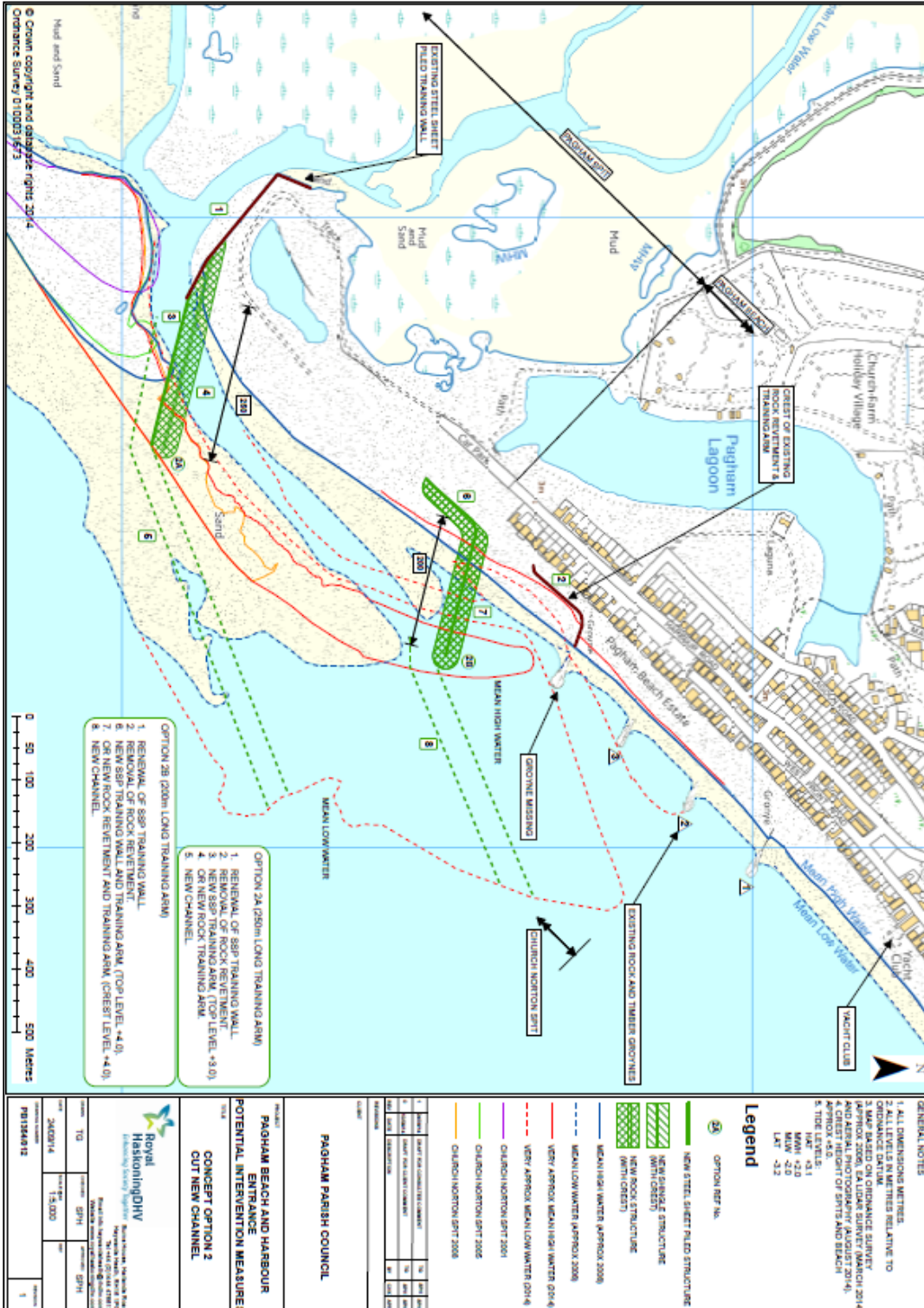
The most recent assessment by the Environment Agency (2014), provided to Arun DC as technical advice, has suggested that if current conditions remain constant then the spit will continue to grow and cause erosion of the beach in front of properties located further along the coast. This means that it is likely that further properties could become within the warning levels. Further defence works could be required to manage this erosion to protect the properties.

In the longer term, it is stated in a number of geomorphological assessments that if the movement of sediment from the Inner Owers is reduced, then it is likely that the spit would be naturally breached, leading to a decrease in the localised erosion. Pagham Beach would then be built up from the deposition of sediment offering protection from coastal erosion from wave action. In this case the level of protection required by Pagham Beach to withstand erosion would not need to be as high as at present. However, it can be noted with high certainty that the location of the properties on an evolving spit system means that a level of risk from coastal change will always remain. This risk will then increase with sea-level rises in the future.

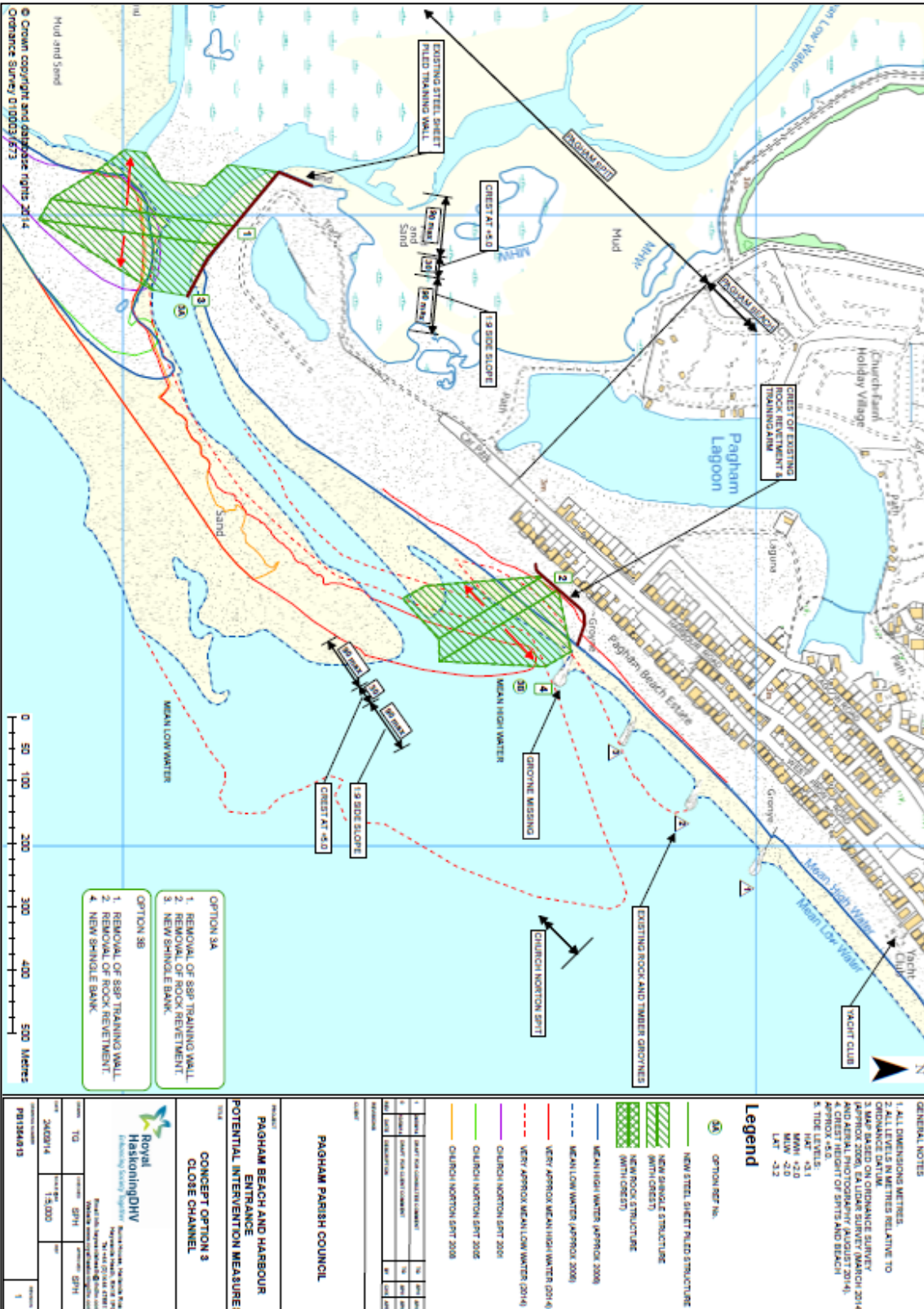
Annex F: Location of Pagham and relevant features



Annex G: Intervention on the spit or closing the channel options



Source: Royal Haskoning DHV (2014)



Source: Royal Haskoning DHV (2014)