REPORT

Cocker Tidal Channel and Cockerham Marsh SSSI Restoration Investigation

Task 2a - Optioneering

Client:	Lancashire Wildlife Trust, Natural England & Environment Agency
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Preamble

The present study forms part of an initiative called 'Our Future Coast', which is instigated by the Department for Environment Food and Rural Affairs (Defra), Wyre Council and the Environment Agency.

'Our Future Coast' is focused on working with nature to safeguard coastal communities through seventeen projects across the North West of England, from Formby in the south to Millom Marshes in the north.

The 'Cocker Tidal Channel & Cockerham Marsh SSSI Restoration Investigation' is one of these projects, being led by Natural England in partnership with Lancashire Wildlife Trust and the Environment Agency.

The 'Our Future Coast' programme aims to develop a suite of natural buffer strips to increase coastal resilience of vulnerable hot spots in the North West. Natural coastal buffer strips can provide multiple benefits, including reducing flood risk, reducing coastal erosion, increasing biodiversity and water quality, providing carbon capture and other ecosystem services such as recreation and well-being.

Buffer strips with their rich vegetation, act as natural means of capturing sediment and dissipating wave energy. Buffer strips include developing salt marsh, managed realignment, reclaiming redundant brownfield sites, dune systems, and intertidal lagoons to provide storage of surface water during high tide.

Further information about the programme can be found here:

Our Future Coast | The Flood Hub

1 Introduction

The downstream reach of the River Cocker in Lancashire flows in a north-westerly direction, discharging into southeast Morecambe Bay across the intertidal expanse of Cockerham Sands (Figure 1). The 1.5 km reach between a sluice gate at Cocker Bridge and Morecambe Bay is tidal, flowing within an artificially straightened channel, which was cut in the 1960s.

The cut Cocker channel joins into a naturally meandering channel (Patty's Farm Creek) at a confluence just seaward of Bank End Farm. Beyond this confluence, the Outer Cocker Channel flows in a meandering manner across intertidal areas of Cockerham Sands.

Prior to the new cut in the 1960s (shown red in Figure 2), the natural outflow of the River Cocker was a meandering channel across Cockerham Marsh (shown orange in Figure 2). There is some argument that the new cut has placed increased energy at the confluence (shown as a yellow box in Figure 2) between the cut River Cocker channel and Patty's Farm Creek (shown blue in Figure 2), increasing the tendency for this combined outer channel to incise close to the flood embankment near this point.

Morecambe Bay is a highly dynamic environment, and the alignment of channels can change significantly within a short timescale in response to the governing tidal and sedimentary processes, freshwater discharge from rainfall across the catchment, and the effects of winds, waves and surges during storms.

Following a period of notable channel movement towards the north at the confluence of the cut Cocker Channel and Patty's Farm Creek in 2012, residents alerted the Environment Agency to the loss saltmarsh fronting the flood embankment and raised concerns at that time about potential flood risk to Bank End Farm and Caravan Park and the nearby Bank Houses Caravan Park.

This prompted a Geomorphological Appraisal by the Environment Agency (Swift, 2013) which incorporated Historic Trends Analysis (HTA) of historic maps and datasets as well as Expert Geomorphological Assessment (EGA) informed by observations from a site visit. Recognising the uncertainties associated with the future extent of saltmarsh erosion due to the dynamic nature of the physical environment, the study recommended enhanced monitoring be undertaken, in combination with further assessment of the suitability of options to address the flood risk (whilst allowing the system to respond as naturally as possible to wider environmental forcing) by means of: (i) enhancing protection of the existing channel bank using bio-engineered brushwood mattresses (or similar); (ii) in-channel flow deflectors; and (iii) strengthening of the main flood embankment near Bank End Farm. The study also suggested that options to re-naturalise the tidal channel of the River Cocker could be considered if that too would alleviate erosion and associated flood risk pressure at Bank End Farm.

The present Cocker Tidal Channel and Cockerham Marsh SSSI Restoration Investigation more widely investigates potential for restoration of natural processes, morphology and habitat in this area and how this might provide other benefits to the estuary and the wider catchment, particularly land drainage and flood risk. The study comprises four main tasks, namely:

- Task 1 – Desk-Based Review and Site Visit
- Task 2 – Optioneering, Modelling and Design
- Task 3 – Catchment Nature Based Solutions
- Task 4 – Cockerham Marsh Site of Special Scientific Interest (SSSI)

This report relates to **Task 2a - Optioneering**.

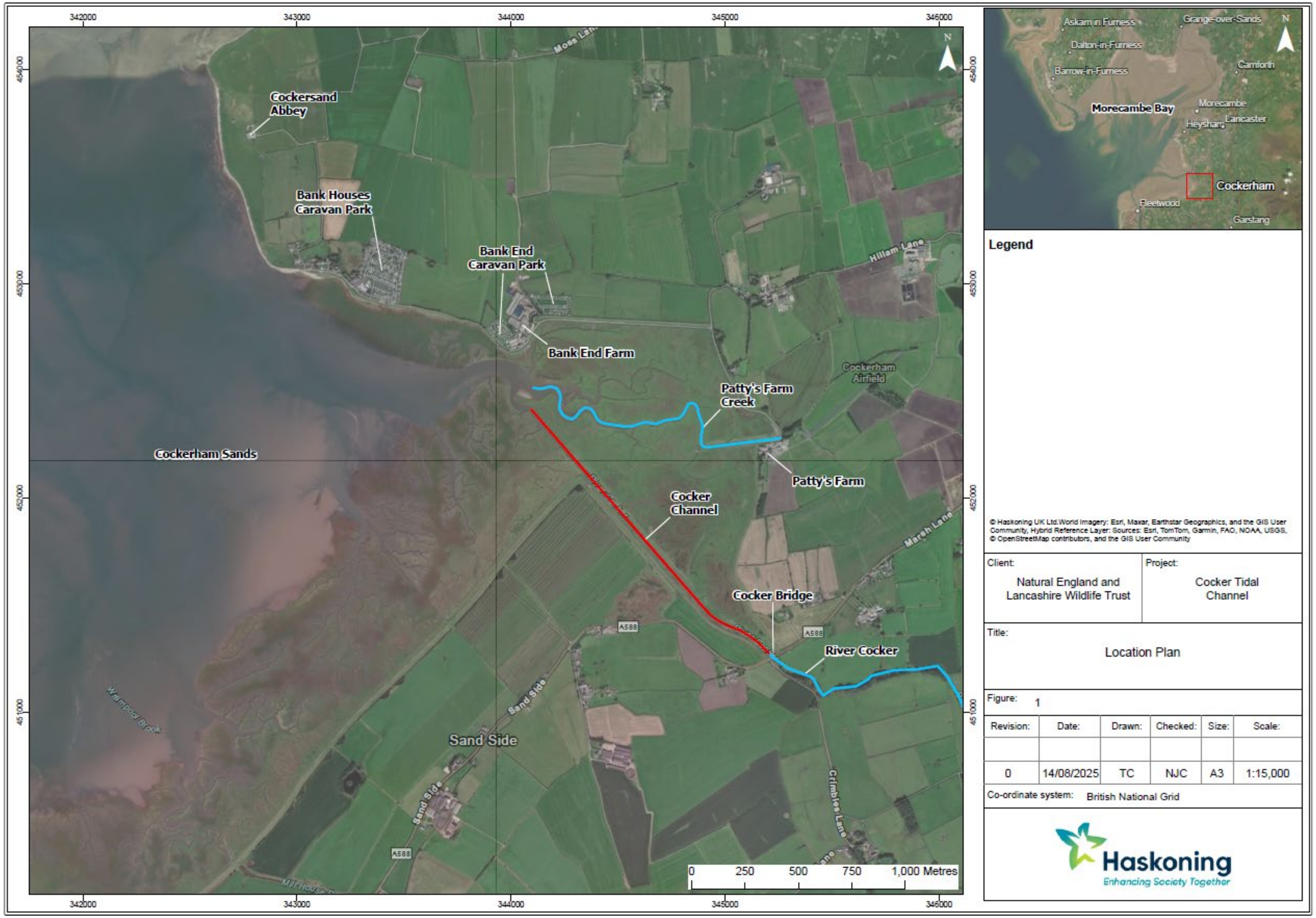

Figure 1 Location plan

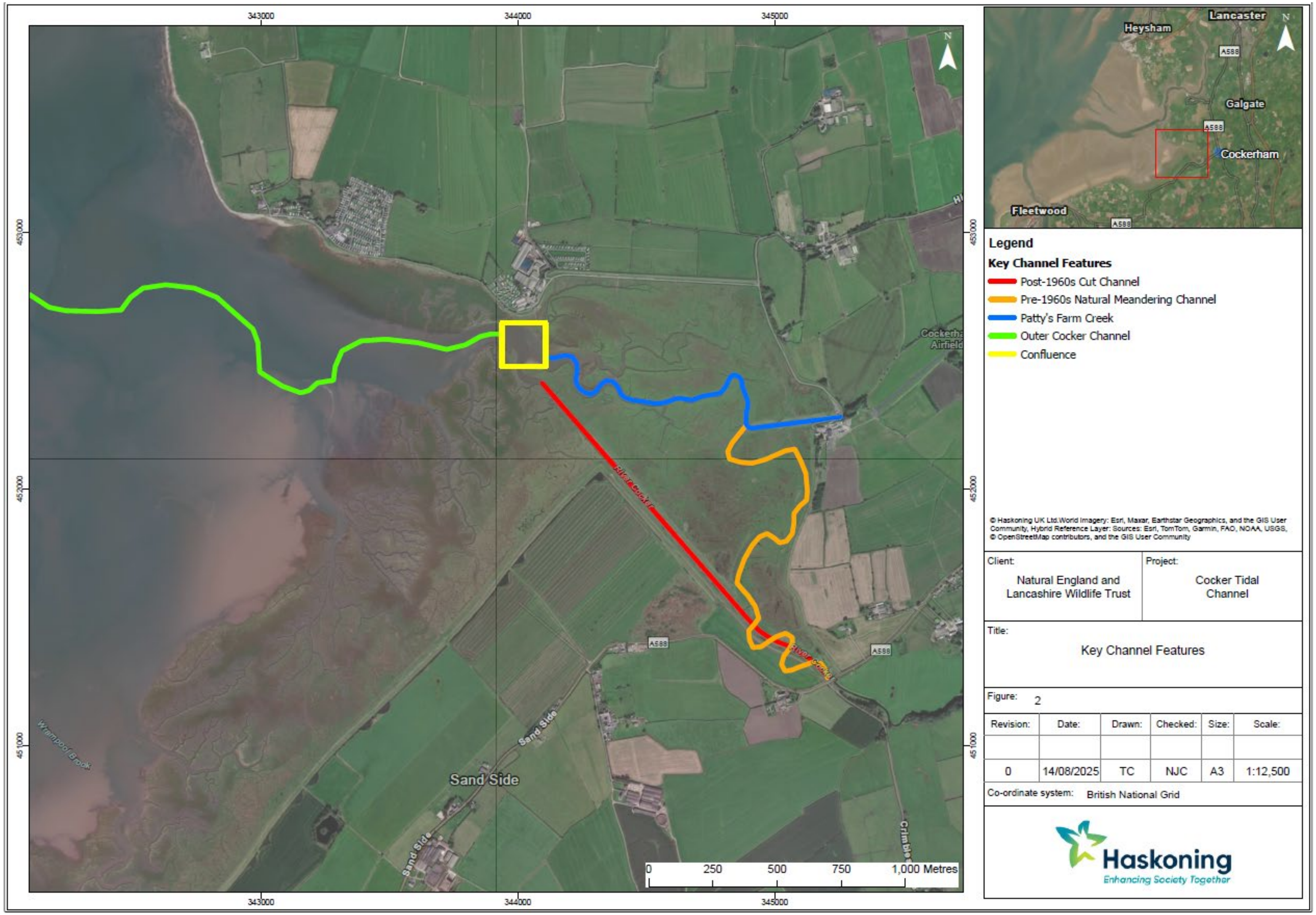

Figure 2 Key channel features (after Swift, 2013)

2 Task 2a – Optioneering

2.1 Background

In 2012, local residents alerted the Environment Agency that erosion of the saltmarsh adjacent to Bank End Farm had occurred due to deeper incision by the tidal channel. At this location, the outer edge of the saltmarsh was eroding northwards and at that time was within approximately 40 m of the Environment Agency's (then maintained) flood embankment and adjacent properties and a caravan site.

The Environment Agency undertook a Geomorphological Appraisal of the site at this time and outlined a long list of options associated with the management of this erosion risk (Swift, 2013). The study recommended a preferred approach of managing erosion risks to the property and the flood embankment at Bank End Farm, whilst allowing the system to adjust as naturally as possible to wider environmental forcing. It recognised that the estuary would remain in a state of dynamic flux as it responds to the 'new' cut, land reclamation, sea level rise and the inherent variability in estuarine processes. To this end, enhanced monitoring of the erosion rates of the saltmarsh was recommended, with results informing an ongoing assessment of three shortlisted options, namely:

- (i) enhancing protection of the existing channel bank using bio-engineered brushwood mattresses (or similar);
- (ii) in-channel flow deflectors; and
- (iii) strengthening of the main flood embankment near Bank End Farm.

Since the previous Geomorphological Appraisal concluded, there is over a decade of additional monitoring data now in existence from the North West Regional Coastal Monitoring Programme, as well as more up-to-date science and guidance on the effects of climate change (including sea level rise, wave heights, surges and rainfall). In addition, it is understood that since 2012 the rate of change in the channel alignment seaward of Bank End Farm has reduced and the concerns raised previously have subsided.

Over this period, there has also been increasing awareness of the value of Natural Flood Management (NFM) approaches (such as re-naturalising physical environments) and Nature Based Solutions (NBS), including in upstream catchments. Furthermore, there is a willingness to further attempt to alter the 'unfavourable declining' condition status of the Cockerham Marsh Site of Special Scientific Interest (SSSI) in relation to its interest feature the Natterjack Toad (*Epidalea calamita*).

The above aspects combined mean that the present study not only brings the 2013 study up to date by collating and analysing additional data, science and guidance to enable a review of the optioneering that was carried out and consider whether the 2013 recommendations are still appropriate, but also has a far greater remit by considering a broader geographical area and investigating a wider range of management interventions.

Most notably, the present study also considers the feasibility of opportunities to reconnect an area of former saltmarsh to the south of the project area (at Cockerham Marsh SSSI), which was reclaimed in 1981 and which did not form part of the previous study's scope. The principal means by which such restoration could be achieved are through lowering or breaching the flood embankment or constructing some form of engineered system into the bank to regulate the tidal exchange.

2.2 Aim and Objectives

The aim of the present study is to investigate potential options for restoration of natural processes, morphology and habitat in the area of the tidal Cocker Channel and Cockerham Marsh SSSI. Specific objectives in pursuing this aim are:

- To assess whether there would be any detrimental impacts or unwanted changes to present-day land drainage and flood risk.
- To evaluate how other benefits to the estuary might be delivered, particularly relating to geomorphology, ecology, land drainage and flood risk (the latter at Bank End Farm).
- To evaluate how other benefits to the wider catchment might be delivered, particularly relating to geomorphology, ecology, land drainage and flood risk.
- To consider options for improving the present ‘unfavourable declining’ condition of Cockerham Marsh SSSI.

3 Long-list of Potential Restoration Options

3.1 Managing Flood Risk at Bank End Farm

The Geomorphological Appraisal by the Environment Agency (Swift, 2013) focused on issues of flood risk at Bank End Farm, considered by its author to be caused by migration northwards of the confluence of the tidal Cocker Channel and Patty’s Farm Creek. The long list of management options to address this risk are reproduced in Table 1 from Swift (2013). Without accompanying sketch drawings, it is in some cases difficult to determine the precise intent of the options through wording alone, although a good general idea is obtainable.

In essence, three principal options and two other options were considered, alongside a base case of ‘Do Nothing’ (Option 1) and a ‘Do Minimum’ case of enhanced monitoring (Option 5). The three principal options were:

- Option 2 – Channel bank / saltmarsh edge protection – this could take the form of ‘soft engineering’ (e.g. brushwood fascines) or ‘hard engineering (e.g. riprap or revetment)
- Option 3 – Deflect the channel – this could be undertaken by structures (e.g. flow deflectors) or other intervention (e.g. dredging)
- Option 4 – Reinforce the existing flood bank.

In addition, the two other options considered include changes to existing land management practices (e.g. the ongoing saltmarsh grazing) (Option 6) and restoration of the natural channel alignment (Option 7).

Despite the concerns raised in 2012, and the Environment Agency’s Geomorphological Appraisal (Swift, 2013) being produced in response, no management intervention is known to have taken place since. Whilst the landowner now considers that erosion of the saltmarsh fronting Bank End Farm has ceased, analysis of available data from beach transect surveys (to September 2024) and aerial photography (from 2017 and 2023) does not support this, although the annual average erosion rate currently is lower than in 2012 when the initial concern was raised. Due to this slow-down in trend, it appears that no major intervention is required at the present time.

Table 1 Long-list of management options for managing flood risk at Bank End Farm, as considered in the Geomorphological Appraisal 2013 (reproduced from Swift, 2013)

Option	Title	Description	Benefits	Constraints	Suitability
1	Do nothing.	No active intervention by any party. This would mean allowing the channel to move 'naturally' in response to conditions.	Requires no input of time or resources. Allows the channel to respond to conditions and for the overall estuary to maintain its dynamic equilibrium.	There is considerable uncertainty about future channel movement which might lead to increased local flood and coastal erosion risks, including the undercutting of existing flood embankment.	**Very low**
2a	Bioengineering works along existing outer bank position using brushwood fascines or similar.	Install bank protection along eroding bank to slow erosion rates and encourage sedimentation along outer bank. Likely to include re-profiling bank.	Relatively low cost and could possibly be installed by EA Ops. May encourage sediment deposition. Adaptable – could be trialled / extended as appropriate.	The defences may be outflanked, requiring extending /. maintenance. Length of protection required will be significant. May lead to unpredictable geomorphic response including the transfer of energy upstream and/or downstream, or to opposite bank. Further consideration needed to understand whether consents would be granted for this approach.	**Moderate to High** – may not eliminate all erosion risk but could significantly reduce erosion rates. Further investigation suggested.
2b	Hard engineering protection works to maintain existing bank position.	Install bank protection works to halt erosion using riprap / revetment. Likely to include reprofiling the bank.	Erosion protection at this location.	Very unlikely to comply with Habitats Regulations Assessment. Erosion may outflank defences, leading to redundant/ineffective hard structures in channel. Hard defences may result in reflection effects, leading to changes in wave and flow regime. Will require capital element and ongoing maintenance / monitoring.	**Very low** – not suitable within dynamic, environmentally sensitive intertidal environment.

Option	Title	Description	Benefits	Constraints	Suitability
3a	Intervention to encourage main flows towards inner bank.	Install flow deflectors / similar to encourage main channel to move towards inner bank and reduce energy along eroding bank.	No earthworks required. Retains semi-natural processes.	The deflectors could have unpredictable effects during extreme events. May move erosion problem elsewhere – this could reduce risks at Bank End but lead to saltmarsh loss further west.	**Moderate to High** – consent may be hard to achieve. May not eliminate all erosion risk. Further investigation suggested.
3b	In channel works to divert channel to inner bank.	Physical intervention to remove confluence bar to allow channel to re-form along the inner bank.	If successful would allow eroding bank to stabilise and reduce erosion risk to property. May improve conveyance from new cut channel.	Channel could switch back to current position. Results in loss of intertidal feature. In channel works could damage intertidal habitats. Could move erosion elsewhere – this could reduce risks at Bank End but lead to saltmarsh loss further west.	**Moderate** – consent may be hard to achieve. May not eliminate all erosion risk. Further investigation suggested.
4	Reinforce existing flood embankment.	Reinforcement of embankment to withstand impact of channel erosion, should this continue to the embankment position. Options could include scour protection and / or capping existing splash wall with more resistant material.	Removes the need tor in-channel works and environmental impact. Allows natural processes to continue. May provide residents / EA with reassurance that flood embankment is fit for purpose should erosion continue.	Works may be redundant if erosion slows / channel switches to southern course. Does not address potential for increased depth / wave height and therefore flood risk as a result of channel orientation towards embankment. Loss of mature saltmarsh may reduce grazing area for local farmers (this would be gained on opposite bank). Works would require significant capital element.	**Moderate to High** – allows natural processes to continue whilst preparing for future erosion. Further monitoring required to inform timing of works.

Project related

Option	Title	Description	Benefits	Constraints	Suitability
5	Enhance monitoring and definition of intervention thresholds.	Work with Regional Monitoring programme and Lancaster City Council to develop enhanced monitoring, setting trigger levels for future action.	Provides further evidence to inform management approach. Low cost, easy to set-up. Could inform similar management issues elsewhere.	Lack of immediate physical intervention could be perceived as 'doing nothing' by community. The complex processes at this site mean that residual uncertainty will remain. Assumes resources will be available for monitoring.	**Very high**
6	Land management measures.	Work with owners of adjacent saltmarshes to understand grazing regime and its impact on channel bank erosion. Recommend changes to land management where necessary.	Encourages dialogue and input from landowners. May result in simple steps to reduce effects of grazing, if shown to affect erosion rates.	Landowners may be reluctant if measures reduce grazing area and force reduction in sheep/cattle numbers. Positive impacts likely to be small compared to other measures – best delivered with a suite of other measures?	**Moderate to High** (if applied in combination with other measures). Needs further consideration.
7	Review maintenance approach and consider restoring historic channel course.	As above – but in addition to understand the role of straightened channel in channel dynamics at Bank End, and whether restoring a more natural course could reduce erosion pressures at Bank End.	Will increase understanding of the wider system; could help to tackle problem at root cause. Potential habitat, biodiversity, fisheries benefits with restoring a more natural course. Data/information could be used to inform benefits of restoring the old natural meandering tidal creek.	Management of erosion at Bank End may be at cost of conveyance, leading to land drainage issues. Introduces much wider issue of land drainage upstream of sluice gates; scope of this work would be large and time consuming.	**Medium** – needs further consideration.

In the event that erosion of the fronting saltmarsh once again becomes an issue of concern, the present study considers that the management options that may be considered are:

- **Option 1 - Do nothing** (Option 1 from Swift, 2013).
- **Option 2 - Protect the saltmarsh edge**:
    - Option 2a - 'Soft engineering' such as polders or coir matting (similar to Option 2a from Swift, 2013);
    - Option 2b - 'Hard engineering' such as riprap or revetment (Option 2b from Swift, 2013);
    - Option 2c - Foreshore recharge (beneficial use of sediment dredged from Heysham Port).
- **Option 3 - Realign the channel near Bank End Farm**:
    - Option 3a - Training of the confluence and Outer Cocker Channel (similar to Option 3a from Swift, 2013);
    - Option 3b - Dredging of the confluence and Outer Cocker Channel (Option 3b from Swift, 2013);
    - Option 3c - Re-naturalise the Inner Cocker Channel (renumbered Option 7 from Swift, 2013 and assessed further in section 2.3.2).
- **Option 4 - Reinforce the existing embankment** (Option 4 from Swift, 2013):
    - Option 4a - Sheet pile toe (to prevent undercutting).
    - Option 4b - Riprap or rock revetment (to reduce face exposure).

In essence, the work of the North West Coastal Monitoring Programme is providing data that can be used for monitoring ongoing trends and therefore contributes to the original 'Do Minimum' approach of enhanced monitoring (Option 5 from Swift, 2013).

Existing land management (e.g. saltmarsh grazing) is not deemed to significantly be contributing to erosion pressures experienced at Bank End Farm, which are governed by wider-scale geomorphological processes. Therefore Option 6 from Swift (2013) is not deemed to be effective in its own right.

There are some minor refinements in detail in the above long-list compared to the original Geomorphological Appraisal (Swift, 2013) but the general options previously considered remain valid, with only one additional option now being considered (as a new Option 2c), that of foreshore recharge at the eroding saltmarsh margin, beneficially using sediment dredged from nearby ports (such as Heysham Port). This has been considered in Table 2.

Table 2 Additional long-listed management option for managing flood risk at Bank End Farm

Option	Title	Description	Benefits	Constraints	Suitability
2c	Foreshore recharge.	Beneficial use of sediment dredged from nearby port(s) (e.g. Heysham) to recharge the foreshore at the eroding saltmarsh margin.	Re-use of otherwise 'waste' material that would be disposed at sea. Could slow down erosion rates (even if placement was sacrificial).	Sediments would need to be tested for geotechnical and chemical suitability. Placement would be subject to marine licence and sampling plans. Sediment may move elsewhere and block channels / land drains.	**Low to moderate -** Does not alter the prevailing geomorphological process.

3.2 Re-naturalising the Tidal Cocker Channel

The aim of the study is to investigate potential options for the restoration of natural processes, morphology and habitat in the area of the tidal Cocker Channel and Cockerham Marsh SSSI. The principal means of achieving this aim would be through:

1. Restoration of a natural alignment to the tidal Cocker Channel (this section); and
2. Restoration of occasional tidal inundation to the Cockerham Marsh SSSI (discussed further in section 3.3).

Both of these approaches are likely to deliver enhancements relating to geomorphology and biodiversity, as well as potentially land drainage and flood risk (the latter at Bank End Farm). However, under either means of delivery it is also important that no detrimental impacts or unwanted changes arise to present-day land drainage and flood risk elsewhere.

The natural Cocker Channel historically adopted a meandering alignment across the saltmarsh at Cockerham Sands. This was artificially straightened by a ‘new’ cut in the 1960s. The natural saltmarsh to the west of the cut became enclosed by reclamation when the Pilling to Cockerham flood embankment was constructed in 1981. This is further discussed in section 3.3 in relation to Cockerham Marsh SSSI, but this embankment now also constrains the ability to re-naturalise the tidal Cocker Channel to the eastern side of the channel only, thereby omitting a small meandering section which formerly (pre-reclamation and pre-cut) ran to the west. Notwithstanding this, the opportunity remains substantial.

When considering options for re-naturalisation, consideration needs to be given to the extent (local reaches versus full length) and type of works required (e.g. ‘encouragement’ of natural processes versus extensive earthworks). The restoration options considered within a long-list are therefore:

- **Option 1 – Do Nothing**.
- **Option 2 – Local interventions** – cut a short channel to connect with **Patty’s Farm Creek**.
- **Option 3 – Local interventions** – cut short channel(s) to connect with **‘new’ Cocker Channel**.
- **Option 4 – Full reinstatement** of natural tidal Cocker Channel.
- **Option 5 – Full reinstatement** of natural tidal Cocker Channel **and infill** of ‘new’ Cocker Channel.

Table 3 Long-list of restoration management options for re-naturalising the tidal Cocker Channel

Option	Title	Description	Benefits	Constraints	Suitability
1	Do Nothing.	No active intervention by any party. Cocker Channel continues to follow artificially straightened cut.	No disruption to farming activities. No change to flood risk upstream of Cocker Bridge Penstock.	Continued erosion of the saltmarsh fronting Bank End Farm embankment (probable) No ecological benefit realised.	**High**
2	Local Interventions - within saltmarsh near Patty's Farm Creek.	Cut a short (~50m) channel from Patty's Farm creek into previous Cocker channel alignment to bring more tidal water to this part of the saltmarsh.	No disruption to farming activities (if new bridge provided) No change to flood risk upstream of Cocker Bridge Penstock. Theoretical local and minor improvement to saltmarsh condition due to more regular inundation of some areas.	Alignment of new cut would be artificial (i.e. not following a natural previous alignment). Intervention does not meet current project scope of restoration of natural Cocker Channel.	**Low**
3	Local Interventions - High level reconnection(s) with 'new' Cocker Channel.	Reconnect the relict Cocker Channel alignment to the straightened channel by local excavation through the higher marsh/land adjacent to the channel. Connection to follow existing level of former channel bed (circa MHWS level).	Minimal material liberated such that it could repurposed locally. No additional works required to accommodate farmer. Some ecological benefits Minor reduction to velocities at Bank End Farm (to be confirmed with modelling) No change to flood risk upstream of Cocker Bridge Penstock (to be confirmed with modelling)	Not full naturalisation. Straight channel would still exist and be dominant course for the river discharge and tidal flows in the Cocker Channel.	**High**
4	Full Restoration of natural Cocker Channel.	Restore the former Cocker Channel through excavation.	Reduce velocities at Bank End Farm embankment (to be confirmed with modelling). Assumed negligible effect on flood risk as straightened Cocker channel to remain (to be confirmed with modelling)	Generates significant volume of material, that without a purpose identified would need to be exported offsite. Material likely to have poor geotechnical properties. Possible on-site uses; • Filling a section of the Delph Drain within Cockerham Marsh SSSI (depending on management options there). • Local construction of bird roosting islands within existing saltmarsh. Farmer will require facilitation works including stock fencing around new channel and bridge(s) over. Channel aligns tidal flow closer to flood embankment near Patty's Farm (to be investigated with modelling).	**High**

Option	Title	Description	Benefits	Constraints	Suitability
5	Full Restoration of natural Cocker Channel with infill of ‘new’ cut.	As *Option 4*, but using the liberated material to infill the existing straight ditch.	Provides use for liberated material resulting in significant cost saving for ‘muck away’. Full naturalisation would bring the greatest ecological benefits and would help develop / maintain saltmarsh in the estuary.	Possible negative impact on flood risk upstream through reduced channel velocities near Cocker Bridge Penstock and thus increased sedimentation (to be confirmed with modelling). Farmer will require facilitation works including stock fencing around new channel and bridge(s) over. Channel aligns tidal flow closer to flood embankment near Patty’s Farm (to be investigated with modelling).	**High**

3.3 Improving the Condition of Cockerham Marsh SSSI

One of the main areas of interest in the restoration of natural processes, morphology and habitat is at Cockerham Marsh SSSI. Since enclosure of the former upper saltmarsh area in 1981, previous attempts at improving the condition status of the sole interest feature of the SSSI (Natterjack toad) have focused on: (i) increasing the number of ponds; (ii) management of the terrestrial habitat; and (iii) spawn translocation, all as recommended by the relevant Natterjack toad guidance (Beebee & Denton, 1996; Baker *et al*, 2011). However, no previous efforts at reinstating (occasional) tidal flushing have been made at the site and this may be deemed the single ‘missing ingredient’ to date from an otherwise potentially successful management approach.

If no further management intervention is applied, the **Do Nothing** (Option 1) outcome is that the SSSI will not recover from its ‘unfavourable declining’ status. Optioneering therefore considers how best to allow occasion tidal inundation of the land at the SSSI in order to: (i) enable it to become an upper saltmarsh habitat; and (ii) cause occasional saline flushing of the ponds. Further advice on terrestrial and pond management aspects of the SSSI will be considered during Task 4 and is not discussed further in this Task 2a report.

The extent and frequency of tidal inundation at a site will depend on two factors, namely: (i) land levels; and (ii) water levels (present day and future sea level rise). Optimal Natterjack toad ponds will be at a land level that becomes inundated with tidal water during only the highest tides in spring and autumn (equinoxal tides) each year, but then ‘freshens-up’ due to runoff or rainwater in late spring/summer. This seasonal (only) seawater inundation removes predators and competitors such as Common frog and Common toad. The ideal pond is <15% seawater or 0.5% salinity. Ponds, which may be asymmetric or symmetrical (saucer-like) in shape, should have a water depth circa 50-70 cm, but with shallower areas (typically 5-10 cm water depth) at its edges for spawning. Side slopes would typically be 1:10 or gentler gradient.

In order to bring tidal water onto the site, options include **removing** (Option 2a) or **breaching** (Option 2b) the flood embankment or **lowering** its crest (Option 2c). Draining water from the site would then have some technical challenges, as the delph ditch at the (inland) toe of the flood embankment appears to drain a considerable distance to the south to discharge at Mill House sluice. An alternative approach would be to introduce some form of **pipework and penstock** (Option 3a) or **channel and sluice** (Option 3b) through the embankment to regulate the tidal exchange on both the flood and ebb phases.

‘Out of the box’ concepts could involve saline treatment to existing ponds (assuming they can be cleared of scrub and grass, be dug out to a suitable profile, and become infilled again with freshwater). Although these ideas have never before been encountered, and therefore they remain unproven, they are added to the long-list for consideration. Saline water could be brought to the ponds by **pumping of seawater** (Option 4a) or **enrichment of freshwater** with sodium chloride (NaCl) (Option 4b).

One further point to consider is that the ponds and terrestrial habitat that supported Natterjack toads historically were surrounded by a wide area of interconnected upper saltmarsh, prior to its reclamation in 1981 with the construction of the Pilling-Cockerham flood embankment. This may mean that even if tidal waters can successfully be brought onto the site to provide occasional tidal flushing during the spring and autumn equinoxes the site is now too isolated to become a sustainable habitat again for this key species. For this reason, further options have been considered of declassifying the SSSI and making better alternative use of the land at the SSSI for **agriculture** (Option 5a) or **biodiversity** (Option 5b). Additionally, an option of **creating pools** for Natterjack toad breeding upon the existing upper saltmarsh outside of the Cockerham Marsh SSSI has been considered (Option 6).

Table 4 Long-list of restoration management options for improving the condition of Cockerham Marsh SSSI

Option	Title	Description	Benefits	Constraints	Suitability
1	Do Nothing.	No active intervention by any party. This would mean allowing the SSSI to continue to decline / become overgrown.	No time, resource or costs required.	Likely lead to declassification of SSSI. Land would convert to agricultural use and lead to loss of biodiversity value Conflicts with government targets for SSSI actions on track to achieving favourable condition in the Environmental Improvement Plan (EIP)	**Very Low**
2a	Modify Flood Embankment – Full Embankment Removal.	Reintroduce tidal influence back onto the site through the removal of the full embankment fronting the SSSI. Construction of setback embankment around SSSI to control flood risk to adjacent land holdings and road. Minor earthworks within SSSI to ensure connectivity for water.	Inundation of the site would be passive (i.e. require no intervention). This would return it to the state when the SSSI was first designated (and Natterjack toads were present / thriving). The removal of the full embankment would maximise the amount of liberated material that could be used to construct the setback embankment.	Uncontrolled tidal influence may lead to unfavourable conditions for Natterjack toads through over inundation. Likely deficit of material for setback embankment, meaning material would have to be imported or won elsewhere. Setback embankment would need to be designed and constructed for extreme water levels and climate change which would be higher than the existing embankment and have a large footprint. Field to the south of the SSSI, that currently drains into the delph ditch, would be cut off by the setback embankment and thus would require drainage intervention. Affectively 'managed realignment' which has presented local opposition in the past. Set back embankment would cut off delph ditch and Northern pond that are within SSSI extents (although Natterjack toads have never been recorded there).	**High**
2b	Modify Flood Embankment – Breach Embankment.	Reintroduce tidal influence back onto the site through the partial removal / breaching of the embankment fronting the SSSI. Construction of setback embankment around SSSI to control flood risk. Minor earthworks within SSSI to ensure connectivity for water.	Inundation of the site would be passive (i.e. require no intervention). This would return it to the state when the SSSI was first designated (and Natterjack toads were present / thriving). Breaching, rather than full removal, may reduce the risk of over inundation by limiting water egress in normal conditions. Although risk remains for storm surges.	As *Option 2a* Greater deficit of material for setback embankment as less liberated.	**Moderate**

Option	Title	Description	Benefits	Constraints	Suitability
2c	Modify Flood Embankment – Lower Crest (Notch Weir).	Reintroduce tidal influence back onto the site through lowering the crest of the embankment. Construction of setback embankment around SSSI to control flood risk. Minor earthworks within SSSI to ensure connectivity for water.	Inundation of the site would be passive (i.e. require no intervention) *. * Although not as passive as appears on face value a control structure to manage drainage may be required (refer to constraints). Further reduce the risk of over inundation during normal condition. Risk would remain for storm surges.	*As Option 2A* Greatest deficit of material for setback embankment. Unlike *Options 2a and 2b* where tidal water could drain off the site on the ebb tide through the channel it came in, under *Option 2c* the water would be prevented from draining back out by the embankment. Therefore, an additional drainage control structure would be required likely connecting back into the delph ditch.	**Very Low**
3a	Regulated Tidal Exchange – Pipe and Penstock Control.	Provide regulated tidal exchange through the construction of a control structure in the form of a pipe / penstock. Construction of setback embankment around SSSI to control flood risk. Minor earthworks within SSSI to ensure connectivity for water.	Control and flexibility - volume and frequency of seawater inundation could be adjusted to suit observations. Potential opportunity to construct a lower embankment around the SSSI (compared to *Option 2)* as existing flood embankment would remain in place and water entering the site would be controlled. Therefore, the embankment could potentially be designed to be nominally higher than HAT (rather than for extreme water levels). Consultation would be required Environment Agency to confirm if acceptable.	Tidal control requires physical intervention through opening and closing of penstock. Works required to delph ditch to prevent tidal water “escaping” down channel before inundating site. Likely in the form of embankment and control structure (penstock, etc.). Infrequent use may result in channel silting up, creating additional maintenance burden. Smaller outlet (compared to *Option 3b*) means more likely to fully block with silt, although greater velocities means also more likely to be self-cleansing.	**High**
3b	Regulated Tidal Exchange – Channel and Sluice Control.	Provide regulated tidal exchange through the construction of a control structure in the form of a channel with a sluice Construction of setback embankment around SSSI to control flood risk. Minor earthworks within SSSI to ensure connectivity for water.	Larger infrastructure would allow faster inundation of site.	Larger infrastructure / more expensive capital costs. Infrequent use may result in channel silting up, creating additional maintenance burden. Larger outlet (compared to *Option 3a*) means less likely to fully block with silt, although smaller velocities means that it is also less likely to be self-cleansing. Little to no benefit over *Option 3a.*	**Very Low**
4a	Saline Treatment – Pumped Seawater.	Periodic introduction of saltwater into SSSI through pumping over embankment or spraying etc.	Very low cost. Flexibility - volume and frequency of seawater could be adjusted to suit	Would require ongoing interventions to maintain SSSI. Limited evidence of practice being used.	**High**

Option	Title	Description	Benefits	Constraints	Suitability
			observations. Including stopping entirely if proving not to be working. Not reliant on water being able to navigate around site because it can be introduce directly to the ponds / scrapes.	May not create suitable foraging and hibernation habitat for natterjacks on the SSSI land around the ponds.	
4b	Saline Treatment – Sodium Chloride Enrichment.	Periodic introduction of sodium chloride into freshwater ponds / scrapes to provide more suitable habitat for Natterjack toads.	Very low cost Flexibility - volume and frequency of enrichment could be adjusted to suit observations.	Requires freshwater to be present in ponds. No evidence of practice being used. May not create suitable foraging and hibernation habitat for natterjacks on the SSSI land around the ponds.	**Low**
5a	Optimise site for other uses – Agriculture.	Interventions to repurpose the SSSI into agricultural land including vegetation flailing, removal of boundary fences, filling of ponds / scrape features.	Provides purpose for the site (beyond *Option 1*). Low cost / Costs to be shared with farmer. Positive community relations.	Will lead to declassification of SSSI. Offers no ecological benefit. Conflicts with government targets for SSSI actions on track to achieving favourable condition in the EIP.	**Low**
5b	Optimise site for other uses – Nature Conservation / Biodiversity.	Interventions to repurpose the SSSI into a nature conservation area (without the focus of natterjack toads). To be steered by habitat assessment but could include creation of pond, areas for nesting birds, high tide roosts for birds, planting of trees, etc.	Provides purpose for the site (beyond *Option 1*). Low cost. Provides ecological benefits.	Will lead to declassification or re-classification of the SSSI. May conflict with government targets for SSSI actions on track to achieving favourable condition in the EIP.	**Moderate**
6	New pools adjacent to SSSI.	Construct new pools in existing upper saltmarsh fronting the SSSI.	Lower cost than on-site works to the existing Cockerham Marsh SSSI.	Potentially marginal limit of technical feasibility (due to saltmarsh level with respect to tidal levels). Different landowner to SSSI landowner.	**Moderate**

3.4 Catchment Nature Based Solutions

Consideration of nature-based solutions that may beneficially be applied in the River Cocker's catchment have been considered in Task 3 and do not form part of this Task 2a report.

4 Options Workshop

The long list of restoration management options presented in section 3 were discussed with the Project Steering Group at an Options Workshop on 9th October 2025 (part 1) and 4th November 2025 (part 2). The long-listed options for: (i) managing flood risk at Bank End Farm; (ii) restoring a more natural tidal Cocker Channel; and (iii) improving the condition of Cockerham Marsh SSSI were screened to a short list. The short-listed options are presented in Table 5, Table 6 and Table 7, respectively.

Table 5 Screening of management options for managing flood risk at Bank End Farm

Option	Title	Screening	Rationale
Bank End 1	Do nothing.	In	This is the base case against which other options will be considered and therefore is important to screen into further assessments.
Bank End 2a	Protect saltmarsh edge: 'Soft engineering'.	Out	Whilst these 'protection' approaches may remain potential options for managing flood risk at Bank End Farm, they do not align with the restoration aims and objectives of the present study and are therefore screened out from further consideration. This does not necessarily mean they are not feasible options; just that they do not fall within the remit of this study.
Bank End 2b	Protect saltmarsh edge: 'Hard engineering'.	Out	
Bank End 2c	Protect saltmarsh edge: Foreshore recharge.	Out	There is potential that dredged material from the Port of Heysham could yield suitable material for foreshore recharge in the vicinity of Bank End. However, the issue of saltmarsh edge erosion seems to be predominantly linked to wider tidal processes and any placed sediment in front of Bank End is likely to become rapidly eroded and subsequently deposited elsewhere. Given that there are ongoing issues with siltation in front of land drains at present, the introduction of significant quantities of additional marine sediment to the system may worsen this problem. Due to this the foreshore recharge option has been screened out from further consideration in this study. If the opportunity for beneficial use of dredged sediment for foreshore recharge was to be further investigated, then potential unintended consequences caused by unwanted additional siltation would need to be thoroughly investigated.
Bank End 3a	Realign the channel near Bank End Farm: Training.	Out	Whilst this 'engineered' approach may remain a potential option for managing flood risk at Bank End Farm (by diverting the main channel further away from shore), it does not align with the restoration aims and objectives of the present study and is therefore screened out from further consideration. This does not necessarily mean it is not a feasible option; just that it does not fall within the remit of this study.
Bank End 3b	Realign the channel near Bank End Farm: Dredging.	Out	The availability of a numerical model developed as part of this study could enable the initial effects on existing hydrodynamics of a straightened (dredged) channel near Bank End Farm to be assessed, but there would be no guarantee that a dredged channel would retain the same alignment over time and natural changes would be likely to continue.

Option	Title	Screening	Rationale
Bank End 3c	Realign the channel near Bank End Farm: Re-naturalisation.	In (see Option 4 in the section on re-naturalising the tidal Cocker Channel)	This restoration option is further considered as Option 4 in the section on re-naturalising the tidal Cocker Channel. Any associated benefits (or impacts) in terms of flood risk at Bank End Farm will be considered as part of those assessments.
Bank End 4a	Reinforce existing flood embankment: Sheet pile toe.	Out	Whilst these may remain potential options for managing flood risk at Bank End Farm, they do not align with the restoration aims and objectives of the present study and are therefore screened out from further consideration. This does not necessarily mean they are not feasible options; just that they do not fall within the remit of this study.
Bank End 4b	Reinforce existing flood embankment: Riprap or revetment.	Out	
Bank End 5	Enhance monitoring.	Out	The monitoring undertaken by the North West Regional Coastal Monitoring programme provides sufficient data (LiDAR, aerial photography, beach profiles) to enable plan changes in the channel alignment and saltmarsh edge to be analysed. There is, of course, always benefit in having more data, but the present monitoring regime is suitable for high-level analysis. [This does not rule out the possible future need for more detailed survey, such as that which has informed the present study in terms of laserscan and drone data, or bathymetric survey or ground investigation at later stages of any project that may be taken forward].
Bank End 6	Land management.	Out	Whilst changes to land management approaches (such as grazing regimes) could potentially have minor benefits, especially to biodiversity, within appropriate units of the Lune Estuary SSSI, it is unlikely to change overall condition status of those units and, in itself, is not deemed a robust management solution to flood risk at Bank End Farm. It is, however, an area in which Natural England will have ongoing interest in relation to the diversity and condition of existing saltmarsh species.

Table 6 Screening of restoration options for re-naturalising the tidal Cocker Channel

Option	Title	Screening	Rationale
TCC 1	Do Nothing.	In	This is the base case against which other options will be considered and therefore is important to screen into further assessments.
TCC 2	Local Interventions - within saltmarsh near Patty's Farm Creek.	Out	From available aerial photographs of Cockerham Sands at high water and from the baseline numerical model runs, it does not seem necessary to cut a channel locally across the saltmarsh to connect the main creek to Patty's Farm creek. This is because large parts of the saltmarsh in this area will be subjected to tidal flooding during the higher spring tides and surges in any year.
TCC 3	Local Interventions - High level reconnection(s) with 'new' Cocker Channel.	In	With progressive siltation of sections of the main natural channel following construction of the 'new' cut, there is less conveyance within upper reaches of the main natural channel. This option would involve relatively shallow 'scraping' of deposited muds to encourage greater flows within these reaches. The 'new' cut would remain as the principal conveyor of water discharging from Cocker Bridge.
TCC 4	Full Restoration of natural Cocker Channel.	In	With progressive siltation of sections of the main natural channel following construction of the 'new' cut, there is less conveyance within upper reaches of the main natural channel. This option would involve full reinstatement of the natural channel by means of dredging deposited muds from within these reaches. The 'new' cut would remain as the principal conveyor of water discharging from Cocker Bridge.
TCC 5	Full Restoration of natural of Cocker Channel with infill of 'new' cut.	Out	There is considerable local opposition to any option that would reduce the conveyance capacity of flood waters off land upstream of Cocker Bridge. Infilling the 'new' cut would reduce conveyance of such waters, directing it instead through the more meandering reinstated natural creek. This option is therefore screened out from further assessment as a potential management option due to its potential for increased (upstream) flood risk. However, the numerical modelling of an 'historic baseline' scenario from Task 2b (Modelling) will coincidentally provide outputs that will be similar to those that would be expected under this management option and therefore help corroborate or refine the decision to screen the option out from further assessment.

Table 7 Screening of restoration options for improving the condition of Cockerham Marsh SSSI

Option	Title	Screening	Rationale
SSSI 1	Do Nothing.	In	This is the base case against which other options will be considered and therefore is important to screen into further assessments.
SSSI 2a	Modify Flood Embankment – Full Embankment Removal.	In	These options are worthy of further consideration, with the preferred sub-option (a, b or c) being a function of the extent of engineering intervention involved. This in turn has a bearing on the quantity of materials to be re-used or imported to site for construction of counter-walls and the overall cost of delivery. No single sub-option has an advantage over any other (at this stage of assessment) that would lead to its screening-in at the expense of the others.
SSSI 2b	Modify Flood Embankment – Breach Embankment.	In	
SSSI 2c	Modify Flood Embankment – Lower Crest (Notch Wier).	In	
SSSI 3a	Regulated Tidal Exchange – Pipe and Penstock Control.	In	This is deemed the least 'interventionalist' approach if RTE is to be considered further.
SSSI 3b	Regulated Tidal Exchange – Channel and Sluice Control.	Out	There is a desire for the solution to be as natural as possible with the minimal engineering intervention required. Given that there is another option that could be applied with less engineering intervention, this option has been screened out from further assessments.
SSSI 4a	Saline Treatment – Pumped Seawater.	Out	These options reply upon unproven approaches. Given the site's history, less speculative solutions are required for further consideration in this study.
SSSI 4b	Saline Treatment – Sodium Chloride Enrichment.	Out	
SSSI 5a	Optimise site for other uses – Agriculture.	Out	These options do not fulfil the aims and objectives of the study and have been screened out from further assessment. However, they may become default options if no other option (including Option 1 Do Nothing) is preferred.
SSSI 5b	Optimise site for other uses – Nature Conservation / Biodiversity.	Out	
SSSI 6	Construct pools in existing upper saltmarsh fronting the SSSI	In	There may be opportunity to create suitable Natterjack toad pool habitat on a localise high-spot of the existing marsh directly adjacent to the SSSI rather than undertake significant engineering works in attempt to bring tidal waters onto the SSSI.

5 Short-listed Restoration Options

5.1 Background

Those restoration options which have been short-listed for further consideration within this investigation are appraised in more detail in this section. Each restoration option is considered in terms of its:

- Technical feasibility;
- Economic viability; and
- Environmental acceptability.

It should be noted that the screening of options presented in section 4 has been undertaken within the context of the specific aims and objectives of this investigation, thereby focusing on natural restoration of geomorphological features or landforms to improve biodiversity and potentially natural flood management. This has led the short-listing to typically reject the more 'heavily engineered' options as well as the less proven options (such as saline treatment) and the more administrative options (such as SSSI declassification or alternative use). This does not necessarily mean that such approaches are not feasible options; rather that they do not fall within the remit of this restoration investigation.

The appraisal of the short-listed options presented in this section is informed by outputs from other aspects of the investigation, namely:

- Task 1 – Desk-Based Review and Site Visit
- Task 2b – Modelling
- Task 4 – Cockerham Marsh Site of Special Scientific Interest (SSSI)

5.2 Managing Flood Risk at Bank End Farm

5.2.1 Bank End Option 1 – Do nothing

5.2.1.1 Technical Feasibility

When projecting into the future, there are three potential outcomes at Bank End Farm under a Do Nothing option.

1. If the recent erosion trend at the saltmarsh edge reverses, due to the channel naturally switching to a less incised alignment, there may well be the accretion of mud and the development of saltmarsh on the northern channel margin.
2. If the channel alignment has stabilised, the recent erosion trend at the saltmarsh edge is likely to have reached the limit of its extent, leaving a reasonable width of residual saltmarsh fronting the flood embankment.
3. If the trend in channel alignment continues without natural limitation there is likely to be ongoing erosion of the saltmarsh edge, reducing its residual width over time.

Under the first and second scenarios, the flood risk at Bank End Farm will not necessarily worsen compared to the present day through natural changes in channel morphology (and associated saltmarsh edge erosion), but flood risk will still progressively increase over future years and decades due to the ongoing effects of sea level rise.

Under the third scenario, flood risk to Bank End Farm (and wider areas of the Thurnham peninsula) will increase not only due to sea level rise, but also due to continued erosion of the saltmarsh margin. This will lead to greater risk of overtopping of the existing flood embankment and may lead to increased risk of structural damage to the existing flood embankment due to increased exposure as the saltmarsh width reduces.

5.2.1.2 Economic Viability

The Do Nothing option has no capital costs, but should flooding occur there would be associated damages incurred to present-day businesses.

5.2.1.3 Environmental Acceptability

From an environmental perspective, it is likely that Do Nothing is more favoured than ‘engineered’ efforts to control the channel morphology through dredging, training or hard engineering. This is because natural processes will be continuing, and the system will retain its dynamic behaviour. However, there could be environmental damages associated with Do Nothing if it leads to breaching or overtopping of the flood embankment and uncontrolled flooding of large parts of the Thurnham peninsula.

5.2.2 Bank End Option 3c – Re-naturalisation of the Tidal Cocker Channel to Reduce Saltmarsh Erosion at Bank End Farm

5.2.2.1 Technical Feasibility

The means of re-naturalising the tidal Cocker Channel are discussed in section 5.3. One theoretical potentially beneficial outcome from such re-naturalisation is that the 'pressure' currently exerted at the confluence of Patty's Farm Creek and the 'new' cut tidal Cocker Channel may become relieved and the recent historic tendency for incision closer to shore of the meander just seaward of Bank End Farm will be alleviated. In turn, this would reduce the potential for erosion of the saltmarsh fronting Bank End Farm associated with the changes in plan position of the channel.

Numerical modelling has shown that the highest currents in this vicinity (which can lead to sediment erosion and transportation and therefore contribute to change in channel alignment) occur due to the effects of the flooding and ebbing spring tides. These are governed at a landscape-scale and are only marginally influenced by flow from the 'new' cut tidal Cocker Channel in the 'baseline' model runs and associated sensitivity runs.

There is potential shown by the modelling that by fully reinstating the natural tidal Cocker Channel and retaining the 'new' cut tidal Cocker Channel, there could be some 'circulation' of tidal flows such that when the tidal waters from the largest spring tides ebb away, they do so at higher velocities just seaward of Bank End Farm. In this location there has been a history of saltmarsh loss, and any exacerbation of currents (even temporarily and on only some stages of the tidal cycle) could increase this propensity.

It is therefore envisaged that this option would not significantly improve, and may in fact slightly worsen, the natural tendency for saltmarsh erosion due to channel dynamism just seaward of Bank End Farm.

5.2.2.2 Economic Viability

Re-naturalisation of the tidal Cocker Channel is estimated to a have a capital cost between £700k and £1,400k depending on how the won material is managed. This is discussed further in section 5.3.

5.2.2.3 Environmental Acceptability

Re-naturalisation of the tidal Cocker Channel could have a number of theoretical environmental benefits, as detailed in section 5.3. However, modelling has shown that whilst this option would not worsen the backing-up of waters (and hence would not worsen tide-locking of discharge flow from the River Cocker through Cocker Bridge tidal gates) compared to the present day, there would only be localised minor advantages in terms of improved hydraulic connectivity to areas of adjacent upper saltmarsh. This is because the dominant inundation process remains submergence by tides propagating from west to east across Cockerham Sands once the threshold level of the marsh surface has been exceeded by the rising water levels.

5.2.3 Summary of Restoration Options for Managing Flood Risk at Bank End Farm

It is unlikely that flood risk reduction at Bank End Farm alone is a sufficient driver for re-naturalising the tidal Cocker Channel (whilst retaining the 'new' cut channel) under TCC Option 3, since the magnitude of change is likely to be relatively small with respect to the governing landscape-scale process, which are dominated by spring tidal flows. Rather, potential for marginally increased tidal currents with the option implemented may increase tendency for channel movement towards the shore at Bank End Farm. It is likely that a marginal reduction in tendency for such change at this location could be delivered by re-naturalising the tidal Cocker Channel and infilling the 'new' cut channel (i.e. fully restoring natural historic conditions), however this could also increase tendency for tide-locking of flows from the River Cocker at Cocker Bridge, potentially increasing risk of land flooding in the lower catchment.

The preferred reinstatement option for managing flood risk at Bank End Farm is **Bank End Option 1 – Do nothing**. However, that means do nothing in terms of natural reinstatement options; continued analysis and interpretation of the monitoring data being collected as part of the North West Coastal Monitoring should continue (especially profile transects, aerial photography and LiDAR). Over time, analysis of these datasets will provide further insight into the changes (or stability) of the channel and fronting saltmarsh seaward of Bank End Farm. Such activities will extend beyond the period of the present investigation. Should the monitoring reveal ongoing loss of fronting saltmarsh due to continuing changes in channel alignment, then some of the other long-listed options previously discussed in section 3 may become valid considerations, although those do not all form part of the remit of the present restoration investigations.

It is also important to note that flood risk at Bank End Farm (and to the wider Thurnham peninsula) will increase over future years and decades due to sea level rise, and this has been considered within the Shoreline Management Plan (and subsequent plans and activities) which provide a route map for managing such risk in a sustainable manner.

5.3 Re-naturalising the Tidal Cocker Channel

5.3.1 TCC Option 1 – Do nothing

5.3.1.1 Technical Feasibility

If no intervention was made to the natural tidal Cocker Channel, the 'new' cut tidal Cocker Channel would remain the principal channel used for the conveyance of fluvial water from the River Cocker, through the sluice gates at Cocker Bridge, to discharge to sea.

It should be noted that there would be ongoing siltation in the 'new' cut which would need occasional dredging / clearance in order that the gates remained functional and the conveyance capacity of the channel remained undiminished, although that is a separate issue to consider.

5.3.1.2 Economic Viability

Under this option, there would be no associated capital costs (although as implied above there would remain ongoing operation and maintenance costs for the sluice gates at Cocker Bridge and maintenance costs for dredging the 'new' cut tidal Cocker Channel).

5.3.1.3 Environmental Acceptability

Under this option, tidal flow to some upper sections of saltmarsh would be limited to only the very highest tides each year, meaning that vegetation in these areas would remain rank.

5.3.2 TCC Option 3 – High level restoration of tidal Cocker Channel

5.3.2.1 Technical Feasibility

Under this option, the uppermost sections of creeks immediately east of the ‘new’ cut would be deepened to remove sediment that has become deposited since the ‘new’ cut was constructed in the 1960s. This siltation has caused the uppermost sections of these creeks to have become largely defunct and surrounding areas of saltmarsh vegetation rank. Figure 3 (see also Appendix A for greater detail) shows the plan locations and typical cross-sections for the works that would be proposed under this option. The works would be focused on reinstating the uppermost section of the historic tidal Cocker Channel (‘Main Creek’) as well as the uppermost sections of three more minor creeks (‘Minor 01’, ‘Minor 02’ and ‘Minor 03’). The approximate volumes of material involved in the deepening of each area are shown in Table 8.

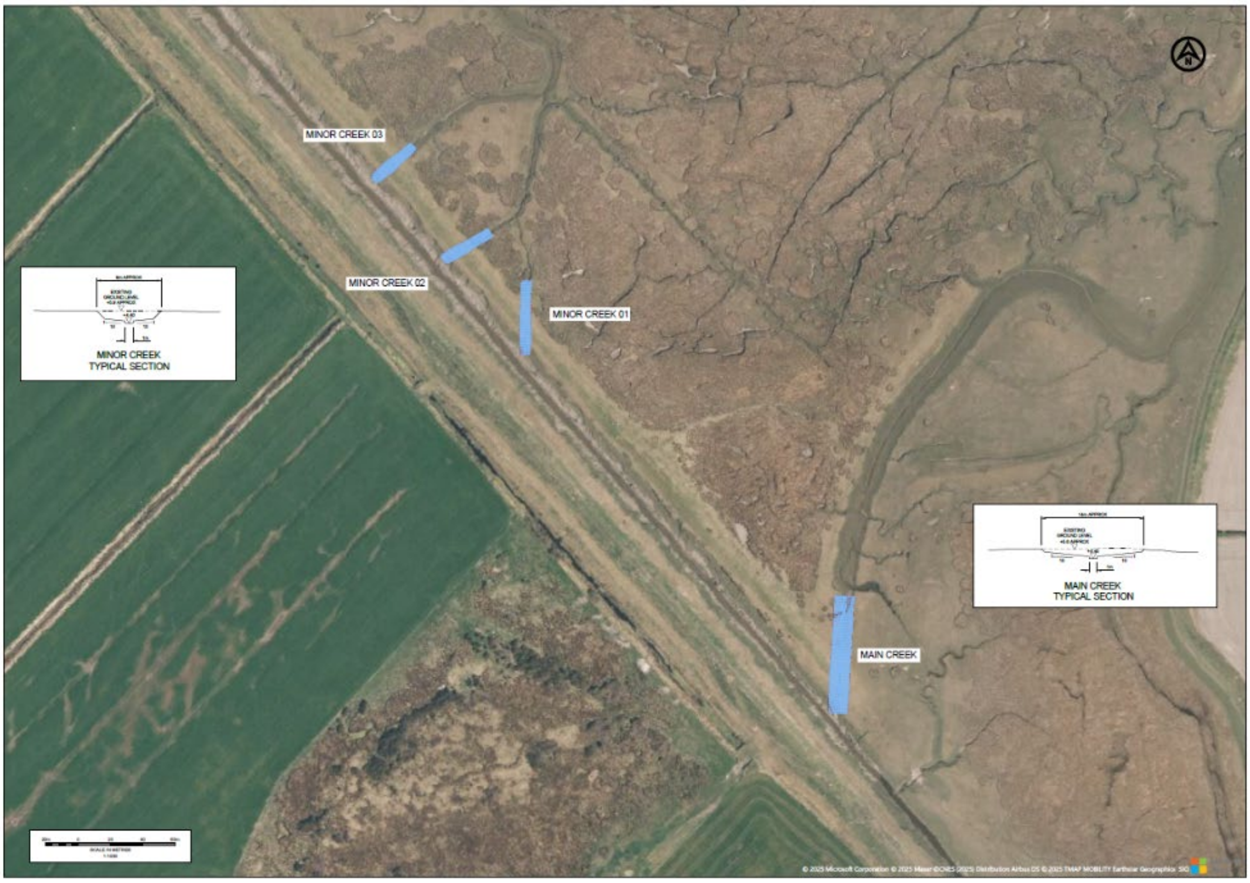

Figure 3 Location of upper creek deepening under Tidal Cocker Channel Option 3

Table 8 Approximate volumes of material excavated from upper creek deepening under Tidal Cocker Channel Option 3

Location	Approximate Volume of Material (m^3)
Main	320
Minor 01	190
Minor 01	140
Minor 01	170
Total	**820**

5.3.2.2 Economic Viability

Table 9 outlines the capital costs for Option 3: High-level restoration. This option generates a reasonable volume of material, making overall costs highly dependent on how this material is managed. The most cost-effective approach is to reuse the material within the wider site, for example, for saltmarsh recharge or bird island creation. If no suitable reuse option is available, the material must be off hauled from the site, likely to a recycling facility. This would incur significant additional costs. To illustrate this, costs for both options are presented under scenarios of: (i) 100% off hauling; and (ii) 100% reuse. As shown, by off hauling the material, the costs rise by almost double.

Due to the nature of this intervention, operation and maintenance costs are expected to be minimal. Future maintenance may be limited to dredging or excavating the cut reaches, if necessary, which could be undertaken as part of any dredging or excavating campaign on the straightened 'new' cut channel, as the requirement for dredging or excavating that channel will remain ongoing.

Table 9 Capital cost

		100% Off Hauled	100% Reuse
Construction Costs		£ 32,800	£ 12,300
General Preliminaries	15%	£ 4,920	£ 1,845
Contractors Overheads and Profit	15%	£ 4,920	£ 1,845
Sub Total		**£ 42,640**	**£ 15,990**
Design Costs and Investigations[1]	15%	£ 2,399	£ 2,399
Consents and Permits[1]	15%	£ 2,399	£ 2,399
Contract Admin & Supervision[1]	10%	£ 1,599	£ 1,599
Client Staff Costs[1]	10%	£ 1,599	£ 1,599
Land Compensation[2]			
Marine Net Gain[3]		£ 5,000	£ 5,000
Sub Total		**£ 12,996**	**£ 12,996**
Contingency[4]	**30%**	**£ 16,691**	**£ 8,696**
Total		**£ 72,327**	**£ 37,682**

1. At this stage of the project, pre-construction costs are typically estimated as a percentage of the total construction value. For both scenarios, these costs have been calculated using the percentages shown in Table 9, based on the 100% reuse scenario, and then applied to both. This approach is based on the assumption that the pre-construction burden will be broadly similar for each scenario, regardless of differences in construction costs.

2. It is assumed there are no land compensation costs associated with this option.

3. It is not anticipated that this option will require planning permission and, therefore, will not be subject to Biodiversity Net Gain mandates. However, the option will require a Marine Licence. It is understood

that a similar concept, Marine Net Gain, is currently under discussion; therefore, a nominal allowance has been included.

4. A contingency of 30% has been applied to reflect the uncertainty associated with an Association for the Advancement of Cost Engineering (AACE) Class 5 cost estimate

5.3.2.3 Environmental Acceptability

By reinstating more frequent natural tidal flows to these currently largely defunct sections of natural creek, it was anticipated that there might be improvement in the quality of the upper saltmarsh habitat across the surrounding adjacent areas of (currently rank) saltmarsh, leading to:

- Geodiversity and biodiversity: Naturally functioning creeks and habitat).
- Birds: Increased bird usage for feeding and roosting.
- Fish: Safe and productive nursery grounds for juvenile fish.
- Water quality: increased filtering and locking away excess nutrients like nitrogen and phosphate from surrounding water runoff.

This was envisaged to be associated with more frequent tidal inundation to areas adjacent to the fully reinstated creeks. However, numerical modelling shows that these envisaged benefits do not appear to be fully manifest, as the tide reaches most areas of upper saltmarsh by submergence due to flooding spring tides as they propagate across Cockerham Sands from the west, rather than extensive areas of saltmarsh becoming inundated through overspilling the banks of the reinstated tidal Cocker Channel, which is considerably more localised process. Therefore, whilst providing marginal environmental benefit, the extent of benefit is considerably less than originally envisaged. There would be no obvious advantages compared to the present day in terms of drainage of water from backing land areas since the new cut tidal Cocker Channel provides the principal route for such flows.

5.3.3 TCC Option 4 – Full restoration of tidal Cocker Channel

5.3.3.1 Technical Feasibility

Under this option, the entirety of the natural course of the tidal Cocker Channel would be deepened and widened to remove sediment that has become deposited since the 'new' cut was constructed in the 1960s, and the 'new' cut will remain open. Figure 4 (see also Appendix A for greater detail) shows the plan location and typical cross-section for the works that would be proposed under this option. The cross-section mimics that of the natural channel to just north of Patty's Farm Creek. The approximate volume of material involved in the deepening of this area is shown in Table 10.

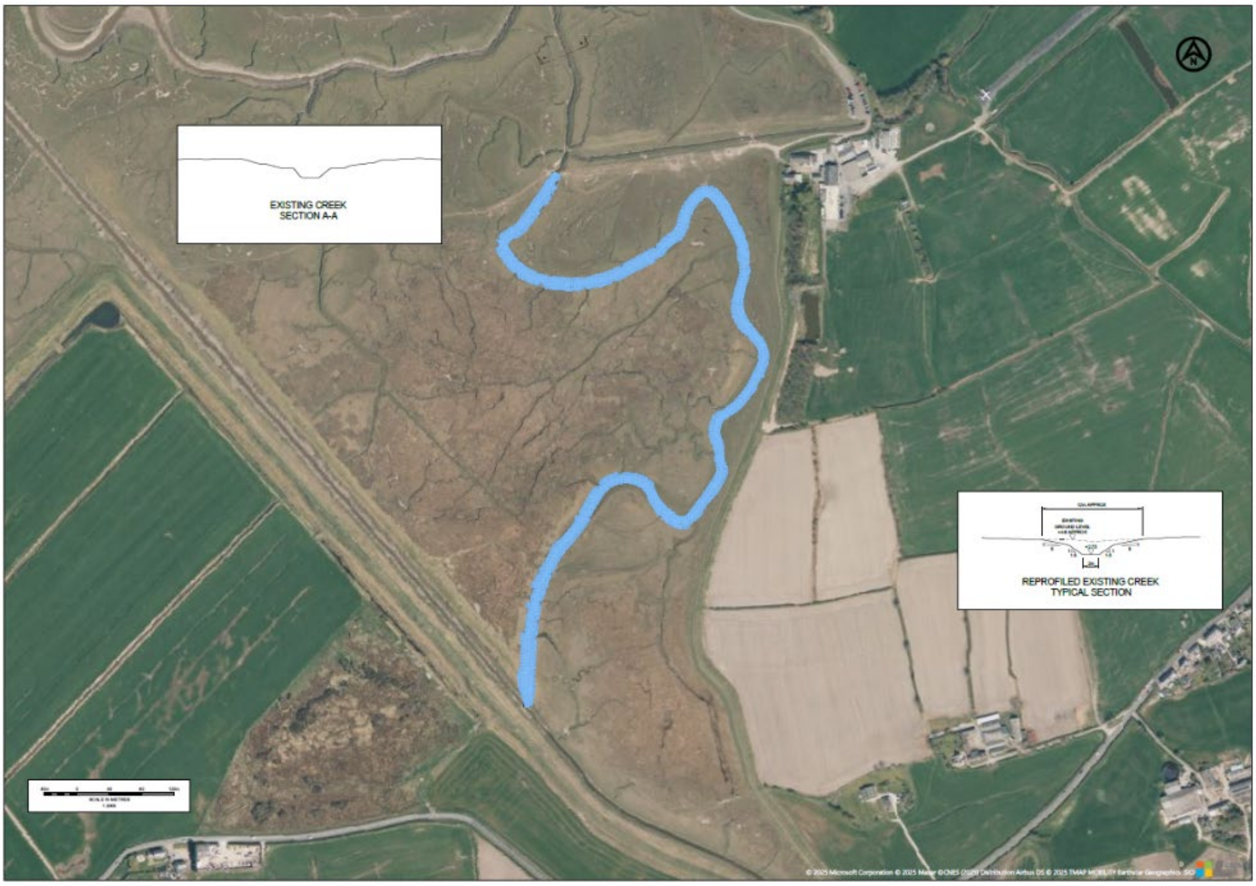

Figure 4 Location of natural tidal Cocker Channel deepening under Tidal Cocker Channel Option 4

Table 10 Approximate volumes of material excavated from natural tidal Cocker Channel deepening under Tidal Cocker Channel

Location	Approximate Volume of Material (m^3)
Tidal Cocker Channel	15,000

5.3.3.2 Economic Viability

Table 11 presents the outline capital costs for TCC Option 4: Full Restoration. As discussed in Section 5.3.2.2, due to the significance around how the excavated material is managed, the option is presented under two scenarios, namely: (i) 100% off-hauling; and (ii) 100% reuse. As shown, off-hauling all material nearly doubles the capital cost compared to reusing it, highlighting the importance of identifying a beneficial reuse for the material on site. It should be noted that any reuse projects must consider existing siltation issues and associated flood risk implications to ensure that such matters are not worsened.

Table 11 Capital cost estimates for Option 4 Full restoration of tidal Cocker Channel

		100% Off Hauled	100% Reuse
Construction Costs		£ 633,000	£ 258,000
General Preliminaries	15%	£ 94,950	£ 38,700
Contractors Overheads and Profit	15%	£ 94,950	£ 38,700
Sub Total		**£ 822,900**	**£ 335,400**
Design Costs and Investigations[1]	15%	£ 50,310	£ 50,310
Consents and Permits[1]	15%	£ 50,310	£ 50,310
Contract Admin & Supervision[1]	15%	£ 50,310	£ 50,310
Client Staff Costs[1]	15%	£ 50,310	£ 50,310
Land Compensation[2]			
Marine Net Gain[3]		£ 5,000	£ 5,000
Sub Total		**£ 206,240**	**£ 206,240**
Contingency[4]	**30%**	**£ 308,742**	**£ 162,492**
Total		**£ 1,337,882**	**£ 704,132**

1. At this stage of the project, pre-construction costs are typically estimated as a percentage of the total construction value. For both scenarios, these costs have been calculated using the percentages shown in Table 11, based on the 100% reuse scenario, and then applied to both. This approach is based on the assumption that the pre-construction burden will be broadly similar for each scenario, regardless of differences in construction costs.

2. It is assumed there no land compensation costs associated with this option.

3. It is not anticipated that this option will require planning permission and, therefore, will not be subject to Biodiversity Net Gain mandates. However, the option will require a Marine Licence. It is understood that a similar concept, Marine Net Gain, is currently under discussion; therefore, a nominal allowance has been included.

4. A contingency of 30% has been applied to reflect the uncertainty associated with an Association for the Advancement of Cost Engineering (AACE) Class 5 cost estimate.

5.3.3.3 Environmental Acceptability

As for TCC Option 3, the envisaged environmental benefits of fully reinstating the channel do not appear to be fully manifest, as the tide reaches most areas of upper saltmarsh by submergence due to flooding spring tides as they propagate across Cockerham Sands from the west, rather than extensive areas of saltmarsh becoming inundated through overspilling the banks of the reinstated tidal Cocker Channel, which is a considerably more localised process. Therefore, whilst providing marginal environmental benefit, the extent of benefit is considerably less than originally envisaged.

There is also potential shown by the modelling that by fully reinstating the natural tidal Cocker Channel and retaining the ‘new’ cut tidal Cocker Channel, there could be some ‘circulation’ of tidal flows such that when the tidal waters from the largest spring tides ebb away, they do so at higher velocities just seaward of Bank End Farm. In this location there has been a history of saltmarsh loss, and any exacerbation of currents (even temporarily and on only some stages of the tidal cycle) could increase this propensity.

5.3.4 Summary of Restoration Options for Re-naturalising the Tidal Cocker Channel

Prior to discussing the options to re-naturalise the tidal Cocker Channel, either partly (TCC Option 3) or fully (TCC Option 4), it is worth considering the processes that prevailed under the historic baseline and how these were affected by construction of the ‘new’ cut in the 1960s.

Historically, the tidal Cocker Channel followed a meandering route across Cockerham Sands between Cocker Bridge and Patty’s Farm and this was the principal channel for conveyance of flows, both tidal and fluvial. Due to its meandering alignment, ebb tide and fluvial flows through the channel were slower than in the present day. However, this had the effect of raising water levels residing within the upper reaches of the channel due to a degree of ‘hydraulic-brake’ within the system. In turn, this caused a tendency for ‘tide-locking’ of drainage from the River Cocker through the sluice gates at Cocker Bridge, and hence increased risk of flooding of land in the lower catchment if heavy rainfall could not discharge from the river to sea.

After the ‘new’ cut was constructed in the 1960s, this issue was alleviated as conveyance capacity of the new, straightened channel, was increased. However, associated with this was a slight tendency for increased ebb flows at the confluence between the ‘new’ cut channel and Patty’s Farm Creek, just seaward of Bank End Farm. This marginally increased the tendency for saltmarsh erosion and, in turn, increased flood risk to Bank End and the Thurnham peninsula, although tidal processes still govern this issue at this location.

If the tidal Cocker Channel was to be partially or fully reinstated, and the ‘new’ cut retained operational, there could be an exacerbation of currents in the Outer Cocker Channel, including just seaward of Bank End, which could (marginally) increase the tendency for saltmarsh erosion. There would unlikely be any change to flood risk in the lower catchment. However, the environmental benefits envisaged as being likely associated with reinstating the former tidal Cocker Channel do not appear to fully manifest, and would arise only very locally to the channel margins. This is due to the topography of the saltmarsh surface which restricts the extent of tidal inundation across the upper saltmarsh from the creeks until a threshold has been exceeded after which the saltmarsh extensively floods from the west across its surface.

The issue of potentially increased flood risk at Bank End could be avoided by not only reinstating the natural tidal Cocker Channel, but also infilling the ‘new’ cut, but this would exacerbate flood risk issues upstream of Cocker Bridge to pre-1960s conditions. Also, the environmental benefit of this remains limited as per TCC Option 4.

Given these findings, it is considered that the preferred option for re-naturalising the tidal Cocker Channel is **Option 1 – Do nothing**. Most of the natural tidal Cocker Channel remains operational, to some degree, at the site, albeit with a lower channel conveyance capacity (due to siltation) and a defunct landward end (where it no longer connects to the ‘new’ cut).

It should be accepted that areas of upper saltmarsh in estuaries with a high tidal range will only occasionally be affected by tidal processes. Furthermore, on the infrequent occasions when these areas become tidally inundated, the heavy sediment load brought by the incoming tide will become deposited across the saltmarsh surface, raising it further within the tidal frame and eventually ‘silting’ to such an extent that it becomes further elevated above the normal tidal frame.

It is important to note that under **Option 1 – Do nothing**, siltation will continue to occur within the ‘new’ cut Cocker Channel. This should be cleared periodically by dredging or excavating to maintain channel conveyance capacity and, at Cocker Bridge, to enable the sluice gates to function as intended.

5.4 Improving the Condition of Cockerham Marsh SSSI

5.4.1 SSSI Option 1 – Do nothing

5.4.1.1 Technical Feasibility

Under a Do nothing scenario, the 'unfavourable – declining' condition status of Cockerham Marsh SSSI will continue. This is because the sole interest feature of the SSSI is the Natterjack toad and the habitats (and functional physical processes that help sustain the suitable habitats) that this species relies upon are no longer present at the site. This is principally due to historic reclamation that has disconnected the site from tidal processes.

5.4.1.2 Economic Viability

This option has no capital cost, but the SSSI is failing to provide the conditions necessary for its sole interest feature to exist so there is associated 'damage' although this may not be possible to monetise.

5.4.1.3 Environmental Acceptability

This is not an environmentally acceptable option given the SSSI's site designation and government targets for SSSIs reaching favourable condition[1]. Due to this, previous attempts have been made to create new ponds, improve existing ponds and translocate spawn and tadpoles but without success. This is largely because the site is now disconnected from tidal processes which, if reaching suitable tidal levels to flood the ponds in spring (but not summer) would kill off the spawn and tadpoles of predators such as Common frog and Common toad and enable the later breeding Natterjack toad to thrive.

[1] *By December 2030, 50% of SSSI features are required to have actions on track to achieve favourable condition.*

5.4.2 SSSI Option 2 – Modify flood embankment

5.4.2.1 Technical Feasibility

If Natterjack toad reinstatement is to be successful, there is a recognised need for (occasional) tidal processes to inundate the site during the spring (and autumn) equinox, but not during the summer. There are various ways (sub-options) in which this can be achieved. Given the similarities between these sub-options, general technical considerations applicable to all have been addressed first to avoid duplication. Specific details individually relevant to sub-options are then discussed in turn.

Site Elevation and Tidal Compatibility

As outlined in section 3.3, the site's success as Natterjack toad habitat relies upon infrequent tidal inundation in any year, with inundation required during only the highest spring tides, especially those occurring during the spring equinox. As a result, tidal data for Heysham (Figure 5) has been compared against 2023 LiDAR data (Figure 6) to assess whether the site's topography aligns with the required tidal threshold to support the Natterjack toads.

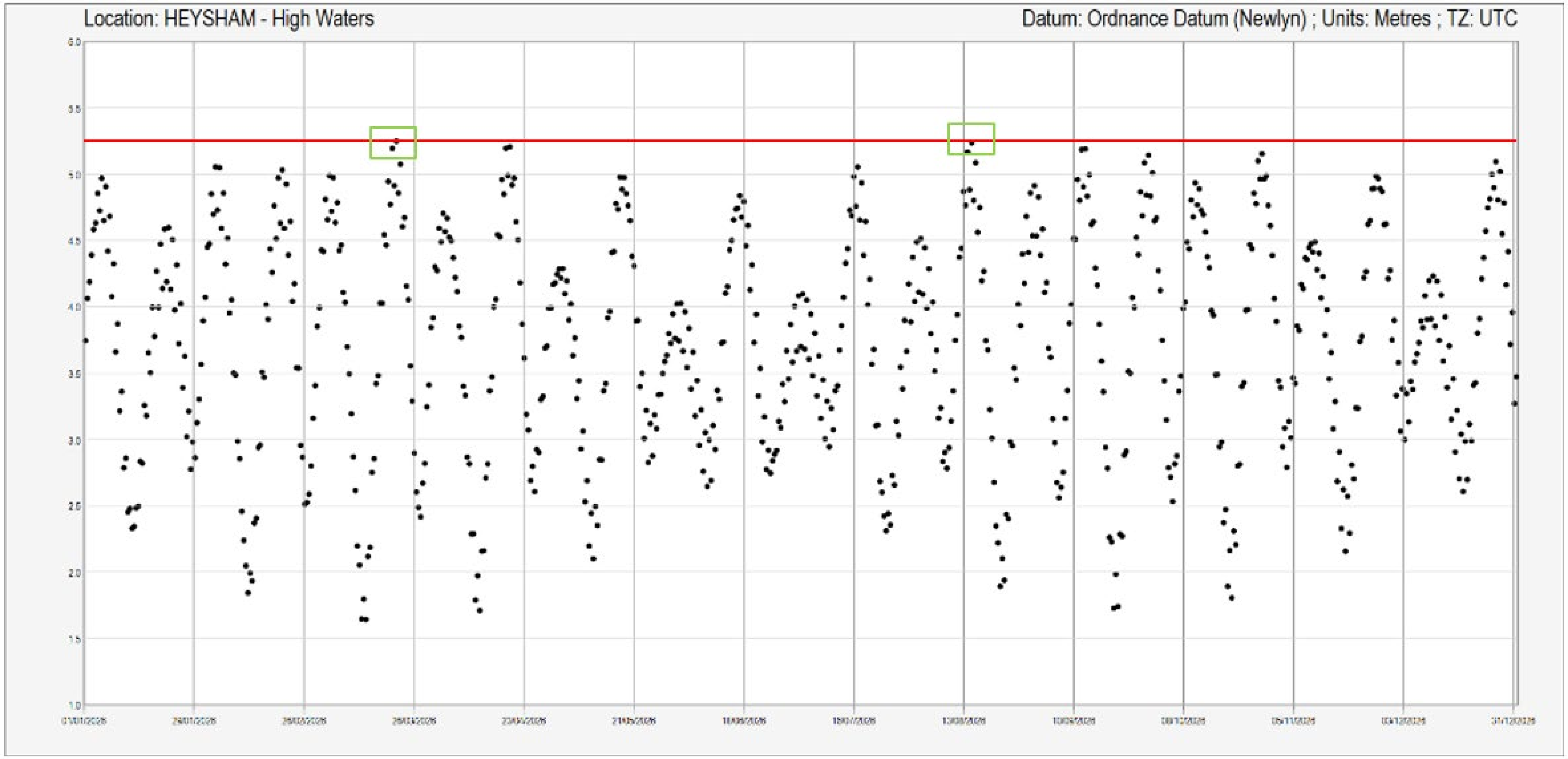

Figure 5 Heysham 2026 tidal data from Poltips-4 tidal software

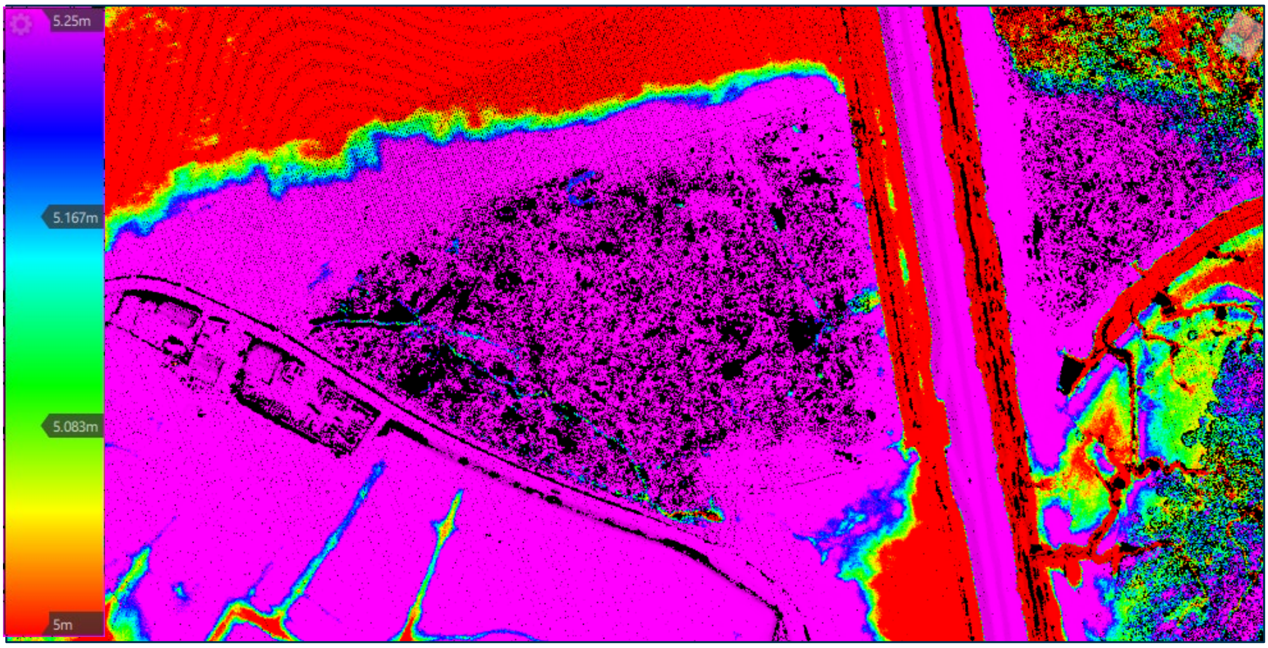

Figure 6 Elevation Plot for Cockerham Marsh using Environment Agency 2023 LiDAR data

Figure 5 indicates that an astronomical tidal level of +5.25mOD would result in inundation approximately once in spring and once in autumn (excluding surge effects, which are meteorologically driven and therefore not predictable in the same manner as astronomical tides). This pattern would theoretically allow for a spring tidal flushing of the site, followed by a disconnected period during the breeding season when tides do not cover the site (notwithstanding surge effects), which is ideal for Natterjack toads. Using this tidal benchmark, Figure 66 presents a LiDAR derived elevation plot with a colour scale representing ground levels. In this figure:

- **Red** indicates areas at or below 5.0mOD, which would be at risk of over-inundation.
- **Blue, Green and Yellow** represents elevations between +5.0mOD and +5.25mOD, the target range for selective tidal inundation.
- **Purple** shows land at or above 5.25mOD, which is too elevated to be influenced by tidal water (notwithstanding surge effects).
- **Black** indicates areas of vegetation growth which has been removed in the software resulting in data gaps.

Despite the site being heavily overgrow with scrub, which may obscure the true extent of inundation, Figure 6 reveals that several localised areas fall within the optimal tidal range. This includes some of the scrapes and areas of past interventions to reintroduce the toads. This suggests that, if the embankment was modified, the site could feasibly support the required tidal conditions for Natterjack toad habitat.

However, it remains uncertain whether tidal water would reliably reach these features due to the presence of data gaps in the LiDAR plot caused by dense vegetation. These gaps limit the ability to fully assess surface connectivity and potential flow paths. If further investigation confirms that tidal flow is impeded, localised excavation could be undertaken to create or enhance channels, ensuring effective tidal reach to these features.

Flood Risk

It is critical under all sub-options that relate to modifications to the existing flood embankment, that the flood risk to adjacent land is not exacerbated. Therefore, when introducing tidal water to the site, it is essential to ensure:

1. Tidal inundation is constrained to within the SSSI; and
2. The standard of protection provided by the existing Pilling to Cockerham sea defence embankment is maintained.

Without additional intervention around the perimeter of the SSSI, tidal water entering the site would be immediately intercepted by the delph ditch and drained northwest (initially, for a short length) and then southwest towards an outfall at Mill House, bypassing the SSSI. During larger tidal events, this water could spill from the delph ditch at a low point to the northwest of the SSSI, potentially flooding adjacent agricultural land. Methods to mitigate this have been considered under each of the sub-options.

However, this drainage concern is secondary to the overriding requirement to maintain flood protection to areas adjacent to the SSSI (adjacent fields and the backing highway). The SSSI sits at an elevation of approximately +5.6mOD to +5.7mOD, significantly lower than the existing embankment crest level of +7.7mOD (based on LiDAR data). As outlined in the Task 1 report, this level provides a 1 in 200-year standard of flood protection through to 2100, accounting for climate change. To maintain this level of protection to adjacent areas while allowing tidal exchange to the SSSI, a setback defence around the perimeter of the SSSI would be required.

For purposes of this assessment, it is assumed that the only acceptable solution would be an earthen embankment (i.e. it has been assumed for this investigation that a vertical concrete or sheet pile wall would be too imposing at 2.5m high above ground level). In accordance with the latest Environment Agency advice, the minimum specifications for a flood embankment includes a 4m crest width and 1 in 4 side slopes. Therefore, hypothetically assuming a crest elevation of +7.8mOD and a base elevation of 5.5mOD, this would result in an embankment footprint of 22.4m^2 per linear metre. Based upon the length of embankment that would be required around the SSSI's permitter, this would be equivalent to a 19,000m^2 footprint. During detailed design (if taken forward), considerations would need to be given to a cut-off wall (or similar) beneath the embankment to prevent saline intrusion that could permeate under the embankment and affect neighbouring fields.

The designated area of the SSSI, excluding the delph ditch and northern pond, is approximately 55,500m^2. Constructing the embankment within this footprint would result in an approximate 34% loss of area and notably the loss of some of the historic interventions (some habitat scrapes). Consideration would have to be given to whether the embankment could be constructed in the adjacent agricultural field to minimise loss of the SSSI. For purposes of this investigation (aimed at maximising the benefit to the SSSI) this case has been assumed, but this would encounter additional land ownership challenges if taken forward in practice. If moving onto detailed design, this matter would need to be confirmed and addressed accordingly, noting a likely preference from Natural England and Lancashire Wildlife Trust for retaining the structure within the boundaries of the SSSI even if this reduces the amount of land that could be restored to upper saltmarsh.

Additional consideration would have to be given to the required access into the SSSI. If vehicle access was required, the slopes could be slackened locally but at the expense of more loss of SSSI footprint, or some form of gateway from the road (as in the present day) could be maintained, but with a flood gate.

External Land Drainage

The field adjacent to the southern boundary of the SSSI is assumed to drain via a buried toe drain that runs parallel to the flood embankment, discharging into the delph ditch within the SSSI. If the SSSI is breached to allow tidal inundation, there is a risk that tidal water could flow up this pipe and flood the agricultural land it currently drains. To mitigate this, a control structure such as a flap valve will be required to prevent backflow during tidal events.

Option 2a – Embankment Removal
This sub-option, as shown in Figure 7 (see also Appendix A for greater detail), involves the removal of approximately 190m of flood embankment fronting the main body of the SSSI (i.e. the embankment remains in front of most of the delph ditch and the northern pool).

The embankment would be lowered to match the ground level on the landward side at +4.6mOD, which corresponds approximately to Mean High Water Springs (MHWS). This means the embankment would no longer constrain tidal inundation during the higher spring tides, allowing water to enter the site behind the embankment when the tidal threshold is met. A low flow channel would be incorporated to allow drainage of the delph ditch locally.

Figure 7 SSSI Option 2a Embankment Removal

It is assumed under this sub-option that the material liberated from the breaching of the embankment could be reused to construct the set-back embankment, which would extend across the delph ditch at both its northern and southern crossings. Works could be delivered either during a low neap tide window or through the use of temporary protection measures to ensure the standard of flood protection is maintained to adjacent land areas during construction. The removal of the embankment is estimated to yield approximately 9,500m³ of material; however, even with reuse, there would still be a material deficit of approximately 17,500m³.

It is proposed a short length of existing embankment would be left at the transition with the new set back embankment to act as erosion control.

As discussed in the general considerations above, if built solely within the SSSI site, the set back embankment would reduce the area of the SSSI by 34%. Due to this, it is proposed that the setback embankment is constructed in the adjacent agricultural land (although this is not possible adjacent to the road, where the embankment will unavoidably encroach into the SSSI). This would obviously be subject to land ownership discussion and would carry additional costs.

Option 2b – Embankment breaching

This sub-option, as shown in Figure 8 (see also Appendix A for greater detail), involves a localised breach of 40m being made within the flood embankment fronting the SSSI, rather than the full removal discussed in sub option 2a. The main benefit of breaching compared to the full embankment removal would be reduced construction time, although as the set back embankment would account for most the construction programme, the overall time saving would be negligible. If in the unlikely scenario the material could not be reused in the set back embankment, this option would then also mean reduced costs exporting the liberated material offsite.

Figure 8 SSSI Option 2b Embankment Breaching

However, by only locally breaching the embankment rather than fully removing it, the amount of liberated material is reduced to only 2,000m^3. This would result in a deficit of material of 25,000m^3, which as presented in section 5.4.2.2, would notably impact on cost.

Option 2c – Embankment Crest Lowering (notch weir)

This sub-option, as shown in Figure 9 (see also Appendix A for greater detail), involves lowering a 40m length of the embankment crest adjacent to the SSSI. The final crest level would be determined during the detailed design stage but is expected to be nominally below the target inundation level, approximately +5.1mOD. To prevent the scouring of the embankment during an inundation event, caused by water cascading down the embankment slope, erosion protection would be required. This could be in the form of rip rap stone, gabion mattresses or a concrete channel.

Figure 9 SSSI Option 2c Embankment Lowering

Compared to Options 2a and 2b, this sub-option requires the least excavation, resulting in the shortest construction programme. However, since the construction of the set-back embankment would still account for the majority of the programme, the overall time savings are likely to be negligible. One, albeit minor, advantage of this option is it offers greater flexibility in terms of the construction window, as it is less constrained by tidal conditions.

This approach yields the least amount of excavated material (compared to sub options 2a and 2b), approximately 1000m³ which will result in the greatest deficit of material required to construct the set-back embankment.

Furthermore, unlike a full embankment removal or an embankment breach, this configuration does not allow water entering the site (via rainfall or the delph ditch) to drain back through the embankment. As a result, a second flow control structure would be required on the northern set-back embankment to enable drainage via the delph ditch. This would likely consist of a flap valve and penstock arrangement.

5.4.2.2 Economic Viability

Table 12 presents outline capital costs for the three sub-options under Option 2: Modify Existing Flood Embankment with a further breakdown included in Appendix B. As shown, Option 2a – Full Removal is the least expensive, while Option 2c – Notch Weir is the most expensive, with a difference in costs of approximately £500k.

The variation in costs is primarily driven by the volume of imported material required to construct the setback embankment, which accounts for the majority of the construction cost. It is assumed that material recovered from the existing embankment can be reused. Therefore, the more embankment removed, the less imported material is needed, resulting in lower overall costs. However, this assumption is subject to geotechnical and chemical testing to confirm suitability for reuse. If the recovered material proves unsuitable, costs would increase significantly to account for both the additional imported material and the off-haul of unsuitable material from site.

Due to the nature of the intervention, it is expected that the operation and maintenance costs will be relatively low and will also be broadly similar for all of the sub-options. It is expected that maintenance would be limited to vegetation control on the embankment, and annual inspections and maintenance of the flap valve from the toe drain to the south (or for Option 2c annual inspections and maintenance of two flap valves).

Table 12 Comparison of costs for sub-options to modify the existing flood embankment

		Option 2a Full Removal	Option 2b Breach	Option 2c Notch Weir
Construction Costs		£ 984,500	£ 1,244,500	£ 1,280,750
General Preliminaries	15%	£ 147,675	£ 186,675	£ 192,113
Contractors Overheads and Profit	15%	£ 147,675	£ 186,675	£ 192,113
Sub-Total		**£ 1,279,850**	**£ 1,617,850**	**£ 1,664,975**
Design Costs and Investigations [1.]	5%	£ 85,000	£ 85,000	£ 85,000
Consenting and permitting [1.]	5%	£ 85,000	£ 85,000	£ 85,000
Contract Admin & Supervision [1.]	10%	£ 165,000	£ 165,000	£ 165,000
Client Staff Costs [1.]	10%	£ 165,000	£ 165,000	£ 165,000
Land Compensation (Embankment Footprint Only) [2.]		£ 21,000	£ 21,000	£ 21,000
Biodiversity Net Gain [3.]		£ 10,000	£ 10,000	£ 10,000
Sub-Total		**£ 531,000**	**£ 531,000**	**£ 531,000**

		Option 2a Full Removal	Option 2b Breach	Option 2c Notch Weir
				£ -
Contingency [4.]	**30%**	**£ 543,255**	**£ 644,655**	**£ 658,793**
Total		**£ 2,354,105**	**£ 2,793,505**	**£ 2,854,768**

1. At this stage of a project, pre-construction costs are typically estimated as a percentage of the total construction value. For this comparison, these costs have been calculated based on the most expensive option, using the percentages in the table, and then applied uniformly across all sub options. This approach reflects the assumption that the pre-construction burden will be broadly similar for all sub-options, regardless of differences in construction costs.

2. The land compensation value presented here is an estimate for the land directly beneath the embankment footprint and does not include costs associated with purchasing the SSSI land itself.

3. Biodiversity Net Gain is a legal requirement in England that ensures development projects leave biodiversity in a measurably better state than before, typically having to demonstrate at least 10% net gain. It is expected that BNG would be a requirement of the project as a result of loss of 'watercourse' through infilling the delph ditch and loss of terrestrial 'habitat area' as a result of the tidal inundation.

4. A contingency of 30% has been applied to reflect the uncertainty associated with an Advancement of Cost Engineering (AACE) Class 5 cost estimate.

5.4.2.3 Environmental Acceptability

All three sub-options could be successful in allowing occasional tidal inundation of the Cockerham Marsh SSSI, although Option 2c (embankment crest lowering) requires the greatest extent of 'hard' engineering and ongoing operational requirements due to its erosion protection measures and control structure for drainage into the delph ditch. If the flood embankment around the permitter of the SSSI was moved to inside of the SSSI boundaries, there would be a substantial loss of restoration habitat potential due to the embankment's footprint under all sub-options.

Option 2a (embankment removal) provides the greatest hydraulic connectivity between Cockerham Sands and the Cockerham Marsh SSSI and would be likely to require the least import of material for the set-back embankment and for those reasons is environmentally preferred, although Option 2b (embankment breaching) would also be suitable.

All options would require a set-back flood embankment to the perimeter of the SSSI and some local land levelling to ensure tidal connectivity to all ponds and pools on site. There would also be the need for site management in terms of vegetation clearance and ongoing scrub control, as well as careful attention to water levels within ponds and pools and its effect on Natterjack toad spawn and tadpoles during the breeding season.

5.4.3 SSSI Option 3a – Regulated tidal exchange: pipe and penstock control

5.4.3.1 Technical Feasibility

Under this option, tidal processes would be introduced to the site through the construction of a Regulated Tidal Exchange (RTE) system using pipework and a penstock control. This approach would allow seawater to flow into and out of the SSSI in a controlled manner.

The RTE would be implemented by installing a pipe through the existing embankment. On the seaward end, a winchable flap valve would normally remain closed to prevent tidal ingress. At the targeted high tides, the flap valve would be winched open to permit inundation. While this approach introduces the need for an active intervention, the infrequency of the required tidal exchange is thought to make it an acceptable solution in this context. The final invert level would be determined during the detailed design stage and would require balance between enabling drainage of the delph ditch, maximising flexibility (lower the better) and reducing the construction burden (higher the better).

A penstock would be installed on the landward side of the pipe to provide redundancy in case of flap valve failure. The penstock would normally remain open and only be closed if the flap valve failed. This arrangement means that freshwater in the SSSI, either rainwater or from the Delph Ditch, could still drain back out through the flap valve structure under normal conditions.

Similar to Option 2, it is critical that creating an RTE does not exacerbate flood risk to adjacent land. Without additional intervention around the SSSI perimeter, tidal water entering the site would be intercepted by the Delph Ditch and drained north towards the Mill House outfall, bypassing the SSSI. Therefore, an embankment would need to be constructed around the SSSI perimeter including across the Delph Ditch.

However, unlike Option 2, where modifying the existing embankment would reduce the standard of protection (SOP), a key advantage of the RTE approach is that the SOP of the fronting flood embankment remains unchanged. Therefore, the perimeter embankment in this option only needs to prevent water within the normal tidal range from escaping the SSSI. The proposed embankment, shown in Figure 6, is set with a crest height at 6.0mOD (rather than 7.8mOD in Option 2), providing 300 mm of freeboard above HAT. If taken forward, these assumptions would require agreement from the Environment Agency; however, the inclusion of freeboard and penstock redundancy is intended to demonstrate that flood risk is not compromised.

This reduced height embankment would require approximately 4000m^2 of material to construct. Even without the liberation of any material through breaching of the existing embankment, this is still significantly less material than the embankments in Option 2.

Due to the high suspended sediment volumes in Morecambe Bay and the infrequent operation of the flap valve, there is a significant risk of siltation accumulating at the seaward end of the pipe. This could obstruct the flap valve and compromise both drainage and tidal exchange functions. This is a known and common problem with nearby control structures. As a result, local silt clearance or dredging may be required before the flap valve is operated. One additional benefit of introducing the additional penstock is that it can be used to hold back water and then release in a controlled flush, although this may not prevent the need for dredging.

Figure 10 SSSI Option 3a - Regulated tidal exchange

5.4.3.2 Economic Viability

As shown in Table 13, the estimated capital cost for this option is approximately £800k (see Appendix B for the detailed breakdown). This estimate critically assumes construction of the lower elevation setback embankment at 6.0mOD, which, as noted above, requires approval from the Environment Agency. If this design is not accepted, costs would rise significantly due to the additional material required to construct a higher embankment.

On top of capital costs, this option would carry costs associated with O&M. The RTE control structure would require frequent (annual) inspections of both the penstock and flap valve, as well associated maintenance activities when required. This would also apply to the flap valve on the delph ditch within the setback embankment. It is also expected that prior to operation, silt clearance / dredging in front of the RTE flap valve would be required due to the notable risk of siltation in front of the structure. In the absence of this, it is likely that the flap would not open, resulting in no tidal water entering the site and surface water in the SSSI being unable to drain. The timing of this O&M would be critical to ensure that the flap valve can be operated on the highest tides. This ongoing operational activity may require a ‘non-navigational clearance dredging (for operational purposes)’ self-service Marine Licence from the Marine Management Organisation.

Table 13 Capital cost estimates for Regulated Tidal Exchange

		Option 3a Regulated Tidal Exchange
Construction Costs		£ 280,750
General Preliminaries	15%	£ 42,113
Contractors Overheads and Profit	15%	£ 42,113
Sub-Total		**£ 364,975**
Design Costs and Investigations	15%	£ 54,746
Consenting and permitting	23%	£ 82,118
Contract Admin & Supervision	10%	£ 36,498
Client Staff Costs	10%	£ 36,498
Land Compensation		£ 21,000
Biodiversity Net Gain		£ 10,000
Sub-Total		**£ 240,860**
Contingency [4.]	**30%**	**£ 181,750**
Total		**£ 787,585**

1. At this stage of a project, pre-construction costs are typically estimated as a percentage of the total construction value. For this comparison, these costs have been calculated based on the most expensive option, using the percentages in the table, and then applied uniformly across all sub options. This approach reflects the assumption that the pre-construction burden will be broadly similar for all sub-options, regardless of differences in construction costs.

2. The land compensation value presented here is an estimate for the land directly beneath the embankment footprint and does not include costs associated with purchasing the SSSI land itself.

3. Biodiversity Net Gain is a legal requirement in England that ensures development projects leave biodiversity in a measurably better state than before, typically having to demonstrate at least 10% net gain. It is expected that BNG would be a requirement of the project as a result of loss of 'watercourse' through infilling the delph ditch and loss of terrestrial 'habitat area' as a result of the tidal inundation.

4. A contingency of 30% has been applied to reflect the uncertainty associated with an Advancement of Cost Engineering (AACE) Class 5 cost estimate.

5.4.3.3 Environmental Acceptability

RTE could be successful in allowing occasional tidal inundation of the Cockerham Marsh SSSI, with a greater degree of control enabled compared to modifications to the flood embankment in Option 2. For example, the flap valve could remain closed throughout the breeding period and therefore prevent spawn or tadpoles from becoming affected by saline inundation during periods of tidal surge.

The option would require a set-back flood embankment to the perimeter of the SSSI but this could potentially be lower in crest level (and therefore smaller in associated basal footprint) than needed under Option 2. If this flood embankment was moved to inside of the SSSI boundaries, there would be a notable loss of restoration habitat potential due to the embankment's footprint.

Some local land levelling would be required to ensure tidal connectivity to all ponds and pools on site. There would also be the need for site management in terms of vegetation clearance and ongoing scrub control, as well as careful attention to water levels within ponds and pools and its effect on Natterjack toad spawn and tadpoles during the breeding season.

5.4.4 SSSI Option 6 – Construct pools in existing upper saltmarsh fronting the SSSI

5.4.4.1 Technical Feasibility

Numerical modelling has shown that there is parcel of existing saltmarsh within Cockerham Sands, immediately fronting Cockerham Marsh SSSI (but outwith its boundaries), that is unaffected by tidal influence throughout much of the spring-neap tidal cycle that was simulated. This simulation period was chosen because it covers the autumn equinox tides, which are often the largest astronomical tides in any year.

The model outputs show that even when tidal waters flood the majority of the inter-tidal area of Cockerham Sands, this single small triangular shaped parcel of land remains uncovered (Figure 11). It was only during a single high tide event during the simulation period (the very highest spring tide) that this area became inundated.

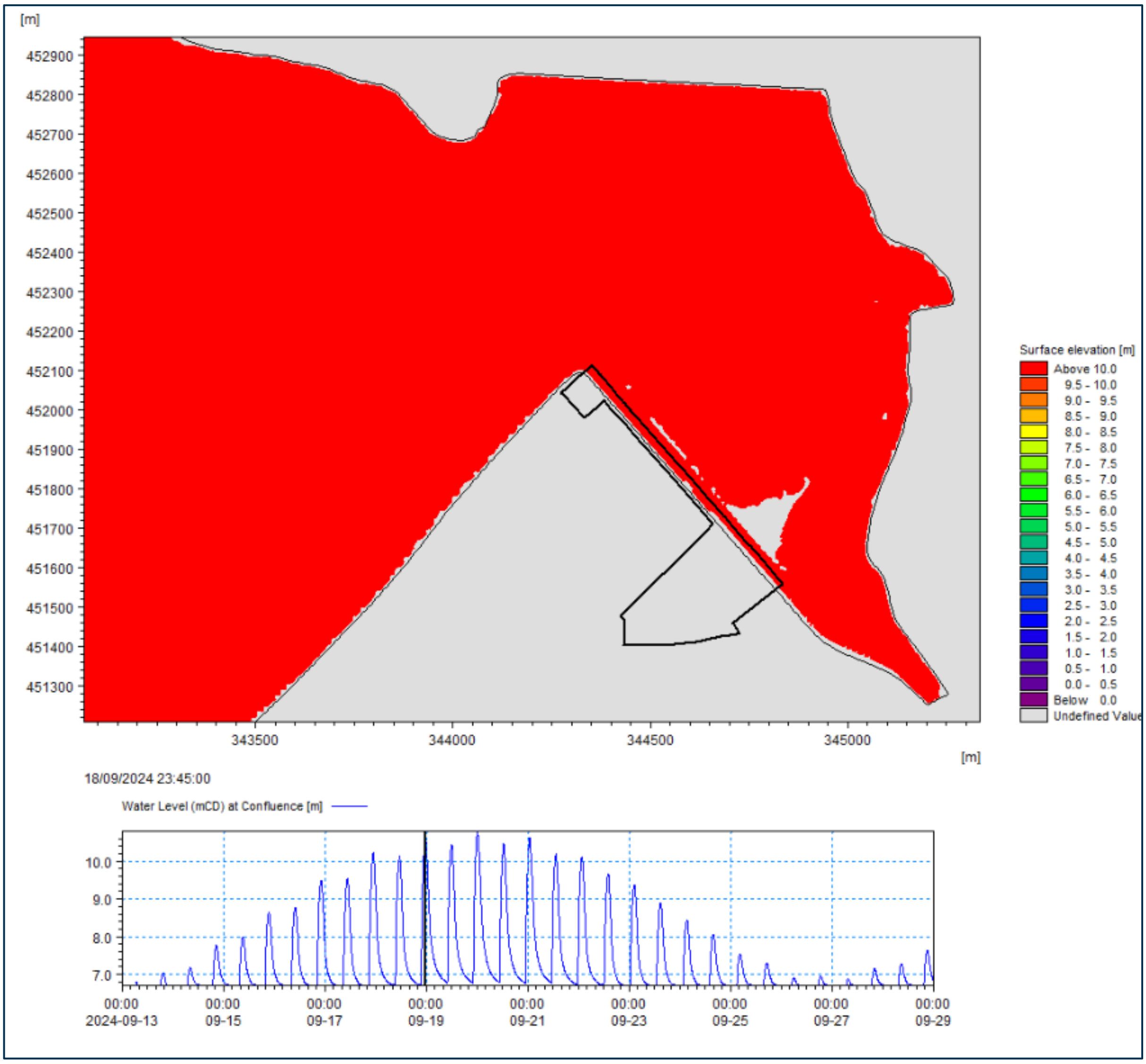

Figure 11 Baseline model outputs: High water elevation (in metres CD) just after high tide 12

When viewing the topography of this area using LiDAR data, it is apparent that this represents a local high spot on the saltmarsh surface (Figure 12).

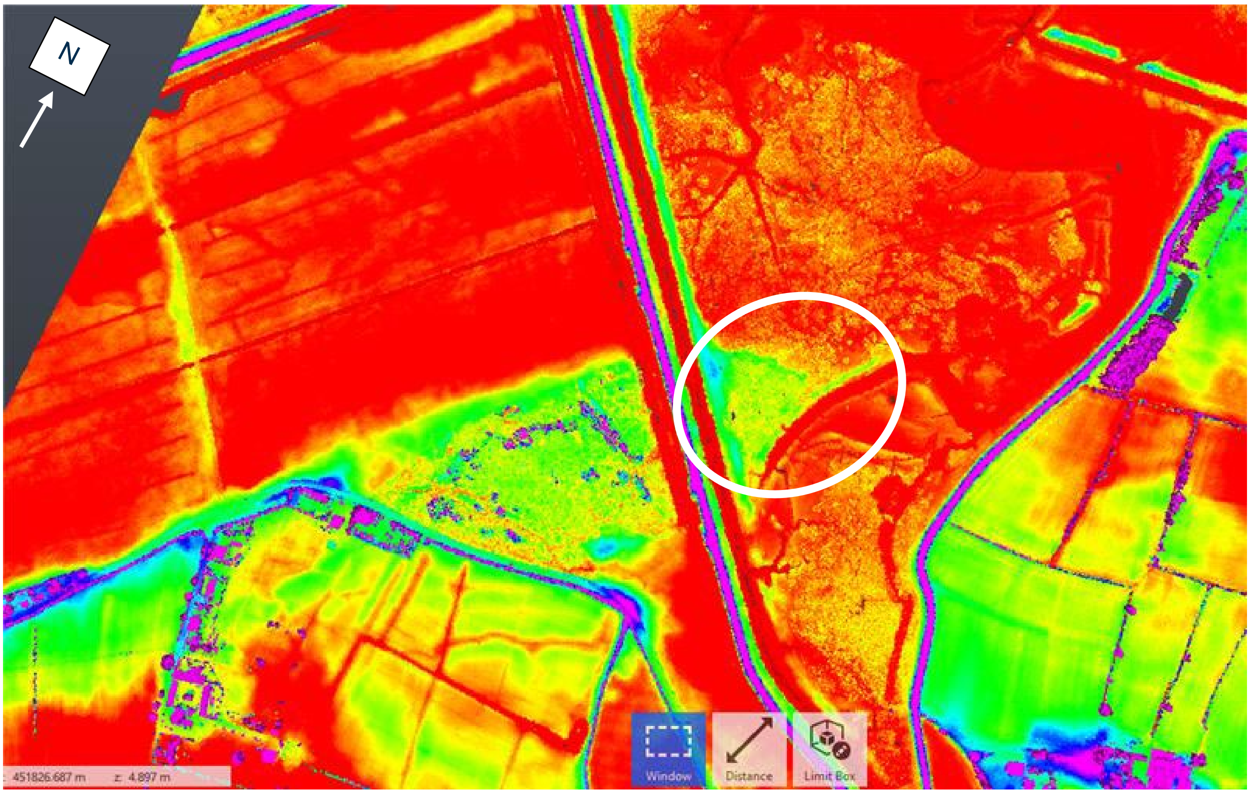

Figure 12 Local 'triangular-shaped' high spot in marsh surface opposite Cockerham Marsh SSSI

A timeseries of water level output at a point within the centre of this land parcel has been extracted from the numerical model (see red dot on Figure 13 for extraction location). This timeseries (Figure 14) shows that the land parcel remains uncovered for most of the simulation period, with only a short period where the very highest spring tide inundates it. The modelling report suggested that this may make this land parcel suitable for digging pools that could potentially become utilised by Natterjack toads. This is investigated further in this section.

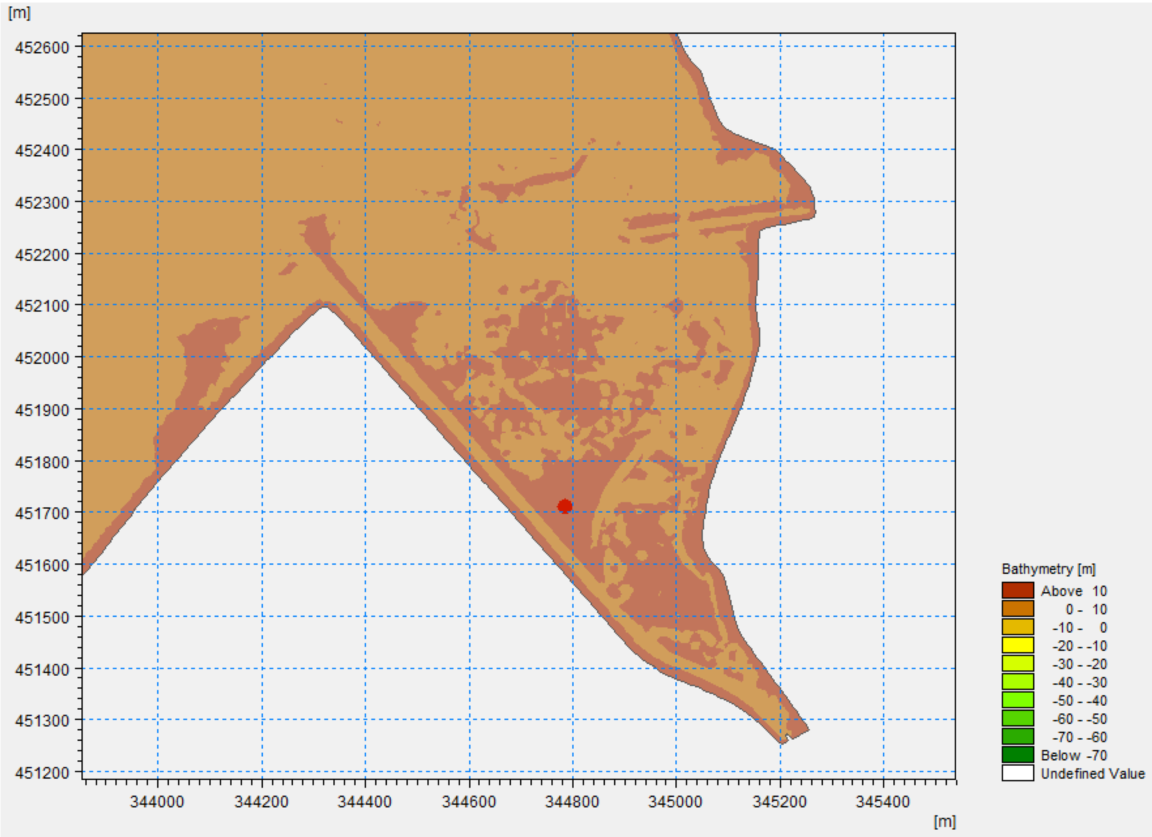

Figure 13 Model extraction point (red dot) at the small triangular shaped parcel

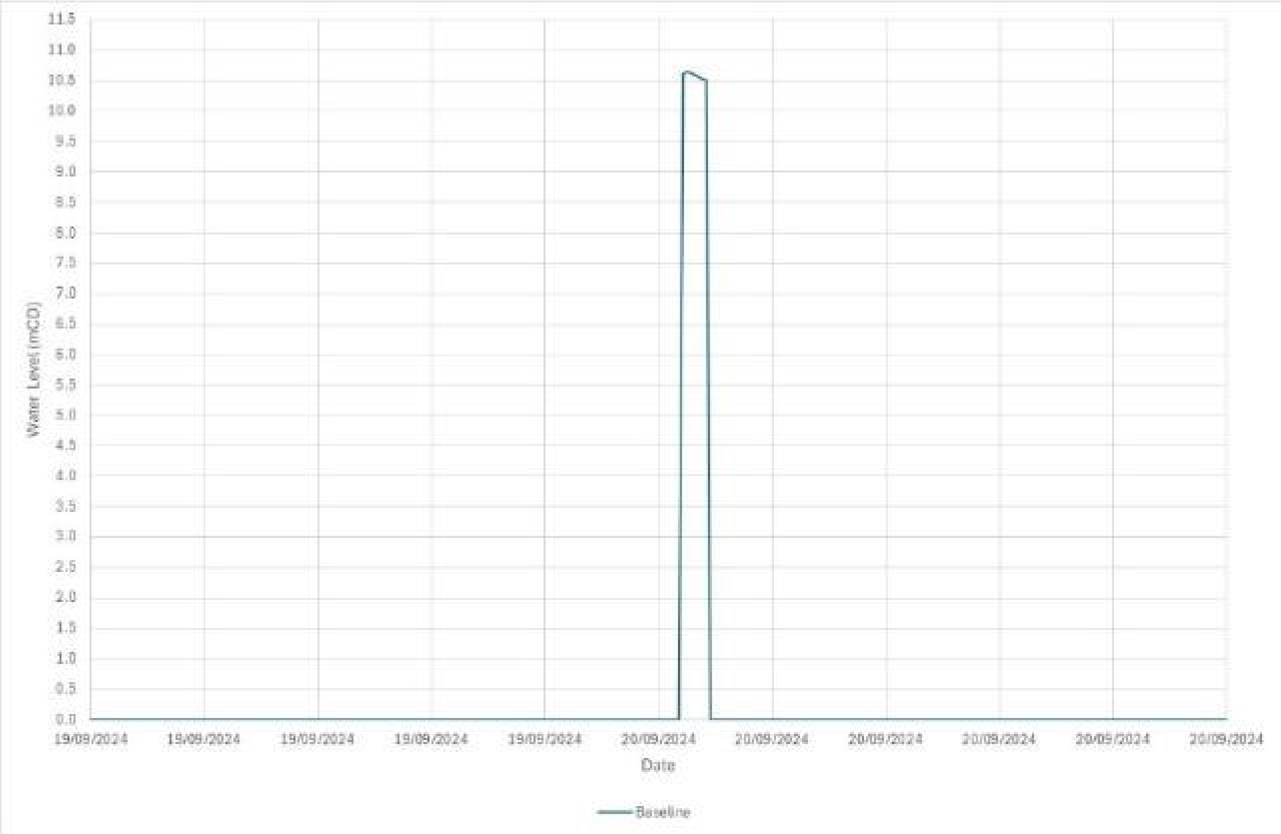

Figure 14 Timeseries of water level at the small triangular shaped parcel of saltmarsh

Natterjack Toad Requirements
It is understood that Natterjack toads breed on upper saltmarsh within shallow pools that are likely to be ephemeral and are highly sensitive to flooding/drying-out.

If these ponds are permanently salty, they will be toxic to spawn and tadpoles but if they are permanently fresh, there will be too many (earlier breeding) competitors/predators.

It is therefore a requirement that the upper saltmarsh pools are inundated during only the highest tides in spring and autumn, but then ‘freshen-up’ due to rainwater in late spring/summer.

This places these habitats at a marginal niche that is sensitive to not only weather-related effects (such as storm surge) but also seasonal or inter-annual variability (e.g. variances in astronomical tidal levels due to seasons or the 18.6-year lunar nodal cycle).

Tidal Level Analysis
Astronomical tidal levels have been modelled at Cockerham Sands over a spring-neap cycle (13th September – 29th September 2024) using the MIKE21 hydrodynamic modelling software from the Danish Hydraulic Institute. This modelling does not include the effects of storm surges, which are meteorological effects.

In addition, astronomical tidal levels have been computed for the nearby port of Heysham (the nearest ‘primary port’ available to Cockerham Sands) using the POLTIPS software from the National Oceanographic Centre. These data have been derived for a period corresponding with the numerical model run in September 2024, as well as for the whole year of 2024 and for a three-year period from the start of 2024 to the end of 2026.

By comparing the modelled output at Bank End (within Cockerham Sands) (see orange and green plots in Figure 15) with the computed output from Heysham for the same time period (see black plot in Figure 15), it can be seen that the high water levels and tidal phasing are broadly similar at the two sites. There is a difference in low water levels because the Heysham gauge is at a location which dries at low tide, whilst the Bank End data is from the outer Cocker Channel, which retains a minimum water depth within its low water channel. The ‘Baseline’ (green) plot of water level at Bank End assumes there is no flow from the River Cocker entering the model domain, whereas the ‘Sensitivity 1’ (green)plot assumes a constant flow from the River Cocker of 1.3m^3/s and so the retained low water level within the channel is higher.

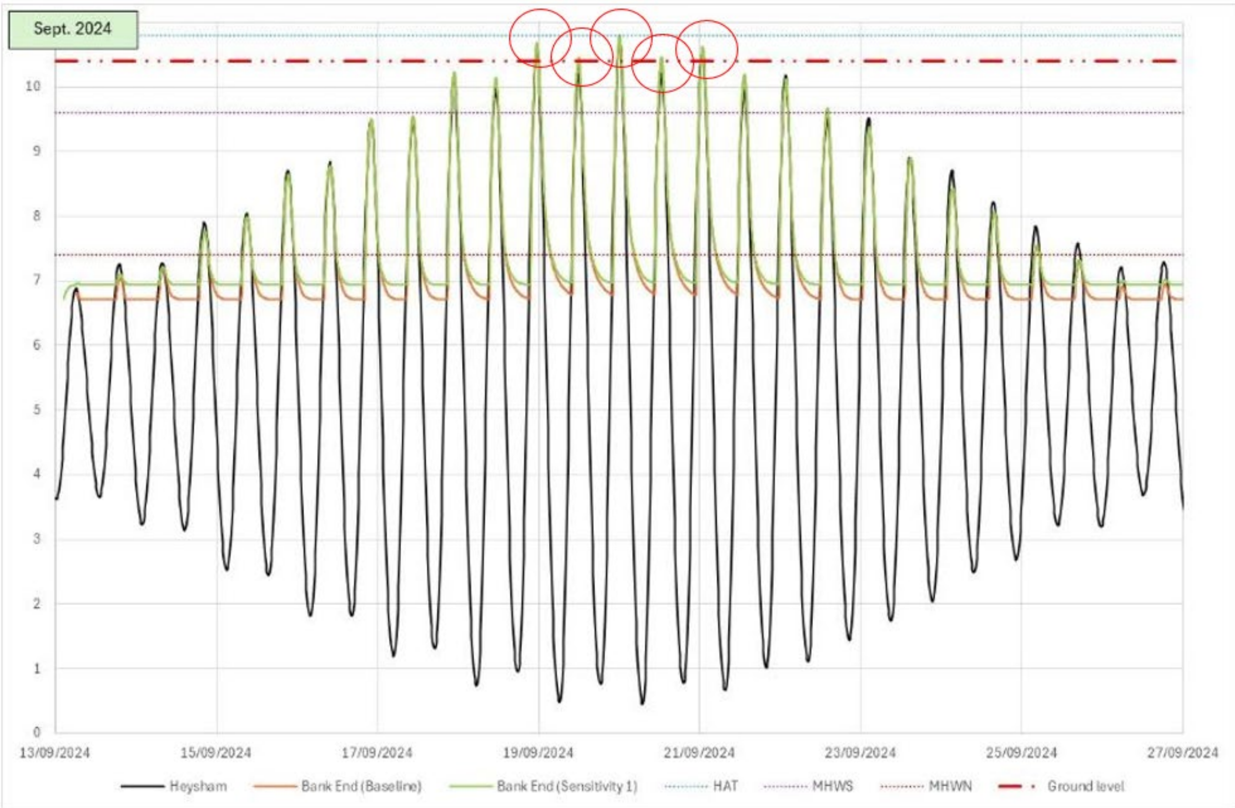

Figure 15 Simulated high and low water levels at Bank End and Heysham in September 2024

It can be seen that within the simulation period, there are some incidences around the highest spring tides (19th and 20th September 2024) when the water levels exceed the ground level (10.4mCD) of the locally high saltmarsh surface (represented by the dashed horizontal red line in Figure 15) and would therefore cause its tidal inundation.

Given that there is good similarity (±0.2m) in high tide levels between Heysham and Bank End, it has been possible to plot a whole year of tidal levels for 2024 using the Heysham data and assess how frequently (and when within that year) tidal levels are likely to exceed the ground level at this point on the saltmarsh. Figures 16 and 17 show that there would likely have been three short periods within which tidal flooding of this section of saltmarsh occurred in spring 2024 (12th February, 12th March and 9th April) followed by a summer with no tidal flooding before a marginal incidence on 22nd August and two subsequent periods within which tidal flooding occurred around 19th September (as modelled) and 18th October. So, in total, there may have been up to six periods within which incidences of tidal inundation of this area of saltmarsh occurred that year (subject to surge effects which may have increased or decreased the number of incidences); up to three in spring, up to three in autumn and with an intervening summer where no flooding is likely to have occurred (subject to surge effects). This seemingly meets the criteria for tidal inundation of a breeding pool during only the highest tides in spring and autumn, with 'freshening-up' due to rainwater in late spring/summer.

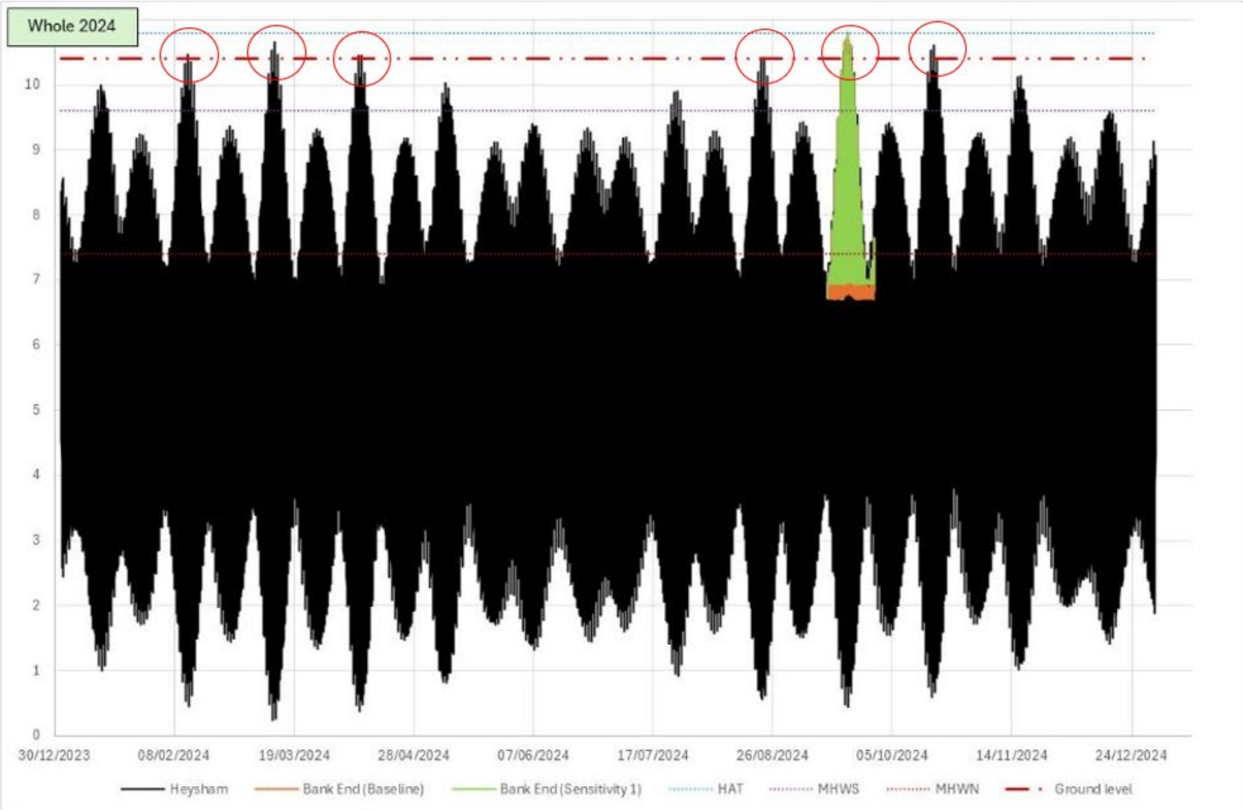

Figure 16 Simulated high and low water levels at Heysham for the whole year of 2024

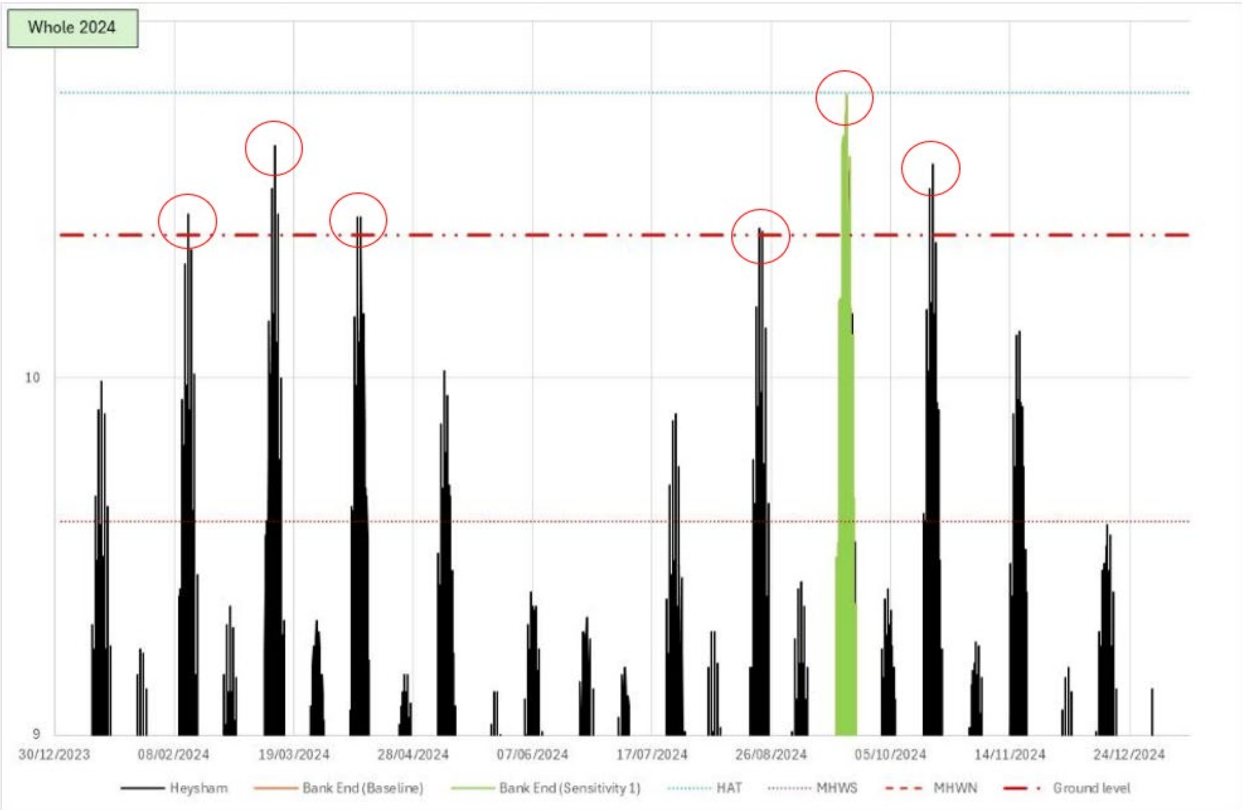

Figure 17 Simulated high (only) water levels at Heysham for the whole year of 2024

However, by way of demonstration of the delicacy of the habitat in such a niche area (at the threshold of occasional but not too frequent tidal inundation) data have also been computed for high water levels (only) at Heysham for the three-year period from 2024 to 2026 inclusive (Figure 18).

This shows that in 2024 there were three periods in spring and three in autumn when tidal levels exceed the saltmarsh level at this location (as previously discussed) as well as two in spring 2025 and one in autumn 2025. However, no high tides reach the threshold level in the year 2026. This is likely to be due to this timing being around the ‘low point’ in the lunar nodal cycle; a phenomenon whereby a small perturbation in the moon’s orbit around the earth can give rise to changes in tidal levels of ±0.3m over a 18.6-year cycle. Whilst this change is small when compared against meteorological effects (storm surge can elevate or depress projected astronomical tidal levels at Cockerham Sands by 1 - 2m), it is nonetheless in excess of the sea level rise that will occur over a similar (19-year) period of time (+0.1m).

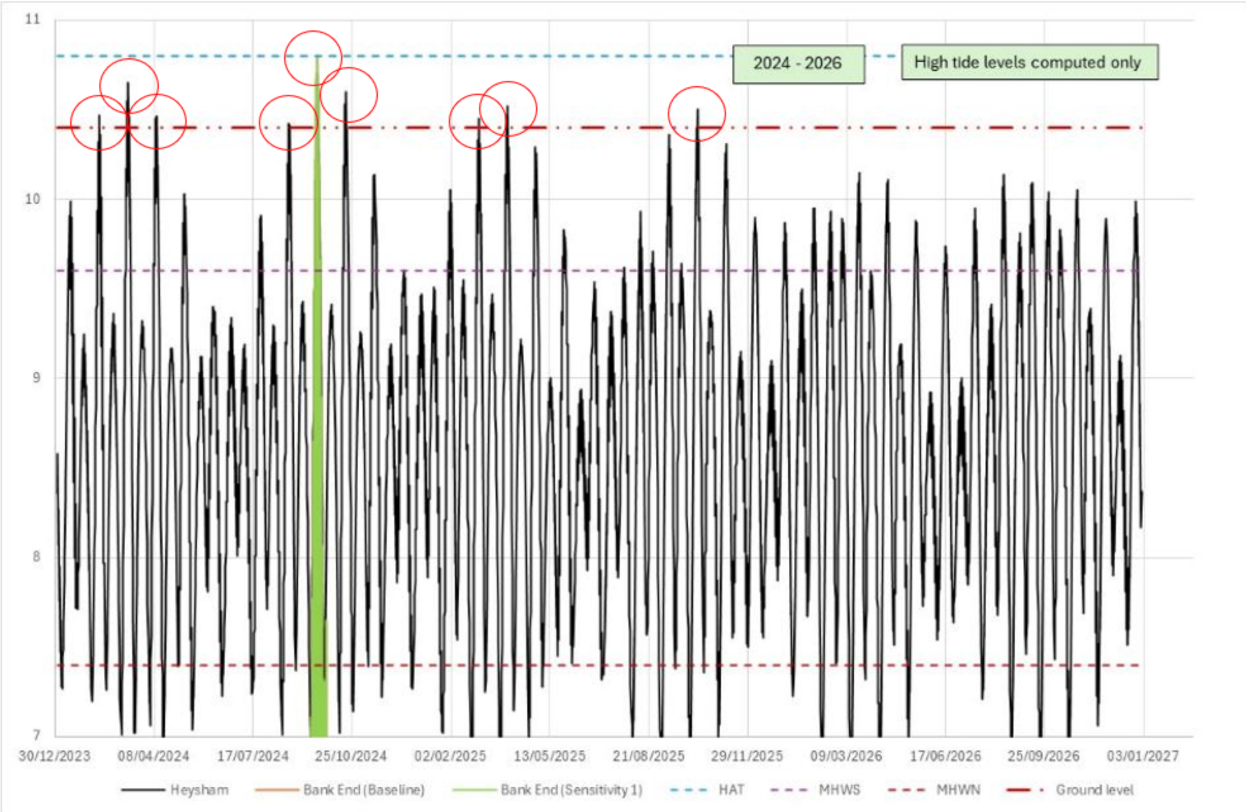

Figure 18 Simulated high (only) water levels at Heysham for the years of 2024, 2025 and 2026

5.4.4.2 Economic Viability

Table 14 outlines the estimated capital costs for constructing pools in the upper saltmarsh. The costs for this option are considerably lower than those associated with other options, reflecting the proportionally smaller benefits it is expected to deliver.

Given the small scale of the intervention, the construction rates have been adjusted to account for the lack of economies of scale. It is unlikely that larger contractors would be interested in such a minor project; therefore, the works are expected to be undertaken by a local contractor or farmers. Pricing from these sources can be less predictable, and there remains a possibility that the works could ultimately be delivered at a lower cost than estimated.

Table 14 Capital cost estimates for constructing pools in the upper saltmarsh

		Option 6: Constructing pools in the upper saltmarsh
Construction Costs		£ 7,350
General Preliminaries	15%	£ 1,103
Contractors Overheads and Profit	15%	£ 1,103
Sub-Total		**£ 9,555**
Design Costs and Investigations	15%	£ 1,433

		Option 6: Constructing pools in the upper saltmarsh
Consenting and permitting	15%	£ 1,433
Contract Admin & Supervision	10%	£ 956
Client Staff Costs	10%	£ 956
Land Compensation		£ -
Biodiversity / Marine Net Gain		£ -
Sub-Total		**£ 4,778**
Contingency	30%	£ 4,300
Total		**£ 18,632**

1. It is assumed there are no land compensation costs associated with this option

2. It is assumed that there are no Biodiversity Net Gain (BNG) or Marine Net Gain (MNG) requirements, although this would need to be confirmed.

5.4.4.3 Environmental Acceptability

There is potential for pools dug within the parcel of higher surface on the existing upper saltmarsh to enhance biodiversity in this presently rank area and provide a habitat that may become suitable for Natterjack toad breeding. However, the area involved is relatively small and may be below a critical *de minimus* size for either intervention (cost-effectiveness) or success (small somewhat and isolated niche habitat). It may be more appropriate to combine this option with one of the options for restoring tidal processes to the SSSI to provide a wider network of connecting habitat between the site and surrounding areas of upper saltmarsh (although this would obviously incur greater costs).

Furthermore, any such pools at this location (or indeed in any potentially suitable upper saltmarsh location) are subject to the vagaries of weather, including storm surge which may flood the pools with tidal water at times when it is not desired, or drought which may result in the pools drying-out during the summer periods.

Such pools, being at a very precarious niche could not necessarily be guaranteed to become successful. There might be some years (towards the trough of the lunar nodal cycle) when insufficient tidal inundation occurs during spring and other years (towards the peak of the lunar nodal cycle in the 2030s or when storm surges occur) when tidal flooding occurs too frequently including during the breeding period. Furthermore, over time, the success or otherwise of the site as a breeding area would depend on the balance between sea level rise and natural sedimentation on the saltmarsh surface. It is entirely possible that any dug pools will relatively rapidly re-fill with marine silt after tidal levels are reached which flood the pools. This would require ongoing maintenance (silt clearance) of these ponds, with associated cost and resource demands.

5.4.5 Summary of Options for Improving the Condition of Cockerham Marsh SSSI

The principal aspect of improving the condition of Cockerham Marsh SSSI for its Natterjack toad interest feature is getting occasional tidal inundation of the site during spring (and autumn) equinox tides, but with the site remaining unaffected by tidal inundation throughout the intervening summer breeding period.

It is technically feasible to achieve this through modifying the flood embankment (Option 2) by either: (i) removing the embankment (Option 2a); (ii) breaching the embankment (Option 2b); or (iii) lowering the embankment crest to form a notch weir (Option 2c). It is also possible to achieve this, with a greater degree of control but a corresponding greater degree of management commitment, through Regulated Tidal Exchange (Option 3). The critical determining factors in selection of the preferred option are: (i) capital cost; (ii) extent of engineering intervention in the natural landscape setting; (iii) degree of desired management 'control' over inundation frequencies; (iv) ongoing maintenance and management requirements. Given that **Option 3 - Regulated Tidal Exchange** has the greatest degree of control and the lowest capital costs, that is likely to be the preferred option although it also has greatest operational and maintenance requirements on an ongoing basis. This option also potentially has the greatest sustainability, given sea level rise, as inundation can be controlled whereas it cannot be for Option 2 that involves modification of the flood embankment.

However, the tidal restoration of tidal processes to the site is not an absolute determiner of success and ongoing ecological management and maintenance of the SSSI for the benefit of its sole key interest species would still be required. This is demonstrated through an analysis of the breeding history success of Natterjack toads at Cockerham Marsh SSSI, based upon records kindly provided by Natural England, which date back to 1969. This is a 57-year period up to and including 2025.

Over this period, records have been reviewed for 44 years (assuming that from 2010 to 2025 it can be stated that no natterjack toads have been present and thus included in the results). In the remaining 13 years, either no records exist or breeding status is unclear in the record.

The timeseries in Figure 19 shows the years in which breeding by Natterjack toads was successful (positive bars on the y-axis) or unsuccessful (negative bars on the y-axis).

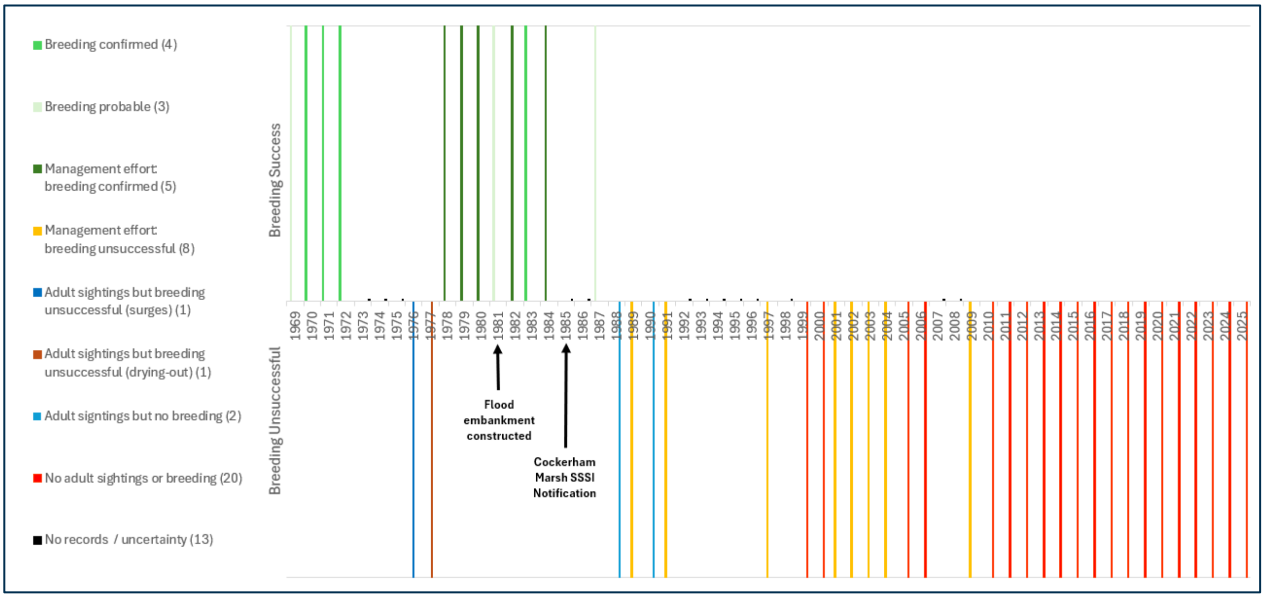

Figure 19 Natterjack toad breeding success or failure from 1969 to 2025

It can be seen that across the 13 breeding seasons prior to construction of the flood embankment in September 1981, all 10 years for which records exist show that probable or confirmed breeding occurred (no records were available for 3 years).

However, in two of those years, breeding did not lead to successful metamorphosis into toads as the pools were either submerged by surge tides and become too saline (1976) or dried-out (1977), killing the spawn or tadpoles.

Furthermore, management intervention was recorded to be necessary in three years (1978, 1979 and 1980) when breeding was recorded as being successful, to collect and transfer spawn or tadpoles from ponds that were drying out to others that were retaining water. In one of those years (1980), reference is made to tadpoles being 'reared' (presumably off-site) and released after ponds dried-up.

After the flood embankment was built in September 1981, probable or confirmed breeding occurred in four of the subsequent six breeding seasons to 1987 (with no records in 1985 or 1986). Two of these years (1982 and 1984) required management intervention to collect and transfer spawn or tadpoles from ponds that were drying out to others that were retaining water.

The year 1987 is stated to be "the last time that natterjack toads were known to have bred on the SSSI Site", however the record also says "Tadpoles were noted and a few probably completed metamorphosis" so it has been considered as a probable breeding season in this analysis. If this year did not record success, then the last confirmed record is actually in 1984 (when management intervention was necessary to ensure success).

Despite considerable and concerted management effort involving sea water top-up, vegetation clearance, pond scraping, new pond construction (with liners), and spawn translocation from other sites, no further sightings of Natterjack toads, their tadpoles or spawn have been made on the Cockerham Marsh SSSI since 1987. Instead, there has been reference to ponds becoming subject to substantial filamentous algae growth float grass and pondweeds.

The most recent site survey (undertaken on 2nd September 2025 as part of this investigation) showed considerable terrestrial vegetation and scrub on the site, the pools were dry and, as expected due to the unconducive habitat, no natterjack toads were found.

The above analysis indicates the niche occupied by suitable breeding habitat for Natterjack toads on upper saltmarshes is highly sensitive to tides (requiring some inundation in spring, but no inundation during breeding periods through the summer) and weather (storm surge or drought). The tolerances that need to be adhered are finer than the magnitude of (small) changes that occur cyclically across natural systems (lunar nodal cycle) and many of these natural factors which can determine success or failure of breeding are not controllable through management intervention.

Ultimately, the habitat and conditions suitable for Natterjack toad breeding are extremely niche. These can successfully be re-created on the SSSI, but not without considerable engineering intervention. Whether the high costs for delivering the options and ongoing high levels of operation and maintenance intervention are deemed proportionate to the low confidence levels of ongoing successful outcome is the critical consideration for the Project Steering Group.

6 Preferred Restoration Management Option(s)

Following the options appraisal in section 5 (supported by numerical modelling from Task 2b), the initial preferred restoration management options are:

Issue / Opportunity	Initial Preferred Restoration Management Option	Comments
Managing Flood Risk at Bank End Farm	Bank End Option 1 – Do nothing	Continued monitoring to review saltmarsh erosion / channel alignment and inform updated assessment and management of flood risk to Bank End Farm (and wider Thurnham Peninsula).
Re-naturalising the Tidal Cocker Channel	Tidal Cocker Channel (TCC) Option 1 – Do nothing	Intervention could increase flood risk in the lower Cocker catchment due to tide-locking or increase ebb flows in the Outer Cocker Channel in the vicinity of Bank End Farm.
Improving the condition of Cockerham Marsh SSSI	Cockerham Marsh SSSI Option 3 - Regulated Tidal Exchange	Option 2 (Modify the Flood Embankment) would also be effective but more costly. Requires a set-back flood embankment around the SSSI's perimeter. Requires some local earthworks for land levelling to optimise tidal connectivity between pools and ponds within the SSSI. Requires a notable operational and management commitment to operate the winchable flap valve in advance of suitable tides. Clearance of siltation in front of the flap value may require a 'non-navigational clearance dredging (for operational purposes)' self-service Marine Licence from the MMO. Restoration of tidal processes alone is not an absolute determiner of success and ongoing ecological management and maintenance of the SSSI for the benefit of its sole key interest species would still be required.

These initial preferred options were discussed at the Project Steering Group meeting on 2nd December 2025. It was agreed that whilst RTE was technically an achievable option for restoring tidal processes to the Cockerham Marsh SSSI, there would be too great residual uncertainty regarding the success (or otherwise) of Natterjack toad breeding to warrant the costs associated with its progression. Furthermore, the assumptions in this report about the set-back flood embankment being located beyond the boundaries of the SSSI would need to be revised, moving the footprint of the embankment to within the SSSI and therefore notably reducing the potential habitat area available for restoration. It was therefore decided that no restoration option would be taken forward to detailed design.

7 Knowledge and Data Gaps

Notwithstanding the Project Steering Group's decision not to take forward any restoration options for improving the condition of Cockerham Marsh SSSI, it is useful to summarise what future next steps would be needed should this position change in the future. Under such a circumstance, it would be necessary to:

- Explore existing **land ownership** in the areas adjacent to the SSSI, to see whether a set-back flood embankment could be constructed to minimise land-take within the SSSI itself. Land ownership in these areas has potential implications on:
    - Purchase / compensation costs;
    - Delivery timescales.

- Explore **land purchase** of the SSSI from the present landowner by the Lancashire Wildlife Trust.

- Investigate the necessary **permissions, licences and consents** (PLCs) that would be required to support the project, including:
    - Planning pre-application advice from the Local Planning Authority (LPA);
    - Planning permission from the LPA (with associated BNG requirements);
    - Marine licence from MMO (with, depending on timelines, potential MNG requirements);
    - Environmental Impact Assessment (EIA) – including EIA screening opinions from the LPA and/or MMO and, if required, subsequent EIA Scoping and Environmental Statement;
    - SSSI consent or SSSI assent (depending on applicant) from Natural England (this is usually incorporated within planning and/or marine licence applications); and
    - Flood risk activity permit from Environment Agency (this is usually incorporated within planning and/or marine licence applications).

- **Soil samples**, with associated laboratory testing to assess geotechnical and chemical suitability for on site re-use.

- **Materials Management Plan** and declaration of intention to use the **CL:AIRE** Definition of Waste Code of Practice (**DoWCoP**) for on site re-use.

- **Topographic survey** – This should be undertaken after scrub and vegetation clearance on the SSSI.

- **Design detailing** of the local land levelling that would be required to re-scrape pools and ponds to a suitable depth and shape and to ensure connectivity of tidal processes between them.

It is noted that the Project Steering Group is leading on ongoing engagement with the local community and key stakeholders.

8 Summary

Following discussion of the draft Optioneering Report and potential restoration options with the Project Steering Group at a Teams workshop on 2nd December 2025, it was agreed that no restoration options would be taken forward to detailed design as part of the present project. Instead, the remaining project timescale would be used to finalise those reports currently in draft status before the end of March 2026.

9 References

Baker, Beebee, Buckley, Gent & Orchard, 2011. The Amphibian Habitat Management Handbook [see Chapter 11 Natterjack Toad and Chapter 12 Translocation and Reintroduction].

Beebee & Denton, 1996. The Natterjack Toad Conservation Handbook.

Haskoning, 2025. Cocker Tidal Channel and Cockerham Marsh SSSI Restoration Investigation. Task 1 – Desk-Based Review and Site Visit. Report to Lancashire Wildlife Trust, Natural England and Environment Agency. Report PC7494-RHD-XX-XX-RP-X-0001, August 2025.

Swift, L., 2013. Tidal Cocker Channel Geomorphological Appraisal. Environment Agency Note dated January 2013, revised May 2013.

Appendix A Option Sketches

DRAWING No.

DO NOT SCALE

NOTES

REV	DATE	DESCRIPTION	BY	CHK	APP

REVISIONS

CLIENT

LANCASHIRE WILDLIFE TRUST
NATURAL ENGLAND
ENVIRONMENT AGENCY

PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

TIDAL COCKER CHANNEL OPTION 3 (TCC-3) - HIGH LEVEL RESTORATION OF TIDAL COCKER CHANNEL

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Enhancing Society Together

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NATURAL ENGLAND
ENVIRONMENT AGENCY

PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

TIDAL COCKER CHANNEL OPTION4 (TCC-4) - FULL RESTORATION OF TIDAL COCKER CHANNEL

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PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

COCKERHAM MARSH SSSI OPTION 2A (SSSI-2A) - MODIFY FLOOD EMBANKMENT: REMOVAL

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PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

COCKERHAM MARSH SSSI OPTION 2B (SSSI-2B) - MODIFY FLOOD EMBANKMENT: BREACHING

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	S4	P01

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PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

COCKERHAM MARSH SSSI OPTION 2C (SSSI-2C) - MODIFY FLOOD EMBANKMENT: CREST LOWERING

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PROJECT

COCKER TIDAL CHANNEL AND COCKERHAM MARSH SSSI RESTORATION INVESTIGATION

TITLE

COCKERHAM MARSH SSSI (SSSI-3) - REGULATED TIDAL EXCHANGE: PIPE AND PENSTOCK CONTROL

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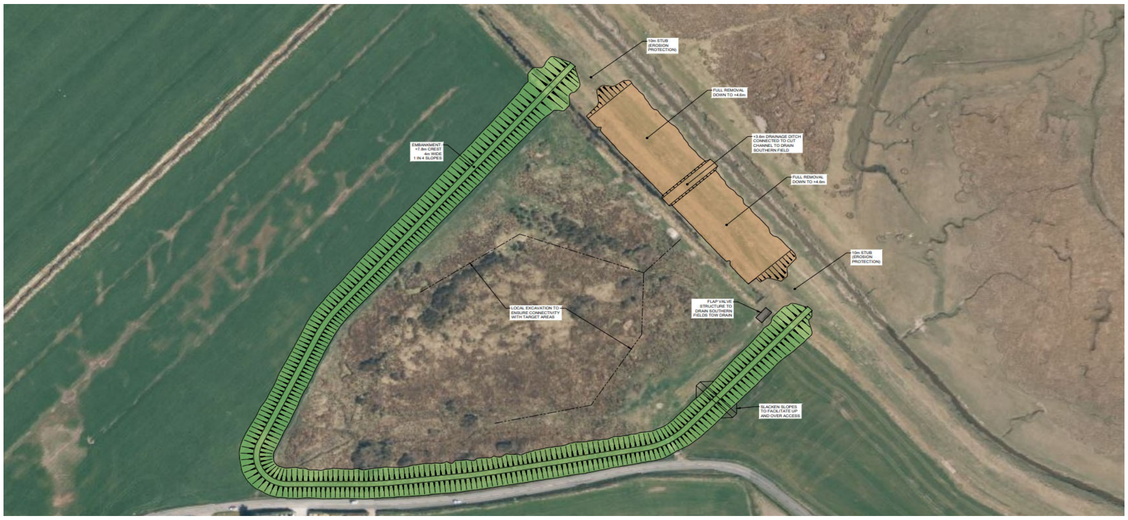
Appendix B Cost Estimates

Option 2a Embankment Removal

Brief Description

Removal of 190m of flood embankment fronting the SSSI. Construction of ~850m set back embankment using a combination of liberated materail and imported material. 1No. Construction of headwall and flapvalve on delph drain pipe.



Item	Description	Quantity	Unit	Rate		Price	
	Element						
1	**Excavation of existing embankment** *Excavation, Handling and Stockpiling*	9500.0	m^3	£	7.50	£	71,250.00
2	**Construction of set back embankment** *Construction only. See Item 3 for materials*	27000.0	m^3	£	7.50	£	202,500.00
3	**Embankment Imported Fill** *Total volume minus won material from breach*	17500.0	m^3	£	40.00	£	700,000.00
4	**Delph Ditch Control Structure** *Installation of headwall and flapvalve onto existing pipework*	1	no	£	10,000.00	£	10,000.00
5	**Local Earthworks** *Excavation of shallow channels to ensure connectivity across site*	100	m^3		7.50	£	750.00
				Sub Total:		**£**	**984,500**
	General Preliminaries				15%	£	147,675.00
	Contractors Overheads and Profit				15%	£	147,675.00
				Sub Total:		**£**	**1,279,850**
	Design Costs and Investigations				~5%	£	85,000.00
	Consenting and Permitting				~5%	£	85,000.00
	Contract Admin & Supervision				~10%	£	165,000.00
	Client Staff Costs				~10%	£	165,000.00
	Land Compensation ***(Embankment Footprint Only***)				-	£	21,000.00
	Biodiversity Net Gain				-	£	10,000.00
				Sub Total:		**£**	**1,810,850**
	Contingency				30%	£	543,255.00
				Sub Total:		**£**	**2,354,105**

Option 2b Embankment Breach

Brief Description

Removal of ~40m of flood embankment fronting the SSSI. Construction of ~850m set back embankment using a combination of liberated materail and imported material. 1No. Construction of headwall and flapvalve on delph drain pipe.

Item	Description	Quantity	Unit	Rate		Price
	Element					
1	**Excavation of existing embankment** *Excavation, Handling and Stockpiling*	1500.0	m^3	£	7.50	£ 11,250.00
2	**Construction of set back embankment** *Construction only. See Item 3 for materials*	27000.0	m^3	£	7.50	£ 202,500.00
3	**Embankment Imported Fill** *Total volume minus won material from breach*	25500.0	m^3	£	40.00	£ 1,020,000.00
4	**Delph Ditch Control Structure** *Installation of headwall and flapvalve onto existing pipework*	1	no	£	10,000.00	£ 10,000.00
5	**Local Earthworks** *Excavation of shallow channels to ensure connectivity across site*	100	m^3		7.50	£ 750.00

Sub Total:		**£ 1,244,500**
General Preliminaries	15%	£ 186,675.00
Contractors Overheads and Profit	15%	£ 186,675.00
Sub Total:		**£ 1,617,850**
Design Costs and Investigations	~5%	£ 85,000.00
Consenting and Permitting	~5%	£ 85,000.00
Contract Admin & Supervision	~10%	£ 165,000.00
Client Staff Costs	~10%	£ 165,000.00
Land Compensation ***(Embankment Footprint Only***)	-	£ 21,000.00
Biodiversity Net Gain	-	£ 10,000.00
Sub Total:		**£ 2,148,850**
Contingency	30%	£ 644,655.00
Sub Total:		**£ 2,793,505**

<u>Option 2c</u> Notched Weir

<u>Brief Description</u>

40m long embankment lowering / notched weir fronting the SSSI. Construction of ~850m set back embankment using a combination of liberated materail and imported material. Construction of 2No. Control strucutre on the delph drain (headwall and flapvalve)

Item	Description	Quantity	Unit	Rate	Price
	Element				
1	**Excavation of existing embankment (Notching)** *Excavation, Handling and Stockpiling*	1000.0	m^3	£ 7.50	£ 7,500.00
2	**Erosion Control for Spilllway** *Rip Rap Stone*	1	no.	£ 10,000.00	£ 10,000.00
3	**Construction of set back embankment** *Construction only. See Item 3 for materials*	27000.0	m^3	£ 7.50	£ 202,500.00
4	**Embankment Imported Fill** *Total volume minus won material from breach*	26000.0	m^3	£ 40.00	£ 1,040,000.00
5	**Delph Ditch Control Structure(s)** *Installation of headwall and flapvalve onto existing pipework*	2	no	£ 10,000.00	£ 20,000.00
6	**Local Earthworks** *Excavation of shallow channels to ensure connectivity across site*	100	m^3	7.50	£ 750.00
				Sub Total:	**£ 1,280,750**
	General Preliminaries			15%	£ 192,112.50
	Contractors Overheads and Profit			15%	£ 192,112.50
				Sub Total:	**£ 1,664,975**
	Design Costs and Investigations			~5%	£ 85,000.00
	Consenting and Permitting			~5%	£ 85,000.00
	Contract Admin & Supervision			~10%	£ 165,000.00
	Client Staff Costs			~10%	£ 165,000.00
	Land Compensation ***(Embankment Footprint Only***)			-	£ 21,000.00
	Biodiversity Net Gain			-	£ 10,000.00
				Sub Total:	**£ 2,195,975**
	Contingency			30%	£ 658,792.50
				Sub Total:	**£ 2,854,768**

Option 3a Regulated Tidal Exchange

Brief Description

Construction of control structure through embankment, 2No headwalls, 1No flap valve and 1No penstock. Construction of ~850m set back embankment using imported material, reduced crest height as pilling embankment remains. 1No. Construction of headwall and flapvalve on delph drain pipe.

Item	Description	Quantity	Unit	Rate	Price
	Element				
1	**Main RTE Control Structure** *Installation of 2No headwalls, 1No flap valve, 1No penstock.*	1	no	£ 80,000.00	£ 80,000.00
2	**Construction of set back embankment** *Reduced crest height +6.0mOD Construction only. See Item 3 for materials*	4000.0	m^3	£ 7.50	£ 30,000.00
3	**Embankment Imported Fill**	4000.0	m^3	£ 40.00	£ 160,000.00
4	**Delph Ditch Control Structure** *Installation of headwall and flapvalve onto existing pipework*	1	no	£ 10,000.00	£ 10,000.00
5	**Local Earthworks** *Excavation of shallow channels to ensure connectivity across site*	100	m^3	7.50	£ 750.00
				Sub Total:	**£ 280,750**
	General Preliminaries			15%	£ 42,112.50
	Contractors Overheads and Profit			15%	£ 42,112.50
				Sub Total:	**£ 364,975**
	Design Costs and Investigations			15%	£ 54,746.25
	Consenting and Permitting			23%	£ 82,119.38
	Contract Admin & Supervision			10%	£ 36,497.50
	Client Staff Costs			10%	£ 36,497.50
	Land Compensation ***(Embankment Footprint Only)***			-	£ 21,000.00
	Biodiversity Net Gain			-	£ 10,000.00
				Sub Total:	**£ 605,836**
	Contingency			30%	£ 181,750.69
				Sub Total:	**£ 787,586**

<u>Option 6</u> Construct pools in existing upper saltmarsh

<u>Brief Description</u>

Excavation of small pools in the upper saltmarsh opposite the SSSI.

Item	Description	Quantity	Unit	Rate	Price
	Element				
1	**Excavation of Pools**	105	m^3	£ 40.00	£ 4,200.00
	3No. 10m x 10m x 0.3m deep pools				
	Rate inflated due to lack of economies of scale.				
2	**Disposal of excavated material**	105	m^3	£ 30.00	£ 3,150.00
	Assume 100% of excavated material is to be offhauled				
				Sub Total:	**£ 7,350**
	General Preliminaries			15%	£ 1,102.50
	Contractors Overheads and Profit			15%	£ 1,102.50
				Sub Total:	**£ 9,555**
	Design Costs and Investigations			15%	£ 1,433.25
	Consenting and Permitting			15%	£ 1,433.25
	Contract Admin & Supervision			10%	£ 955.50
	Client Staff Costs			10%	£ 955.50
	Land Compensation			-	£ -
	Biodiversity Net Gain			-	£ -
				Sub Total:	**£ 14,333**
	Contingency			30%	£ 4,299.75
				Sub Total:	**£ 18,632**