REPORT

Fairbourne Rear Embankment sensitivity of defence standard with Climate Change

Summary Document

Client: Gwynedd Council

Reference: WAT9Y1204R001F0.1

Revision: 0.1/Final

Date: 07 June 2017

Royal HaskoningDHV

Enhancing Society Together

HASKONINGDHV UK LTD.

Rightwell House
Rightwell East
Bretton
Peterborough
PE3 8DW
Water
VAT registration number: 792428892

+44 1733 334455 **T**
+44 1733 262243 **F**
email **E**
royalhaskoningdhv.com **W**

Document title:	Fairbourne Rear Embankment sensitivity of defence standard with Climate Change
Document short title:	
Reference:	WAT9Y1204R001F0.1
Revision:	0.1/Final
Date:	07 June 2017
Project name:	
Project number:	9Y1204
Author(s):	Rachel Jones & Gregor Guthrie
Drafted by:	
Checked by:	Gregor Guthrie
Date / initials:	GG
Approved by:	Rachel Jones
Date / initials:	RJ

Classification
Project related

Disclaimer

Table of Contents

Summary and Implications

1 Background

The West of Wales Shoreline Management Plan (SMP) identifies significant concerns over the medium to long term sustainability of the defence at Fairbourne. There is a clear need to maintain existing defences and reduce flood risk to the area over the short term and this remains the starting point for management.

However, primarily due to climate change, any major increase in protection, specifically with respect to dealing with the potential increase in groundwater levels, flooding from rivers, flooding arising from failure or overtopping of the rear embankment or failure and overtopping of the front facing sea defences, may drive management down an unsustainable route. This would mean that the village would be ever more reliant on defences and as a consequence increasingly vulnerable should any aspect of defence fail. It would also rely on significantly increased levels of funding into the future. For these reasons, the SMP identifies the need for change, with the intent that over the next 40 years we need to decommission the village, such that over this period of time we move to a position that we no longer need to defend.

The present Fairbourne Moving Forward (FMF) project aims to develop how this process of change is managed. It is recognised that there are still important uncertainties that need to be addressed. In particular the need for change is driven primarily by sea level rise. As such, an important aspect of the project is re-examining, in detail, how different aspects of defence will be influenced by climate change – testing the high level assumptions made within the SMP

To this end, a series of studies are being undertaken to look at the implications of sustaining defences over the next 40 years (the project planning horizon up to 2054), examining:

- How defence standards (Standards of Protection (SoP)) might change under different climate change scenarios over that period of time.
- What might then be required to maintain an acceptable SoP in terms of continued investment.
- The degree of flexibility in terms of the 40 year planning horizon – whether this is realistic or whether there may be scope for extending this period.

And also,

- Testing the assumption within the SMP, that costs and risk would increase substantially if we do not plan for change now.

The embankment report, and this summary of that report, considers solely the embankment to the rear of the village. The findings of this report will be drawn together with findings relating to other aspects of risk management in to a final technical document feeding in to the development of the Fairbourne Master Plan.

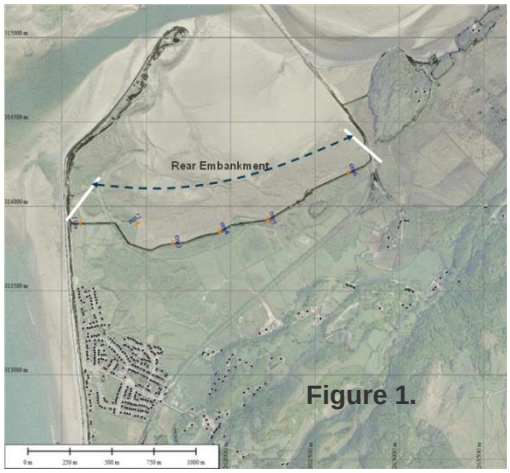


Figure 1.

1.1 The present condition of the embankment.

The embankment runs for around 1,950m to the north of the village, protecting the village from water levels and wave action generated across the estuary (Figure 1). Wave heights within the estuary are obviously substantially less than on the open coast but are still significant in terms of the level of the embankment.

The existing embankment was strengthened and realigned in 2013, in line with the outline design presented in the 2011 Fairbourne Flood Risk Management Scheme Project Appraisal Report (PAR). The main issue prior to this work was the poor condition and generally limited width of the embankment. The works included raising the defence to a consistent level of 5.2m OD and increasing the width at the crest to 5m.

Re-examining this design confirms that, in terms of basic water levels, the embankment provides a SoP with a 0.5% chance of being overtopped (referred to as a T200 year SoP). This includes having a 1m freeboard taking into account the possibility of wave action. In re-examining this, there is the possibility of exceptional wave heights between 0.75m to 1m within the estuary. Should these wave conditions occur then the SoP might reduce to a T100 year level (i.e. there might be a 1% risk that these conditions could occur in any year).

It is concluded that the existing embankment provides, at present, a good standard of protection to the village. It is noted, however, that the main risk is that, under exceptional conditions, overtopping might cause the embankment to fail and that should a breach occur this would open the land behind to more regular flooding. This may be understood from the typical cross section of the area shown in Figure 2.

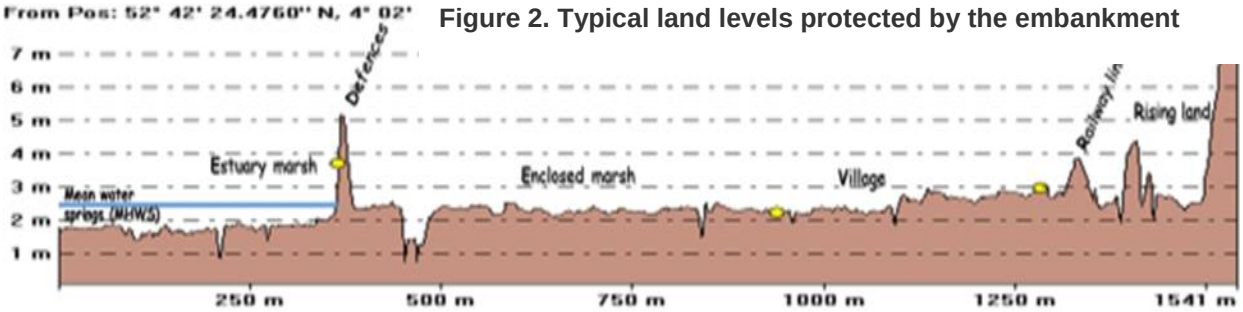


Figure 2. Typical land levels protected by the embankment

2 Future Management

2.1 Design Criteria and Uncertainties

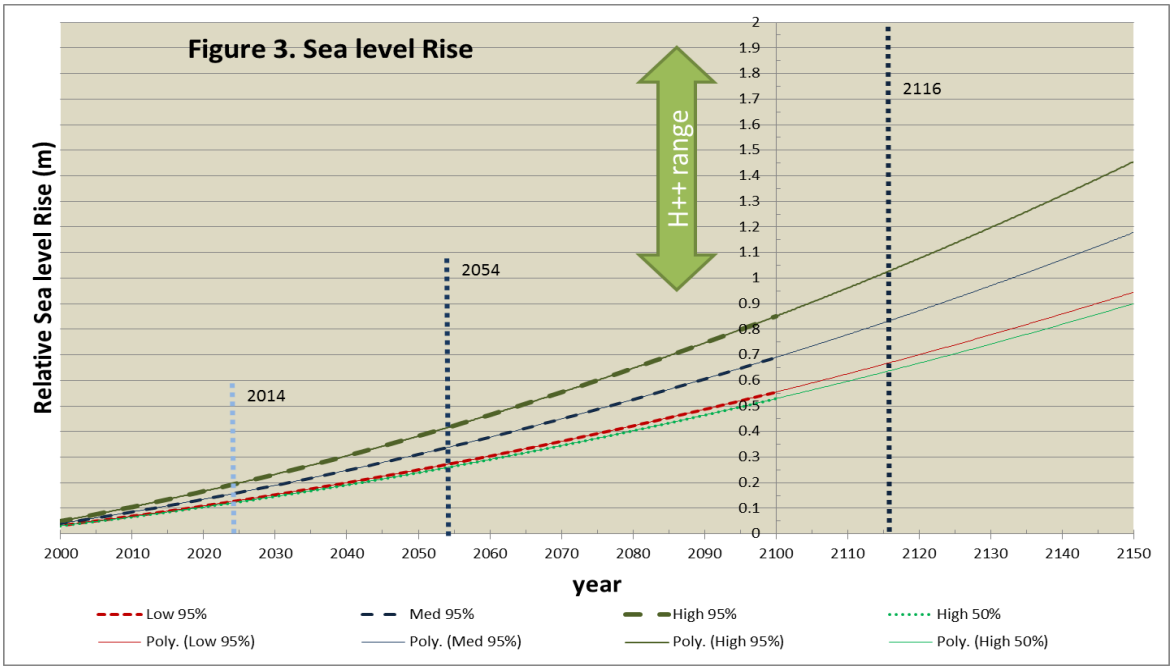
Sea level rise is happening; the crucial uncertainty is the rate at which this is occurring. In examining this, initially, we have looked at how risk might change with different increases in mean sea level (i.e. 0.25m, 0.5m and 1m). In the present, for example, the T200 water level is 4.27m OD. As mean sea levels rise by 0.5m, the extreme water level of 4.27m OD might be expected to occur on average every 10 years (a 10% chance of being exceeded in any year).

A range of different scenarios for sea level rise have been considered nationally within the Climate Projection Project (UK CP09). These scenarios are due to be updated in 2018/19 but seem likely to refine the scenarios rather than radically alter the conclusions of CP09. These scenarios are based on different world views (likely emission scenarios – Low, Medium and High), then considering the range of results from different models creating a range of confidence levels based on different world view scenarios. (e.g. High scenario 5%, 50% and 95% confidence level).

In addition to these baseline scenarios, which assume basic changes in climate change, a further H++ scenario has been derived, which takes account of potential sea level rise due to larger scale ice-melt. This is based on the historical evidence from polar ice cores and is developed in a different manner.

Welsh Assembly Guidance recommends that normal strategic planning works should primarily consider the High 95% range. However, the guidance also recommends that in long term planning, the H++ scenario should also be considered.

Critically, with respect to assessing the influence of sea level rise within the embankment report, it is the point in time that different increases in water level might occur, and how this relates to the 40 year planning horizon considered by FMF (up to 2054). This is shown for a range of scenarios considered by the report in Figure 3.



In addition to this uncertainty (with respect to timing of sea level rise), there is a degree of uncertainty associated with wave heights within the estuary. From analysis, there is the potential to develop between 0.75m and 1m waves under extreme conditions. This level of wave activity is more likely during an exceptional storm event but would critically depend on wind direction. More typically, wave heights between 0.5m and 0.75m might be expected. The degree of wave loading becomes quite crucial in assessing the standard of protection and the degree to which the embankment might need to be raised to avoid failure in the future.

These uncertainties have been included in considering the potential outcomes of managing the flood risk posed by the embankment in to the future. To a degree, in projecting possible management approaches forward, it is necessary to consider what risk there might be, and therefore the degree of acceptability of that risk. This is set out in detail in the report and a summary of this is discussed below.

Two basic management approaches are considered. The first aims to test the basic conclusion set out in the SMP, that continuing to manage flood risk to the area is unsustainable over the long term. The second, based on the outcome of this, looks at what actions might reasonably be considered necessary over the next 40 years or so, in establishing what investment might be required to maintain an appropriate standard of protection while broader scale change happens in terms of decommissioning the village. This second management approach also aims to establish whether there is a degree of flexibility in terms of that 40 year horizon, specifically, under different scenarios of sea level rise, is there the potential to extend that period of time with the reasonable confidence that we can continue to manage the risk.

In both management approaches, it is recognised that overtime the standard of protection will reduce. The report has taken the T75 (i.e. the level that might be exceeded with a chance of 1.33% in any year) as the target SoP as the defences approach the end of their design life.

2.2 Management Approaches.

2.2.1 Testing the SMP Assumption

The SMP has identified that, with around 0.5m sea level rise, there would be the need to substantially improve the condition and level of the embankment and that further significant works would then be required in to the future.

Based on maintaining a SoP at a minimum T75 level, the study of the embankment concludes that under an optimistic sea level rise scenario (UK CP Medium scenario 95% confidence level), if we assume that wave heights would not exceed 0.5m, then the existing embankment would continue to provide a T75 defence until 2086. Taking a more cautious approach, where we allow for the possibility of a more extreme wave height occurring during an extreme storm event, then we would need to undertake works in around 2050.

Based on the normal planning scenario for sea level rise (UK CP High 95%) then, accepting the risk of higher wave heights, works would be required in 2074 to maintain the T75 SoP. If we accept the possibility of higher wave action then, being more cautious in considering the investment and works that would be required; this time horizon would be brought back to 2045.

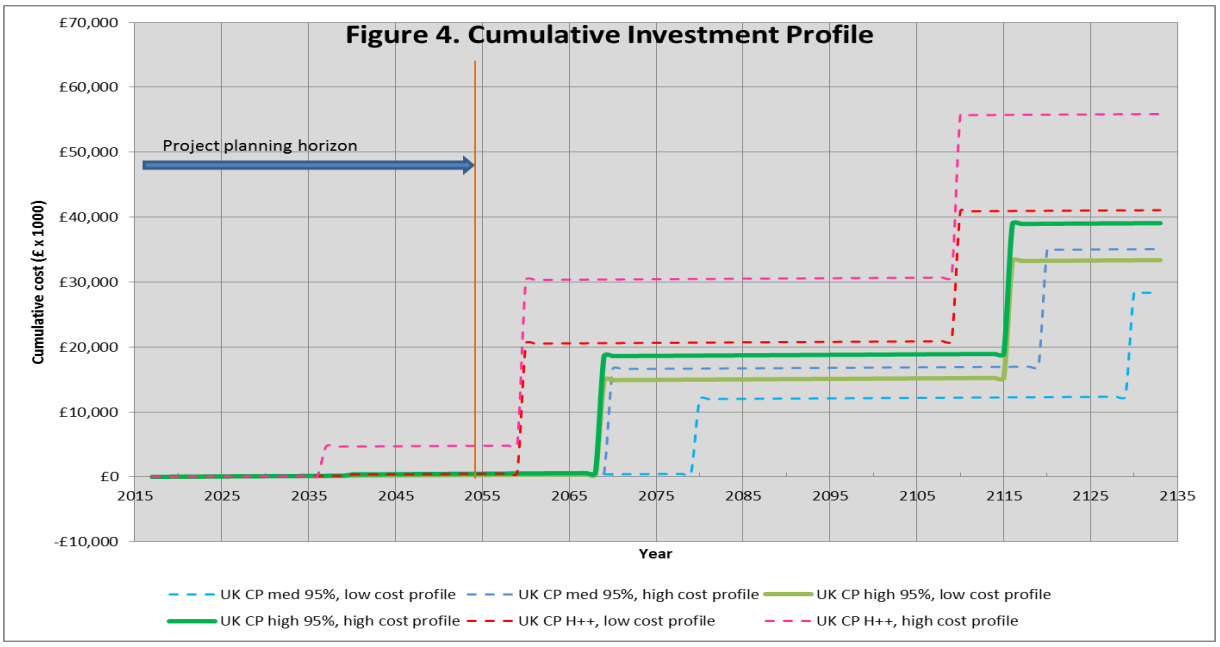
If it was found that sea level rise was tending to follow the more extreme projection of H++ then works might be required in 2050, with the risk that investment would be required substantially earlier (possibly in 2037).

In looking forward from this, based on having undertaken works to sustain the embankment by local strengthening or minor raising of the embankment over its full length, then further more substantial works would still be required to maintain defences into the future. In considering this it has been assumed that works would need to be undertaken with an expectation that they would provide at least a T75 SoP until 2117.

The projected cumulative investment profiles for different sea level scenarios are shown in Figure 4. This is based on estimated costs for increasing the height of the embankment, based again on different sea level rise scenarios. Investment beyond 2116 is shown indicatively taking in to account subsequent acceleration in sea level rise.

Typically, major investment in the order of £20M is likely to be required in around 50 years in order to maintain the existing degree of defence through to 2116. This could be greater under higher sea level rise conditions and may, obviously, be less if sea level rise is less. This cost relates solely to management of the embankment and other aspects of defence may generate different additional cost profiles.

The figure confirms generally the concerns raised by SMP, although demonstrating (as also discussed in the SMP) a degree of variation around the 40 year planning horizon depending on the actual rate of sea level rise. It also indicates that under the H++ condition, there may be the need for significant investment to maintain the defence through to the end of the planning horizon.



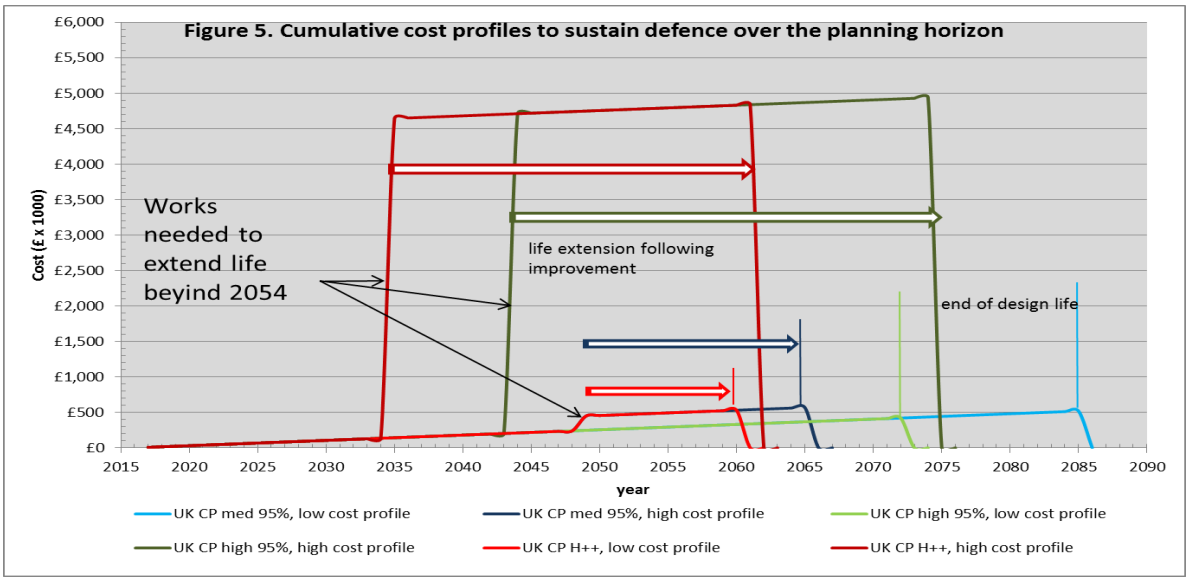
2.2.2 Planning for Change

A similar approach has been taken in assessing what investment might be required to maintain a minimum SoP of T75 over the planning horizon of 40 years (until 2054). In addition, and without incurring substantially greater investment, the assessment also considers the potential costs associated with extending the life beyond the planning horizon under different sea level rise scenarios. This would feed into the broader development of the Master Plan.

As set out above, under the less onerous UK CP medium 95% projection of sea level rise, there may well be no need for significant investment through to 2054. Taking a more cautious approach to potential wave action, the SoP under this sea level rise scenario might become critical in year 2050. This might be addressed by local reinforcement of the crest and back face of the embankment at a typical cost in the order of £200,000. This might be considered the best case scenario.

Taking the UK CP High 95% scenario and accepting the risk of possible failure due to higher wave loading, little works would be required beyond standard maintenance, with the defence potentially providing the minimum SoP through to year 2074. Allowing for the possibility of higher wave action, however, works would be required around 2045. If these works were planned for then, this is likely to secure the defence through to 2074.

Should further evidence (nationally and internationally) come forward suggesting that we are more likely to reach the potential H++ sea level scenario, then it would still be possible to manage the defences through to around 2054 but with additional cost. The typical cost profiles for each sea level rise scenario are shown in Figure 5, showing also the potential cost to extend the design life beyond the planning horizon.



3 Conclusion

The main conclusions of the technical note are summarised below:

- At present the Standard of Protection (SoP) is considered to have an Annual Exceedance Probability of 0.5% (T200), potentially reducing to a T100 under exceptional wave conditions. The typical failure mode would be as a result of structural damage to the embankment due to excessive wave overtopping.
- In principle the assessment made in the SMP2 is valid in identifying that, around the level of 0.5m sea level rise, significant improvements would be necessary purely to maintain a minimum Standard of Protection (T75) to the village.
- There is a reasonable expectation that the existing embankment would continue to provide a minimum SoP (to a T75 level) through to 2054 (the planning horizon of 40 years) without the need for major works to improve the structure. This would critically depend on actual rates of sea level rise and on the present assumptions as to wave loading.
- There is a significant cost risk that under more rapid sea level rise or more severe wave action, that works would be required between years 2045 and 2050 to sustain the defence at a typical cost in the order of £200,000. This cost might increase to £4.5 million under more extreme scenarios.
- This risk needs to be considered in developing the master plan.
- Should works be required, there is potential scope for extending the planning horizon beyond 40 years but with an associated costs risk as set out above. This cost risk would need to be considered in relation to other factors considered in developing the master plan.

Reference Documents

- SMP2
- Fairbourne Moving Forward Project
- Fairbourne Flood Risk Management Scheme PAR (EAW, 2011)
- Accounting for residual uncertainty: updating the freeboard guide – SC120014 (Defra, et. al. 2017)
- UK CP09
- Shore Protection Manual