Case study 57. Rhymney Great Wharf

Author: Huw Alford

Main driver: Improved defence and habitat enhancement

Project stage: Constructed 2005

Photo 1: Rhymney wharf flood embankment post 3 January 2014 tidal event (8.03m above Ordnance Datum at Newport 2 gauge)

Project summary:

The Severn Estuary foreshore has international importance, reflected by the following designations: Site of Special Scientific Interest (SSSI), Special Protection Area (SPA), possible Special Area of Conservation (pSAC) and Ramsar. The site itself is located seaward of the Wentlooge Sea Defences, where the upper, vegetated saltmarsh is referred to as the 'wharf' and the lower unvegetated foreshore as the 'mudflats'.

The Wentlooge Sea Defences (Map 1) protect an area of low-lying land, of which approximately 32km^2 lies below mean high water springs (MHWS). The wharf acts as part of the sea defence by reducing the incident wave energy on the embankments themselves.

Study of the foreshore highlighted that the wharf had been eroding locally at a fairly constant rate over a long period. In 2003, pockets of erosion were in close proximity to the flood defence embankment and as such continued erosion was predicted to undermine the embankment by the year 2008. As an immediate mitigation against further erosion of the wharf, thus protecting the defences, it was decided to use harder, more traditional engineering in the form of blockstone and rip-rap. As a longer term strategy, polder were used in an effort to regenerate the mudflats and increase protection to the wharf scarp.

Key facts:

The works that were carried out have effectively stopped/slowed the erosion of the wharf, thus:

- maintaining the ecologically important land
- preventing the undermining of the defences and maintaining their function
- protecting ~30km^2 of agricultural land, business and numerous communities within the Wentlooge Levels

Map 1: Location of Rhymney Great Wharf (source: MyMap, accessed 6 January 2017)

1. Contact details

Contact details	
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Partners:	Natural Resources Wales (Environment Agency Wales), Atkins
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2. Location and coastal/estuarine water body description

Coastal/estuarine water body summary	
National Grid Reference:	ST 24254 78170
Town, County, Country:	Cardiff, Glamorgan, Wales
Regional Flood and Coastal Committee (RFCC) region:	South Wales
Water Framework Directive water	GB 10905602770

body reference:	
Land use, geology, substrate, tidal range:	Agricultural Mercia mudstone group beneath tidal flat deposits Tidal range: nearly 15m

3. Background summary of the coastal/estuarine water body

Socioeconomic/historic context

Rhymney (or Rumney) Great Wharf forms part of the seaward boundary of the Wentlooge Levels that lie between the east of Cardiff and the west of Newport. The land of the Wentlooge Levels is primarily used for agriculture, although there are a couple of industrial/business sites and numerous historic communities. The Levels consist of reclaimed land that is believed to have been created by the Romans. Sea defences of sorts are thought to have existed in some form since this time.

Flood and coastal erosion risk management problem(s)

The centuries' long existence of the sea defences demonstrates the well-known and ongoing flood risk posed to the area from tidal flooding. Much of the risk is owed to the Bristol Channel famously having the second highest tidal range in the world. The low-lying land of the levels behind the defences is also at risk from fluvial/surface water flooding from the many drainage channels that were originally created to drain and claim the land from the channel. No tidal flooding has been recorded at the Rhymney Great Wharf area in recent history. However, the risk remains high and the importance of the sea defences has recently been highlighted by a succession of very high tidal events where water levels were seen to get to within 500mm of the embankment crest. With the predicted increase in tidal levels associated with climate change, both tidal levels and wave energy are expected to increase – further increasing the tidal flood risk to the area. Furthermore, increased rainfall linked with climate change will also see an increased risk from fluvial and surface water flooding to the land behind the defences.

The largest issue at present, and in to the indefinite future, is the risk of tidal flooding through overtopping of the defences and via a breach in the defences that could result from the erosion of the wharf. The prevention of erosion and, where possible, the reinstatement of the wharf and the mudflats on the seaward side of the defences is integral to the long-term integrity of the existing defences and, in turn, the successful management of flood risk management to the area.

Other environmental problems

The Severn Estuary foreshore has international importance, reflected by its designations as an SSSI, SPA, pSAC and Ramsar site. As a result, any works to the area need to be very sympathetic to the ecology and appropriate permissions, consents and assents are required.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood and coastal erosion risk management problem(s) and solution(s)

The erosion of the wharf had been known to be an issue for many years and monitoring of the position of the wharf scarp had shown a rapid retreat in the decade before the work began. Following a period of high tides and storm events, the erosion had reached a position where the defences were at a high risk of a breach and sections of the seaward face had begun to slip. Environment Agency Wales sought the expertise of consultants, Atkins, to assess the erosion issue of the wharf and the mudflats that were affecting the integrity of the flood embankments. Information was gained via from past monitoring data, consultation with stakeholders (Environment Agency Wales, Countryside Council for Wales), desktop

studies, walkovers and ground investigation works. Atkins was commissioned to carry out a pre-feasibility study to assess the justification for any remedial work with the assumption that no intervention would lead to a breach in the defences within 5 years.

What was the design rationale?

The works carried out at Rhymney Great Wharf can be categorised as:

- Short-term measures to stop and prevent further erosion of the wharf to protect the integrity of the defences in the 'immediate' timeframe
- Long-term measures to re-establish the mudflats in front of the wharf to offer natural erosion protection to the defences through energy dispersion

The long-term measures will help to compensate for the high tidal levels and increased wave energy expected with climate change.

At the outset, the short-term work to stop the further erosion of the wharf scarp consisted of just placing geotextile over the eroding face and securing it in place with wooden stakes and stainless steel staples (see Figure 1).

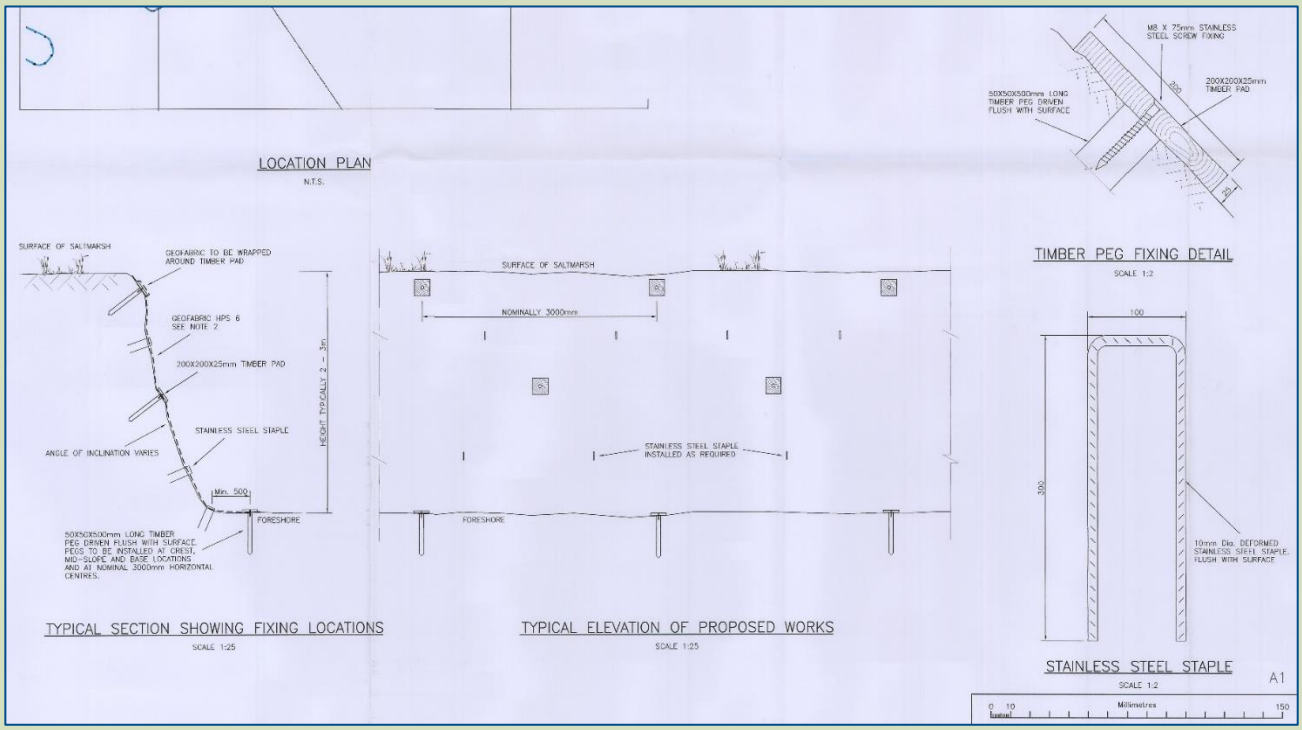


Figure 1: Drawing of the details of the initial short-term erosion protection (source: Atkins)

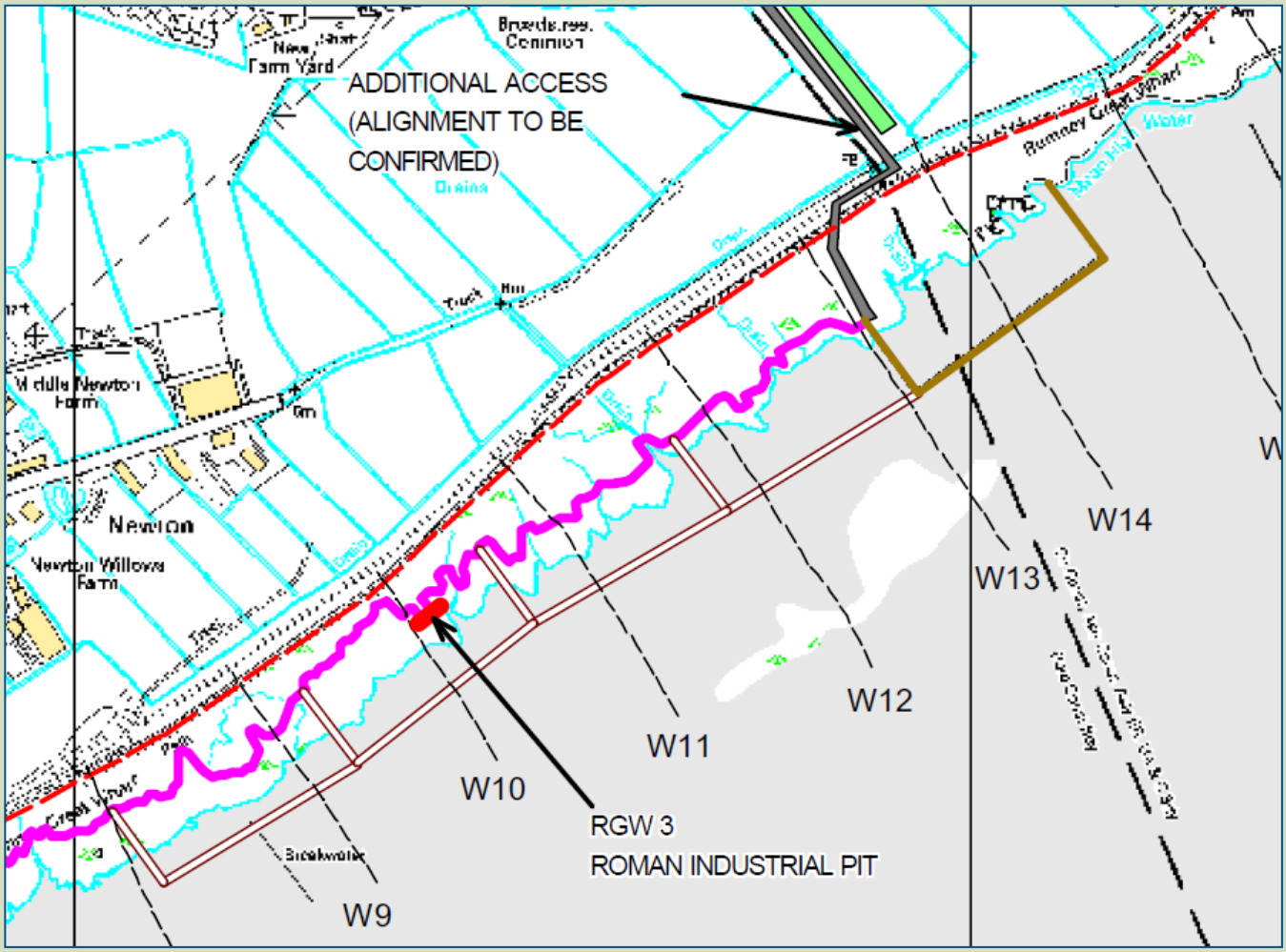
Unfortunately, these measures were not capable of dealing with the tidal energy at the location and after just the first tide of sufficient height to reach the work (3 days after installation) the system failed. It was then decided that harder, more traditional methods would be required in the form of block stone and, at locations of decreased energy, small aggregates were used (that is, rip-rap). Initially the intention was to reinstate/recharge the mudflats via direct placement of material dredged from Cardiff Bay. After a detailed study by Atkins on behalf of Environment Agency Wales was carried out into the proposal, however, it was concluded that this method was not suitable for the following reasons.

- The site is too hydrodynamically exposed to guarantee medium- to long-term success of dredged material placement.
- The polder areas are naturally accreting without any intervention and alternative eroding sites, such as Little Wharf further south of Rumney, may be a more appropriate focus.
- There could be a significant environmental impact in placing aqueous or dewatered material on the

foreshore.

- Economically, the cost of de-watering dredged material far outweighs the current combined maintenance, dredging and disposal costs.

Because of the accreting nature of the area, the favoured option was to attempt to encourage increased deposition of material through the use of rows of larch stakes infilled with willow faggots placed in twin rows parallel and perpendicular to the coast to create 'cells' (see Map 2).



Map 2: Layout of the larch stakes/willow faggots on the site shown by brown parallel lines, with the alignment of the block stone protection to the wharf scarp shown as a pink line (source: Atkins 2006)

Project summary	
Area of transitional and coastal water body or length benefiting from project:	~32km^2
Types of measures/interventions used (Working with Natural Processes and traditional):	Both traditional hard engineering in the form of block stone and rip-rap along with Working with Natural Processes (WWNP) in the form of polders and use of geotextile
Numbers of measures/interventions used (Working with Natural Processes and traditional):	There were 3 main measures used in the project: • Lining of the wharf scarp with geotextile and covering with appropriate sized block stone along around a 1.5km length

	• Lining of the eroded channels and infilling with block stone and rip-rap at required sites Use of 2 rows of 3m long tantalised larch stakes at 600mm centres, rows 300mm apart driven 1.5m into the mudflat level, with willow bundles between to a height of 1m. This work was an attempt to capture sediment to reinstate the higher level of the mudflats and was carried out over a total length of ~2km.
Standard of protection for project as a whole:	The existing defences were built to a 1 in 200 year standard of protection (thought to be about 1 in 140 year with current sea levels). The works carried out have acted to maintain this standard of protection. A percentage attributed to the WWNP cannot really be quantified.
Estimated number of properties protected:	Rhymney Great Wharf and the defences benefit the entire Wentlooge area (~32km^2). The pre-feasibility report states that 1,751 residential properties and 223 non-residential properties are protected (Chung 2006).

How effective has the project been?

The success of the project as a whole is divided.

- The short-term measure to stop the erosion using geotextile covered with block stone has been a success. The retreat of the wharf scarp alignment has effectively stopped and, at present, the integrity of the defences remains. Further erosion has been very minimal; in the 12+ years since installation there have been isolated losses of up to 500mm around some of the block stones at the top of the wharf scarp in a few of the more exposed locations.
- Long-term measures to re-establish the mudflats in front of the wharf have been less successful. No notable accretion has been seen, albeit no real further loss.

5. Project construction

How were individual measures constructed?

The drawing in Figure 2 shows how the more traditional and 'hard' engineered scarp protection was constructed. Photo 2 shows the scrap protection after construction in 2005 and again in 2010.

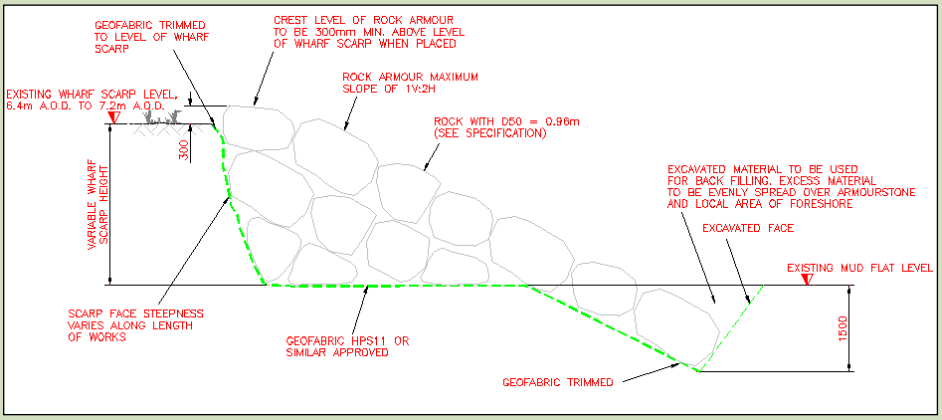


Figure 2: Construction drawing for scarp protection (source: Atkins)

Photo 2: Post construction in 2005 (left) and 2010 (right) (source: Natural Resources Wales)

The block stone revetment was designed to withstand and disperse the wave energy, while the geotextile was to help prevent washout of the fine wharf material.

A small amount of excavation was carried out on the mudflats in front of the scarp toe, grading it down to ~1,500mm into the mud. A geotextile was simply laid flat over the face of the scarp and the mud, before being pinned with steel staples to temporarily hold it in place where required. Block stone was then placed directly on top of the geotextile and built up to form a revetment. The toe of the revetment, due to the excavation, was lower than the level of the mudflat and the interface between them was backfilled with excess material.

A similar method was used for the eroded channels that had formed along the top of the wharf, only using smaller aggregate as protection (see drawing in Figure 3).

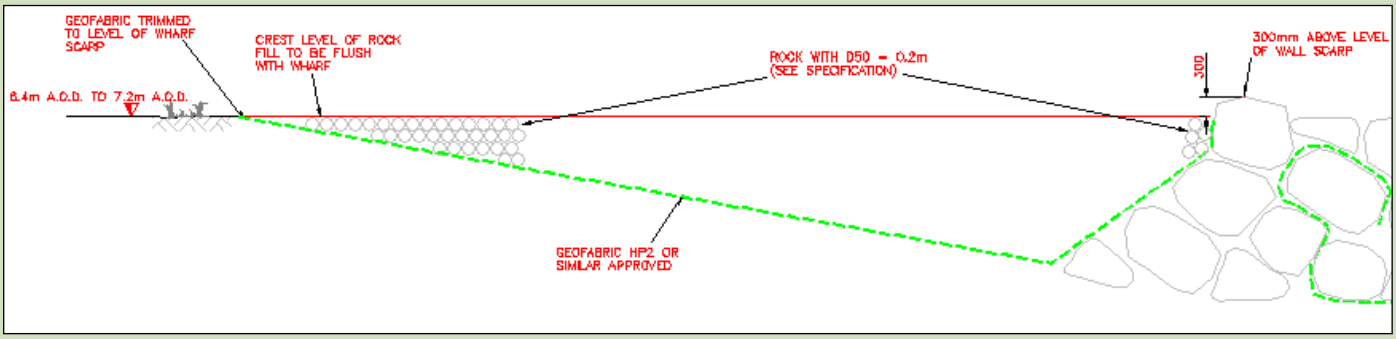


Figure 3: Construction drawing for channel erosion protection (source: Atkins)

The attempt to encourage silt deposition and allow regeneration of the wharf and increase erosion protection to the wharf scarp was made by placing 2 rows of 3m long tanalised larch stakes at 600mm centres, rows 300mm apart driven 1.5m into the level of the mudflat. Willow bundles were then placed in between the stakes to a height of 1m. The construction drawings are shown in Figure 4.

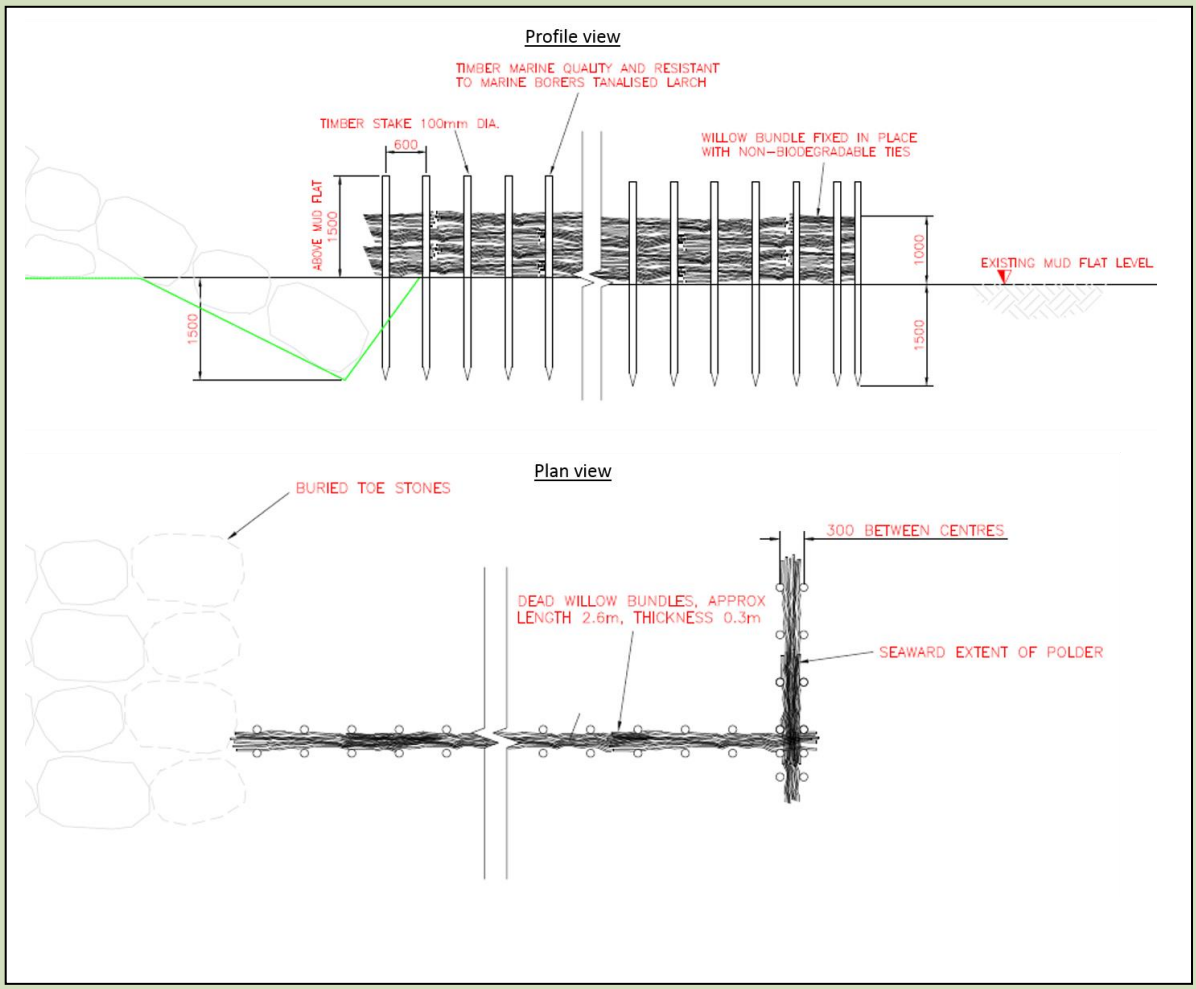


Figure 4: Construction drawing for polders (source: Atkins)

How long were measures designed to last?

No timescale was given to the life of either of the works carried out. It was suggested by the designers that the works be closely monitored, with inspections being carried out after high tidal events and storms in addition to the annual inspections to check for movement, damage and any erosion issues. If issues were found then the appropriate remedial work should be carried out so that the assets could continue to function as designed.

Considering the location and the materials used for the works, a realistic life of around 20 years would be expected.

Were there any landowner or legal requirements which needed consideration?

The Severn Estuary foreshore has international importance, reflected by its designations as a SSSI, SPA, pSAC and Ramsar site. As a result, the works to the area needed assent from the Countryside Council for Wales in addition to a flood defence consent.

Due to the history of the area and the presence of ancient monuments and sites, it was necessary to consult both Cadw and the Glamorgan and Gwent Archaeological Trust.

As the land required for both access and works is third party owned, the project also involved negotiations with the landowner. These were carried out through land agents.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed:	2005
How was the project funded:	Capital project with flood and coastal risk management (FCRM) funding via the Welsh Government
Total cash cost of project (£):	£3.4 million
Overall cost and cost breakdown for WWNP/NFM measures (£):	Rocking armouring of new slope to protect scarp: £1,480,000 Construction of polders: £190,000
WWNP/NFM costs as a % of overall project costs:	Rock armouring: 43.5% Polders: 5.6%
Unit breakdown of costs for WWNP/NFM measures:	Information not available
Cost–benefit ratio (and timescale in years over which it has been estimated):	Cost benefit of 24 based on a 100 years' timescale – present value of the deliverable (PVD) estimates of nearly £77 million. This figure was based on the benefits against the 'do nothing' baseline figure where a breach of the defences was assumed in year 4, therefore resulting in frequent flooding of the Wentlooge Levels.

7. Wider benefits

What wider benefits has the project achieved?

No wider benefits have been linked to the project.

How much habitat has been created, improved or restored?

The prevention of further retreat of the alignment of the scarp means that the project has effectively maintained the wharf habitat.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

The required asset maintenance requirements were included by the designer in the health and safety file (Atkins 2005). These included a biannual walkover of the scheme and additional asset inspections following any significant tidal events or storms. The consultant also provided a list of inspections that should be carried out during each site visit with information on:

- what the signs of damage/degeneration are
- the consequence
- the required works to remediate the issue

At present there are no planned maintenance activities for the site and significant issues are dealt with as and when deemed necessary.

In the years since completion, very little damage has been caused to the stone revetment. However, the wood stakes and faggots of the polders have suffered a reasonable amount of damage, the major issue being the loss of willow material from in between the stakes. Although the required remedial work for such issues was stated in the health and safety file, no work has been carried out on the asset to repair the damage caused. This may be a reason why no real accumulation of mud has been seen on the mudflats.

Is the project being monitored?

In the first 3–4 years after completion of the project, the site was monitored as suggested by the designer. However, the site has only been inspected in recent years as part of the annual inspection programme.

Has adaptive management been needed?

Nothing to date – no real maintenance has taken place.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

The design of the polders used was perhaps unsuitable for the location given the higher energy environment. Greater success may have been achieved if a higher number of parallel rows had been used within each polder field. A point to take away is that it is difficult to generalise parameters for the appropriate use of soft engineering/NFM methods, especially in higher energy coastal environments. Sites need to be assessed for suitability on an individual basis. There needs to be a greater understanding of the capabilities and limitations of the differing techniques.

The failure of the polder fields to reinstate the mudflats may, in part, be a result of the lack of any annual maintenance work or ad hoc repairs following damage to the asset as specified by the designer. This emphasises the importance of:

- establishing a well though-out maintenance regime for these NFM techniques
- the knowledge and skills within the workforce to carry out such works
- the need to 'set aside' extra revenue for these works during the project design and construction phases

10. Bibliography

ATKINS, 2005. *Rhymney Great Wharf health and safety file*. Prepared for Environment Agency Wales.

Atkins, 2006. *Rhymney Great Wharf polders: environmental report*. Report for Environment Agency Wales.

CHUNG, P., 2006. *Pre-feasibility study. Incorporating dredged material within polders at Rhymney Great Wharf*. Report for Environment Agency Wales.

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Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.