# Appendix A

# Optioneering and Risk Workshop

# Optioneering and Risk Workshop

# Thursday 20th November 2008

# Sneaton Castle, Whitby

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|---|---|---|
| **Present:** | Stewart Rowe | Scarborough Borough Council |
| | Chris Grogan | Royal Haskoning |
| | Bill Estill | Scarborough Borough Council |
| | Robin Siddle | Scarborough Borough Council |
| | Nick Cooper | Royal Haskoning |
| | Cllr. Joseph Plant | Scarborough Borough Council |
| | Cllr. Herbert Tindall | Scarborough Borough Council |
| | John Riby | Scarborough Borough Council |
| | Patrick Berkhold | Scarborough Borough Council |
| | Steve Goring | Environment Agency |
| | Keith Crawford | Environment Agency |
| | Paul Lane | Marine Fisheries Agency |
| | Cllr. Steve Smith | Whitby Town Council |
| | Cllr. P. Booth | Scarborough Borough Council |
| | Cllr. M. Ward | Scarborough Borough Council |

**Apologies:** Susan Wilson (Natural England), Cllr. Andrew Backhouse, English Heritage, Cllr. Clegg, Cllr. Kenyon, Cllr. Mortimer, Martin Pedley (all Scarborough Borough Council), Cllr. Broadley.

**Key Findings:**

1) Introductions were made and an opening presentation was made by Stewart Rowe relating to the background to the Whitby Coastal Strategy and the Further Investigations at Whitby Harbour.

2) A presentation was made by Nick Cooper and Chris Groigan of Royal Haskoning using the Powerpoint file: 'Workshop 20_11_2008.ppt'

3) Key issues identified during discussion:

- Loss of the link bridge between the East Pier and its extension has been of some public concern. This was removed when a sea storm physically displaced the abutment, moving it some metres seaward and buckling the bridge.
- The presence of the Whitby fault and its implications for piling works (i.e. do we need to pile further through sands and gravels to reach competent bedrock?)
- Revetment option - could this be implemented without compromising the stability of the existing structures (i.e. increased loading on one side)
- Does the revetment option also help with structural problems as well as with overtopping performance?

- Economics - what is the economic value of a listed structure?
- What is the area of impact of overtopping discharges?
- Would Option 5 be considered as maintenance or eligible for capital upgrade?
- We need to engage with Natural England, English Heritage and Scarborough Borough Council planners.
- Managed realignment schemes with a west-facing alignment will act as a sediment trap. Those with east facing alignment would need a capital dredge across Whitby Rock.
- In any refurbishment, careful consideration would need to be given to stone sources (type, colour, etc) so as not to create an adverse visual impact and to match existing antiquity to ensure maintenance of heritage value
- There are potting areas off Whitby Rock.
- The East Pier and West Pier may each need different responses to address specific issues and constraints.
- Due to the urgency of some of the defects, especially the landward end of the East Pier, what can meaningfully be done now to reduce risk while funding for a full scheme is pursued?
- Access to the East Pier extension needs some consideration due to the need to enable access to service the lighthouses and undertake maintenance to ensure the harbour functions as a harbour of refuge.
- Based on the options presented, numbers 1, 2, 3, 4, 8, 9 and 10 were eliminated by the delegates for a variety of economic, environmental and technical reasons, with further examination requested of options 5, 6 and 7. It was then recognised that option 7 alone would not address the present poor structural condition and therefore was eliminated on technical grounds.
- Options 1 and 2 were not considered viable but it was recognised that they will need to be further assessed to investigate the associated economic damages. This will provide a basis against which options 5 and 7 will be assessed.
- The attendees noted a preference for option 7 as it was deemed important to deliver improved performance and improve condition simultaneously.
- Regarding overtopping performance, it was considered that public opinion is unlikely to favour a rock revetment on the West Pier because it is a public amenity beach. Also crest raising by large values or a high parapet wall were deemed likely to be publicly unacceptable.
- Whilst the East Pier rock revetment would have a direct impact in terms of its footprint across the designated site, it would help ensure the integrity of the piers; the absence of which would result in smothering and erosion of the interest features.

- Any flood gate on the slipway would need to be robust as the wave loading is high even at this landward position. Perhaps a local revetment at the toe of the West Pier would assist in reducing wave loadings.

- The slipway is used by ambulance services and for cliff rescues.

- After considering various means of implementing the favoured option the following was considered the best overall approach (subject to further assessment, discussions with planners, Natural England and English Heritage, and public consultation):

- Capital refurbishment of both piers and both extensions to rectify present defects

- Rock revetment (ideally not full structure height) along the outer face of the East Pier

- (Possibly) small rock revetment at the root of the West Pier and/or a flood gate to assist with local flooding from wave run-up along the slipway

- Parapet crest wall to reduce overtopping along the West Pier

- Revetment along seaward face of both extensions

- Benefits appraisal:

    - The principal attraction of Whitby is its harbour setting, against which its Abbey is dramatically set.

    - In the absence of a capital scheme, tourist industry would decline, fisheries would decline, dredging costs would increase, risk to life and properties would increase, other tidal and flood defences would need to be improved. The damage to the economy would lead to the decline of the town and its communities.

    - Use of the pier is a valued experience in itself. There are also associated health benefits of promenading along the pier.

    - Reducing risk of loss of life
    - Loss of harbour (duty of care)
    - Traffic disruption
    - Asset value of SSSI
    - Asset value of Grade II listed structure
    - Relocation of lifeboat
    - Loss of jobs

    - NB: existing maintenance budget is £35k per year for the whole of the harbour area (excluding dredging)

    - Final scheme choice needs to be a balance between technical performance (i.e. what is an acceptable standard of service / condition), cost and other constraints (e.g. environmental, planning, heritage, aesthetic)

- Would performance of piers be better if there was a solid link between them and their respective extensions?

- Get into NRG programme early

- Key project risks
  1) Funding / Outcome Measures
  2) Environmental (nature conservation, earth science heritage, landscape and visual, heritage)
  3) Working in hostile marine environment

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| Full minutes from the meeting are available on request to Robin Siddle of Scarborough Borough Council. |

# Appendix B

# Benefits Appraisal

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# Benefits Appraisal

## 1. Pre-amble

Assessing the economic benefits of the Whitby Harbour piers is not easily undertaken in a conventional PAG3 economic appraisal sense since the piers form an integral part of a wider coastal and flood defence system that also incorporates:

- Natural beaches and foreshore outcrops to both the west and east;
- Coastal defences protecting sea cliffs;
- Quay walls along the River Esk estuary;
- Jetties and other small structures within the harbour.

All of the above components, which have critical inter-dependencies, combine to provide an overall coastal and flood defence system to the coastline between Sandsend and Abbey Cliff and to the lower reaches of the River Esk estuary. The absence of any one of these components would severely increase the risk from flooding and/or coastal erosion.

It is for this reason that the Whitby Coastal Strategy assessed the economic damages that would occur to the whole strategy frontage and the costs of the measures that were collectively required across this wider area to address the risks presented from:

- Potential breach of the Whitby Harbour piers;
- Potential for renewed recession of protected sea cliffs;
- Flooding of property along the lower reaches of the River Esk estuary and Whitby Harbour quays;
- Wave overtopping of the sea defences on the open coast; and
- Recession of the unprotected sea cliffs.

The Strategy identified total present day benefits of £254,538,400 within the overall frontage over 60 years. This was composed of £17,478,000 relating to the flood risk damages along the lower reaches of the River Esk and £237,060,400 relating to the coastline. Of the coastal aspects, direct benefits of £25,218,700 were identified over 60 years and indirect benefits over the same timeframe were £211,841,700.

Following advice from the Environment Agency, the previous economics appraisal process has been re-evaluated for purposes of the further investigations at Whitby Harbour.

In this assessment, the economic damages that would result from implementing a ‘Do Nothing’ option are considered to include:

- Direct and indirect damages from tidal flooding in the lower reaches of the River Esk estuary caused by higher waves overtopping quayside defences;
- Direct and indirect damages from erosion of adjacent coastal frontages;
- Direct and indirect damages caused by wave run-up the slipway;
- Loss of life due to loss of refuge at Whitby Harbour;
- Increased dredging requirements in the estuary;
- Loss of Grade II Listed Structures;
- Loss of geological SSSI;
- Loss of fishing income;
- Loss of tourist income;

- Loss of amenity;
- Loss of jobs;
- Relocation of lifeboat station as part of the exit strategy.

The assessment of economic damages has been undertaken in accordance with the Flood and Coastal Defence Project Appraisal Guidance (PAG) series and *The Benefits of Flood and Coastal Risk Management* (often known as the *Multi-Coloured Manual*, or MCM).

In assessing damages within some specific categories, such as the impact on tourism and losses to the local fishing economy, reasonable assumptions have been made and/or available statistics have been used. Many of these assumptions or statistics have been confirmed through communications with the Whitby Harbour Master and the relevant departments of Scarborough Borough Council.

## 2. Damages from Tidal and Wave Flooding

Flood risk in the lower reaches of the River Esk estuary and around Whitby Harbour can come from three sources:

1. High river flows – especially when coinciding with high astronomical spring tides or high sea surge events;

2. High sea surges;

3. Wave overtopping of quayside walls – especially during high astronomical spring tides or high sea surge events.

Modelling work that was undertaken as part of the original Strategy identified that high river flows are the least significant contributor to flood risk in the lower reaches of the estuary, and that tides and waves are far more significant.

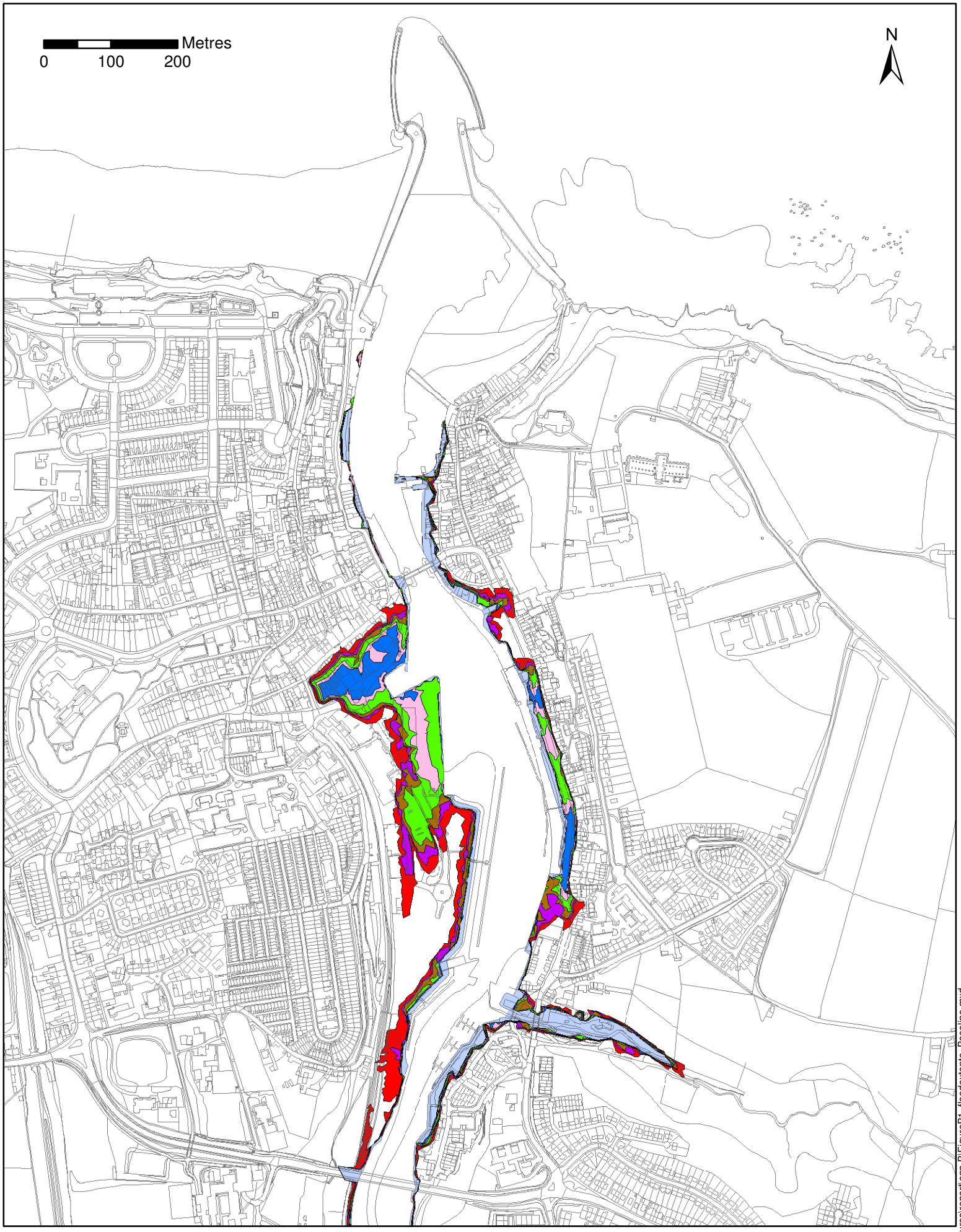
It is recognised that it is the crest elevation level of the quayside walls that is the determining factor in preventing flooding during times of high river flow, high tidal states or high sea surges, but the Whitby Harbour piers play a vital role in reducing wave heights in the harbour and estuary that otherwise could lead to overtopping of quay walls.

To assess the benefits of maintaining the presence of the Whitby Harbour structures the following methodology has been applied:

- Flood zone maps have been created to identify the extent of flooding that would occur under tidal events of different ‘present climate’ return periods, should the quay walls become overtopped. The number, location and type of properties within these flood zones have been calculated based on a LiDAR-based Digital Ground Model and the National Property Dataset. This information has been used to calculate annual average damages. Figure B1 depicts the flood zone used in this scenario.

- The above step has been repeated using tidal events of different ‘future climate’ (2057) return periods, to take into consideration sea level rise. Figure B2 depicts the flood zone used in this scenario.

- The above steps have been repeated with water levels elevated by 110mm; this being a typical increased wave height within the estuary in the absence of the piers as defined by SWAN modelling. The difference in the annual average damages between this and the initial assessments is the 'benefit' of having the harbour piers compared against not having them present. Figures B3 ('present climate') and B4 ('future climate') depict the flood zone used in these scenarios.

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- 3RP: 3.45m
- 10RP: 3.61m
- 50RP: 3.85m
- 100RP: 3.99m
- 200RP: 4.1m
- 1000RP: 4.31m

Title:
All Extreme Water Level Events Present Climate

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

| Date: | Scale: |
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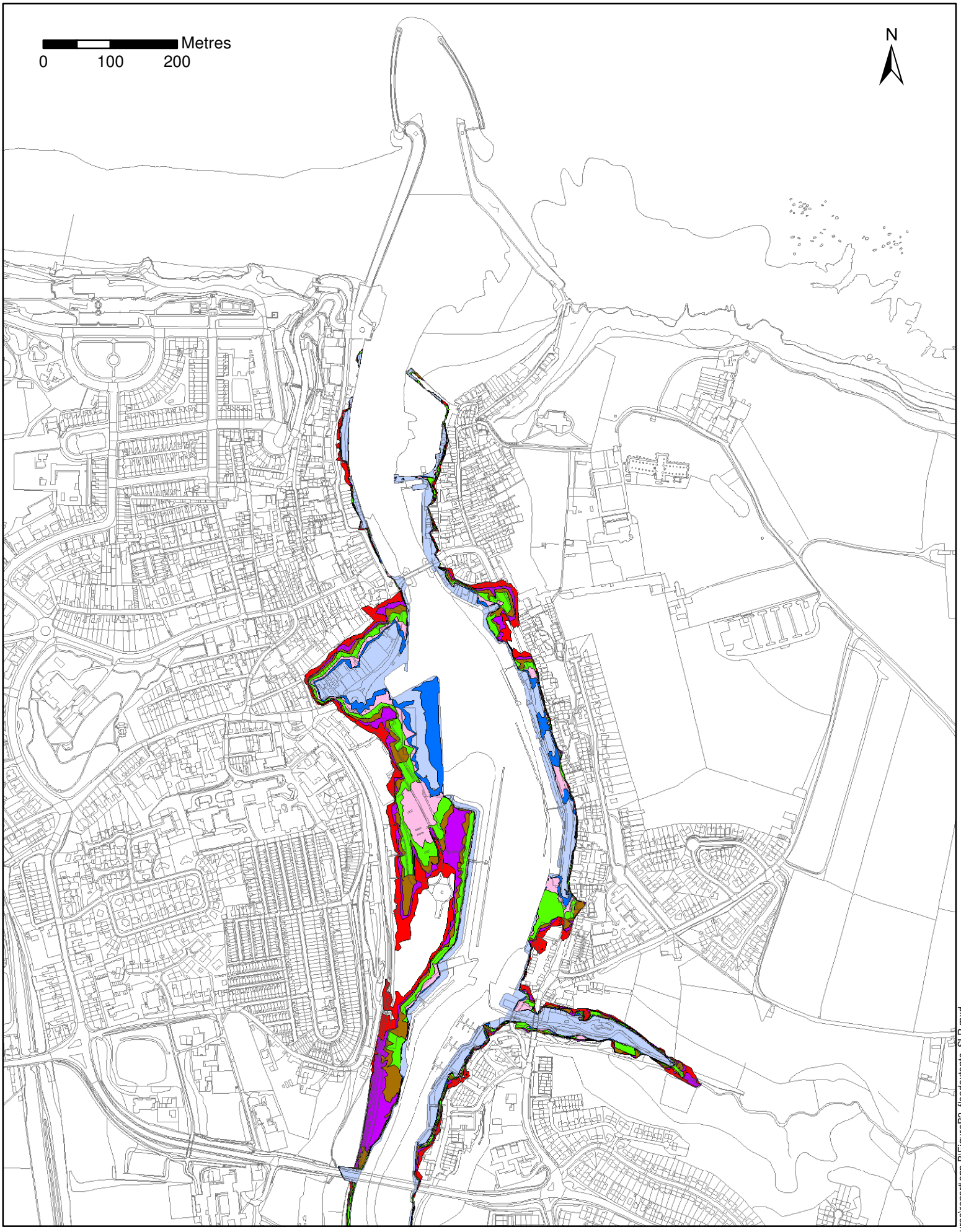


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- 50RP +SLR: 4.13m
- 100RP +SLR: 4.27m
- 200RP +SLR: 4.38m
- 1000RP +SLR: 4.59m

Title:
All Extreme Water Level Events '2050' Climate

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

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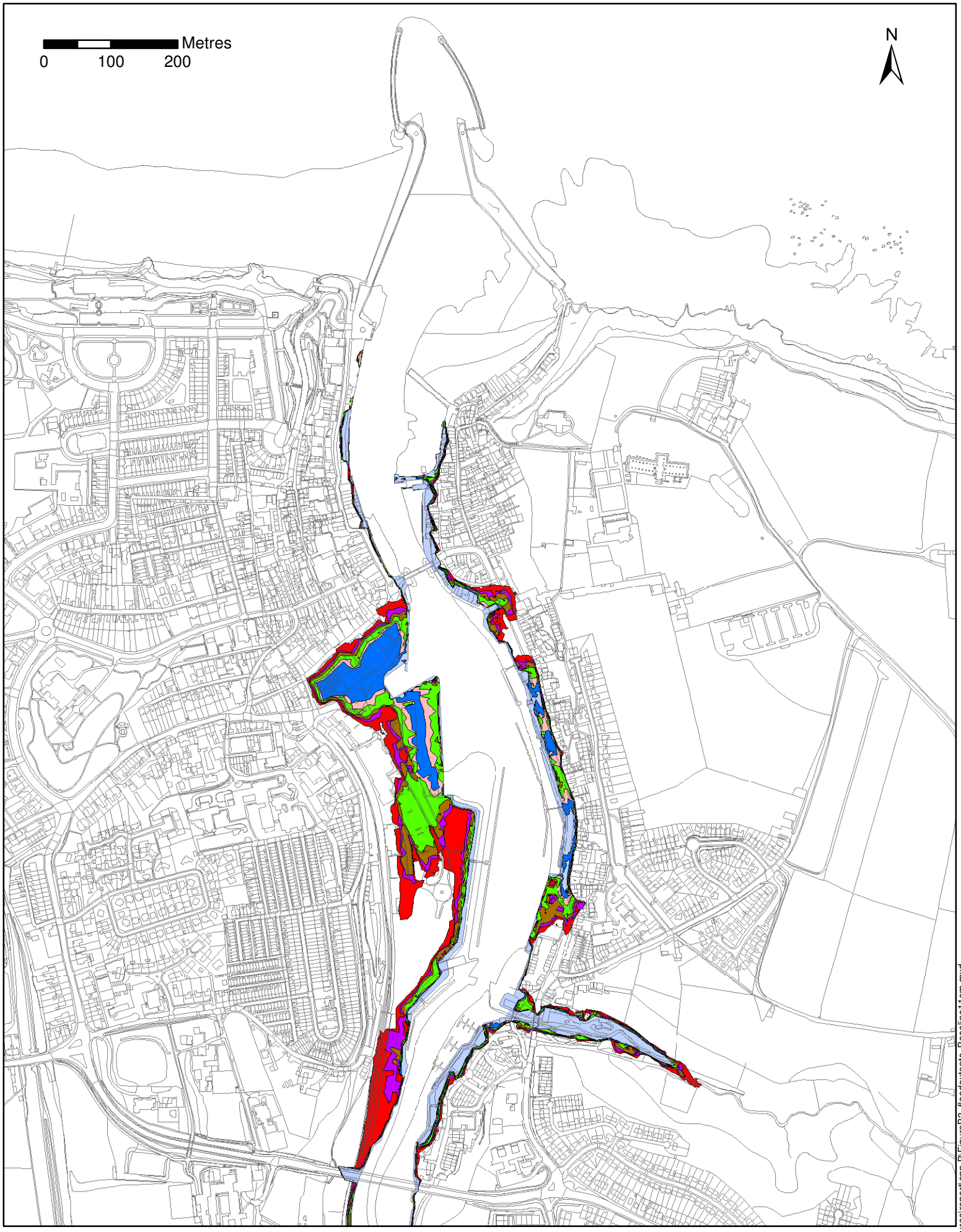


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- 50RP: 3.96m
- 100RP: 4.1m
- 200RP: 4.21m
- 1000RP: 4.42m

Title:
All Extreme Water Level Events for Present Climate plus Waves

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

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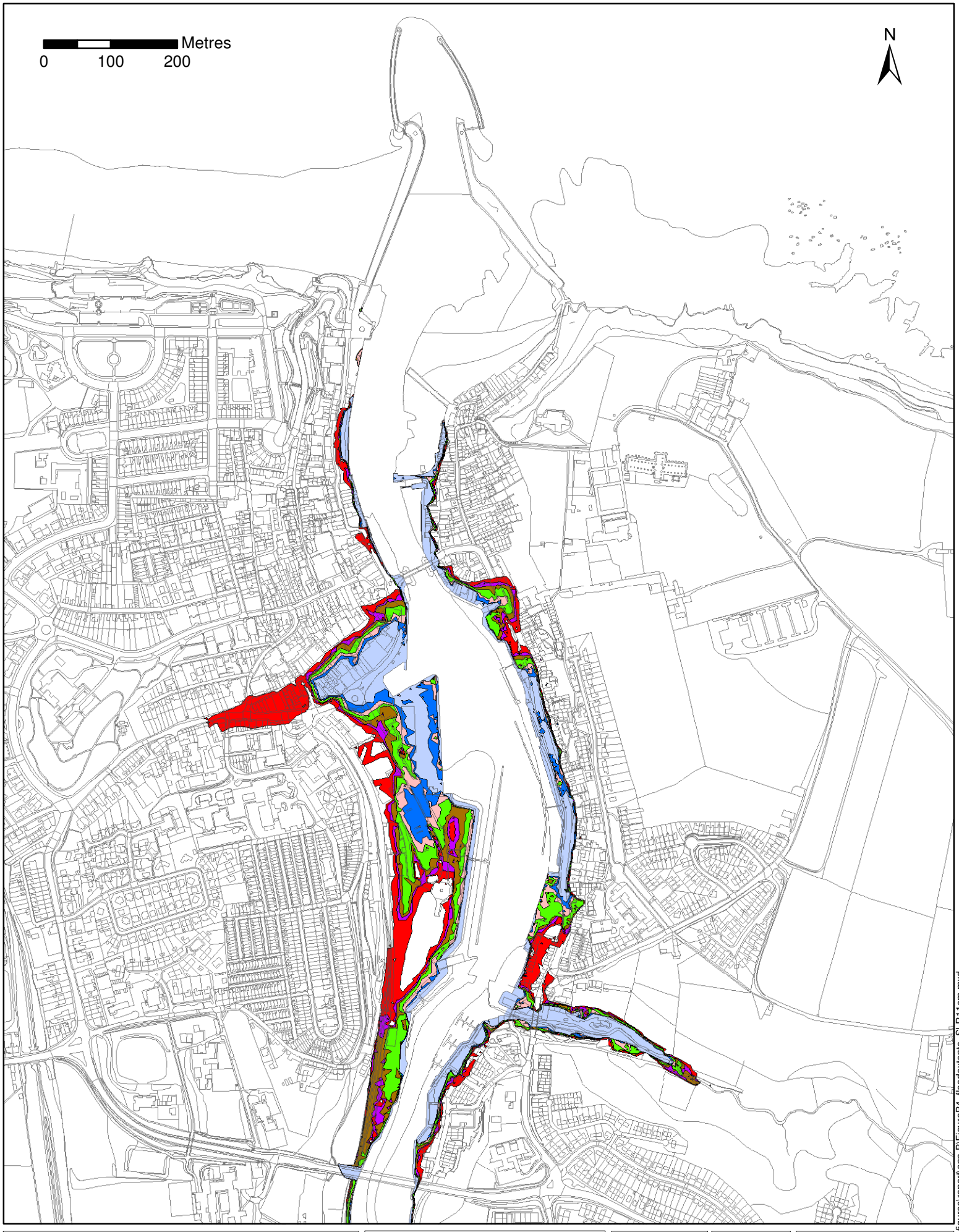


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- 10RP +SLR: 4.0m
- 50RP +SLR: 4.24m
- 100RP +SLR: 4.38m
- 200RP +SLR: 4.49m
- 1000RP +SLR: 4.7m

Title:
All Extreme Water Level Events for '2050' Climate plus Waves

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

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In the above assessments, the reach from the harbour mouth upstream to the A171 has been considered as the probable zone of influence of the harbour piers. Table B1 shows the number of properties affected under each scenario under the different return period events.

**Table B1 Number* of Properties in Whitby Affected** by Each Flood Return Period Event**

| Return Period | Tide and Wave | | Tide only | |
|---|---|---|---|---|
| | Present Climate | Future Climate | Present Climate | Future Climate |
| 1 in 1 year | 168 | 261 | 162 | 219 |
| 1 in 3 years | 224 | 286 | 203 | 254 |
| 1 in 10 years | 265 | 315 | 224 | 280 |
| 1 in 50 years | 304 | 353 | 282 | 331 |
| 1 in 100 years | 326 | 366 | 299 | 345 |
| 1 in 200 years | 351 | 379 | 321 | 365 |
| 1 in 1,000 years | 336 | 486 | 355 | 387 |

*Note: These numbers have been reviewed against those previously presented in the Whitby FAS Project Appraisal Report and found to be considerably higher. This difference has been attributed to the much greater accuracy of the DTM used to define property thresholds for this study. In reference to the DTM used in the previous study the PAR states "*This method does not give the reliably accurate levels that are required for an accurate economic analysis*".

**Note: The table does not include properties which incur flood damage to foundations only.

Values of damages caused by the baseline tidal flooding have been calculated using guidance from PAG and the MCM in order to establish Annual Average Damages (AAD). These include the onset of damage to foundations and the capping of residential properties to their current value. The Present Value (PV) damages have been estimated for a period of 50 and 100 years with present value taken into account using a declining long term discount rate of 3.5% for years 0-30, 3.0% for years 31-75, and 2.5% for years 76-100 as recommended in the 'Green Book'.

For residential properties, damage to foundations is incurred when water levels reach within 300mm below the property threshold. For commercial properties foundation damage is incurred 1m below the threshold. As flooding is a result of tidal inundation, a flooding duration of less than 12 hours has been used for the calculation of damages.

The property values that are used for the purpose of residential property capping have been calculated based on Average House Prices from the Office of National Statistics published in 2006 shown on Table B2. The values have then been increased with a Consumer Prices Index (CPI) multiplier to bring them in line with 2008 prices. Following the MCM guidance, commercial property prices have not been capped for the purpose of calculating PV damages.

**Table B2 Average House Prices from Office of National Statistics (2006*)**

| House Type | Whitby | England |
|---|---|---|
| Detached houses | £246,736 | £314,542 |
| Semi-detached houses | £155,829 | £186,950 |
| Terraced houses | £140,451 | £165,031 |
| Flats | £118,655 | £188,227 |
| All dwellings | £160,091 | £206,715 |

*Note: Prices above do not include CPI multiplier

*Tidal Flooding (Present Climate)*
Taking the above figures into consideration, the baseline tidal flooding results in an Annual Average Damage (AAD) of **£5,833,777**. This includes the capping of 139 residential properties.

*Tidal and Wave Flooding (Present Climate)*
This increase in water level associated with waves in the lower reaches of the estuary results in an Annual Average Damage (AAD) of **£7,678,184**. Thus, capital works at Whitby Harbour will result in a reduction of Annual Average Damage (AAD) by **£1,844,407** for the present climate scenario.

*Tidal Flooding (Future Climate)*
In addition to the above, the same methodology has been applied for the calculation of flood damages in 50 years time with the added impact of sea level rise. The future climate scenario (2057) for tidal level only results in an Annual Average Damage (AAD) of **£11,735,071**.

*Tidal and Wave Flooding (Future Climate)*
When water levels are increased to take into account the action of waves, the future climate Annual Average Damage (AAD) is increased to **£14,329,756**. Thus, capital works at Whitby Harbour will result in a reduction of Annual Average Damage (AAD) by **£2,594,685**.

*Present Value Damages*
If we conservatively assume that the 'present' climate scenario remains valid for nominally the next 50 years and the 'future' climate scenario is valid from 2057 until 2107, present value damages of tidal (only) flooding equates to **£120,892,299** over 100 years and the present value damages from tidal and waves (combined) equates to **£164,804,796** over an equivalent period (Annex A).

The total benefit of maintaining the piers at Whitby Harbour for flood damage reduction over 100 years is **£43,912,496**. Over the first 50 years, the benefit equals **£31,294,941**.

## 3. Damages from Erosion of Adjacent Coastal Frontages

Whitby is located at a highly active area of coastline where processes of coastal erosion and alongshore and onshore-offshore sediment transport are considerable. As such, the risk from coastal erosion over the next 100 years is expected to be significant. The loss of the piers at Whitby Harbour would exacerbate this problem, accelerating the rate of coastal erosion within close proximity to the harbour and resulting in significant economic losses. This section provides details of the economic benefits of maintaining the piers at Whitby Harbour in relation to their function as a protection against coastal erosion.

*Loss of land and property to the west of Whitby West Pier*

The piers at Whitby act to protect the local coastline in two distinct ways. Primarily, Whitby West Pier and its extension act as a large groyne, trapping sediment which moves west to east along the coast and in the nearshore zone, and helping to maintain the healthy beach at Whitby Sands.

Secondly, the piers act as breakwaters, intercepting waves travelling towards the coast and reducing the wave energy which impacts upon the beach and coastal cliffs.

Loss of the piers would clearly have significant implications for the beach and cliffs. Removal of the groyne would prevent sediment from being deposited at Whitby Sands and would result in the rapid lowering of the beach and loss of sand between Upgang Beach and the West Pier.

This lowering of the beach would, in turn, reduce protection to the coastal cliffs west of Whitby Harbour and result in an increase in the rate of coastal cliff recession. This cliff recession would become exacerbated close to the harbour mouth, where the breakwater effects of the piers would be lost, resulting in even faster rates of erosion.

In addition, increased rates of cliff erosion will result in the loss of land and property along the cliff top in-between the harbour and Upgang Beach.

In order to quantify the economic loss to the local economy as a result of this coastal erosion, each of these effects has been individually calculated.

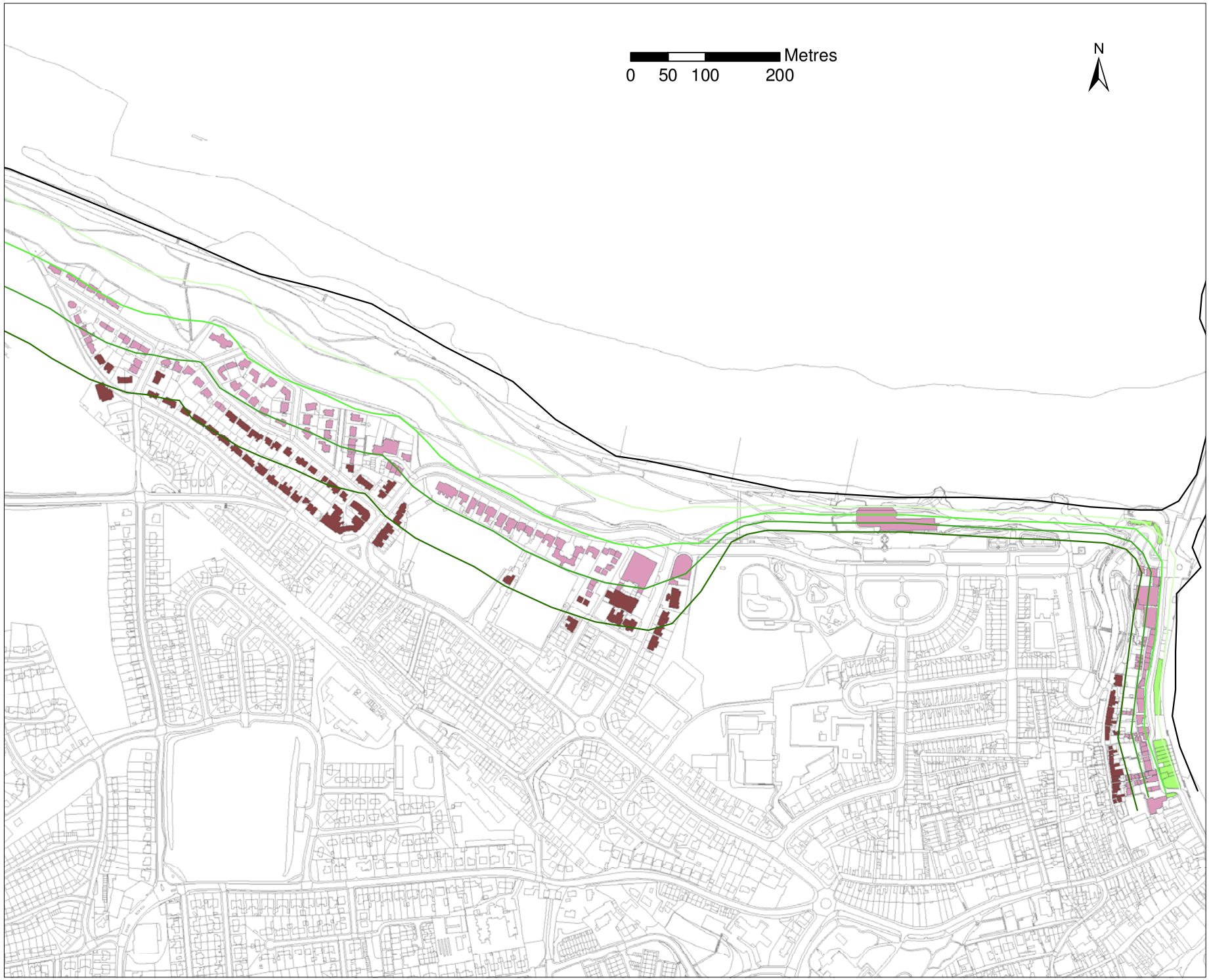
The Shoreline Management Plan (SMP2) provides detailed information on the rates of coastal erosion and the projected shoreline position for the next 20, 50 and 100 years around Whitby. With the loss of the piers, and associated loss of the beach, it is expected that the rate of coastal cliff erosion will accelerate. Figure B5 illustrates the area to the west of Whitby West Pier that would be expected to be directly lost within the next 100 years following the loss of the piers.

It should be noted that not all of the properties within the 100 year erosion area will be lost at the same time and in order to appropriately discount the value of properties lost in the future, erosion lines for 30 and 75 years, have also been included. As per the Green Book, properties lost in the 30 year zone have been discounted by 3.5% per year, between 31 and 75 years by 3% per year, and between 71 and 100 years, property values have been discounted by 2.5% per year.

Annex B provides details of the properties located within each of the erosion zones and their estimated value which has been appropriately discounted depending on the period in which the property will be lost.

The total cost of property losses in the absence of the piers to the west of the harbour is £3,963,694 (£1,411,075 after discounting), between years 0 and 30. This value accounts for a total of 22 properties primarily located along Pier Road and adjacent to the West Pier. Note that properties have been discounted assuming that all are lost at year 30. In reality some will be lost before that time so the actual value will be greater.

Between years 31 and 75, a total of 232 properties are expected to be lost in the absence of the piers due to coastal erosion including Whitby Pavilion Theatre and 79 residential properties in the vicinity of West Cliff. The total value of these properties amounts to **£42,624,367** at present value, reducing to **£4,006,691** after discounting. Note that properties have been discounted assuming all are lost at year 75. In reality some will be lost before that time so the actual value will be greater.




**Erosion lines (years)**

- 0
- 30
- 50
- 75
- 100

**Effected buildings (years)**

- 0 - 30
- 31 - 75
- 76 - 100

Title:
Cliff Erosion Impact on properties (West)

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

| Date: | Scale: |
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Between years 76 and 100, a total of 147 properties are expected to be lost in the absence of the piers due to coastal erosion. This includes an additional 88 residential properties near West Cliff and 59 properties in the Haggersgate area of the town. The total value of these properties amounts to **£23,966,953** at present value, reducing to **£1,246,282** after discounting. Note that properties have been discounted assuming all are lost at year 100. In reality some will be lost before that time so the actual value will be greater.

In total, the cost of property to the west of Whitby Piers lost in the absence of the piers as a result of coastal erosion is expected to reach **£6,664,047** over 100 years after discounting. Over a 50 year time period, the loss of property is expected to be **£1,862,630**. The SMP2 shows that the current defense policy in this area is to "hold the line" and thus the total benefit to the scheme for coastal erosion in this area is equal to the value of property that would be lost.

*Loss of land and property within Whitby Harbour at Tate Hill Sands*

Tate Hill Sands is an urbanised seafront area located within the protection of the current piers at Whitby Harbour. This area is built at the foot of a remnant cliff scarp which is currently not actively eroding. It can be assumed that this cliff scarp is not active due to the protection provided by the piers and that loss of the piers would result in the reactivation of erosive processes in this location.

Applying the same method as described above. It has been assumed that if the piers were to collapse, the 100 year 'with present management' erosion line provided by the SMP2 would be realised within 50 years.

Figure B6 illustrates the area to the east of Whitby Harbour at Tate Hill Sands which is expected to be directly lost within the next 100 years in the absence of the piers. As above, erosion maps have been produced based on the 0 to 30, 31 to 75, and 76 to 100 year discounting periods.

Annex C provides details of the properties located within each of these erosion zones and their estimated value with and without discounting.

Between 0 and 30 years, the total cost of property lost to coastal erosion in the absence of the piers is expected to reach £2,640,023 (£939,848 after discounting). This value accounts for 14 residential properties and 9 commercial properties.

Between years 31 and 75 years, a total of 72 residential properties and 64 commercial properties are expected to be lost in the absence of the piers as a result of coastal erosion. This results in a total damage cost of £17,499,575 (£1,644,960 after discounting). In addition, St Mary's Church is expected to be lost to erosion during this period, for which an economic value has not been established and thus the total loss will be greater than the value presented above.

Between 76 and 100 years, a total of 86 properties are expected to be lost in the absence of the piers to coastal erosion, including 56 residential properties. This results in a total damage cost of £12,374,006 (£643,448 after discounting).

In total, the cost of property to the east of Whitby Piers at Tate Hill Sands lost in the absence of the piers as a result of coastal erosion is expected to reach £3,228,256 over 100 years after discounting. However, even if the piers are maintained, there is still expected to be a loss of property. Over 100 years the value of this loss will be £1,000,215 (after discounting) (Annex C). Therefore, the total benefit of maintaining the piers to reduce loss of property to the Tate Hill Sands are of Whitby is **£2,228,041** over 100 years.


**Erosion lines (years)**

- 0
- 30
- 50
- 75
- 100

**Effected buildings (years)**

- 0 - 30
- 31 - 75
- 76 - 100

Title:
Cliff Erosion Impact on properties (East)

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

| Date: | Scale: |
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Over 50 years, the total loss of property is expected to be £2,753,120 in the absence of the piers. If the piers are maintained, the remaining loss of property will be £523,801, providing a 50 year benefit of **£2,229,319**.

## 4. Damages Caused by Wave Run-Up

Discussions with the Whitby Harbour Master have highlighted that significant amounts of flooding can occur to properties at the southern end of the West Pier as a result of waves breaking onto Whitby Sands. During heavy storm events, waves have been known to break onto the highest point of the beach and run-up the lifeboat access ramp on the west side of the pier causing localised, but considerable, disruption.

In order to estimate the financial damages associated with these wave run up events the following methodology has been followed. As no records of the frequency of this occurrence exist (other than anecdotal statements that it is 'quite frequent') and there are no detailed records of the financial impacts to local businesses and residents, a number of conservative assumptions have been made. For the purposes of the economic appraisal, it has been assumed that such run-up events occur once each year and that they affect the small area highlighted in Figure B7.

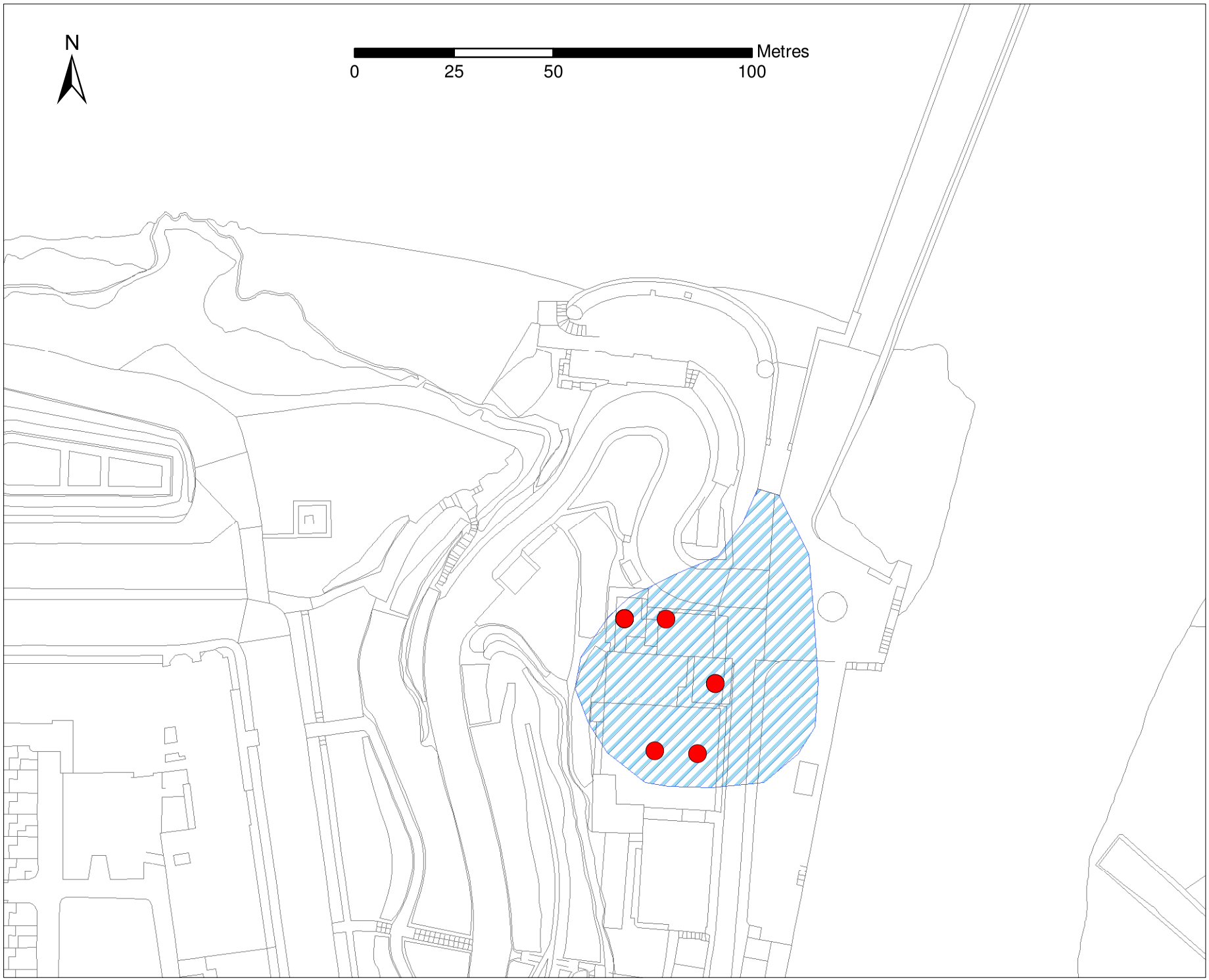
In order to estimate damage costs associated with these events, the methodologies described within the MCM have been adjusted to assume that the properties identified in Figure B7 are inundated to a depth of 50mm with a flood duration of less than 12 hours. (A flood depth of 50mm is significantly lower than the average 1 in 1 year flood depth of 539mm so this is considered a reasonable flood depth).

Figure B7 identifies 5 commercial properties that are affected by these wave run-up events. These are Pleasure Land Amusements, Whitby Fisherman's Football Club, The Endeavour Office, The RNLI Museum, and Whitby Yacht Club.

The details of these properties, based on information from the national property dataset have been used to calculate a total damage cost of **£146,834** per event (Annex D).

The total PV damage cost of wave run-up events have been estimated for a period of 100 years with present value taken into account using a declining long term discount rate of 3.5% for years 0-30, 3.0% for years 31-75 and 2.5% for years 76-100 as recommended in the 'Green Book'.

Based on the above average annual damage (AAD) the 100 year PV damage equates to **£5,265,656** and the 50 year PV damage equals **£4,353,916**. Local works to the slipway associated with the capital scheme along the West Pier will be designed to prevent such wave run-up events in the future and thus the benefit is taken as these damage values.




Wave runup

Title:
Wave Impact on properties behind the slipway

Project:
Whitby Coastal Strategy Further Investigations at Whitby Harbour

Client:
Scarborough Borough Council

| Date: | Scale: |
|---|---|
| January 2009 | 1 : 1,250 |

| Figure: | Drawn: | Checked: |
|---|---|---|
| B7 | TC | AG |

ROYAL HASKONING

I:\9T0429\Technical_Data\gis\figures\report\FigureB7_wave_impact_on_properties.mxd

## 5. Loss of Life Due to Loss of Refuge at Whitby Harbour

Whitby Harbour is a well established maritime facility which has been used for over a century to allow safe passage of vessels from the North Sea into the River Esk estuary and to provide shelter to passing vessels during periods of extreme sea conditions. With the effects of climate change projected to result in increasingly severe storm events over the next 50 years, it is anticipated that Whitby Harbour with be increasingly utilised as a port in which vessels can take shelter during such events.

As such, it may be argued that the Harbour has a duty of care for vessels travelling within this area of the North Sea and that this care should be maintained in order to prevent the loss of life and damage to vessels caught in heavy seas off Whitby.

Information provided by the Whitby Harbour Master suggests that between 15 and 20 vessels make unscheduled entry into the harbour each year in order to take shelter from heavy seas. If it is assumed that there is an average of 5 people on each of these vessels, it could be argued that the harbour is directly responsible for the welfare of up to 100 people per year. This is a worst case scenario and does not take into account at actions of the life boat service that would be able to intervene in the event of emergencies.

The value of a single life has been set at £1,500,000 for economic appraisal purposes. If it were assumed that on average in the absence of the Whitby Harbour the loss of life was much lower at 1 death every 5 years, this would give a post discounting benefit of **£9,485,404** over 100 years and **£7,846,333** over 50 years (Annex E).

## 6. Increased Dredging Requirements in the Estuary

The current cost of dredging the navigation channel at Whitby Harbour in order to allow safe passage of vessels in and out of the River Esk estuary is currently set at approximately £150,000 (2009 budget). It is known that the present piers and extensions trap approximately 60% of the material that is transported along the coast and nearshore. Therefore some of the 40% of sediment that bypasses the piers enters the channel, whilst some moves further offshore carried in suspension in the water column. If we conservatively assume that the £150,000 budget is used to dredge all of the 40% of sediment bypassing the pier from the channel, then the pro-rata cost for dredging the whole 100% of sediment is £375,000.

Over 100 years, an annual dredging cost of £150,000 results in a discounted PV cost of £4,471,882 (Annex E). Loss of the piers and an increase in the annual dredging cost to £375,000 would result in a discounted PV damage of £11,179,704 over 100 years and £9,259,713 over 50 years.

The benefit of maintaining the piers would be a saving of £6,707,823 over 100 years and £5,555,828 over 50 years.

## 7. Loss of Grade II Listed Structures

If the main piers were allowed to deteriorate, the value derived from their listed status would be lost to the nation. Whilst it would not be possible to directly replicate the antiquity of the structures, efforts could be made to clad a new replacement structure with petrographically similar stone blockwork as an approximate analogue value.

The estimated cost of such replacement works to the main piers only (as the pier extensions are not listed) is £167,241,000.

It is assumed that the main piers would be lost and reconstructed in year 30. The discounted PV benefit is therefore £64,792,122 over 50 years and £69,822,499 over 100

years. These values assume an annual maintenance cost of 1% of the capital construction cost. This accounts for 20 years for maintenance for the 50 year PV benefit and 70 years of maintenance of the 100 year PV benefit. Calculations of these benefits are presented in Annex E.

## 8. Loss of Geological SSSI

It is known that the present size, type and location of the piers and pier extensions are responsible for the geological foreshore SSSI to be maintained free of sediment. If the piers were lost, sediment would cover the geological interest and its educational value to the nation would be lost.

It is assumed that reconstruction of basic structures in an identical orientation at the mouth of the River Esk estuary would enable the coastal processes to re-instate to present characteristics and therefore sweep the interest feature free of sediment. The cost of demolishing remnant derelict structures and reconstructing on the same alignment is estimated at £202,456,000.

If it is assumed that the main piers would be lost and reconstructed in year 30. The discounted PV benefit is therefore £79,205,045 over 50 years and £86,038,422 over 100 years. These figures assume an annual maintenance cost of 1% of the capital construction cost. This accounts for 20 years for maintenance for the 50 year PV benefit and 70 years of maintenance of the 100 year PV benefit. Calculations of these benefits are presented in Annex E.

## 9. Loss of Fishing Income

The piers at Whitby Harbour serve two very important roles for the local fishing industry. Primarily, the piers act as breakwaters, allowing fishing vessels safe passage in and out of the River Esk estuary during heavy seas and ultimately allow the delivery of catches. Secondly, the piers protect vessels that are berthed within the harbour, preventing them from damage that may otherwise be caused by incoming waves.

*Damage to Fishing Fleet*

As protection from the piers is lost it is anticipated that damage to the fishing fleet itself will be incurred. During 2008, approximately 100 different commercial vessels made entry into the harbour. It is assumed that the majority of these craft are fishing vessels.

It has been estimated that due to the deterioration of the piers, each vessel is likely to sustain an average of £400 worth of damage per year which would previously not occur. This results in an average damage to the commercial fleet of £400,000 per year. If this value is used to calculate PV costs over 100 years, this results in a total PV damages to the fishing fleet of **£11,925,018** and £9,877,027 over 50 years (Annex E).

*Loss of Fishing Income*

It is anticipated that the loss of the piers would result initially in the gradual decline of the fishing industry at Whitby as the number of trawls that can be carried out will be reduced due to worsening sea condition in the vicinity of the harbour. (The loss of protection from the piers means that vessels will not be able to go out in conditions that they may have previously been able to).

It is recognised that with this demise, some of the fleet (or its quota) may be transferred to another port, such as Scarborough or Teesside. However, to continue to fish the traditional grounds these vessels would have longer haul distances, and be at greater risk of being damaged or experiencing downtime due to bad weather. By way of a proxy, we have estimated the economic damage from this as the equivalent of a direct loss of fishing income from Whitby itself.

The present annual fishing income to Whitby is approximately £141,050 (2007/08). If this value were to be sustained over the next 100 years, the total PV income would be £4,205,060 (including discounts). It is anticipated that following the loss of the piers, the fishing industry would see an annual reduction of 10% for the first 20 years beyond which it would become unsustainable and cease altogether. Thus, the PV income of the fishing industry over the next 100 years would be £1,023,929.

The benefit to the fishing industry over the next 100 years is **£3,181,131** and **£2,458,958** over the next 50 years (Annex E).

*Consequential Effects*
However, in addition to the above, the loss of the local fishing industry is likely to have a number of immeasurable knock on effects to the local economy and businesses. Businesses that are likely to be affected are boat yards and marine repair mechanics, fish wholesale and independent fish mongers and retailers, fish and chips vendors and other local eateries and restaurants. Considering Whitby's fame for seafood establishments, this is likely to have further knock on effects for the tourist industry and the wider local economy.

## 10. Loss of Tourist Income

It has been assumed that upon deterioration of the piers (in the absence of intervention), the whole of the beach between Upgang Beach and the West Pier will have disappeared within 10 years and that the size of Sandsend Beach will have halved over the same time frame. This will undoubtedly have negative impacts on the town's tourist income, which is governed by its attractive and dramatic coastal setting.

A recent study carried out by Tourism UK was commissioned to investigate tourist behaviour across the Yorkshire Moors and Coast Area. The findings of this study showed that 26% of visitors that stay over night in the area participate in beach related activities. It also identified that 6% of day trippers use the beach. Table B3 below presents statistics of the number of visitors to Whitby during 2004/05.

**Table B3 Annual visitor numbers to Whitby 2004 - 2005**

| | | |
|---|---|---|
| **Day visitors** | **830,000** | **55%** |
| **Staying visitor days** | **690,000** | **45%** |
| **Total visitor days** | **1,520,000** | **100%** |

Based on statistics produced by Tourism UK, the average spend profile of visitors to Whitby is £53.49 per day for visitors staying over night, and £35.64 for day trippers. Combined with the data in **Table B3** above, this equates to an average annual income of approximately **£66,489,300.**

If we assume that in the absence of the piers the 6% of day trippers that use the beach did not visit Whitby there would be a reduction in tourist income of 3.27%. If we then assume that of the 26% of staying visitors that use the beach some 10% of these also stay away there would be a further reduction in tourist income of 1.18%, giving a total reduction in tourist income of 4.45%. Assuming that the tourist income were to remain stable for the foreseeable future (in reality the tourist sector is growing in Whitby) this would result in a loss of **£2,958,773** per year once the beach has been entirely lost.

This results in a total PV loss over a 100 year period of **£76,026,509**. This assuming a gradual decline in beach related income over the first 10 years until the beach is completely lost (Annex E). The total PV loss to the local economy over a 50 year period is expected to be **£60,877,655**.

## 11. Loss of Amenity

It is known that the present size, type and location of the piers and pier extensions are conducive to amenity and recreational usage, such as promenading and fishing. If the piers were lost, this amenity and recreational benefit would also be lost.

It is assumed that reconstruction of basic structures in an identical orientation at the mouth of the River Esk estuary would enable these benefits to be reinstated. The cost of demolishing remnant derelict structures and reconstructing on the same alignment is estimated at £202,456,000.

If it is assumed that the main piers would be lost and reconstructed in year 30. The discounted PV benefit is therefore £79,205,045 over 50 years and £86,038,422 over 100 years. These values assume an annual maintenance cost of 1% of the capital construction cost. This accounts for 20 years for maintenance for the 50 year PV benefit and 70 years of maintenance of the 100 year PV benefit. Calculations of these benefits are presented in Annex E.

## 12. Loss of Jobs

The loss of the piers and the associated consequential impacts would have major impacts on the livelihoods of many people within the town of Whitby, leading to loss of jobs. Present economic assessment techniques do not allow for this to be included within benefits appraisals since it is considered that these jobs could be re-created elsewhere within the UK and therefore the 'damage' is not to the nation, even though it will severely affect Whitby. Due to this, no values have been included for the inevitable loss of jobs that would arise if the piers were lost.

## 13. Relocation of Lifeboat Station as Part of Exit Strategy

The current, newly constructed, lifeboat station at Whitby is located on the east bank of the River Esk estuary within a zone that is well sheltered by the piers. The station is also protected by a small secondary pier inside the shelter of the primary piers which provides a second layer of protection to launching rescue vessels.

It is envisaged that if the piers were to be lost, this would have a considerable impact of the condition and operational efficiency of the station.

Increased wave energy impacting upon the secondary pier is likely to significantly reduce the expected life span of the structure, increasing the cost of maintenance and inevitably leading to its collapse.

Royal Haskoning works with the RNLI around the UK and therefore has extensive and recent experience in the design and construction of lifeboat stations. Due to this, it has been possible to establish an approximate construction cost of a replacement life boat station of the same specifications as the current station.

An approximate cost of £4 million is provided. This includes the cost of construction on which would bring the facilities up to the standard of new legislative requirements. If this cost is discounted to assume that the lifeboat station is not lost of the first 30 years, a present value damage cost of **£1,424,000** is incurred.

14. Summary of Benefits

Table B4 provides a summary of the benefits which are expected as a direct result of capital investment in the pier structures at Whitby Harbour.

**Table B4 Summary of Benefits Appraisal**

| Benefit Category | Value (£) | |
|---|---|---|
| | 50 years | 100 years |
| Damages from Tidal and Wave Flooding | £31,294,941 | £43,912,496 |
| Damages from Erosion of Adjacent Coastal Frontages | £4,091,949 | £8,892,088 |
| Damages Caused by Wave Run-Up | £4,353,915 | £5,265,655 |
| Loss of Refuge at Whitby Harbour | £7,846,333 | £9,485,404 |
| Increased Dredging Requirements in the Estuary | £5,555,828 | £6,707,823 |
| Loss of Grade II Listed Structures | £64,792,122 | £69,822,499 |
| Loss of Geological SSSI | £79,205,045 | £86,038,422 |
| Loss of Fishing Income | £2,458,958 | £3,181,131 |
| Damage to Fishing Fleet | £9,877,027 | £11,925,018 |
| Loss of Tourist Income | £60,877,655 | £76,026,509 |
| Loss of Amenity * | £79,205,045 | £86,038,422 |
| Loss of Jobs * | Not included in monetary terms | Not included in monetary terms |
| Relocation of Lifeboat Station | £1,424,000 | £1,424,000 |
| **Total Benefit (all categories)** | **£350,982,818** | **£408,719,467** |
| **Total Benefit (excluding those categories marked *)** | **£271,777,773** | **£322,781,045** |

* These categories may need to be excluded from the benefits appraisal as the approaches to the assessment of benefits is non-conventional and probably does not truly reflect the 'value' of the assets. It would be possible to better quantify loss of amenity value through a Contingent Valuation study, but the benefits seem sufficiently robust without these categories included.

# Appendix B

# Annexes

**Flooding over 100 years with waves**

| Year | 2008 | 2108 | Totals over 100 years | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|
| Discount rate | 3.50 | 2.50 | | | |
| | 1.00 | 0.05 | 29.86 | 1.11 | 158 |
| | | | | | |
| Total | £ 7,736,023.77 | £ 14,405,786.36 | £ 265,511,662.71 | Total inc. Emergency | Total Value to Capped Properties |
| Total (uncapped) | £ 3,107,511.64 | £ 7,770,806.56 | £ 116,913,690.64 | **£ 164,804,796.25** | £ 20,326,683.06 |

**Flooding over 100 years without waves**

| Year | 2008 | 2108 | Totals over 100 years | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|
| Discount rate | 3.50 | 2.50 | | | |
| | 1.00 | 0.05 | 29.86 | 1.11 | 145 |
| | | | | | |
| Total | £ 5,887,436.62 | £ 11,799,741.30 | £ 206,389,973.57 | Total inc. Emergency | Total Value to Capped Properties |
| Total (uncapped) | £ 2,092,013.42 | £ 5,838,374.30 | £ 81,846,220.52 | **£ 120,892,299.58** | £ 18,826,240.17 |

**Flooding over 50 years with waves**

| Year | 2008 | 2058 | Totals over 50 years | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|
| Discount rate | 3.50 | 3.00 | | | |
| | 1.00 | 0.20 | 24.69 | 1.11 | 143 |
| | | | | | |
| Total | £ 7,736,023.77 | £ 7,736,023.77 | £ 191,022,296.83 | Total inc. Emergency | Total Value to Capped Properties |
| Total (uncapped) | £ 3,137,204.40 | £ 3,137,204.40 | £ 77,465,634.58 | **£ 115,540,213.70** | £ 18,749,903.23 |

**Flooding over 50 years without waves**

| Year | 2008 | 2058 | Totals over 50 years | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|
| Discount rate | 3.50 | 3.00 | | | |
| | 1.00 | 0.20 | 24.69 | 1.11 | 137 |
| | | | | | |
| Total | £ 5,887,436.62 | £ 5,887,436.62 | £ 145,375,932.04 | Total inc. Emergency | Total Value to Capped Properties |
| Total (uncapped) | £ 2,117,909.66 | £ 2,117,909.66 | £ 52,296,629.42 | **£ 84,245,272.05** | £ 17,858,201.52 |

Flood damage with and without waves over 50 and 100 years

## Annex B

Erosion Damage to the West of Whitby Piers With Piers

| Year | Total Damage | |
|---|---|---|
| 0 - 30 | £ | 350,193 |
| 31 - 75 | £ | 415,412 |
| 76 - 100 | £ | 89,479 |
| **Total** | **£** | **855,085** |

Erosion Damage to the West of Whitby Piers Without Piers

| Year | Total Damage | |
|---|---|---|
| 0 - 30 | £ | 1,411,075 |
| 31 - 75 | £ | 4,006,691 |
| 76 - 100 | £ | 1,246,282 |
| **Total** | **£** | **6,664,047** |

## Annex C

Erosion Damage to the East of Whitby Piers With Piers

| Year | Total Damage | |
|---|---|---|
| 0 - 30 | £ | 8,322 |
| 31 - 75 | £ | 622,455 |
| 76 - 100 | £ | 369,439 |
| **Total** | **£** | **1,000,216** |

Erosion Damage to the East of Whitby Piers Without Piers

| Year | Total Damage | |
|---|---|---|
| 0 - 30 | £ | 939,848 |
| 31 - 75 | £ | 1,644,960 |
| 76 - 100 | £ | 643,448 |
| **Total** | **£** | **3,228,257** |

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Wave run up damage costs over 50 years

| | Year | 2008 | 2058 | Totals over 50 years | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|---|
| | **Discount rate** | 3.5 | 3 | | | |
| | | 1.00 | 0.20 | 24.69 | 1.107 | 0 |
| | | | | | | |
| | Total | 146833.72 | 146833.72 | 3625701.70 | **Total inc. Emergency** | Total Value to Capped Properties |
| | Total (uncapped) | 146833.72 | 146833.72 | 3625701.70 | **£ 4,353,915.79** | 0 |
| **Property _ID** | **AAD** | **AAD yr0** | **AADyr 100** | **PVD** | **Market Value** | **capped?** |
| | | | | | | |
| PLEASURELAND AMUSEMENTS | 110499.01 | 110499.01 | 110499.01 | 2728504.34 | | 0 |
| WHITBY FISHERMANS FOOTBALL CLUB | 4219.77 | 4219.77 | 4219.77 | 104196.95 | | 0 |
| THE ENDEAVOUR OFFICE | 6783.71 | 6783.71 | 6783.71 | 167507.21 | | 0 |
| R N L I MUSEUM | 22270.43 | 22270.43 | 22270.43 | 549914.01 | | 0 |
| WHITBY YACHT CLUB | 3060.81 | 3060.81 | 3060.81 | 75579.19 | | 0 |

Wave run up damage costs over 100 years

| | Year | 2008 | 2108 | Totals over 100yrs | Increse due to Emergency Costs | Number capped |
|---|---|---|---|---|---|---|
| | **Discount rate** | 3.5 | 2.5 | | | |
| | | 1.00 | 0.05 | 29.86 | 1.107 | 0 |
| | | | | | | |
| | Total | 146833.72 | 146833.72 | 4384948.75 | **Total inc. Emergency** | Total Value to Capped Properties |
| | Total (uncapped) | 146833.72 | 146833.72 | 4384948.75 | **£ 5,265,655.91** | 0 |
| **Property _ID** | **AAD** | **AAD yr0** | **AADyr 100** | **PVD** | **Market Value** | **capped?** |
| | | | | | | |
| PLEASURELAND AMUSEMENTS | 110499.01 | 110499.01 | 110499.01 | 3299872.05 | | 0 |
| WHITBY FISHERMANS FOOTBALL CLUB | 4219.77 | 4219.77 | 4219.77 | 126016.52 | | 0 |
| THE ENDEAVOUR OFFICE | 6783.71 | 6783.71 | 6783.71 | 202584.38 | | 0 |
| R N L I MUSEUM | 22270.43 | 22270.43 | 22270.43 | 665069.81 | | 0 |
| WHITBY YACHT CLUB | 3060.81 | 3060.81 | 3060.81 | 91405.99 | | 0 |

Wave run up damages over 50 and 100 years

ROYAL HASKONING

## Whitby PV Damages

Discount PV factors

| 0-30 | 3.5% |
|---|---|
| 31-75 | 3.0% |
| 76-99 | 2.5% |

| | | Dredging (Present) | | 50 years | Dredging (No Piers) | | 50 years | Fishing Income (Present) | | 50 years | Fishing Income (No Piers) | | 50 years | Damage to Boats | | 50 years | Loss to tourist income from beach | | 50 years | 3 DEATHS A YEAR | | 50 years | 1 Death every 5 years | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total PV Cost | | £4,471,882 | £3,703,885 | | £11,179,704 | £9,259,713 | | £4,205,060 | £3,482,887 | | £1,023,929 | £1,023,929 | | £11,925,018 | £9,877,027 | | £76,026,509 | £60,877,655 | | £44,718,818 | £37,038,853 | | £9,485,404 |
| Year | PV factor | Actual | PV cost | PV cost | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | |
| 0 | 1.000 | 150000 | 150,000 | 150,000 | 375,000 | 375,000 | 375,000 | 141,050 | 141,050 | 141,050 | 141,050 | 141,050 | 141,050 | 400,000 | 400,000 | 400,000 | £295,877.39 | 295,877 | 295,877 | 1500000 | 1,500,000 | 1,500,000 | 1500000 | 1,500,000 |
| 1 | 0.966 | 150000 | 144,928 | 144,928 | 375,000 | 362,319 | 362,319 | 141,050 | 136,280 | 136,280 | 126,945 | 122,652 | 122,652 | 400,000 | 386,473 | 386,473 | £591,754.77 | 571,744 | 571,744 | 1500000 | 1,449,275 | 1,449,275 | 0 | 0 |
| 2 | 0.934 | 150000 | 140,027 | 140,027 | 375,000 | 350,067 | 350,067 | 141,050 | 131,672 | 131,672 | 114,251 | 106,654 | 106,654 | 400,000 | 373,404 | 373,404 | £887,632.16 | 828,614 | 828,614 | 1500000 | 1,400,266 | 1,400,266 | 0 | 0 |
| 3 | 0.902 | 150000 | 135,291 | 135,291 | 375,000 | 338,229 | 338,229 | 141,050 | 127,219 | 127,219 | 102,825 | 92,743 | 92,743 | 400,000 | 360,777 | 360,777 | £1,183,509.54 | 1,067,458 | 1,067,458 | 1500000 | 1,352,914 | 1,352,914 | 0 | 0 |
| 4 | 0.871 | 150000 | 130,716 | 130,716 | 375,000 | 326,791 | 326,791 | 141,050 | 122,917 | 122,917 | 92,543 | 80,646 | 80,646 | 400,000 | 348,577 | 348,577 | £1,479,386.93 | 1,289,200 | 1,289,200 | 1500000 | 1,307,163 | 1,307,163 | 0 | 0 |
| 5 | 0.842 | 150000 | 126,296 | 126,296 | 375,000 | 315,740 | 315,740 | 141,050 | 118,760 | 118,760 | 83,289 | 70,127 | 70,127 | 400,000 | 336,789 | 336,789 | £1,775,264.31 | 1,494,725 | 1,494,725 | 1500000 | 1,262,960 | 1,262,960 | 1500000 | 1,262,960 |
| 6 | 0.814 | 150000 | 122,025 | 122,025 | 375,000 | 305,063 | 305,063 | 141,050 | 114,744 | 114,744 | 74,960 | 60,980 | 60,980 | 400,000 | 325,400 | 325,400 | £2,071,141.70 | 1,684,875 | 1,684,875 | 1500000 | 1,220,251 | 1,220,251 | 0 | 0 |
| 7 | 0.786 | 150000 | 117,899 | 117,899 | 375,000 | 294,747 | 294,747 | 141,050 | 110,864 | 110,864 | 67,464 | 53,026 | 53,026 | 400,000 | 314,396 | 314,396 | £2,367,019.08 | 1,860,456 | 1,860,456 | 1500000 | 1,178,986 | 1,178,986 | 0 | 0 |
| 8 | 0.759 | 150000 | 113,912 | 113,912 | 375,000 | 284,779 | 284,779 | 141,050 | 107,115 | 107,115 | 60,717 | 46,109 | 46,109 | 400,000 | 303,765 | 303,765 | £2,662,896.47 | 2,022,234 | 2,022,234 | 1500000 | 1,139,117 | 1,139,117 | 0 | 0 |
| 9 | 0.734 | 150000 | 110,060 | 110,060 | 375,000 | 275,149 | 275,149 | 141,050 | 103,493 | 103,493 | 54,646 | 40,095 | 40,095 | 400,000 | 293,492 | 293,492 | £2,958,773.85 | 2,170,944 | 2,170,944 | 1500000 | 1,100,596 | 1,100,596 | 0 | 0 |
| 10 | 0.709 | 150000 | 106,338 | 106,338 | 375,000 | 265,845 | 265,845 | 141,050 | 99,993 | 99,993 | 49,181 | 34,865 | 34,865 | 400,000 | 283,568 | 283,568 | £2,958,773.85 | 2,097,530 | 2,097,530 | 1500000 | 1,063,378 | 1,063,378 | 1500000 | 1,063,378 |
| 11 | 0.685 | 150000 | 102,742 | 102,742 | 375,000 | 256,855 | 256,855 | 141,050 | 96,612 | 96,612 | 44,263 | 30,318 | 30,318 | 400,000 | 273,978 | 273,978 | £2,958,773.85 | 2,026,599 | 2,026,599 | 1500000 | 1,027,419 | 1,027,419 | 0 | 0 |
| 12 | 0.662 | 150000 | 99,267 | 99,267 | 375,000 | 248,169 | 248,169 | 141,050 | 93,345 | 93,345 | 39,837 | 26,363 | 26,363 | 400,000 | 264,713 | 264,713 | £2,958,773.85 | 1,958,067 | 1,958,067 | 1500000 | 992,675 | 992,675 | 0 | 0 |
| 13 | 0.639 | 150000 | 95,911 | 95,911 | 375,000 | 239,777 | 239,777 | 141,050 | 90,188 | 90,188 | 35,853 | 22,925 | 22,925 | 400,000 | 255,762 | 255,762 | £2,958,773.85 | 1,891,852 | 1,891,852 | 1500000 | 959,106 | 959,106 | 0 | 0 |
| 14 | 0.618 | 150000 | 92,667 | 92,667 | 375,000 | 231,668 | 231,668 | 141,050 | 87,138 | 87,138 | 32,268 | 19,934 | 19,934 | 400,000 | 247,113 | 247,113 | £2,958,773.85 | 1,827,877 | 1,827,877 | 1500000 | 926,673 | 926,673 | 0 | 0 |
| 15 | 0.597 | 150000 | 89,534 | 89,534 | 375,000 | 223,834 | 223,834 | 141,050 | 84,191 | 84,191 | 29,041 | 17,334 | 17,334 | 400,000 | 238,756 | 238,756 | £2,958,773.85 | 1,766,064 | 1,766,064 | 1500000 | 895,336 | 895,336 | 1500000 | 895,336 |
| 16 | 0.577 | 150000 | 86,506 | 86,506 | 375,000 | 216,265 | 216,265 | 141,050 | 81,344 | 81,344 | 26,137 | 15,073 | 15,073 | 400,000 | 230,682 | 230,682 | £2,958,773.85 | 1,706,342 | 1,706,342 | 1500000 | 865,059 | 865,059 | 0 | 0 |
| 17 | 0.557 | 150000 | 83,581 | 83,581 | 375,000 | 208,951 | 208,951 | 141,050 | 78,594 | 78,594 | 23,523 | 13,107 | 13,107 | 400,000 | 222,882 | 222,882 | £2,958,773.85 | 1,648,640 | 1,648,640 | 1500000 | 835,806 | 835,806 | 0 | 0 |
| 18 | 0.538 | 150000 | 80,754 | 80,754 | 375,000 | 201,885 | 201,885 | 141,050 | 75,936 | 75,936 | 21,171 | 11,398 | 11,398 | 400,000 | 215,344 | 215,344 | £2,958,773.85 | 1,592,889 | 1,592,889 | 1500000 | 807,542 | 807,542 | 0 | 0 |
| 19 | 0.520 | 150000 | 78,023 | 78,023 | 375,000 | 195,058 | 195,058 | 141,050 | 73,368 | 73,368 | 19,054 | 9,911 | 9,911 | 400,000 | 208,062 | 208,062 | £2,958,773.85 | 1,539,023 | 1,539,023 | 1500000 | 780,234 | 780,234 | 0 | 0 |
| 20 | 0.503 | 150000 | 75,385 | 75,385 | 375,000 | 188,462 | 188,462 | 141,050 | 70,887 | 70,887 | 17,148 | 8,618 | 8,618 | 400,000 | 201,026 | 201,026 | £2,958,773.85 | 1,486,979 | 1,486,979 | 1500000 | 753,849 | 753,849 | 1500000 | 753,849 |
| 21 | 0.486 | 150000 | 72,836 | 72,836 | 375,000 | 182,089 | 182,089 | 141,050 | 68,490 | 68,490 | 0 | 0 | 0 | 400,000 | 194,228 | 194,228 | £2,958,773.85 | 1,436,694 | 1,436,694 | 1500000 | 728,356 | 728,356 | 0 | 0 |
| 22 | 0.469 | 150000 | 70,373 | 70,373 | 375,000 | 175,931 | 175,931 | 141,050 | 66,174 | 66,174 | 0 | 0 | 0 | 400,000 | 187,660 | 187,660 | £2,958,773.85 | 1,388,111 | 1,388,111 | 1500000 | 703,726 | 703,726 | 0 | 0 |
| 23 | 0.453 | 150000 | 67,993 | 67,993 | 375,000 | 169,982 | 169,982 | 141,050 | 63,936 | 63,936 | 0 | 0 | 0 | 400,000 | 181,314 | 181,314 | £2,958,773.85 | 1,341,170 | 1,341,170 | 1500000 | 679,928 | 679,928 | 0 | 0 |
| 24 | 0.438 | 150000 | 65,694 | 65,694 | 375,000 | 164,234 | 164,234 | 141,050 | 61,774 | 61,774 | 0 | 0 | 0 | 400,000 | 175,183 | 175,183 | £2,958,773.85 | 1,295,816 | 1,295,816 | 1500000 | 656,936 | 656,936 | 0 | 0 |
| 25 | 0.423 | 150000 | 63,472 | 63,472 | 375,000 | 158,680 | 158,680 | 141,050 | 59,685 | 59,685 | 0 | 0 | 0 | 400,000 | 169,259 | 169,259 | £2,958,773.85 | 1,251,996 | 1,251,996 | 1500000 | 634,720 | 634,720 | 1500000 | 634,720 |
| 26 | 0.409 | 150000 | 61,326 | 61,326 | 375,000 | 153,314 | 153,314 | 141,050 | 57,667 | 57,667 | 0 | 0 | 0 | 400,000 | 163,535 | 163,535 | £2,958,773.85 | 1,209,658 | 1,209,658 | 1500000 | 613,257 | 613,257 | 0 | 0 |
| 27 | 0.395 | 150000 | 59,252 | 59,252 | 375,000 | 148,130 | 148,130 | 141,050 | 55,716 | 55,716 | 0 | 0 | 0 | 400,000 | 158,005 | 158,005 | £2,958,773.85 | 1,168,752 | 1,168,752 | 1500000 | 592,518 | 592,518 | 0 | 0 |
| 28 | 0.382 | 150000 | 57,248 | 57,248 | 375,000 | 143,120 | 143,120 | 141,050 | 53,832 | 53,832 | 0 | 0 | 0 | 400,000 | 152,662 | 152,662 | £2,958,773.85 | 1,129,229 | 1,129,229 | 1500000 | 572,482 | 572,482 | 0 | 0 |
| 29 | 0.369 | 150000 | 55,312 | 55,312 | 375,000 | 138,281 | 138,281 | 141,050 | 52,012 | 52,012 | 0 | 0 | 0 | 400,000 | 147,499 | 147,499 | £2,958,773.85 | 1,091,042 | 1,091,042 | 1500000 | 553,122 | 553,122 | 0 | 0 |
| 30 | 0.356 | 150000 | 53,442 | 53,442 | 375,000 | 133,604 | 133,604 | 141,050 | 50,253 | 50,253 | 0 | 0 | 0 | 400,000 | 142,511 | 142,511 | £2,958,773.85 | 1,054,147 | 1,054,147 | 1500000 | 534,418 | 534,418 | 1500000 | 534,418 |
| 31 | 0.346 | 150000 | 51,885 | 51,885 | 375,000 | 129,713 | 129,713 | 141,050 | 48,789 | 48,789 | 0 | 0 | 0 | 400,000 | 138,361 | 138,361 | £2,958,773.85 | 1,023,444 | 1,023,444 | 1500000 | 518,852 | 518,852 | 0 | 0 |
| 32 | 0.336 | 150000 | 50,374 | 50,374 | 375,000 | 125,935 | 125,935 | 141,050 | 47,368 | 47,368 | 0 | 0 | 0 | 400,000 | 134,331 | 134,331 | £2,958,773.85 | 993,635 | 993,635 | 1500000 | 503,740 | 503,740 | 0 | 0 |
| 33 | 0.326 | 150000 | 48,907 | 48,907 | 375,000 | 122,267 | 122,267 | 141,050 | 45,989 | 45,989 | 0 | 0 | 0 | 400,000 | 130,418 | 130,418 | £2,958,773.85 | 964,694 | 964,694 | 1500000 | 489,068 | 489,068 | 0 | 0 |
| 34 | 0.317 | 150000 | 47,482 | 47,482 | 375,000 | 118,706 | 118,706 | 141,050 | 44,649 | 44,649 | 0 | 0 | 0 | 400,000 | 126,620 | 126,620 | £2,958,773.85 | 936,596 | 936,596 | 1500000 | 474,823 | 474,823 | 0 | 0 |
| 35 | 0.307 | 150000 | 46,099 | 46,099 | 375,000 | 115,248 | 115,248 | 141,050 | 43,349 | 43,349 | 0 | 0 | 0 | 400,000 | 122,932 | 122,932 | £2,958,773.85 | 909,317 | 909,317 | 1500000 | 460,993 | 460,993 | 1500000 | 460,993 |
| 36 | 0.298 | 150000 | 44,757 | 44,757 | 375,000 | 111,892 | 111,892 | 141,050 | 42,086 | 42,086 | 0 | 0 | 0 | 400,000 | 119,351 | 119,351 | £2,958,773.85 | 882,832 | 882,832 | 1500000 | 447,566 | 447,566 | 0 | 0 |
| 37 | 0.290 | 150000 | 43,453 | 43,453 | 375,000 | 108,633 | 108,633 | 141,050 | 40,860 | 40,860 | 0 | 0 | 0 | 400,000 | 115,875 | 115,875 | £2,958,773.85 | 857,118 | 857,118 | 1500000 | 434,530 | 434,530 | 0 | 0 |
| 38 | 0.281 | 150000 | 42,187 | 42,187 | 375,000 | 105,469 | 105,469 | 141,050 | 39,670 | 39,670 | 0 | 0 | 0 | 400,000 | 112,500 | 112,500 | £2,958,773.85 | 832,154 | 832,154 | 1500000 | 421,874 | 421,874 | 0 | 0 |
| 39 | 0.273 | 150000 | 40,959 | 40,959 | 375,000 | 102,397 | 102,397 | 141,050 | 38,515 | 38,515 | 0 | 0 | 0 | 400,000 | 109,223 | 109,223 | £2,958,773.85 | 807,916 | 807,916 | 1500000 | 409,587 | 409,587 | 0 | 0 |
| 40 | 0.265 | 150000 | 39,766 | 39,766 | 375,000 | 99,414 | 99,414 | 141,050 | 37,393 | 37,393 | 0 | 0 | 0 | 400,000 | 106,042 | 106,042 | £2,958,773.85 | 784,385 | 784,385 | 1500000 | 397,657 | 397,657 | 1500000 | 397,657 |
| 41 | 0.257 | 150000 | 38,607 | 38,607 | 375,000 | 96,519 | 96,519 | 141,050 | 36,304 | 36,304 | 0 | 0 | 0 | 400,000 | 102,953 | 102,953 | £2,958,773.85 | 761,538 | 761,538 | 1500000 | 386,075 | 386,075 | 0 | 0 |
| 42 | 0.250 | 150000 | 37,483 | 37,483 | 375,000 | 93,707 | 93,707 | 141,050 | 35,246 | 35,246 | 0 | 0 | 0 | 400,000 | 99,955 | 99,955 | £2,958,773.85 | 739,358 | 739,358 | 1500000 | 374,830 | 374,830 | 0 | 0 |
| 43 | 0.243 | 150000 | 36,391 | 36,391 | 375,000 | 90,978 | 90,978 | 141,050 | 34,220 | 34,220 | 0 | 0 | 0 | 400,000 | 97,043 | 97,043 | £2,958,773.85 | 717,823 | 717,823 | 1500000 | 363,912 | 363,912 | 0 | 0 |
| 44 | 0.236 | 150000 | 35,331 | 35,331 | 375,000 | 88,328 | 88,328 | 141,050 | 33,223 | 33,223 | 0 | 0 | 0 | 400,000 | 94,217 | 94,217 | £2,958,773.85 | 696,916 | 696,916 | 1500000 | 353,313 | 353,313 | 0 | 0 |
| 45 | 0.229 | 150000 | 34,302 | 34,302 | 375,000 | 85,756 | 85,756 | 141,050 | 32,256 | 32,256 | 0 | 0 | 0 | 400,000 | 91,473 | 91,473 | £2,958,773.85 | 676,617 | 676,617 | 1500000 | 343,022 | 343,022 | 1500000 | 343,022 |
| 46 | 0.222 | 150000 | 33,303 | 33,303 | 375,000 | 83,258 | 83,258 | 141,050 | 31,316 | 31,316 | 0 | 0 | 0 | 400,000 | 88,808 | 88,808 | £2,958,773.85 | 656,910 | 656,910 | 1500000 | 333,031 | 333,031 | 0 | 0 |
| 47 | 0.216 | 150000 | 32,333 | 32,333 | 375,000 | 80,833 | 80,833 | 141,050 | 30,404 | 30,404 | 0 | 0 | 0 | 400,000 | 86,222 | 86,222 | £2,958,773.85 | 637,776 | 637,776 | 1500000 | 323,331 | 323,331 | 0 | 0 |
| 48 | 0.209 | 150000 | 31,391 | 31,391 | 375,000 | 78,479 | 78,479 | 141,050 | 29,518 | 29,518 | 0 | 0 | 0 | 400,000 | 83,710 | 83,710 | £2,958,773.85 | 619,200 | 619,200 | 1500000 | 313,914 | 313,914 | 0 | 0 |
| 49 | 0.203 | 150000 | 30,477 | 30,477 | 375,000 | 76,193 | 76,193 | 141,050 | 28,659 | 28,659 | 0 | 0 | 0 | 400,000 | 81,272 | 81,272 | £2,958,773.85 | 601,165 | 601,165 | 1500000 | 304,771 | 304,771 | 0 | 0 |
| 50 | 0.197 | 150000 | 29,589 | 29,589 | 375,000 | 73,974 | 73,974 | 141,050 | 27,824 | 27,824 | 0 | 0 | 0 | 400,000 | 78,905 | 78,905 | £2,958,773.85 | 583,656 | 583,656 | 1500000 | 295,894 | 295,894 | 0 | 0 |
| 51 | 0.192 | 150000 | 28,728 | | 375,000 | 71,819 | | 141,050 | 27,014 | | 0 | 0 | | 400,000 | 76,607 | | £2,958,773.85 | 566,656 | | 1500000 | 287,276 | | 1500000 | 287,276 |
| 52 | 0.186 | 150000 | 27,891 | | 375,000 | 69,727 | | 141,050 | 26,227 | | 0 | 0 | | 400,000 | 74,376 | | £2,958,773.85 | 550,152 | | 1500000 | 278,909 | | 0 | 0 |
| 53 | 0.181 | 150000 | 27,078 | | 375,000 | 67,696 | | 141,050 | 25,463 | | 0 | 0 | | 400,000 | 72,209 | | £2,958,773.85 | 534,128 | | 1500000 | 270,785 | | 0 | 0 |
| 54 | 0.175 | 150000 | 26,290 | | 375,000 | 65,725 | | 141,050 | 24,721 | | 0 | 0 | | 400,000 | 70,106 | | £2,958,773.85 | 518,571 | | 1500000 | 262,898 | | 0 | 0 |
| 55 | 0.170 | 150000 | 25,524 | | 375,000 | 63,810 | | 141,050 | 24,001 | | 0 | 0 | | 400,000 | 68,064 | | £2,958,773.85 | 503,467 | | 1500000 | 255,241 | | 0 | 0 |
| 56 | 0.165 | 150000 | 24,781 | | 375,000 | 61,952 | | 141,050 | 23,302 | | 0 | 0 | | 400,000 | 66,082 | | £2,958,773.85 | 488,803 | | 1500000 | 247,807 | | 1500000 | 247,807 |
| 57 | 0.160 | 150000 | 24,059 | | 375,000 | 60,147 | | 141,050 | 22,623 | | 0 | 0 | | 400,000 | 64,157 | | £2,958,773.85 | 474,566 | | 1500000 | 240,589 | | 0 | 0 |
| 58 | 0.156 | 150000 | 23,358 | | 375,000 | 58,395 | | 141,050 | 21,964 | | 0 | 0 | | 400,000 | 62,288 | | £2,958,773.85 | 460,743 | | 1500000 | 233,582 | | 0 | 0 |
| 59 | 0.151 | 150000 | 22,678 | | 375,000 | 56,695 | | 141,050 | 21,325 | | 0 | 0 | | 400,000 | 60,474 | | £2,958,773.85 | 447,324 | | 1500000 | 226,778 | | 0 | 0 |
| 60 | 0.147 | 150000 | 22,017 | | 375,000 | 55,043 | | 141,050 | 20,704 | | 0 | 0 | | 400,000 | 58,713 | | £2,958,773.85 | 434,295 | | 1500000 | 220,173 | | 0 | 0 |
| 61 | 0.143 | 150000 | 21,376 | | 375,000 | 53,440 | | 141,050 | 20,101 | | 0 | 0 | | 400,000 | 57,003 | | £2,958,773.85 | 421,645 | | 1500000 | 213,760 | | 1500000 | 213,760 |

Discount rates

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 0.138 | 150000 | 20,753 | | 375,000 | 51,884 | | 141,050 | 19,515 | | 0 | 0 | | 400,000 | 55,342 | | £2,958,773.85 | 409,364 | | 1500000 | 207,534 | | 0 | 0 |
| 63 | 0.134 | 150000 | 20,149 | | 375,000 | 50,372 | | 141,050 | 18,947 | | 0 | 0 | | 400,000 | 53,731 | | £2,958,773.85 | 397,441 | | 1500000 | 201,489 | | 0 | 0 |
| 64 | 0.130 | 150000 | 19,562 | | 375,000 | 48,905 | | 141,050 | 18,395 | | 0 | 0 | | 400,000 | 52,166 | | £2,958,773.85 | 385,865 | | 1500000 | 195,621 | | 0 | 0 |
| 65 | 0.127 | 150000 | 18,992 | | 375,000 | 47,481 | | 141,050 | 17,859 | | 0 | 0 | | 400,000 | 50,646 | | £2,958,773.85 | 374,626 | | 1500000 | 189,923 | | 0 | 0 |
| 66 | 0.123 | 150000 | 18,439 | | 375,000 | 46,098 | | 141,050 | 17,339 | | 0 | 0 | | 400,000 | 49,171 | | £2,958,773.85 | 363,715 | | 1500000 | 184,391 | | 1500000 | 184,391 |
| 67 | 0.119 | 150000 | 17,902 | | 375,000 | 44,755 | | 141,050 | 16,834 | | 0 | 0 | | 400,000 | 47,739 | | £2,958,773.85 | 353,121 | | 1500000 | 179,021 | | 0 | 0 |
| 68 | 0.116 | 150000 | 17,381 | | 375,000 | 43,452 | | 141,050 | 16,344 | | 0 | 0 | | 400,000 | 46,348 | | £2,958,773.85 | 342,836 | | 1500000 | 173,807 | | 0 | 0 |
| 69 | 0.112 | 150000 | 16,874 | | 375,000 | 42,186 | | 141,050 | 15,868 | | 0 | 0 | | 400,000 | 44,998 | | £2,958,773.85 | 332,851 | | 1500000 | 168,744 | | 0 | 0 |
| 70 | 0.109 | 150000 | 16,383 | | 375,000 | 40,957 | | 141,050 | 15,405 | | 0 | 0 | | 400,000 | 43,688 | | £2,958,773.85 | 323,156 | | 1500000 | 163,829 | | 0 | 0 |
| 71 | 0.106 | 150000 | 15,906 | | 375,000 | 39,764 | | 141,050 | 14,957 | | 0 | 0 | | 400,000 | 42,415 | | £2,958,773.85 | 313,744 | | 1500000 | 159,058 | | 1500000 | 159,058 |
| 72 | 0.103 | 150000 | 15,442 | | 375,000 | 38,606 | | 141,050 | 14,521 | | 0 | 0 | | 400,000 | 41,180 | | £2,958,773.85 | 304,606 | | 1500000 | 154,425 | | 0 | 0 |
| 73 | 0.100 | 150000 | 14,993 | | 375,000 | 37,482 | | 141,050 | 14,098 | | 0 | 0 | | 400,000 | 39,981 | | £2,958,773.85 | 295,734 | | 1500000 | 149,927 | | 0 | 0 |
| 74 | 0.097 | 150000 | 14,556 | | 375,000 | 36,390 | | 141,050 | 13,688 | | 0 | 0 | | 400,000 | 38,816 | | £2,958,773.85 | 287,120 | | 1500000 | 145,560 | | 0 | 0 |
| 75 | 0.094 | 150000 | 14,132 | | 375,000 | 35,330 | | 141,050 | 13,289 | | 0 | 0 | | 400,000 | 37,686 | | £2,958,773.85 | 278,757 | | 1500000 | 141,321 | | 0 | 0 |
| 76 | 0.092 | 150000 | 13,787 | | 375,000 | 34,468 | | 141,050 | 12,965 | | 0 | 0 | | 400,000 | 36,766 | | £2,958,773.85 | 271,958 | | 1500000 | 137,874 | | 1500000 | 137,874 |
| 77 | 0.090 | 150000 | 13,451 | | 375,000 | 33,628 | | 141,050 | 12,649 | | 0 | 0 | | 400,000 | 35,870 | | £2,958,773.85 | 265,325 | | 1500000 | 134,511 | | 0 | 0 |
| 78 | 0.087 | 150000 | 13,123 | | 375,000 | 32,808 | | 141,050 | 12,340 | | 0 | 0 | | 400,000 | 34,995 | | £2,958,773.85 | 258,854 | | 1500000 | 131,230 | | 0 | 0 |
| 79 | 0.085 | 150000 | 12,803 | | 375,000 | 32,007 | | 141,050 | 12,039 | | 0 | 0 | | 400,000 | 34,141 | | £2,958,773.85 | 252,540 | | 1500000 | 128,030 | | 0 | 0 |
| 80 | 0.083 | 150000 | 12,491 | | 375,000 | 31,227 | | 141,050 | 11,745 | | 0 | 0 | | 400,000 | 33,308 | | £2,958,773.85 | 246,381 | | 1500000 | 124,907 | | 0 | 0 |
| 81 | 0.081 | 150000 | 12,186 | | 375,000 | 30,465 | | 141,050 | 11,459 | | 0 | 0 | | 400,000 | 32,496 | | £2,958,773.85 | 240,372 | | 1500000 | 121,860 | | 1500000 | 121,860 |
| 82 | 0.079 | 150000 | 11,889 | | 375,000 | 29,722 | | 141,050 | 11,179 | | 0 | 0 | | 400,000 | 31,704 | | £2,958,773.85 | 234,509 | | 1500000 | 118,888 | | 0 | 0 |
| 83 | 0.077 | 150000 | 11,599 | | 375,000 | 28,997 | | 141,050 | 10,907 | | 0 | 0 | | 400,000 | 30,930 | | £2,958,773.85 | 228,789 | | 1500000 | 115,988 | | 0 | 0 |
| 84 | 0.075 | 150000 | 11,316 | | 375,000 | 28,290 | | 141,050 | 10,641 | | 0 | 0 | | 400,000 | 30,176 | | £2,958,773.85 | 223,209 | | 1500000 | 113,159 | | 0 | 0 |
| 85 | 0.074 | 150000 | 11,040 | | 375,000 | 27,600 | | 141,050 | 10,381 | | 0 | 0 | | 400,000 | 29,440 | | £2,958,773.85 | 217,765 | | 1500000 | 110,399 | | 0 | 0 |
| 86 | 0.072 | 150000 | 10,771 | | 375,000 | 26,927 | | 141,050 | 10,128 | | 0 | 0 | | 400,000 | 28,722 | | £2,958,773.85 | 212,453 | | 1500000 | 107,707 | | 1500000 | 107,707 |
| 87 | 0.070 | 150000 | 10,508 | | 375,000 | 26,270 | | 141,050 | 9,881 | | 0 | 0 | | 400,000 | 28,021 | | £2,958,773.85 | 207,272 | | 1500000 | 105,080 | | 0 | 0 |
| 88 | 0.068 | 150000 | 10,252 | | 375,000 | 25,629 | | 141,050 | 9,640 | | 0 | 0 | | 400,000 | 27,338 | | £2,958,773.85 | 202,216 | | 1500000 | 102,517 | | 0 | 0 |
| 89 | 0.067 | 150000 | 10,002 | | 375,000 | 25,004 | | 141,050 | 9,405 | | 0 | 0 | | 400,000 | 26,671 | | £2,958,773.85 | 197,284 | | 1500000 | 100,016 | | 0 | 0 |
| 90 | 0.065 | 150000 | 9,758 | | 375,000 | 24,394 | | 141,050 | 9,175 | | 0 | 0 | | 400,000 | 26,021 | | £2,958,773.85 | 192,472 | | 1500000 | 97,577 | | 0 | 0 |
| 91 | 0.063 | 150000 | 9,520 | | 375,000 | 23,799 | | 141,050 | 8,952 | | 0 | 0 | | 400,000 | 25,386 | | £2,958,773.85 | 187,778 | | 1500000 | 95,197 | | 1500000 | 95,197 |
| 92 | 0.062 | 150000 | 9,288 | | 375,000 | 23,219 | | 141,050 | 8,733 | | 0 | 0 | | 400,000 | 24,767 | | £2,958,773.85 | 183,198 | | 1500000 | 92,875 | | 0 | 0 |
| 93 | 0.060 | 150000 | 9,061 | | 375,000 | 22,652 | | 141,050 | 8,520 | | 0 | 0 | | 400,000 | 24,163 | | £2,958,773.85 | 178,730 | | 1500000 | 90,610 | | 0 | 0 |
| 94 | 0.059 | 150000 | 8,840 | | 375,000 | 22,100 | | 141,050 | 8,313 | | 0 | 0 | | 400,000 | 23,573 | | £2,958,773.85 | 174,370 | | 1500000 | 88,400 | | 0 | 0 |
| 95 | 0.057 | 150000 | 8,624 | | 375,000 | 21,561 | | 141,050 | 8,110 | | 0 | 0 | | 400,000 | 22,998 | | £2,958,773.85 | 170,117 | | 1500000 | 86,244 | | 0 | 0 |
| 96 | 0.056 | 150000 | 8,414 | | 375,000 | 21,035 | | 141,050 | 7,912 | | 0 | 0 | | 400,000 | 22,437 | | £2,958,773.85 | 165,968 | | 1500000 | 84,140 | | 1500000 | 84,140 |
| 97 | 0.055 | 150000 | 8,209 | | 375,000 | 20,522 | | 141,050 | 7,719 | | 0 | 0 | | 400,000 | 21,890 | | £2,958,773.85 | 161,920 | | 1500000 | 82,088 | | 0 | 0 |
| 98 | 0.053 | 150000 | 8,009 | | 375,000 | 20,022 | | 141,050 | 7,531 | | 0 | 0 | | 400,000 | 21,356 | | £2,958,773.85 | 157,971 | | 1500000 | 80,086 | | 0 | 0 |
| 99 | 0.052 | 150000 | 7,813 | | 375,000 | 19,533 | | 141,050 | 7,347 | | 0 | 0 | | 400,000 | 20,835 | | £2,958,773.85 | 154,118 | | 1500000 | 78,133 | | 0 | 0 |

Discount rates

ROYAL HASKONING

## Whitby PV Damages

Discount PV factors

| 0-30 | 3.5% | 50 years | Main Pier (Cladded) and Extensions | | 50 years | Main Pier (Cladded) No Extensions | | 50 years | Main Pier and Extensions No Cladding | | 50 years | Option 5 | | 50 years | Option 7 | | 50 years | Pier Maintenance Budget including decadal surveys | | 50 years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31-75 | 3.0% | | | | | | | | | | | | | | | | | | | |
| 76-99 | 2.5% | | | | | | | | | | | | | | | | | | | |
| | Total PV Cost | £7,846,333 | | £94,278,773 | £86,529,176 | | £69,822,499 | £64,792,122 | | £86,038,422 | £79,205,045 | | £25,377,803 | £23,490,640 | | £23,995,468 | £23,336,341 | | £515,729 | £428,810 |
| Year | PV factor | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | | Actual | PV cost | |
| 0 | 1.000 | 1,500,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 7500 | 7,500 | 7,500 |
| 1 | 0.966 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 7500 | 7,246 | 7,246 |
| 2 | 0.934 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7120000 | 6,646,596 | 6,646,596 | 7169230.769 | 6,692,554 | 6,692,554 | 7500 | 7,001 | 7,001 |
| 3 | 0.902 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7120000 | 6,421,832 | 6,421,832 | 7169230.769 | 6,466,235 | 6,466,235 | 7500 | 6,765 | 6,765 |
| 4 | 0.871 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3560000 | 3,102,334 | 3,102,334 | 7169230.769 | 6,247,570 | 6,247,570 | 7500 | 6,536 | 6,536 |
| 5 | 0.842 | 1,262,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 299742.4474 | 299,742 | 1792307.692 | 1,509,075 | 1,509,075 | 7500 | 6,315 | 6,315 |
| 6 | 0.814 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 289606.2294 | 289,606 | 116500 | 94,773 | 94,773 | 7500 | 6,101 | 6,101 |
| 7 | 0.786 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 279812.782 | 279,813 | 116500 | 91,568 | 91,568 | 7500 | 5,895 | 5,895 |
| 8 | 0.759 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 270350.514 | 270,351 | 116500 | 88,471 | 88,471 | 7500 | 5,696 | 5,696 |
| 9 | 0.734 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 261208.2261 | 261,208 | 116500 | 85,480 | 85,480 | 7500 | 5,503 | 5,503 |
| 10 | 0.709 | 1,063,378 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 252375.0977 | 252,375 | 116500 | 82,589 | 82,589 | 127500 | 90,387 | 90,387 |
| 11 | 0.685 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 243840.6741 | 243,841 | 116500 | 79,796 | 79,796 | 7500 | 5,137 | 5,137 |
| 12 | 0.662 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 235594.8542 | 235,595 | 116500 | 77,098 | 77,098 | 7500 | 4,963 | 4,963 |
| 13 | 0.639 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 227627.8784 | 227,628 | 116500 | 74,491 | 74,491 | 7500 | 4,796 | 4,796 |
| 14 | 0.618 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 476000 | 294064.1322 | 294,064 | 116500 | 71,972 | 71,972 | 7500 | 4,633 | 4,633 |
| 15 | 0.597 | 895,336 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 212493.0602 | 212,493 | 236500 | 141,165 | 141,165 | 7500 | 4,477 | 4,477 |
| 16 | 0.577 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 205307.3046 | 205,307 | 116500 | 67,186 | 67,186 | 7500 | 4,325 | 4,325 |
| 17 | 0.557 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 198364.5455 | 198,365 | 116500 | 64,914 | 64,914 | 7500 | 4,179 | 4,179 |
| 18 | 0.538 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 191656.5657 | 191,657 | 116500 | 62,719 | 62,719 | 7500 | 4,038 | 4,038 |
| 19 | 0.520 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 185175.4258 | 185,175 | 116500 | 60,598 | 60,598 | 7500 | 3,901 | 3,901 |
| 20 | 0.503 | 753,849 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 178913.4549 | 178,913 | 116500 | 58,549 | 58,549 | 127500 | 64,077 | 64,077 |
| 21 | 0.486 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 172863.2414 | 172,863 | 116500 | 56,569 | 56,569 | 7500 | 3,642 | 3,642 |
| 22 | 0.469 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 167017.6245 | 167,018 | 116500 | 54,656 | 54,656 | 7500 | 3,519 | 3,519 |
| 23 | 0.453 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 161369.6856 | 161,370 | 116500 | 52,808 | 52,808 | 7500 | 3,400 | 3,400 |
| 24 | 0.438 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 476000 | 208467.5957 | 208,468 | 116500 | 51,022 | 51,022 | 7500 | 3,285 | 3,285 |
| 25 | 0.423 | 634,720 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 150640.3282 | 150,640 | 236500 | 100,074 | 100,074 | 7500 | 3,174 | 3,174 |
| 26 | 0.409 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 145546.2108 | 145,546 | 116500 | 47,630 | 47,630 | 7500 | 3,066 | 3,066 |
| 27 | 0.395 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 140624.3583 | 140,624 | 116500 | 46,019 | 46,019 | 7500 | 2,963 | 2,963 |
| 28 | 0.382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 135868.9452 | 135,869 | 116500 | 44,463 | 44,463 | 7500 | 2,862 | 2,862 |
| 29 | 0.369 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 356000 | 131274.3432 | 131,274 | 116500 | 42,959 | 42,959 | 7500 | 2,766 | 2,766 |
| 30 | 0.356 | 534,418 | 220,351,000 | 78,506,304 | 78,506,304 | 167,241,000 | 59,584,358 | 59,584,358 | 202456000 | 72,130,702 | 72,130,702 | 356000 | 126835.1142 | 126,835 | 116500 | 41,506 | 41,506 | 127500 | 45,425 | 45,425 |
| 31 | 0.346 | 0 | 1,513,600 | 523,556 | 523,556 | 982,500 | 339,848 | 339,848 | 1334650 | 461,657 | 461,657 | 356000 | 123140.8875 | 123,141 | 116500 | 40,298 | 40,298 | 7500 | 2,594 | 2,594 |
| 32 | 0.336 | 0 | 1,513,600 | 508,307 | 508,307 | 982,500 | 329,950 | 329,950 | 1334650 | 448,211 | 448,211 | 356000 | 119554.2598 | 119,554 | 116500 | 39,124 | 39,124 | 7500 | 2,519 | 2,519 |
| 33 | 0.326 | 0 | 1,513,600 | 493,502 | 493,502 | 982,500 | 320,339 | 320,339 | 1334650 | 435,156 | 435,156 | 356000 | 116072.0968 | 116,072 | 116500 | 37,984 | 37,984 | 7500 | 2,445 | 2,445 |
| 34 | 0.317 | 0 | 1,513,600 | 479,128 | 479,128 | 982,500 | 311,009 | 311,009 | 1334650 | 422,482 | 422,482 | 476000 | 150677.2066 | 150,677 | 116500 | 36,878 | 36,878 | 7500 | 2,374 | 2,374 |
| 35 | 0.307 | 460,993 | 1,513,600 | 465,173 | 465,173 | 982,500 | 301,951 | 301,951 | 1334650 | 410,176 | 410,176 | 356000 | 109409.0837 | 109,409 | 236500 | 72,683 | 72,683 | 7500 | 2,305 | 2,305 |
| 36 | 0.298 | 0 | 1,513,600 | 451,624 | 451,624 | 982,500 | 293,156 | 293,156 | 1334650 | 398,230 | 398,230 | 356000 | 106222.4113 | 106,222 | 116500 | 34,761 | 34,761 | 7500 | 2,238 | 2,238 |
| 37 | 0.290 | 0 | 1,513,600 | 438,470 | 438,470 | 982,500 | 284,617 | 284,617 | 1334650 | 386,631 | 386,631 | 356000 | 103128.5547 | 103,129 | 116500 | 33,749 | 33,749 | 7500 | 2,173 | 2,173 |
| 38 | 0.281 | 0 | 1,513,600 | 425,699 | 425,699 | 982,500 | 276,328 | 276,328 | 1334650 | 375,370 | 375,370 | 356000 | 100124.8104 | 100,125 | 116500 | 32,766 | 32,766 | 7500 | 2,109 | 2,109 |
| 39 | 0.273 | 0 | 1,513,600 | 413,300 | 413,300 | 982,500 | 268,279 | 268,279 | 1334650 | 364,437 | 364,437 | 356000 | 97208.55375 | 97,209 | 116500 | 31,811 | 31,811 | 7500 | 2,048 | 2,048 |
| 40 | 0.265 | 397,657 | 1,513,600 | 401,262 | 401,262 | 982,500 | 260,465 | 260,465 | 1334650 | 353,822 | 353,822 | 356000 | 94377.23665 | 94,377 | 116500 | 30,885 | 30,885 | 127500 | 33,801 | 33,801 |
| 41 | 0.257 | 0 | 1,513,600 | 389,575 | 389,575 | 982,500 | 252,879 | 252,879 | 1334650 | 343,516 | 343,516 | 356000 | 91628.3851 | 91,628 | 116500 | 29,985 | 29,985 | 7500 | 1,930 | 1,930 |
| 42 | 0.250 | 0 | 1,513,600 | 378,228 | 378,228 | 982,500 | 245,513 | 245,513 | 1334650 | 333,511 | 333,511 | 356000 | 88959.59718 | 88,960 | 116500 | 29,112 | 29,112 | 7500 | 1,874 | 1,874 |
| 43 | 0.243 | 0 | 1,513,600 | 367,212 | 367,212 | 982,500 | 238,363 | 238,363 | 1334650 | 323,797 | 323,797 | 356000 | 86368.54096 | 86,369 | 116500 | 28,264 | 28,264 | 7500 | 1,820 | 1,820 |
| 44 | 0.236 | 0 | 1,513,600 | 356,516 | 356,516 | 982,500 | 231,420 | 231,420 | 1334650 | 314,366 | 314,366 | 476000 | 112117.9925 | 112,118 | 116500 | 27,441 | 27,441 | 7500 | 1,767 | 1,767 |
| 45 | 0.229 | 343,022 | 1,513,600 | 346,132 | 346,132 | 982,500 | 224,680 | 224,680 | 1334650 | 305,210 | 305,210 | 356000 | 81410.63338 | 81,411 | 236500 | 54,083 | 54,083 | 7500 | 1,715 | 1,715 |
| 46 | 0.222 | 0 | 1,513,600 | 336,051 | 336,051 | 982,500 | 218,136 | 218,136 | 1334650 | 296,320 | 296,320 | 356000 | 79039.44989 | 79,039 | 116500 | 25,865 | 25,865 | 7500 | 1,665 | 1,665 |
| 47 | 0.216 | 0 | 1,513,600 | 326,263 | 326,263 | 982,500 | 211,782 | 211,782 | 1334650 | 287,690 | 287,690 | 356000 | 76737.32999 | 76,737 | 116500 | 25,112 | 25,112 | 7500 | 1,617 | 1,617 |
| 48 | 0.209 | 0 | 1,513,600 | 316,760 | 316,760 | 982,500 | 205,614 | 205,614 | 1334650 | 279,310 | 279,310 | 356000 | 74502.26212 | 74,502 | 116500 | 24,381 | 24,381 | 7500 | 1,570 | 1,570 |
| 49 | 0.203 | 0 | 1,513,600 | 307,534 | 307,534 | 982,500 | 199,625 | 199,625 | 1334650 | 271,175 | 271,175 | 356000 | 72332.29332 | 72,332 | 116500 | 23,671 | 23,671 | 7500 | 1,524 | 1,524 |
| 50 | 0.197 | 0 | 1,513,600 | 298,577 | 298,577 | 982,500 | 193,811 | 193,811 | 1334650 | 263,277 | 263,277 | 356000 | 70225.5275 | 70,226 | 116500 | 22,981 | 22,981 | 127500 | 25,151 | 25,151 |
| 51 | 0.192 | | 1,513,600 | 289,880 | | 982,500 | 188,166 | | 1334650 | 255,608 | | 356000 | 68180.12378 | | 116500 | 22,312 | | 7500 | 1,436 | |
| 52 | 0.186 | | 1,513,600 | 281,437 | | 982,500 | 182,685 | | 1334650 | 248,164 | | 356000 | 66194.29494 | | 116500 | 21,662 | | 7500 | 1,395 | |
| 53 | 0.181 | | 1,513,600 | 273,240 | | 982,500 | 177,364 | | 1334650 | 240,935 | | 356000 | 64266.30576 | | 116500 | 21,031 | | 7500 | 1,354 | |
| 54 | 0.175 | | 1,513,600 | 265,282 | | 982,500 | 172,198 | | 1334650 | 233,918 | | 476000 | 83426.31598 | | 116500 | 20,418 | | 7500 | 1,314 | |
| 55 | 0.170 | | 1,513,600 | 257,555 | | 982,500 | 167,183 | | 1334650 | 227,105 | | 356000 | 60577.15691 | | 236500 | 40,243 | | 7500 | 1,276 | |
| 56 | 0.165 | | 1,513,600 | 250,053 | | 982,500 | 162,313 | | 1334650 | 220,490 | | 356000 | 58812.7737 | | 116500 | 19,246 | | 7500 | 1,239 | |
| 57 | 0.160 | | 1,513,600 | 242,770 | | 982,500 | 157,586 | | 1334650 | 214,068 | | 356000 | 57099.78029 | | 116500 | 18,686 | | 7500 | 1,203 | |
| 58 | 0.156 | | 1,513,600 | 235,699 | | 982,500 | 152,996 | | 1334650 | 207,833 | | 356000 | 55436.67989 | | 116500 | 18,141 | | 7500 | 1,168 | |
| 59 | 0.151 | | 1,513,600 | 228,834 | | 982,500 | 148,540 | | 1334650 | 201,780 | | 356000 | 53822.01931 | | 116500 | 17,613 | | 7500 | 1,134 | |
| 60 | 0.147 | | 1,513,600 | 222,169 | | 982,500 | 144,213 | | 1334650 | 195,903 | | 356000 | 52254.38768 | | 116500 | 17,100 | | 127500 | 18,715 | |
| 61 | 0.143 | | 1,513,600 | 215,698 | | 982,500 | 140,013 | | 1334650 | 190,197 | | 356000 | 50732.41522 | | 116500 | 16,602 | | 7500 | 1,069 | |

Discount rates

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62 | 0.138 | | 1,513,600 | 209,416 | | 982,500 | 135,935 | | 1334650 | 184,657 | | 356000 | 49254.77206 | | 116500 | 16,118 | | 7500 | 1,038 |
| 63 | 0.134 | | 1,513,600 | 203,316 | | 982,500 | 131,976 | | 1334650 | 179,279 | | 356000 | 47820.16705 | | 116500 | 15,649 | | 7500 | 1,007 |
| 64 | 0.130 | | 1,513,600 | 197,394 | | 982,500 | 128,132 | | 1334650 | 174,057 | | 476000 | 62077.01406 | | 116500 | 15,193 | | 7500 | 978 |
| 65 | 0.127 | | 1,513,600 | 191,645 | | 982,500 | 124,400 | | 1334650 | 168,987 | | 356000 | 45075.09384 | | 236500 | 29,945 | | 7500 | 950 |
| 66 | 0.123 | | 1,513,600 | 186,063 | | 982,500 | 120,776 | | 1334650 | 164,065 | | 356000 | 43762.22703 | | 116500 | 14,321 | | 7500 | 922 |
| 67 | 0.119 | | 1,513,600 | 180,644 | | 982,500 | 117,259 | | 1334650 | 159,287 | | 356000 | 42487.59905 | | 116500 | 13,904 | | 7500 | 895 |
| 68 | 0.116 | | 1,513,600 | 175,382 | | 982,500 | 113,843 | | 1334650 | 154,647 | | 356000 | 41250.09617 | | 116500 | 13,499 | | 7500 | 869 |
| 69 | 0.112 | | 1,513,600 | 170,274 | | 982,500 | 110,527 | | 1334650 | 150,143 | | 356000 | 40048.63706 | | 116500 | 13,106 | | 7500 | 844 |
| 70 | 0.109 | | 1,513,600 | 165,315 | | 982,500 | 107,308 | | 1334650 | 145,770 | | 356000 | 38882.1719 | | 116500 | 12,724 | | 127500 | 13,925 |
| 71 | 0.106 | | 1,513,600 | 160,500 | | 982,500 | 104,183 | | 1334650 | 141,524 | | 356000 | 37749.68146 | | 116500 | 12,353 | | 7500 | 795 |
| 72 | 0.103 | | 1,513,600 | 155,825 | | 982,500 | 101,148 | | 1334650 | 137,402 | | 356000 | 36650.17617 | | 116500 | 11,994 | | 7500 | 772 |
| 73 | 0.100 | | 1,513,600 | 151,286 | | 982,500 | 98,202 | | 1334650 | 133,400 | | 356000 | 35582.69531 | | 116500 | 11,644 | | 7500 | 750 |
| 74 | 0.097 | | 1,513,600 | 146,880 | | 982,500 | 95,342 | | 1334650 | 129,515 | | 476000 | 46191.12842 | | 116500 | 11,305 | | 7500 | 728 |
| 75 | 0.094 | | 1,513,600 | 142,602 | | 982,500 | 92,565 | | 1334650 | 125,742 | | 356000 | 33540.10304 | | 236500 | 22,282 | | 7500 | 707 |
| 76 | 0.092 | | 1,513,600 | 139,124 | | 982,500 | 90,307 | | 1334650 | 122,676 | | 356000 | 32722.05174 | | 116500 | 10,708 | | 7500 | 689 |
| 77 | 0.090 | | 1,513,600 | 135,731 | | 982,500 | 88,105 | | 1334650 | 119,683 | | 356000 | 31923.95292 | | 116500 | 10,447 | | 7500 | 673 |
| 78 | 0.087 | | 1,513,600 | 132,420 | | 982,500 | 85,956 | | 1334650 | 116,764 | | 356000 | 31145.31992 | | 116500 | 10,192 | | 7500 | 656 |
| 79 | 0.085 | | 1,513,600 | 129,190 | | 982,500 | 83,859 | | 1334650 | 113,916 | | 356000 | 30385.67797 | | 116500 | 9,944 | | 7500 | 640 |
| 80 | 0.083 | | 1,513,600 | 126,039 | | 982,500 | 81,814 | | 1334650 | 111,138 | | 356000 | 29644.56388 | | 116500 | 9,701 | | 127500 | 10,617 |
| 81 | 0.081 | | 1,513,600 | 122,965 | | 982,500 | 79,819 | | 1334650 | 108,427 | | 356000 | 28921.52573 | | 116500 | 9,464 | | 7500 | 609 |
| 82 | 0.079 | | 1,513,600 | 119,966 | | 982,500 | 77,872 | | 1334650 | 105,783 | | 356000 | 28216.12267 | | 116500 | 9,234 | | 7500 | 594 |
| 83 | 0.077 | | 1,513,600 | 117,040 | | 982,500 | 75,972 | | 1334650 | 103,203 | | 356000 | 27527.92455 | | 116500 | 9,008 | | 7500 | 580 |
| 84 | 0.075 | | 1,513,600 | 114,185 | | 982,500 | 74,119 | | 1334650 | 100,686 | | 476000 | 35909.26853 | | 116500 | 8,789 | | 7500 | 566 |
| 85 | 0.074 | | 1,513,600 | 111,400 | | 982,500 | 72,312 | | 1334650 | 98,230 | | 356000 | 26201.47489 | | 236500 | 17,406 | | 7500 | 552 |
| 86 | 0.072 | | 1,513,600 | 108,683 | | 982,500 | 70,548 | | 1334650 | 95,834 | | 356000 | 25562.41452 | | 116500 | 8,365 | | 7500 | 539 |
| 87 | 0.070 | | 1,513,600 | 106,033 | | 982,500 | 68,827 | | 1334650 | 93,497 | | 356000 | 24938.941 | | 116500 | 8,161 | | 7500 | 525 |
| 88 | 0.068 | | 1,513,600 | 103,446 | | 982,500 | 67,149 | | 1334650 | 91,216 | | 356000 | 24330.67414 | | 116500 | 7,962 | | 7500 | 513 |
| 89 | 0.067 | | 1,513,600 | 100,923 | | 982,500 | 65,511 | | 1334650 | 88,991 | | 356000 | 23737.24307 | | 116500 | 7,768 | | 7500 | 500 |
| 90 | 0.065 | | 1,513,600 | 98,462 | | 982,500 | 63,913 | | 1334650 | 86,821 | | 356000 | 23158.28592 | | 116500 | 7,578 | | 127500 | 8,294 |
| 91 | 0.063 | | 1,513,600 | 96,060 | | 982,500 | 62,354 | | 1334650 | 84,703 | | 356000 | 22593.44968 | | 116500 | 7,394 | | 7500 | 476 |
| 92 | 0.062 | | 1,513,600 | 93,717 | | 982,500 | 60,833 | | 1334650 | 82,637 | | 356000 | 22042.38993 | | 116500 | 7,213 | | 7500 | 464 |
| 93 | 0.060 | | 1,513,600 | 91,432 | | 982,500 | 59,350 | | 1334650 | 80,622 | | 356000 | 21504.77066 | | 116500 | 7,037 | | 7500 | 453 |
| 94 | 0.059 | | 1,513,600 | 89,201 | | 982,500 | 57,902 | | 1334650 | 78,655 | | 476000 | 28052.26318 | | 116500 | 6,866 | | 7500 | 442 |
| 95 | 0.057 | | 1,513,600 | 87,026 | | 982,500 | 56,490 | | 1334650 | 76,737 | | 356000 | 20468.5503 | | 236500 | 13,598 | | 7500 | 431 |
| 96 | 0.056 | | 1,513,600 | 84,903 | | 982,500 | 55,112 | | 1334650 | 74,865 | | 356000 | 19969.31737 | | 116500 | 6,535 | | 7500 | 421 |
| 97 | 0.055 | | 1,513,600 | 82,832 | | 982,500 | 53,768 | | 1334650 | 73,039 | | 356000 | 19482.26085 | | 116500 | 6,376 | | 7500 | 410 |
| 98 | 0.053 | | 1,513,600 | 80,812 | | 982,500 | 52,456 | | 1334650 | 71,258 | | 356000 | 19007.08375 | | 116500 | 6,220 | | 7500 | 400 |
| 99 | 0.052 | | 1,513,600 | 78,841 | | 982,500 | 51,177 | | 1334650 | 69,520 | | 356000 | 18543.49635 | | 116500 | 6,068 | | 7500 | 391 |

| | 50 year benefit | 100 year benefit |
|---|---|---|
| Dredging | £5,555,828 | £6,707,823 |
| Fishing Income | £2,458,958 | £3,181,131 |
| Damage to Boats | £9,877,027 | £11,925,018 |
| Loss of Tourist Income | £60,877,655 | £76,026,509 |
| Deaths (3 per year) | £37,038,853 | £44,718,818 |
| Deaths 1 every 5 years | £7,846,333 | £9,485,404 |

Discount rates

# Appendix C

# Cost Breakdowns

# COST BREAKDOWNS

## Pre-amble

To inform the economic appraisal of the potential management options, outline estimates of scheme costs have been performed. The estimates have largely been based on the use of *Spon's Civil Engineering and Highway Works Price Book 2008*. Due to the particularly specialist nature of the works envisaged as part of the various options, some specific inputs have also been made from other sources, including:

- Activity schedules from recently completed coastal defence and pier refurbishment schemes in the north east, including rock revetments at Lynemouth (Northumberland) and Trow Quarry (South Shields, Tyne and Wear) and pier refurbishment at Roker Pier (Tyne and Wear) – this was used as a 'benchmarking' exercise;

- Discussions with Carillion regarding repointing and rock revetment construction costs;

- Discussions with Easipoint regarding restoration mortar costs, noting the historic attributes of the main piers and the need for underwater works on parts of the structures;

- Discussions with Cemex regarding concrete costs;

- Discussions with Keller Ground Engineering regarding grouting costs; and

- Discussions with Briggs Marine regarding costs for rock delivery and use of jack-up barges.

These sources have been used to develop outline scheme construction costings, based on certain coarse assumptions regarding some aspects at this stage, for various options. A 60% optimism bias has then been added to the estimated scheme construction costs.

The following components have contributed to the overall cost estimates:

- Outline scheme construction costs;
- Optimism bias @ 60% of outline scheme construction costs;
- Design and supervision costs @ 20% of outline scheme construction costs;
- Site Investigation costs @ 5% of outline scheme construction costs; and
- Scarborough Borough Council staff costs @ 5% of outline scheme construction costs.

A summary of the costings for various options (and associated works implementation methods) is provided in the following table, with a more detailed breakdown for each on the relevant accompanying sheet.

**Summary of Scheme Costings**

| Option | Works Implementation Methods | Location | Reference | Cost (£M) |
|---|---|---|---|---|
| Option 5: Modify Existing Structures (Condition only) | Pointing | Main Piers | Sheet 1 | 2.7 |
| | Pointing & grouting | Main Piers | Sheet 2 | 3.3 |
| | Pointing, grouting & partial sheet pile toe protection to worst affected lengths (circa 75m in total) | Main Piers | Sheet 3 | 6.9 |
| | Outer protective shell | Main Piers | Sheet 4 | 32.6 |
| | Sheet piling and concrete fill | Pier Extensions | Sheet 5 | 10.9 |
| | Pointing, grouting & partial sheet pile toe protection to main piers and sheet piling and concrete fill around pier extensions. | Main Piers and Pier Extensions | Sheet 3 + Sheet 5 | 17.8 |
| Option 6: Modify Existing Structures (Performance only) | Raise defence with crest wall (small) | Main Piers | Sheet 6 | 0.6 |
| | Raise defence with crest wall (large) | Main Piers | Sheet 7 | 5.3 |
| | Raise defence by raising entire crest by 0.3m (sustained level of performance) | Main Piers | Sheet 8 | 2.5 |
| | Raise defence by raising entire crest by 5.0m (improved level of performance) | Main Piers | Sheet 9 | 9.7 |
| | Rock revetment (full height) | Main Piers and Pier Extensions | Sheet 10 | 23.5 |
| | Rock revetment (half height) | Main Piers and Pier Extensions | Sheet 11 | 5.5 |
| | Rock revetment (quarter height) | Main Piers and Pier Extensions | Sheet 12 | 1.5 |
| Option 7: Modify Existing Structures (both Condition and Performance) | Pointing, grouting & sheet pile toe protection to main piers, sheet piling & fill to pier extensions, with crest wall on main pier (large) | Main Piers and Pier Extensions | Sheet 3 + Sheet 5 + Sheet 7 | 23.1 |
| | Pointing, grouting & sheet pile toe protection to main piers, sheet piling & fill to pier extensions, with raise entire crest (improved level) on main pier | Main Piers and Pier Extensions | Sheet 3 + Sheet 5 + Sheet 9 | 27.5 |
| | Pointing, grouting & sheet pile toe protection to main piers, sheet piling & fill to pier extensions, with half height rock revetment on main piers and pier extensions | Main Piers and Pier Extensions | Sheet 3 + Sheet 5 + Sheet 11 | 23.3 |

**9T0429** **Sheet 1**

**Whitby Pier Refurbishment**

**Option 5 Pointing**

| | | |
|---|---|---|
| total area of wall= | 11180 | $m^2$ |
| length of joints in $1m^2$= | 2 | m |
| mean depth of joints= | 50 | mm |
| mean width of joints= | 10 | mm |
| total length of joints= | 22360 | m |
| volume of mortar= | 11.18 | $m^3$ |

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Rake out existing mortar to 25mm depth | 11180 | m | 12.75 | £ 142,545.00 | | assume half of joints need raking out |
| Provision of restoration mortar | 11180 | $m^3$ | 71.43 | £ 798,587.40 | | |
| Place restoration mortar | 22360 | m | 7.32 | £ 163,675.20 | 315 | |
| Sub Total | | | | £ 1,104,807.60 | | |
| Add Preliminaries | 15% | | | £ 165,721.14 | | |
| Sub Total | | | | £ 1,270,528.74 | | |
| Add OH & P | 12.5% | | | £ 158,816.09 | | |
| Sub Total | | | | £ 1,429,344.83 | | |
| Risk | 60% | | | £ 857,606.90 | | |
| Design and supervision costs | 20.0% | | | £ 285,868.97 | | |
| Site Investigation costs | 5.0% | | | £ 71,467.24 | | |
| Scarborough BC | 5.0% | | | £ 71,467.24 | | |
| Total | | | | £ 2,715,755.18 | | |

**9T0429** **Sheet 2**
**Whitby Pier Refurbishment**

**Option 5 Pointing and Grouting**

| Description | Quantity | Unit | Rate | Total | SPONS |
|---|---|---|---|---|---|
| **Main Piers** | | | | | |
| Pointing | 1 | - | 1104807.6 | £ 1,104,807.60 | from pointing sheet |
| Grout injection | 12000 | m3 | 20 | £ 240,000.00 | Keller estimate based on 14-20 weeks, 4No. Drilling rigs, 1No. Grouting setup and 4No. Grout pumps. Rate given for 10% pier volume. Using cement/PFA blend of grout (NOT heritage or specialist) |
| Sub Total | | | | £ 1,344,807.60 | |
| Add Preliminaries | 15% | | | £ 201,721.14 | |
| Sub Total | | | | £ 1,546,528.74 | |
| Add OH & P | 12.5% | | | £ 193,316.09 | |
| Sub Total | | | | £ 1,739,844.83 | |
| Risk | 60% | | | £ 1,043,906.90 | |
| Design and supervision costs | 20.0% | | | £ 347,968.97 | |
| Site Investigation costs | 5.0% | | | £ 86,992.24 | |
| Scarborough BC | 5.0% | | | £ 86,992.24 | |
| Total | | | | £ 3,305,705.18 | |

**9T0429** **Sheet 3**

**Whitby Pier Refurbishment**

**Option 5 Pointing, grouting and sheet pile toe protection to worst 75m**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Pointing | 1 | - | £ 1,104,807.60 | £ 1,104,807.60 | | |
| Grouting | 1 | - | £ 1,344,807.60 | £ 1,344,807.60 | | |
| Pre-excavation for piling | 525 | $m^3$ | 8.04 | £ 4,221.00 | | |
| Backfill with concrete | 262.5 | $m^3$ | 86.33 | £ 22,661.63 | | |
| 75m of interlocking sheet piles, 4m high driven 2m into ground | 300 | $m^2$ | 109.25 | £ 32,775.00 | 267 | |
| Provision of concrete; Grade C40 20mm aggregate | 75 | $m^3$ | 86.33 | £ 6,474.75 | | |
| Placing of mass concrete | 75 | $m^3$ | 47.03 | £ 3,527.25 | 188 | |
| Pumping from readymix truck @25m3/hour | 75 | $m^3$ | 2.97 | £ 222.75 | 188 | |
| Provision of jack-up barge | 75 | m | 3600 | £ 270,000.00 | | based on Briggs Marine quote |
| Sub Total | | | | £ 2,789,497.58 | | |
| Add Preliminaries | 15% | | | £ 418,424.64 | | |
| Sub Total | | | | £ 3,207,922.21 | | |
| Add OH & P | 12.5% | | | £ 400,990.28 | | |
| Sub Total | | | | £ 3,608,912.49 | | |
| Risk | 60% | | | £ 2,165,347.49 | | |
| Design and supervision costs | 20.0% | | | £ 721,782.50 | | |
| Site Investigation costs | 5.0% | | | £ 180,445.62 | | |
| Scarborough BC | 5.0% | | | £ 180,445.62 | | |
| Total | | | | £ 6,856,933.73 | | |

**9T0429** **Sheet 4**

**Whitby Pier Refurbishment**

**Option 5 Outer cladding replacement**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Grout injection | 1 | - | £ 1,344,807.60 | £ 1,344,807.60 | | |
| Pre excavation for piling | 2540 | $m^3$ | 8.04 | £ 20,421.60 | | |
| Backfill with concrete | 1270 | $m^3$ | 86.33 | £ 109,639.10 | | |
| 1270m of interlocking sheet piles, 12m high driven 2m into ground | 15240 | $m^2$ | 109.25 | £ 1,664,970.00 | 267 | |
| Provision of foamed concrete | 11110 | $m^3$ | 83 | £ 922,130.00 | | based on quote from Cemex |
| Pumping from readymix truck @25m3/hour | 11110 | $m^3$ | 2.97 | £ 32,996.70 | 188 | |
| Placing of mass concrete | 11110 | $m^3$ | 47.03 | £ 522,503.30 | 188 | |
| Stone cladding | 10160 | $m^2$ | 390.96 | £ 3,972,153.60 | 314 | |
| Stone paving | 1282 | $m^2$ | 83.04 | £ 106,457.28 | | |
| Provision of jack-up barge | 1270 | m | 3600 | £ 4,572,000.00 | | based on Briggs Marine quote |
| Sub Total | | | | £ 13,268,079.18 | | |
| Add Preliminaries | 15% | | | £ 1,990,211.88 | | |
| Sub Total | | | | £ 15,258,291.06 | | |
| Add OH & P | 12.5% | | | £ 1,907,286.38 | | |
| Sub Total | | | | £ 17,165,577.44 | | |
| Risk | 60% | | | £ 10,299,346.46 | | |
| Design and supervision costs | 20.0% | | | £ 3,433,115.49 | | |
| Site Investigation costs | 5.0% | | | £ 858,278.87 | | |
| Scarborough BC | 5.0% | | | £ 858,278.87 | | |
| Total | | | | £ 32,614,597.13 | | |

**9T0429** **Sheet 5**

**Whitby Pier Refurbishment**

**Option 5 Sheet pile protection to whole of both west and east pier extensions**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| Jack up barge and labour | 1 | | 2500000 | £ 2,500,000.00 | | Quote from Briggs Marine. 15-20k per day, 58 panels, 1 panel every other day = 116 days (NO MATERIAL NO RISK) |
| | 1360 | | | | | |
| | 680 | | | | | |
| 680m of interlocking sheet piles; 8m high driven 2m into ground. | 5440 | $m^2$ | 109.25 | £ 594,320.00 | 267 | |
| Pre boring 600mm diameter holes | 1133 | nr | 223.8 | £ 253,640.00 | 257 | |
| Bored to 2m maximum depth | 2267 | m | 109.14 | £ 247,384.00 | | |
| Removal of material arising from pile bores | 640 | $m^3$ | 3.08 | £ 1,972.23 | 255 | |
| Disposal of material arising from pile bores | 640 | $m^3$ | 26.93 | £ 17,244.18 | 173 | |
| Mobilisation of plant and equipment for ties | 1 | nr | 10250 | £ 10,250.00 | 159 | |
| Permanent anchorage in rock, 0-50t load. Ties at 1.2m centres | 567 | nr | 78.24 | £ 44,336.00 | | |
| Provision of concrete; Grade C40 20mm aggregate | 5640 | $m^3$ | 86.33 | £ 486,929.98 | | |
| Placing of mass concrete | 5640 | $m^3$ | 47.03 | £ 265,264.88 | | |
| Pumping from readymix truck @25m3/hour | 5640 | $m^3$ | 2.97 | £ 16,751.79 | 188 | |
| Sub Total | | | | £ 4,438,093.05 | | |
| Add Preliminaries | 15% | | | £ 665,713.96 | | |
| Sub Total | | | | £ 5,103,807.00 | | |
| Add OH & P | 12.5% | | | £ 637,975.88 | | |
| Sub Total | | | | £ 5,741,782.88 | | |
| Design and supervision costs | 20.0% | | | £1,148,356.58 | | |
| Site Investigation costs | 5.0% | | | £ 287,089.14 | | |
| Scarborough BC | 5.0% | | | £ 287,089.14 | | |
| Risk | 60% | | | £ 3,445,069.73 | | |
| Total | | | | £ 10,909,387.47 | | |

**9T0429** **Sheet 6**

**Whitby Pier Refurbishment**

**Option 5 Raise defence level with small crest wall**

| Description | Quantity | Unit | Rate | Total | SPONS |
|---|---|---|---|---|---|
| **Main Piers** | | | | | |
| Formwork; fair finish | | | | | |
| plane horizontal, width 0.2 - 0.4 m | 35 | $m^2$ | 39.58 | £ 1,385.30 | 194 |
| plane,vertical width 0.2 - 0.4m | 122.5 | $m^2$ | 78.29 | £ 9,590.53 | 196 |
| plane, vertical, width 0.4 - 1.22m | 17.5 | $m^2$ | 62.37 | £ 1,091.48 | 196 |
| Reinforcement - mild steel to BS4449. Bars 12mm nominal size, supplied in bent & cut lengths. | 0 | T | 1319.19 | £ - | 198 based on 1 T of rebar per 12m3. |
| Rubbing down concrete surfaces after striking shutters | 560.0 | $m^2$ | 1.74 | £ 974.40 | 203 |
| Stone cladding | 560 | $m^2$ | 390.96 | £ 218,937.60 | |
| Sub Total | | | | £ 231,979.30 | |
| Add Preliminaries | 15% | | | £ 34,796.90 | |
| Sub Total | | | | £ 266,776.20 | |
| Add OH & P | 12.5% | | | £ 33,347.02 | |
| Sub Total | | | | £ 300,123.22 | |
| Risk | 60% | | | £ 180,073.93 | |
| Design and supervision costs | 20.0% | | | £ 60,024.64 | |
| Site Investigation costs | 5.0% | | | £ 15,006.16 | |
| Scarborough BC | 5.0% | | | £ 15,006.16 | |
| Total | | | | £ 570,234.12 | |

**9T0429** **Sheet 7**

**Whitby Pier Refurbishment**

**Option 5 Raise defence level with large crest wall**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Formwork; fair finish | | | | | | |
| plane horizontal, width 0.4 - 1.22 m | 53 | $m^2$ | 44.69 | £ 2,368.57 | 194 | |
| plane horizontal, width exceeding 1.22m | 158 | $m^2$ | 43.02 | £ 6,797.16 | 194 | |
| plane, vertical, width 0.4 - 1.22m | 53 | $m^2$ | 62.37 | £ 3,305.61 | 196 | |
| plane vertical, width exceeding 1.22m | 753 | $m^2$ | 58.17 | £ 43,802.01 | 196 | |
| Provision of concrete; Grade C40 20mm aggregate | 3466 | $m^3$ | 86.33 | £ 299,219.78 | 189 | |
| Placing of concrete walls; thickness 150 - 300mm | 3466 | $m^3$ | 27.06 | £ 93,789.96 | 192 | |
| Reinforcement - mild steel to BS4449. Bars 12mm nominal size, supplied in bent & cut lengths. | 288.8 | T | 1319.19 | £ 381,026.05 | 198 | based on 1 T of rebar per 12m3. |
| Rubbing down concrete surfaces after striking shutters | 3220.0 | $m^2$ | 1.74 | £ 5,602.80 | 203 | |
| Stone cladding | 3220.0 | $m^2$ | 390.96 | £ 1,258,891.20 | | 300mm thickness |
| Piles, 600mm diameter, Concrete 35 N/mm2, 20mm aggregate; installed by continuous flight auger. | | | | | 258 | |
| Number of piles | 56 | nr | 127.57 | £ 7,143.92 | | based on clear site with reasonable access |
| Concreted length | 840 | m | 34.65 | £ 29,106.00 | | |
| Depth bored to 15m maximum depth | 56 | nr | 26.94 | £ 1,508.64 | | |
| Removal of material arising from pile bores | 760 | $m^3$ | 3.08 | £ 2,340.80 | 255 | |
| Dispoasal of material arising from pile bores | 760 | $m^3$ | 26.93 | £ 20,466.80 | 173 | |

| | | |
|---|---|---|
| Sub Total | | £ 2,155,369.30 |
| Add Preliminaries | 15% | £ 323,305.39 |
| Sub Total | | £ 2,478,674.69 |
| Add OH & P | 12.5% | £ 309,834.34 |
| Sub Total | | £ 2,788,509.03 |
| Risk | 60% | £ 1,673,105.42 |
| Design and supervision costs | 20.0% | £ 557,701.81 |
| Site Investigation costs | 5.0% | £ 139,425.45 |
| Scarborough BC | 5.0% | £ 139,425.45 |
| Total | | £ 5,298,167.15 |

**9T0429** **Sheet 8**
**Whitby Pier Refurbishment**

**Option 5 Raise entire crest level - sustained crest level**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Formwork; fair finish | | | | | | |
| plane,vertical width 0.2 - 0.4m | 41 | $m^2$ | 78.29 | £ 3,209.89 | 196 | |
| Provision of foamed concrete | 1980 | $m^3$ | 83 | £ 164,340.00 | | based on quote from Cemex |
| Pumping from readymix truck @25m3/hour | 1980 | $m^3$ | 2.97 | £ 5,880.60 | 188 | |
| Placing of mass concrete | 1980 | $m^3$ | 47.03 | £ 93,119.40 | 188 | |
| Removal of deck & storage for reuse | 7280 | $m^2$ | 26.85 | £ 195,468.00 | | |
| Laying recycled material (75% of surfacing) | 5460 | $m^2$ | 32 | £ 174,720.00 | | |
| Laying new material (25% of surfacing) | 1820 | $m^2$ | 83.04 | £ 151,132.80 | | |
| Stone cladding | 560 | $m^2$ | 390.96 | £ 218,937.60 | | |
| Sub Total | | | | £ 1,006,808.29 | | |
| Add Preliminaries | 15% | | | £ 151,021.24 | | |
| Sub Total | | | | £ 1,157,829.53 | | |
| Add OH & P | 12.5% | | | £ 144,728.69 | | |
| Sub Total | | | | £ 1,302,558.23 | | |
| Risk | 60% | | | £ 781,534.94 | | |
| Design and supervision costs | 20.0% | | | £ 260,511.65 | | |
| Site Investigation costs | 5.0% | | | £ 65,127.91 | | |
| Scarborough BC | 5.0% | | | £ 65,127.91 | | |
| Total | | | | £ 2,474,860.63 | | |

**9T0429** **Sheet 9**

**Whitby Pier Refurbishment**

**Option 5 Raise entire crest level - improved crest level**

| Description | Quantity | Unit | Rate | Total | SPONS | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Formwork; fair finish | | | | | | |
| plane horizontal, width exceeding 1.22m | 840 | $m^2$ | 43.02 | £ 36,136.80 | 194 | |
| plane vertical, width exceeding 1.22m | 700 | $m^2$ | 58.17 | £ 40,719.00 | 196 | |
| Provision of foamed concrete | 35750 | $m^3$ | 83 | £ 2,967,250.00 | | based on quote from Cemex |
| Piles, 600mm diameter, Concrete 35 N/mm2, 20mm aggregate; installed by continuous flight auger. | | | | | 258 | |
| Number of piles | 110 | nr | 127.57 | £ 14,032.70 | | based on clear site with reasonable access |
| Concreted length | 1650 | m | 34.65 | £ 57,172.50 | | |
| Depth bored to 15m maximum depth | 110 | nr | 26.94 | £ 2,963.40 | | |
| Removal of material arising from pile bores | 1500 | $m^3$ | 3.08 | £ 4,620.00 | 255 | |
| Disposal of material arising from pile bores | 1500 | $m^3$ | 26.93 | £ 40,395.00 | 173 | |
| Removal of deck & storage for reuse | 7280 | $m^2$ | 26.85 | £ 195,468.00 | | |
| Laying recycled material (75% of surfacing) | 5460 | $m^2$ | 32 | £ 174,720.00 | | |
| Laying new material (25% of surfacing) | 1820 | $m^2$ | 83.04 | £ 151,132.80 | | |
| Stone cladding | 700 | $m^2$ | 390.96 | £ 273,672.00 | | |
| Sub Total | | | | £ 3,958,282.20 | | |
| Add Preliminaries | 15% | | | £ 593,742.33 | | |
| Sub Total | | | | £ 4,552,024.53 | | |
| Add OH & P | 12.5% | | | £ 569,003.07 | | |
| Sub Total | | | | £ 5,121,027.60 | | |
| Risk | 60% | | | £ 3,072,616.56 | | |
| Design and supervision costs | 20.0% | | | £ 1,024,205.52 | | |
| Site Investigation costs | 5.0% | | | £ 256,051.38 | | |
| Scarborough BC | 5.0% | | | £ 256,051.38 | | |
| Total | | | | £ 9,729,952.43 | | |

**9T0429** **Sheet 10**

**Whitby Pier Refurbishment**

**Option 6 Rock revetment: Full height**

| Description | Quantity | Unit | Rate | Total | |
|---|---|---|---|---|---|
| **Main Piers** | | | | | |
| Supply rock (Norwegian Granite) | 37968 | $m^3$ | 106 | £ 4,024,608.00 | rates from Trow Quarry |
| Place rock | 37968 | $m^3$ | 13.25 | £ 503,076.00 | |
| Excavation for toe | 960 | $m^3$ | 8.04 | £ 7,718.40 | |
| **Extensions** | | | | | |
| Supply rock (Norwegian Granite) | 41900 | $m^3$ | 106 | £ 4,441,400.00 | |
| Place Rock | 41900 | $m^3$ | 13.25 | £ 555,175.00 | |
| Excavation for toe | 1060 | $m^3$ | 8.04 | £ 8,522.40 | |
| Sub Total | | | | £ 9,540,499.80 | |
| Add Preliminaries | 15% | | | £ 1,431,074.97 | |
| Sub Total | | | | £ 10,971,574.77 | |
| Add OH & P | 12.5% | | | £ 1,371,446.85 | |
| Sub Total | | | | £ 12,343,021.62 | |
| Risk | 60% | | | £ 7,405,812.97 | |
| Design and supervision costs | 20.0% | | | £ 2,468,604.32 | |
| Site Investigation costs | 5.0% | | | £ 617,151.08 | |
| Scarborough BC | 5.0% | | | £ 617,151.08 | |
| Total | | | | £ 23,451,741.07 | |

**9T0429** **Sheet 11**

**Whitby Pier Refurbishment**

**Option 6 Rock revetment: Half height**

| Description | Quantity | Unit | Rate | Total | |
|---|---|---|---|---|---|
| **Main Piers** | | | | | |
| Supply rock (Norwegian Granite) | 10080 | $m^3$ | 106 | £ 1,068,480.00 | rates from Trow Quarry |
| Place rock | 10080 | $m^3$ | 13.25 | £ 133,560.00 | |
| Excavation for toe | 960 | $m^3$ | 8.04 | £ 7,718.40 | |
| **Extensions** | | | | | |
| Supply rock (Norwegian Granite) | 8590 | $m^3$ | 106 | £ 910,540.00 | |
| Place Rock | 8590 | $m^3$ | 13.25 | £ 113,817.50 | |
| Excavation for toe | 818 | $m^3$ | 8.04 | £ 6,576.72 | |
| Sub Total | | | | £ 2,240,692.62 | |
| Add Preliminaries | 15% | | | £ 336,103.89 | |
| Sub Total | | | | £ 2,576,796.51 | |
| Add OH & P | 12.5% | | | £ 322,099.56 | |
| Sub Total | | | | £ 2,898,896.08 | |
| Risk | 60% | | | £ 1,739,337.65 | |
| Design and supervision costs | 20.0% | | | £ 579,779.22 | |
| Site Investigation costs | 5.0% | | | £ 144,944.80 | |
| Scarborough BC | 5.0% | | | £ 144,944.80 | |
| Total | | | | £ 5,507,902.55 | |

**9T0429** **Sheet 12**

**Whitby Pier Refurbishment**

**Option 6 Rock revetment: Quarter height**

| Description | Quantity | Unit | Rate | | Total | |
|---|---|---|---|---|---|---|
| **Main Piers** | | | | | | |
| Supply rock (Norwegian Granite) | 2020 | $m^3$ | 159 | £ | 321,180.00 | rates from Trow Quarry |
| Place rock | 2020 | $m^3$ | 13.25 | £ | 26,765.00 | |
| Excavation for toe | 960 | $m^3$ | 8.04 | £ | 7,718.40 | |
| **Extensions** | | | | | | |
| Supply rock (Norwegian Granite) | 1510 | $m^3$ | 159 | £ | 240,090.00 | |
| Place Rock | 1510 | $m^3$ | 13.25 | £ | 20,007.50 | |
| Excavation for toe | 620 | $m^3$ | 8.04 | £ | 4,984.80 | |
| Sub Total | | | | £ | 620,745.70 | |
| Add Preliminaries | 15% | | | £ | 93,111.86 | |
| Sub Total | | | | £ | 713,857.56 | |
| Add OH & P | 12.5% | | | £ | 89,232.19 | |
| Sub Total | | | | £ | 803,089.75 | |
| Risk | 60% | | | £ | 481,853.85 | |
| Design and supervision costs | 20.0% | | | £ | 160,617.95 | |
| Site Investigation costs | 5.0% | | | £ | 40,154.49 | |
| Scarborough BC | 5.0% | | | £ | 40,154.49 | |
| Total | | | | £ | 1,525,870.52 | |

# Appendix D

# Review of *Environmental Studies*

# 1 Pre-amble

The Whitby Coastal Strategy was accompanied by *Environmental Studies* in an appendix. This document has been reviewed as part of the present study and used to inform the environmental appraisal associated with the management options. In addition, the review has highlighted some aspects that will need to be considered further as part of an Environmental Impact Assessment accompanying any planning application associated with a preferred scheme. This information is presented in this Appendix.

# 2 Specific Comments

The report correctly identifies the designated sites for nature conservation and heritage and provides copies of their citations in the appendices.

Section 3 Planning and Environmental Policies needs updating as many of the old PPG guidance notes have been superseded by more recent PPS guidance since 2002. In addition, future work associated with the EIA will need to check the 1999 Scarborough Local Plan for Policies that are no longer active or have been included in others. Under the provisions of the Planning and Compulsory Purchase Act 2004, a number of policies in the Local Plan expired on 27th September 2007. Similarly, a check should be made of the SMP2, LEAP and heritage coast strategy.

Section 4 Architecture and Historic Heritage provides a detailed summary of the key features between Sandsend to Abbey Cliff. Information on defences from WW1 and WW2 to be found along the shore is not to the same level of detail – a point noted by English Heritage in its response of 26 September 2001.

Section 6 Ecology. A brief summary of the key features of the geological SSSI could be included in this section. The national importance of the SSSI is underplayed in comparison to the SINC on page 19. The ecology of the harbour area is summarised from the SMP; however, it should be updated to recognise the Water Framework Directive, the significance of water quality, effects upon it and current or proposed water quality management. The River Esk is noted particularly for its generally good water quality and salmonid fisheries and the report acknowledges the conservation importance of salmon, and how the scheme should not adversely affect salmon habitats and behaviour. Other migratory species including European eels, river and sea lampreys should be included.

Although the area is not designated as a SPA or SSSI for bird interest features, birds of national significance such as turnstone and sandpipers are mentioned. The diversity of feeding, roosting (and potentially, breeding) habitats along this stretch of coast is high and the potential disturbance of birds either during the overwinter period or during the breeding season should be recognised in any subsequent EIA together with proposed mitigation or compensation where applicable.

Reference to Biodiversity policy will need to be updated since the UK Action Plan of 1984. The UK Biodiversity Action Plan (UK BAP) is the UK Government's response to the Convention on Biological Diversity signed in 1992. It describes the UK's biological resources, commits a detailed plan for the protection of these resources, provides major reviews of the Priority Species and Habitats together with the targets for those priorities.

Section 7 Geology. The report only provides a brief summary of geological features. Further detail is provided in Appendix Report Volume III. The palaeontological significance of the cliff below the Abbey and the wave cut platform below is therefore not fully recognised. Some detail form the citation (Appendix A) should have been included in the main text. This subject area will require further investigation and assessment in an EIA as one of the proposed options will impact both directly and indirectly upon them.

Section 9 Social and Economic. The harbour provides the base for long established coastal fisheries (primarily shellfish inc. crab, lobster, prawns) and maritime coastal and Baltic trade in general cargoes (see Section 9 Social and Economic). Together with tourism and recreation, fisheries and sea trade provide the main components of the town's economy.

Data on tourism and employment are outdated. Data relating to the fishing industry and maritime trade are also out of date and need review; however, it is unlikely that changes to these sources of income and employment since 1998/1999 will have made a significant difference to the town's overall prosperity during that period - it is likely that tourism, recreation and the establishment of new business ventures will have compensated for any loss. Nevertheless, the importance of fisheries and maritime trade to the town cannot be underestimated and any scheme that could affect navigation or fisheries should be considered against these factors. Habitat loss, disturbance, changes to water quality, and sediment transport on, and in the vicinity of, any fishery will most likely receive an emotive response.

Section 10 Conclusions. The report recognised the importance of the landscape quality of the coast, but underplays the significance of nature conservation. This is unfortunate. It is because of conservation and careful control of planning and development that the landscape plays such an important role in the character and prosperity of the coast between Whitby and Sandsend. Mention of a tidal barrier having no effect on the ecology of the harbour is alarming.

To focus on nature conservation and earth science heritage issues, five principal points are highlighted:

- Potential for disturbance to marine ecology (inc. fisheries and migratory species of conservation importance) via noise, water quality, and changes to sediment transport/geomorpohology.

- Potential for socio-economic effects on fisheries, tourism and maritime trade (inc. potential for effects to safety of navigation).

- Potential for disturbance to roosting and feeding bird species (especially summer and winter migrants). It is considered unlikely that breeding birds could be affected.

- Potential impacts from rock placement across the foreshore to both the immediate west (amenity) and immediate east (geological designations) of the harbour structures.

- As discussed, incorporation of the Water Framework Directive re: inshore and river water quality should be made in line with the review of planning policy and legislation (and socio-economic update).

Environmental Scoping – in terms of the usefulness of the report as a basis for the production of an environmental scoping report, it does provide some useful information; however, many of the data (and reference to policies/guidance etc.) are now out of date.

# Appendix E

# Formal Responses from Natural England and English Heritage

19/5/14(c)

Date: 17 February 2009
Our ref: NZ91 SR2G
Your ref: Whitby coastal strategy

NATURAL ENGLAND

Genesis 1
University Road
Heslington
York
YO10 5ZQ

T 01904 435500
F 01904 435520

Stewart Rowe
Scarborough Borough Council
Town Hall
St Nicholas Street
Scarborough
North Yorkshire
YO11 2HG


Dear Stewart

**Whitby Coastal Strategy**
**Impacts on Whitby – Saltwick SSSI**

This advice is a response to the information provided in the document 'Whitby Coastal Strategy- Further Investigations at Whitby Harbour' (Royal Haskoning Jan 2009). Our understanding is that there is a possibility that a rock revetment will be placed against the outer faces of the East Pier and extension which would cover a strip of the Whitby – Saltwick SSSI between 5m and 10m wide at the extreme northern end of the SSSI. Scarborough Borough Council has requested advice about the potential impacts this would have on the SSSI features and procedures with respect to SSSIs.

The features of the SSSI are:

- Vertebrate palaeontology, in particular Jurassic and Cretaceous reptilia (fossil reptile sites)
- Palaeobotany, in particular exposures of the plant fossil beds from the middle Jurassic.
- Stratigraphy, important exposures of the Lower Jurassic (Toarcian) Whitby Mudstone Formation.

A rock revetment placed against the East Pier and extension would have minimal impact on the coastal processes which are required to maintain rock exposures on the cliff faces in the SSSI. There would also be no impact on the majority of the SSSI to the south of the pier area with respect to concealment of features. We understand that there is unlikely to be excavation required before the rock revetment is installed. We are unaware of any geological features in the area adjacent to the East Pier that are not present in other parts of the site. However, there is a small risk that the rock revetment could conceal a feature (eg fossil bed). We therefore advise that the area should be checked by a geological consultant (and the results discussed with Natural England) before plans for a rock revetment are finalised.

This advice is based on current information, once the preferred scheme has been finalised, we will be providing our statutory advice on the Environmental Impact Assessment. If any aspects of the preferred scheme will impact on the SSSI, Scarborough Borough Council should give Notice to

Natural England under the Wildlife and Countryside Act 1981 (as amended). Details of the assenting procedure are laid out on Natural England's website.
www.naturalengland/ information for SSSI owner and occupiers/ duties of public bodies to conserve and enhance SSSIs.

I trust that the above is of use.

Yours sincerely

S. Wilson.

Susan Wilson
Conservation Adviser
Susan.wilson@naturalengland.org.uk

19/7/14(i)

ENGLISH HERITAGE
YORKSHIRE & THE HUMBER REGION



Mr Stewart Rowe
Scarborough Borough Council
Town Hall
St. Nicholas Street
SCARBOROUGH
North Yorkshire
YO11 2HG

Direct Dial: 01904 601973
Direct Fax: 01904 601999

Our ref: PA00009723

Your ref: SR/JR 19/7/14i

23 March 2009

Dear Mr Rowe

**Request for Pre-application Advice**

**WHITBY COASTAL STRATEGY AT WHITBY HARBOUR, WEST & EAST PIERS, WHITBY, SCARBOROUGH, NORTH YORKSHIRE**

Thank you for consulting English Heritage on 'Whitby Coastal Strategy: Further investigations at Whitby Harbour, draft report', dated January 2009. Thank you also for your e-mail dated 3rd February 2009. We welcome the opportunity for pre-application discussion on this important case. Please accept my most sincere apology for not responding sooner.

Whitby's historic east and west piers date back to medieval times in their origins with much of their present fabric dating to the 18th century and early 19th century. The date of the pier extensions is given in the present report as 1908-14. They are listed Grade II, along with their lighthouses (dated 1854 and 1831 respectively). They lie within Whitby's Conservation Area and are prominent features within it, with views towards them from many angles (as well as views from them). It is our understanding that they are owned by Scarborough Borough Council.

'Whitby Coastal Strategy: Further investigations at Whitby Harbour, draft report' is a complex document with numerous options. It is our understanding that Option 7 is preferred, which includes a combination of Options 5 and 6 - i.e. repairs and improvement of the present structural condition of the main piers and pier extensions and modification of the exiting structures to improve their present defence

performance.

English Heritage supports the principle of repairing and extending the life of the existing historic piers. At this stage we should confirm that we would not favour Option 1 ('do nothing') nor Options 8, 9 and 10 (which involve the removal of the piers). We would also have concerns about the truncation of the piers as shown in Option 4.

We also recognise that some improvement to the performance of the piers is likely to be reasonably necessary, given their strategic importance as part of Whitby's flood defence system. We note that various methods of performance improvement are given within Options 5, 6 and 7, some of which are more sympathetic to the retention of the historic fabric and visual appearance of the piers than others. (The suggestions in Options 6 and 7 of adding a crest or a wave wall to the pier(s) - or indeed raising the height of the pier(s) themselves in Option 6 - are likely to be damaging to the historic and architectural integrity of the piers.)

We would wish to consider in more detail the visual impact of the various sheet piling options. We note that rock revetments are among the preferred options and we would like to learn more about the visual impact these might have on the piers and the surrounding environment. We note the recommendation (page 123) for more detailed modelling to be done to test the overtopping performance of the different implementation methods, in order to inform detailed design. We presume that lessons learnt during the repair and improvement of the Grade II listed pier at Scarborough have been fed into the proposals, but we would welcome confirmation of this.

We recognise the need to take action in relation to the piers in order to ensure their continued survival and indeed the survival of parts of the historic town of Whitby itself. We would wish to see this done in a way which minimises as far as reasonably possible the visual impact of the proposed changes upon the piers and their extensions and upon Whitby and its Conservation Area.

I would like the opportunity to meet with you on site to discuss the nature of the problems and the proposed solutions in more detail. I suggest it would be useful if your Council's Conservation Officer, Chris Hall, was also able to attend. Please contact me either by e-mail or by phone to organise this, if you agree. With best wishes.

37 TANNER ROW YORK YO1 6WP
*Telephone 01904 601901 Facsimile 01904 601999*
*www.english-heritage.org.uk*

ENGLISH HERITAGE

YORKSHIRE & THE HUMBER REGION

Yours sincerely

**Diane Green**
Historic Buildings Inspector
E-mail: diane.green@english-heritage.org.uk

cc Chris Hall, Scarborough Borough Council

37 TANNER ROW YORK YO1 6WP

*Telephone 01904 601901 Facsimile 01904 601999*
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# Appendix F

# Public Consultation Brochure and Questionnaire

# Whitby Harbour
# Surveys & Investigations

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BOROUGH of SCARBOROUGH

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**February 2009**

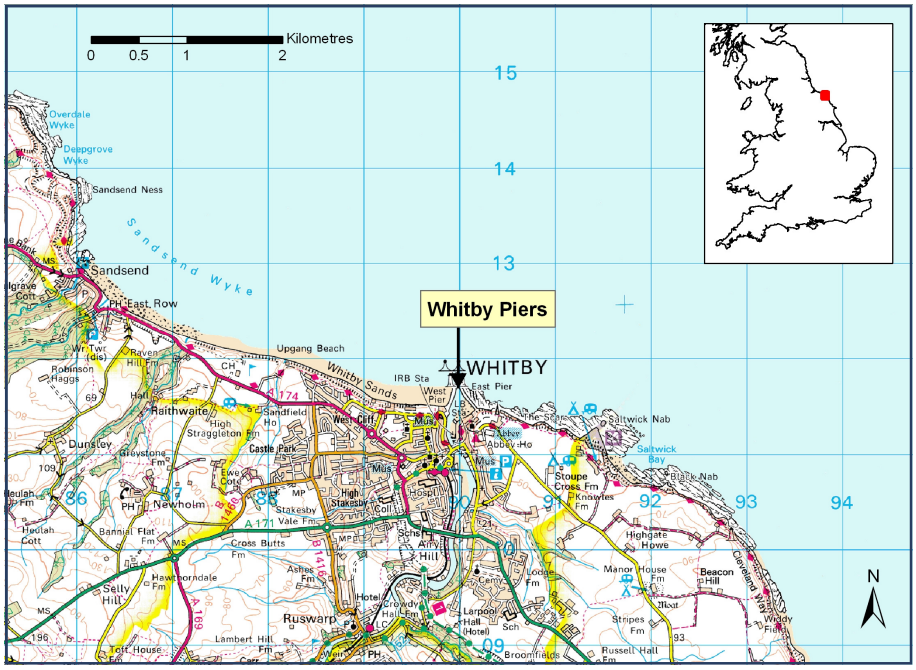
ROYAL HASKONING

## Background

The Whitby Coastal Strategy was completed in July 2002. It covered the coastline from Sandsend to Abbey Cliff and the lower reaches of the River Esk estuary.

The Strategy recognised the critical importance of the Whitby Harbour structures to:

- providing a coastal defence to the town of Whitby against coastal erosion;
- reducing tidal flood risk along the lower reaches of the River Esk estuary;
- providing navigational shelter to vessels during storms;
- retaining beaches along Whitby Sands and Upgang Beach;
- enabling important economic activities such as tourism, fishing, and the marina.




One of the most significant findings of the Strategy was the identification of the poor condition and performance of the Whitby Harbour structures.

The Strategy made recommendations for a major scheme of investment to the structures to significantly improve the wave protection and flood defence performance of the harbour.

It also recommended further investigations at Whitby Harbour to fully characterise the extent and nature of the structural problems. This information also helps define the engineering works required and the costs and timescales for their implementation.

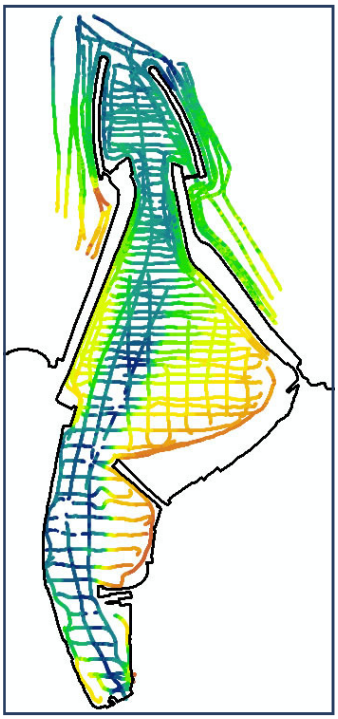
The further investigations on the Whitby Harbour structures have now been undertaken and findings have been used to re-evaluate assessments of their condition and proposed ways forward with a major scheme to improve their condition and performance.

## Further Investigations of Structural Condition

A comprehensive series of surveys and physical investigations was designed and undertaken between February and October 2008. This included:

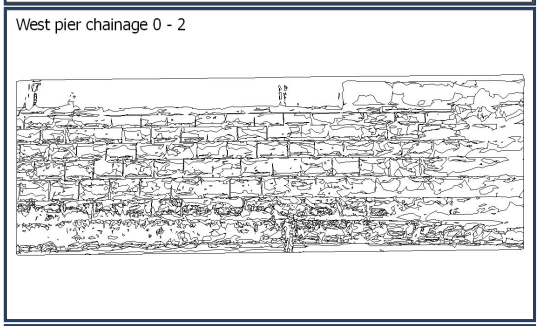
- Topographic, digital measured and photographic surveys;
- Dive survey and visual inspections;
- Ground probing radar and microgravity surveys;
- Ground investigation; and
- Hydrographic, geophysical and seismic surveys.

### Dive Survey

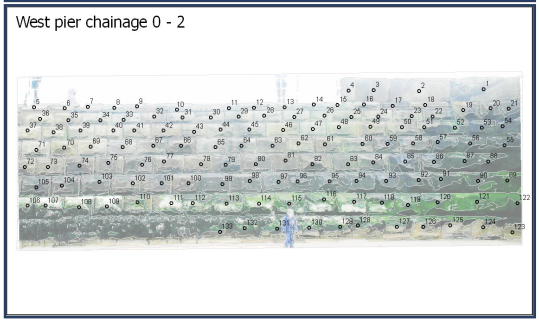


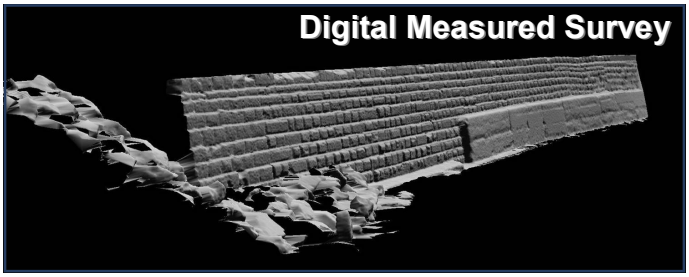
### Hydrographic Survey

### Topographic Survey



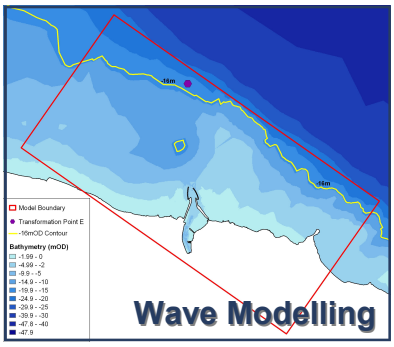


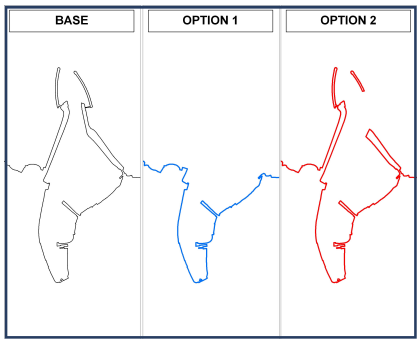



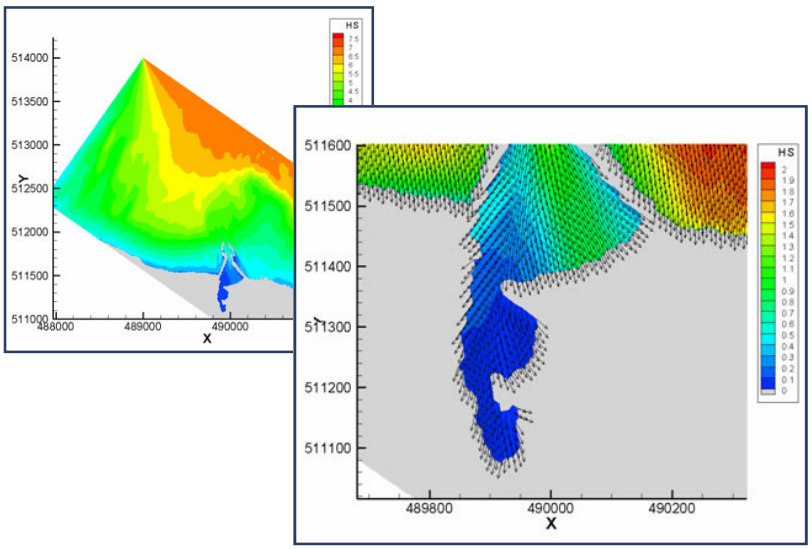
## Further Investigations of Defence Performance

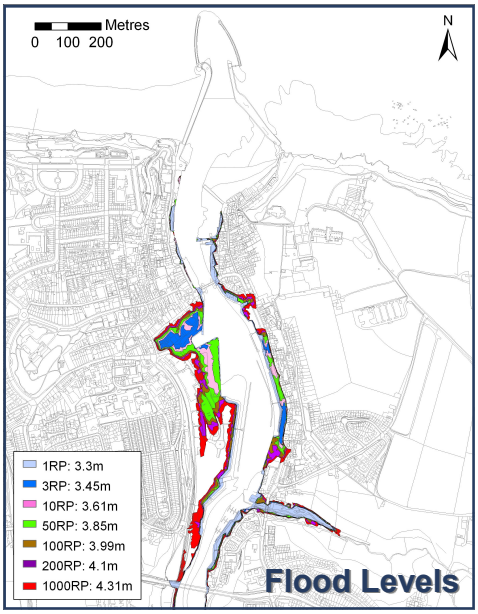
A series of modelling and assessment investigations was designed and undertaken throughout 2008. These have improved understanding of the present-day coastal processes in the vicinity of Whitby Harbour. The vulnerability of the structures to failure has also been assessed, along with the implications of different management options on the coastal processes. This included:

- Wave and water level modelling;
- Beach behaviour analysis;
- Wave overtopping assessments; and
- Flood level assessments along the lower reaches of the River Esk estuary.

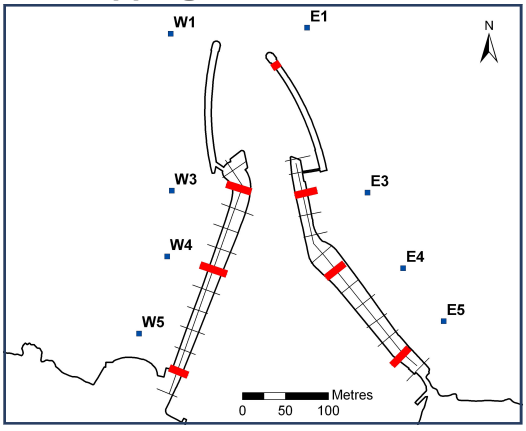


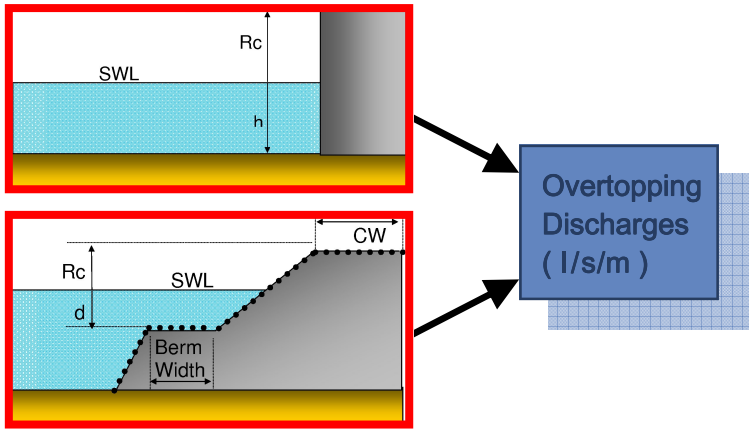




## Overtopping Assessment



## Overview Assessment of Existing Structures

From the further surveys and investigations, the following conclusions have been made:

### Main West Pier

The overall condition is poor, with movement of sandstone blocks, opening of joints, scour at sea bed level, cracking and chipping of blocks, and voiding behind facing blocks. Overtopping discharges are in excess of target thresholds for serviceability and will worsen over time due to sea level rise.

### West Pier Extension

The overall condition is poor, with opening of concrete joints and extensive voiding in the protective steel sheet piling. Overtopping discharges are likely to be in excess of target thresholds for avoidance of structural damage.

### East Pier

The overall condition is poor, with cracking, chipping, displacement and settlement of sandstone blocks, opening of joints, and voids behind facing blocks. There is evidence of the onset of corrosion to sections of protective sheet piling. There is also a series of three hollows in the sea bed adjacent to the pier. Overtopping discharges are in excess of target thresholds for serviceability and are greatest at the landward end of the pier. Overtopping will worsen over time due to sea level rise.

### East Pier Extension

The overall condition is very poor, with a major void at the south-east corner that results in an entire section of concrete visible above water being suspended via a cantilevering action from the rest of the structure. In addition, there are numerous voids in the sheet piles caused through corrosion of the steel and loss of backing concrete. Overtopping discharges are great along this structure and well in excess of target thresholds for avoidance of structural damage.

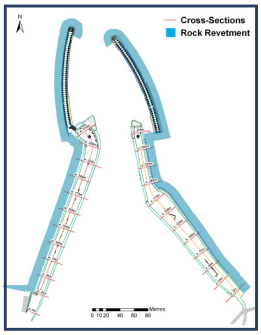
### Summary

The present investigations have highlighted that the existing piers are in poor condition and that the landward end of the East Pier Extension particularly is at risk in the short term.

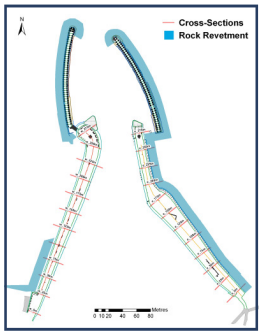
**The management options that have been considered for Whitby Harbour are:**

| Option | | Description |
|---|---|---|
| 1 | | **Do Nothing** – the 'walk-away' base case against which other options are compared. |
| 2 | | **Do Minimum** – continue with present practice involving modest reactive maintenance, primarily for reasons of harbour operations and health and safety. |
| Do Something | 3 | **Advance the Line** – protect the existing harbour structures through construction of a new structure(s) to seaward. |
| | 4 | **Managed Realignment** – changes in harbour plan form alignment to reduce exposure. |
| | 5 | **Modify** existing structures to improve present structural condition. |
| | 6 | **Modify** existing structures to improve present defence performance (especially with respect to overtopping discharges). |
| | 7 | **Modify** existing structures to improve present structural condition and present defence performance. |
| | 8 | **Managed Removal** – removal of harbour structures and management of flood and erosion risk through other means. |
| | 9 | **Managed Relocation** of vulnerable assets – relocation of properties, businesses, infrastructure and other assets at risk of erosion and flooding. |
| | 10 | **Demolish and Rebuild** – the existing piers and extensions would be demolished and rebuilt on their existing alignment. |

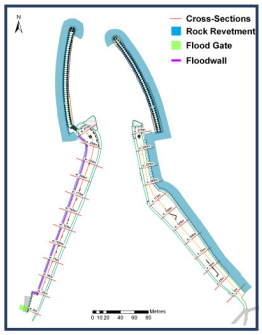
**OPTION 7A**



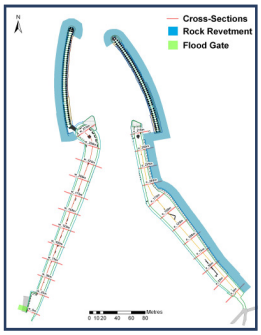

**OPTION 7B**



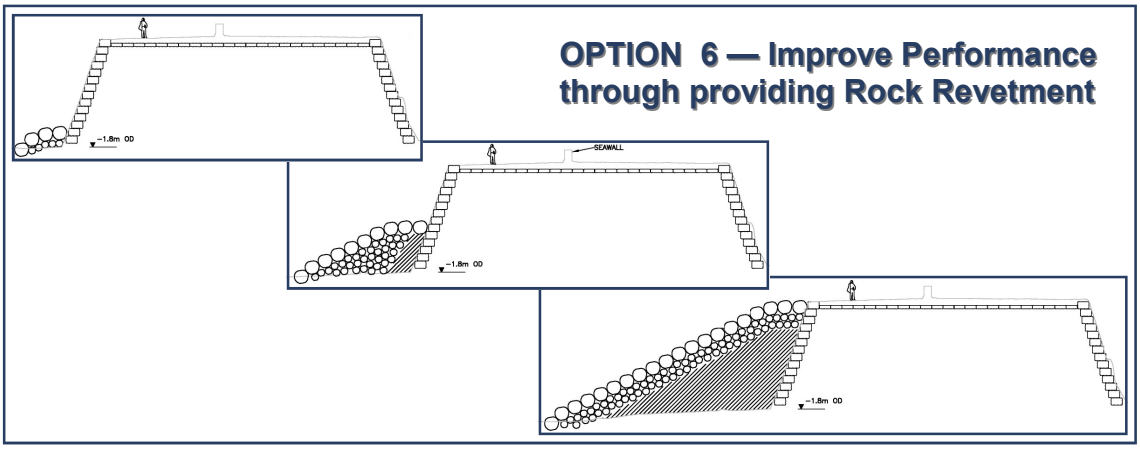

**OPTION 7C**




**OPTION 7D**




**OPTION 6 — Improve Performance through providing Rock Revetment**



**Preferred Approach**
Following an assessment of the management options against technical, economic and environmental criteria, a preferred approach has been identified involving:

- Pointing, grouting and partial sheet pile protection to the main piers;
- Sheet piling and concrete fill to the pier extensions;
- Rock armour revetment to the seaward side of the main piers and extensions, with the possible use of a wave return wall along the crest of the West Pier as an alternative to rock armour depending on feedback from public consultation and discussion with regulatory bodies.

**Next Steps**
Consultation with the public and with the regulatory bodies is now being undertaken. This is a very important stage in the process towards designing and delivering a solution to the problems at Whitby Harbour that provides the greatest benefit to the town whilst minimising any potential adverse impacts.

**Feedback**
We welcome your views on the scheme proposals. Please use the Feedback Form provided in our leaflet. For further information on the project you can also contact:

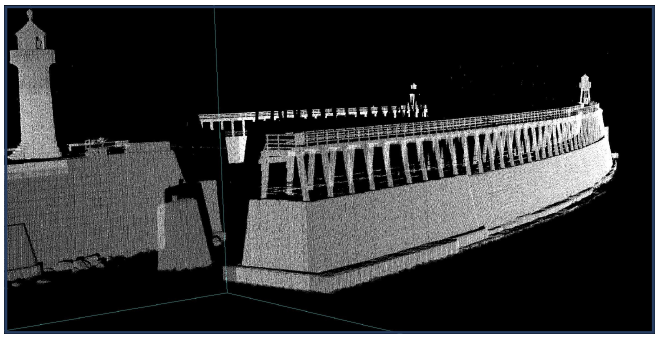
**Stewart Rowe**

Principal Coastal Officer
Projects and Procurement Unit
**Scarborough Borough Council**

tel. (01723) 232444

fax. (01723) 503826

stewart.rowe@scarborough.gov.uk
www.scarborough.gov.uk



# Whitby Harbour — Surveys & Investigations

**Feedback**

We welcome your views on the scheme proposals. Please forward this feedback form to: Stewart Rowe, Principal Coastal Officer, Projects and Procurement Unit, Scarborough Borough Council, Town Hall, St Nicholas Street, Scarborough, YO11 2HG.

| | |
|---|---|
| **Name:** | **Organisation** (if relevant)**:** |
| **Address:** | |
| **Tel.:** | **e-mail:** |

**Q1. Have you found the consultation processes informative?**

**Yes** ☐ **A bit** ☐ **No** ☐

**Q2. What more information would you like?**

**Q3. Do you understand the thinking behind the preferred approaches?**

**Yes** ☐ **A bit** ☐ **No** ☐

**Q4. What is unclear to you?**

**Continued overleaf**

# Whitby Harbour — Surveys & Investigations

**Q5. Do you agree that the proposed approaches are the best way forward?**

**Yes** ☐ **Mostly** ☐ **No** ☐

**Q6. What reservations or concerns do you have?**

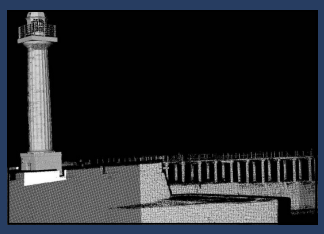
**Q7. What alternative approaches can you think of that would overcome your reservations or concerns?**

**Q8. Would you like to remain informed during the next stages of this project?**

**Yes** ☐ **No** ☐

**Q9. Do you have any other comments?**

## Thank you for your input



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# Appendix G

# Public Consultation Responses

# Public Consultation feedback for the Whitby Strategy further Investigations at Whitby Harbour

| Ref | Have you found the consultation informative? | What more information would you like? | Do you understand the thinking behind the preferred approaches? | What is unclear to you? | Do you agree that the proposed approaches are the best way forward? | What reservations or concerns do you have? | What alternative approaches can you think of that would overcome your reservations or concerns? | Would you like to remain informed during the next stages of the project? | Do you have any other comments? |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Yes | Blank | Yes | Blank | Yes | Blank | Blank | Yes | I and other people that I have talked to would like to see your preferred approach of pointing, grouting and sheet pile if at all necessary. Also small amount of rock armour if necessary. |
| 2 | Yes | An update as things progress. | No | There was no preferred option highlighted. Just a list of options to be considered. | Yes | At this stage of investigation it seems reasonable, but an apparent emphasis was on rock amour. Nothing should be given weight until all model tests are completed. | As above. Try to weight any plan towards repair and stabilisation of the exiting with no changes to the design except the essential. | Yes | Consider the groins suggested at the meeting. Don't go for submerged rock amour at any price! If used it must show at high-tide & wave action. Put in place a proper planned maintenance programme for future years. The do it and forget it system used by SBC in the past and indeed today is just not good enough. Don't hide or loose feedback that you or they don't like!! |
| 3 | No | I do not believe I have been party to a consultation process. I have recieved information and been instructed what SBC WILL be doing. At no point in time have I witnessed any form of discussion which could be viewed as consultation | Yes | It is obvious that minimising the cost to SBC is the only consideration. | Defiantly Disagree | The rock armourment is ugly and environmentally disasterous. The changing of wave patterns has unknown and potentially devasting effects. | I would like to see the piers sensitively restored to a high standard and a plan for appropriate maintenance in place. The use of wave energy technologies could potentially reduce wave damage whilest having the pay off of carbon zero energy production | Yes | Blank |
| 4 | Yes | Blank | Yes | Blank | Defiantly Agree | The Whitby coastline is a Site of National Importance for Purple Sandpiper and Turnstone, several hundred of which use the horizontal joints of the inner piers and extensions as high tide roosts. | If the piers are rebuilt / clad in rock armour, will it be possible to maintain these roost sites or provide alternative, equally sheltered, sites? | Yes | This work is vital to the future of Whitby as a town. Any loss of the piers / extensions and big waves will wash right into Whitby harbour, destroying boats, jettys, shops, houses - and people. |
| 5 | No | Blank | Yes | Blank | Disagree | NO rock armour to the piers | Alternative plan | No | Blank |
| 6 | Yes | The Storm/Flood Gate on the west pier slipway (sandy Bank) –This is a real priority – It should be started as soon as possible as public safety (Wave–Dodgers) and property is at risk on each spring-tide with normal northerly winds. An idea of type and construction would be useful, also manning and legal responsibility would need careful thought. (The West pier extension gate is a similar example) The resulting pile of timber, seaweed etc against the closed gate will decide the design to allow opening and access to clear the debris. | Yes | Blank | Mostly | Any revetment that narrows the harbour entrance between the extensions , (as depicted in option 7 A,B,C and D) is not acceptable. That narrow entrance is already difficult due to the strong west-to-East going tides. Rock amour moves in strong wave/tide conditions- any unseen displacement into the navigation channel is a very real risk. | 1.) Stop any loose rock amour revetment short of the extension ends. 2.) West Pier overtopping may be better dissipated by a below-eye-level wall on the seaward side, with the rock armour at half the height of the pier (as depicted in option 6) | Yes | As Whitby is now largely a tourist town I hope that when all the engineering is completed that consideration is given to retaining as many as possible of the Capstans and mooring posts on the pier with good information displays about their original purposes. The option of a raised/pitched deck and central wave return wall is not acceptable as it destroys the whole nature of their promenade effect. It could effect public safety on the windward side in many ways beyond space to discuss on this form. |

| Ref | Have you found the consultation informative? | What more information would you like? | Do you understand the thinking behind the preferred approaches? | What is unclear to you? | Do you agree that the proposed approaches are the best way forward? | What reservations or concerns do you have? | What alternative approaches can you think of that would overcome your reservations or concerns? | Would you like to remain informed during the next stages of the project? | Do you have any other comments? |
|---|---|---|---|---|---|---|---|---|---|
| 7 | A Bit | Your research into the The effectiveness of rock revetments. | A bit | Why you have waited so long before deciding to do anything. | Mostly | I fail to understand how revetments would prevent wave overtopping or have any effect on the probable future risk in sea levels. | The re-instatement of the groins on long sands | Yes | I was present at the public meeting that you addressed about the state of the piers in Whitby. On the evening of the 20th of February. I'd be grateful if you'd consider the following points. The background section of your document underlines the critical importance of the piers. The first three points you list are clearly matters of public safety; the other two have obvious economic implications. Nobody disputes that something has to be done. My impression, based on what you said, is that there have to be modifications. There would appear to be a disagreement about the suitability of rock armour revetments. People at the meeting mentioned the existing revetments at Staithes and Skinningrove. While neither of these is in your area, you failed to mention if you had contacted the relevant Councils, or anyone else who may have been involved with similar sea defences. Someone must know how effective rock revetments are for you to include them as part of your preferred approach. Several people at the meeting suggested alternatives to this; I was surprised that there was nobody taking notes.<br><br>While a show of hands at the meeting was not overwhelmingly against revetments nobody spoke up for them. Your document makes no mention of the absence of groins on the long beach between Whitby and Sandsend. Surely the groins must be reinstated as part of whatever option is chosen? This action would have a positive bearing on at least four of the points listed in your background section. It would also be fairly cheap when compared to some of the figures mentioned at the meeting. It bothers me that you choose to call two public meetings at short notice on the same day to discuss something so important to Whitby and the event was not well publicised. I'm baffled that your document has only now been produced in response to a strategy that was completed in 2002. I'm pleased that Council has decided something must be done to improve the situation, since the options of either doing nothing or doing the minimum will eventually prove to be the most expensive of all. |
| 8 | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Blank | My members were very concerned to learn that Scarborough Borough Council is proposing to use 'Rock Amour' to protect the piers and extensions. Councillors voted unanimously against the used of Rock Armour and strongly believe that the piers and extension, which are a listed structure, should be repaired and maintained to their original condition. Councillors would appreciate evidence of all maintenance and repairs carried out on the piers and extensions since 1974. |
| 9 | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Blank | I am writing to comment on the proposal in the Whitby Coastal Strategy consultation.<br><br>DO NOTHING<br>"Do nothing" is an unsustainable option. It terminates any future viability of Whitby as a town. If the projections of a pier failure within ten years of 2002 are proved accurate, then the character of Whitby as a harbour town will disappear.<br><br>The abandonment of the harbour defences means the abandonment of the concept of Whitby as a harbour town, as a town centred on the river and the sea. This will mean Whitby having to effectively turn its back on its marine character. Any such process should be an active decision to become a non-maritime town rather than something forced upon it through other processes.<br><br>DO MINIMUM<br>"Do minimum", while improving the state of the piers and harbour defences, just postpones the "Do Nothing" option. While any amount of work just postpones any failure, the "no minimum" option as outlined is just a continuation of current maintenance and repairs. With no increased investment the deterioration of the piers will accelerate and repairs will not be able to keep up. Within a few years the "do minimum" option becomes the "do nothing" option, or becomes a more expensive "do something" option.<br><br>DO SOMETHING<br>I believe that the only viable option is some form of "do something", and the earlier, the cheaper. Any investment made today will be paid back by the greater investment not needed later.<br><br>The draft report costs the damage to the town and harbour infrastructure due to failure of the piers as some £166,000,000 within the next 100 years. Compare that to a guide cost of some £15,000,000 in the draft report, or £150,000 per year if considered as an annual cost.<br><br>DO SOMETHING OPTIONS<br>I feel the option that would best improve the harbour defences while also conserving the architechtural and heritage value of the existing pier structures would be an appropriate mix of options 5, 6 and 7, repairs and improvements to existing structures to conserve and improve their condition and improve their defensive performance.<br><br>I agree with the arguments identified by the Sneaton Castle Options Workshop on 20th November last year, against options 1-4 and 8-10, and will not persue those options further, other than to urge that the recommendation not to persue those options should be taken.<br><br>THE PIERS<br>The west face of the West Pier should remain a vertical wall. It is a visual amenity to and part of the character of Whitby Sands. As such rock revetments to the west face would be inappropriate.<br><br>The visible stone faces of neither pier should be faced in visible cladding. The visible faces - both sides of the West Pier and the west side of the East Pier should retain a similar profile and visible appearence as they currently have.<br><br>There may be effective ways to provide strengthing and improved structural condition by works within the pier body itself, behind the existing stone faces.<br><br>However, suitable facing, fill and reinforcement that would be invisible for the majority of time would be suitable. For the West Pier, this would probably have to be lower than the general sand level, particularly as the slipway access to the Sands is in line with the pier. On the inner sides of both piers suitable strengthening cladding could be appropriate so as to be invisible for, say, 80% of the tidal range. However, the safety issues of any structures underwater that are wider than the visible pier structure would have to be taken into account. On balance, I feel that between the two piers the facing surface should continue down below water in the line implied by the visible structure. |

| Ref | Have you found the consultation informative? | What more information would you like? | Do you understand the thinking behind the preferred approaches? | What is unclear to you? | Do you agree that the proposed approaches are the best way forward? | What reservations or concerns do you have? | What alternative approaches can you think of that would overcome your reservations or concerns? | Would you like to remain informed during the next stages of the project? | Do you have any other comments? |
|---|---|---|---|---|---|---|---|---|---|
| 9 cont. | | | | | | | | | Rock revetments could be appropiate for the east face of the East Pier, as The Scar is currently little used as amenity space and has no direct access, other than over the Spa Bridge causeway. Additionally, the general character of the east cliff toes and foreshore are broken and fallen rock. Also, the causeway replacing the Spa Bridge includes an amount of rock revetment.<br><br>Figure 30 proposes raising the finished footsurface of the whole pier to increase the crest height. I feel that this is a better option that a wall along one side, but an increase in height of the full 5m shown in the diagram would have a significant change on the character of the piers.<br><br>A 5m increase in height of the East Pier is the least problametic. It would mean the downward sloping causeway from the Haggerlythe would slope down less. The view of the Scar from Tate Hill beach is already obscured by the East Pier, so there would be no loss of view. However, a 5m increase in height almost doubles the visual massing, going from about 8m in height to about 13m.<br><br>A 5m increase in height for the West Pier is problematic as the West Pier is an extension of Pier Road. Pier Road is at almost the same height above OD as the West Pier finished footway. A 5m increase in height would require some form of access to the new surface. Additionally, if the pier is raised 5m it leaves Pier Road as a weak spot through which higher cresting water would be funnelled. The battery parade would also have to be raised.<br><br>It may be possible to achieve the required improvements by raising the height progressively as you move away from the land.<br><br>Any change in the surface height of the West Pier would require Alderman Pannett's railings being removed. If this is done, they must be retained and replaced (with any suitable repairs) on the finished surface.<br><br>The major and unavoidable issue with raising the pier surface is the two Listed stone lighthouses. Simply raising the pier surface would effectively bury the lighthouses. Any raising of the piers must include very careful listed-building-appropriate, and probably quite expensive, works to raise the lighthouses to the new surface height.<br><br>Any increase in pier crest height should be combined with sea-facing walls to lessen the raised height needed, but as discussed above, any walls should be no higher than about 0.5m, of a similar height and character as the existing walls.<br><br>THE PIER EXTENSIONS<br>Addressing the pier extensions is a much simpler issue, being simply a concrete subsea base supporting a timber structure.<br><br>I feel that the best solution for the pier extensions would be to fill, clad and rebuild as appropriate the concrete base. However, my earlier comment about subsea structures not being out of line with the above-sea structure also applies here, and more so as this is the deep-water area.<br><br>Figure 28 shows a squared block construction around the base. The existing base does have projecting "toes", which become visible at low tide<br><br>The timber structure should be repaired and replaced as appropriate - it probably should be completely replaced and rebuilt from scratch. As with the current extensions, there should be two accessible levels and they should be linked from the piers. Obviously, if the finished footsurface of the piers is raised, the finished footsurface of the top level of the pier extensions should be at the same height. |
| 10 | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Blank | I write with interest regarding your proposal to refurbish/repair the existing harbour defences in Whitby.<br><br>I wonder whether if any thought has been placed on the now well-established scientific findings/predictions related to sea level rise and global warming. (My reference is to this particular stretch of Jurassic coastline.)<br><br>The Inter-government Pannel on Climate Change (IGPCC) has recently met in Copenhagen, and new evidence suggests that sea level rise will proceed at a 50% greater rate than originally predicted several years ago. So in 25 years the mean high water level could be between 0.5 & 1m higher than it is today.<br><br>The measures you are proposing, apart from a total rethink, will only be effective for approx a generation if that. Even a 0.5 -1m elevation in the mean sea level would have a dramatic effects on the entire coastal area unless some form of substantial sea defence programme, possibly including sea lochs was considered/established.<br><br>My suggestion as a mere concerned & informed member of the community and society, is that in order to preserve the heritage of the coast and Whitby (In part if not in total) into the remainder of the next century, consideration should be given to undertake some more in-depth research with computer modelling of the area, taking account of newly projected sea level rise.<br><br>Why not do more research now before vast sums of money are used for short-term fix, when long-term solutions albeit more costly will protect the area in the long term for generations of dwellers and visitors.<br><br>Whilst there is some scepticism regarding climate models for the future, CO2 rise with warming & consequent sea level rise are considered imminent (within the century) & whatever we do or do not do in terms of changing our lifestyles – many areas of the country and indeed the world will need to adapt. Please send our money wisely. |

| Ref | Have you found the consultation informative? | What more information would you like? | Do you understand the thinking behind the preferred approaches? | What is unclear to you? | Do you agree that the proposed approaches are the best way forward? | What reservations or concerns do you have? | What alternative approaches can you think of that would overcome your reservations or concerns? | Would you like to remain informed during the next stages of the project? | Do you have any other comments? |
|---|---|---|---|---|---|---|---|---|---|
| 11 | A Bit | A more comprehensive suite of technical appendices to the summary report available for the consultation. | Yes | Blank | No | The decision making process is based upon an incomplete to simplistic understanding of the internal structures of the piers & extensions. | A more detailed knowledge of the history and development of the structure will allow correct management decisions to be made. | Yes | Blank |
| 12 | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Most of my comments and concerned are related to Q5, Q6 and Q7.<br><br>Re the various options outlined I would prefer the council "Do Something". Like many people living in Whitby, the visual aspect of the piers, especially the West pier, is probably more, or just as important than their function. They have become a signature or iconic feature of Whitby in the same way as the Castle on the cliff at Scarborough is. Therefore the approaches which aim to remove, or change the overall appearance are obviously far too radical. This in effect removes options, 1, 2, 3, 4, and because putting rock armour infront of the west pier would dramatically alter its profile and appearance then approaches 6, 7A,7B. are the least preferred solution.<br><br>Options 7C & 7D approaches would be much more acceptable as they have no rock armour on the West main pier. Although from the small diagrams it is impossible to ascertain any difference between the two.<br><br>Rock armour used on the extensions probably will not alter the visual appearance in any significant way given that for a large proportion of time they'll be below water. Rock armour on the east pier is far less obtrusive and is totally acceptable. I just hope if used it doesn't get washed away in storms!! |
| 13 | No | Do we have any of the skills of harbour maintenance in this town? Do you think there is value for the community in your proposals? | No | Your role in this project. I admire your skills in project presentation. | No | Suffice it to say that I do have some regards to the integrity of this commitment. | Programme of Maintenance | Yes | Yes |
| 14 | YES | The National Strategy & thus where whitby harbour & coast fits into this for priorities. | Yes | Blank | Mostly | No remedial measures in the meantime for emergency situations | Blank | Yes | Blank |
| 15 | Yes | Blank | Yes | Blank | Yes | Blank | Blank | Yes | It is very important that actual designs are based in detailed structural modelling and that they are in place as soon as possible. This work is urgently needed. |
| 16 | Blank | Blank | Blank | Blank | Blank | Blank | Blank | Blank | I was very taken aback by proposals, highlighted in the Whitby Gazette, by Scarborough Borough Council to rock armour revet the Whitby piers. I wish to register my strongest opposition to this idea. Whitby's piers are unique. There very substance and beauty are a part of that very magic which attracts visitors from around the world to savour a true sense maintaining them along there true lines into the future. we have to be accountable to those who follow us. |

# Appendix H

# Risk Register – Site Investigations and Surveys

**WHITBY PIERS – FURTHER INVESTIGATIONS**

**RISK REGISTER – VERSION 3**

**June 2007**

- Version 1 compiled after a Risk Workshop held on Monday 10th December 2006 at Whitby. This was attended by:
  - Stewart Rowe – Scarborough Borough Council – Client Project Manager
  - Bill Estill – Harbour Master
  - Nick Cooper – Royal Haskoning – Consultant Project Manager
  - Chris Grogan – Royal Haskoning – Consultant Investigations Manager
  - Richard Pike – Royal Haskoning – Geotechnical
  - Dickon Howell – Royal Haskoning – Environmental
  - Mike Watkiss – Royal Haskoning – CDM Coordinator
  - Will Culley – Royal Haskoning – Dive Surveyor

- Version 2 & 3 compiled from issues raised through tendering investigations and items raised at progress meeting. These are attended by:
  - Cllr Andrew Backhouse – Scarborough Borough Council – Environment Division
  - Stewart Rowe – Scarborough Borough Council – Client Project Manager
  - Robin Siddle – Scarborough Borough Council
  - Bill Estill – Harbour Master or his assistants
  - Chris Grogan – Royal Haskoning – Consultant Investigations Manager
- This version is to be update as appropriate throughout the course of the study.

| Ref | Risk | Likelihood | Consequence | Mitigation | Residual Likelihood | Residual Consequence |
|---|---|---|---|---|---|---|
| 1 | Injury or death to divers undertaking underwater survey due to collision with another vessel | Medium | High | Undertake dive survey before vessel traffic increases (i.e. before end March). Notice to Mariners via Harbour Master. Inform harbour users via Harbour Master's meetings with users. Divers' adherence to working restrictions (maximum dive durations). 4 person teams operating. Undertake as much inspection as possible via boat / foreshore and limit dive requirements to bare essentials. Flag location of diving activities. Harbour Master will also have someone in attendance. Dives from lorry marked / shadowed by boat to warn of activity. | Low | High |
| 2 | Construction plant used for Ground Investigation washed off piers due to overtopping | Medium | High | Reschedule timing of Ground Investigation away from January/February to (expected) calmer conditions. Plant to be removed from pier after each day's activities. | Low | High |
| 3 | Access/egress of surveyors and/or plant to the pier extensions (including rapid egress due to changing weather conditions) | Medium | Medium | Focus investigations on main piers and down-scale type of investigation on pier extensions. Harbour Master's vessel (e.g. RIB or pilot boat) available to transport surveyors to and from pier extensions during suitable weather conditions. Harbour Master makes decisions about when access is called off due to adverse weather. Communications links to be established between Harbour Master and surveyors. Weather regularly monitoring. | Low | Medium |
| 4 | Adverse impact on the environment from plant / vessel spillage | Medium | Medium | Adhere to CIRIA best practice guides: C650 - Environmental good practice - site guide; C584 - Coastal and marine environmental site guide. | Low | Medium |
| 5 | Working near or on water – drowning/hypothermia | Medium | High | At least 2 people on site. Emergency contact details know by staff. Liaison with Harbour Master. Tide tides | Low | High |

| Ref | Risk | Likelihood | Consequence | Mitigation | Residual Likelihood | Residual Consequence |
|---|---|---|---|---|---|---|
| | | | | known in advance of visit. | | |
| 6 | Health and Safety of workers on piers / plant operating on piers | Medium | High | Early CDM Coordinator involvement in design of investigations to 'design-out' risks | | |
| 7 | Project costs exceed provision estimates | High | High | Re-design investigation scope to ensure delivery within budget. | Medium | High |
| 8 | Project programme delays due to adverse weather | High | Medium | Design investigations with float to accommodate this | Medium | Medium |
| 9 | Project programme delays due to refusal / delay of permissions | Medium | Medium | Application for necessary consents and permissions made early | Low | Medium |
| 10 | Study scope 'creeps' beyond its intended focus | High | Medium | Clarity of scope and focus exclusively on the key coastal defence function of the piers | Low | Medium |
| 11 | Injury or death to divers undertaking underwater survey due to funnelling of tides through pier extensions | Medium | High | Dive these areas during slack tides. Undertake as much inspection as possible via boat / foreshore and limit dive requirements to bare essentials. | Low | High |
| 12 | Turbidity in water makes visual inspection difficult during dive surveys | Medium | Medium | Design anticipating low visibility and employ tactile inspection techniques. | Low | Medium |
| 13 | Plant access to landward end of East Pier via narrow streets | Medium | Medium | Early contractor involvement. Suggest use of 4-wheeled drive vehicles. Draw upon experience of SBC who have previously mobilised a 10-T crane along these streets. | Low | Medium |
| 14 | Striking of electrical cables / utilities in pier structure during intrusive investigations | Medium | High | Services check in advance of intrusive works | Low | High |
| 15 | Plant movement through the streets will cause public disturbance | Medium | Low | Erect a plant compound near the East Pier. Move plant early in morning or late in day. | Low | Low |
| 16 | First Aid and Emergency treatment | Medium | High | First Aider on site, knowledge of emergency service numbers (ambulance, lifeboat, RAF Boulmer/Leming) | Low | High |
| 17 | Abseil survey – falls from heights | Medium | High | Use of cherry-picker in preference to abseiling | Low | High |
| 18 | Adverse PR | Medium | Medium | Advertisement in local paper. Notice to Mariners. SBC produced information poster on investigations. Contractors given Q&A. | Low | Medium |
| 19 | Integrity and strength of timber structures on pier extensions to support GI plant. | High | High | Design-out need for GI on pier extensions of possible. Otherwise structural inspection of timber needed. | Low | High |
| 20 | Damage to heritage interests of piers | Medium | Medium | Lift surface slabs rather than drill through them. | Low | Medium |
| 21 | Emergency access blocked to public accident not associated with the work. | Medium | High | Risk included in Pre-construction information for each investigation. Works to be located to allow access long piers. | Low | Medium |
| 22 | Plant movement through streets causing damage to cobbled surfaces and stone blocks on piers | Medium | medium | Use plant with tyres, rubber tracks or protect surfacing with plywood boards | Low | Low |
| 23 | Hazard from open excavations in pier surface during GI works | Medium | high | Fill in open excavations temporarily with clean stone subbase | Low | Medium |
| 24 | Traffic congestion to east side of swing bridge from low loader with GI equipment | high | medium | Avoid use of low loader by reduced rig size. Transport on flat bed truck. Delivery times early in morning. | low | medium |
| 25 | Collapse of temporary fencing around GI works due to high winds or vandalism leading to hazard for public | medium | high | Wire heras fence panels together around works to reduce collapse. Provide wire ties for bracing to improve stability | low | medium |
| 26 | Stability of rotary rig on steep slope access to east pier | medium | high | Guide rotary rig up and down access route using tractor or tether to ensure stability | low | medium |
| 27 | Effects of weather on topographical laser scan work. Work affected by strong winds, fog, & snow. | high | medium | Plan site survey work around forecast as mobilisation fairly easy due to close location. Reschedule work around bad periods | low | medium |

| Ref | Risk | Likelihood | Consequence | Mitigation | Residual Likelihood | Residual Consequence |
|---|---|---|---|---|---|---|
| 28 | Limited laser scan definition possible due to seaweed | medium | medium | Seek to clear seaweed from pier walls although coverage quite extensive, depending upon finance. Or accept limited information | medium | medium |
| 29 | Limited effectiveness of ground probing radar through large structures. Depth of penetration limited to 2m max. | high | medium | Apply microgravity techniques along with side scan of pier walls with GPR, to gain clearer definition | low | Medium |
| 30 | Use of boat to undertake side scan using GPR disrupted by bad weather or swell | medium | medium | GBG clarify that boat work only required for calibration and quality assurance. Results acceptable without boat work | medium | low |
| 31 | Gi work costs to foreshore investigation likely to be extensive due to need for jack up barge or staging, which could be disrupted by weather. Further consents required for works on foreshore to SSSI and SAC sites. | high | high | Remove foreshore investigation from GI Works. Check with the EA that this would be acceptable. Extent of works options unknown during feasibility, so need and extent of foreshore investigation best left until detailed design. | Low | Low |
| 32 | GI works likely to encounter difficult driving due to varied and unknown construction of piers | medium | high | GPR results used to target GI works. Consideration of various techniques in tender and tender assessment with contractors. Likelihood that shell & auger and rotary rig required. Further plant options and techniques may be required. Contingency provided within budget. | medium | medium |
| 33 | Rotary rig can discharge arisings from drilling operation out over working area and pier, leading public safety issue and pollution incident | medium | high | Rotary rig to use water flushing system with arisings controlled by collection system and re-circulated through filter tank. Bunded area around drilling area to be provided to catch arising and splash water. | low | medium |
| 34 | Disruption to survey through public crowding and public conflict with works or works vehicles/vessels | medium | medium | Avoid all surveys occurring around Easter, Whitsun break and summer holidays. Information notice pinned to vehicles around works. Contractors told to refer public to SBC communications manager. | low | low |
| 35 | Conflict between different surveys occurring at same time (eg. GI works and dive works) | medium | medium | RH investigations manage to design investigations to avoid overlap as far as possible. CDM coordinator to coordinate work operations to avoid conflict. GI contractor appointed Principal contractor to coordinate activities during works. | low | medium |
| 36 | Safety concern over diving in 1 – 2m ravine adjacent to outer face of east main pier. Danger increased by rough sea conditions and swell | medium | high | Undertake dive / wading survey during calm weather and conditions. Consider survey at low tide with safety provisions. | medium | medium |
| 37 | Defra guidance on scheme grant aid award revised to remove priority scores and apply outcome | High | Medium | Ensure that PAR prepared in accordance with new guidance | medium | medium |
| | | | | | | |

# Appendix I

# Risk Register – Re-evaluation of Strategic Options and Concept Designs

# WHITBY PIERS – FURTHER INVESTIGATIONS

# RISK REGISTER – STAGE 2 [(1)]

# VERSION 1, November 2008

| Ref | Risk | Likelihood | Consequence | Mitigation | Residual Likelihood | Residual Consequence |
|---|---|---|---|---|---|---|
| 1 | Unable to identify management solutions to the problems with the harbour piers that have been identified during Stage 1. | Low | High | Brainstorming of a 'long-list' of management options amongst the project team and Management Group. | Low | High |
| 2 | Abortive work in assessing the impacts and benefits of a range of options that will not be viable for implementation | Medium | High | Screening of the 'long-list' to produce a 'short-list' that will be subject to more detailed assessments. | Low | High |
| 3 | Unable to gain consensus amongst key stakeholder on the preferred strategic management option(s) | Medium | High | Workshop held at early stage of assessment process to discuss opportunities and constraints associated with strategic management options | Low | High |
| 4 | Unable to gain consensus amongst key stakeholder on the methods and timescales for implementation of the preferred strategic management option(s) | Medium | High | Workshop held at early stage of assessment process to discuss opportunities and constraints associated with strategic management options. Review by stakeholders of detailed draft of report | Low | High |
| 5 | Inaction / delay in delivery of preferred option(s) will lead to increased risk of flooding and erosion to the town | Medium | High | Early engagement of key decision-makers during development of the options so that views are considered and timescales are known by all. | Low | High |
| 6 | Preferred option(s) has unacceptable or undesirable environmental impacts. Particularly on the key geological and historical interest features. | Medium | High | Early discussions with Natural England, Environment Agency, English Heritage and other key stakeholders through Workshop and Consultation. Identify means of reducing or removing environmental impacts during outline and detailed design. | Low | Medium |
| 7 | Preferred option(s) generates insufficient economic benefits to warrant grant-aid investment from central government funding for coastal defence. | Medium | High | Early discussion with economic specialists at the Environment Agency (Steve Goring – Leeds; and Bill Watts – NRG). Consider fullest possible range of justifiable economic benefit categories in assessments. Pragmatic approach to be adopted that demonstrably justifies the arguments under each 'benefit category'. Use of Workshop to help identify wide range of benefits categories. | Low | High |
| 8 | Preferred option(s) generates insufficient score under the Outcomes Measure to warrant timely grant-aid investment from central government funding for coastal defence. | High | High | Consider harbour piers as part of the overall flood and coastal defence system, and include justifiable measures from the widest possible considerations. Use of Workshop to help identify key issues and inter-connectivity. | Medium | High |
| 9 | Structure(s) deteriorate and possibly even fail before a scheme is fully implemented, increasing the scale of scheme works that are required and placing peoples, properties and the natural and historic environment at increased risk. | High | High | Phasing of approach to remedy the worst afflicted areas as part of a capital scheme. Preparedness contingency for emergency works in event of a failure. | Medium | Medium |

(1) A Risk Register was prepared and revised during Stage 1 of the Further Investigations. This particularly focused on risks associated with undertaking the surveys and investigations that were carried out. The present Risk Register has been prepared for Stage 2 – which involves updating the preferred management options.

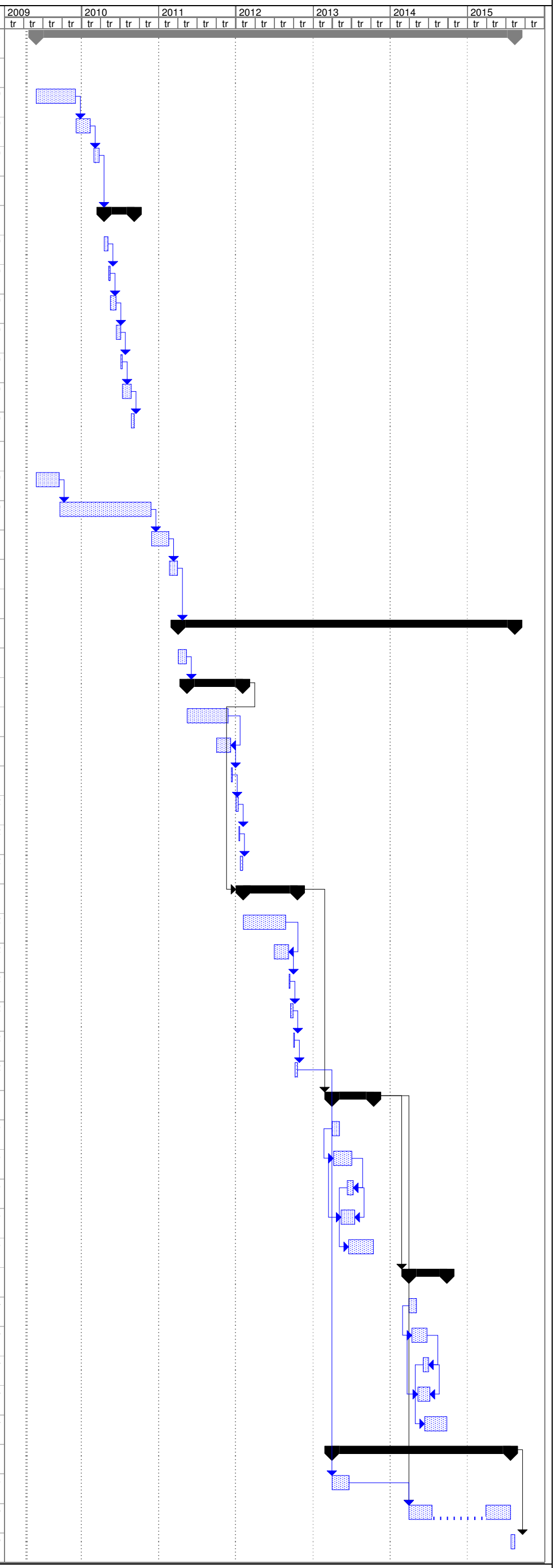
| Ref | Risk | Likelihood | Consequence | Mitigation | Residual Likelihood | Residual Consequence |
|---|---|---|---|---|---|---|
| 10 | Environment Agency procedures change during preparation / review by the Agency of the PAR (a new PAR 'streamlining process' is in preparation) | High | Low | Maintain awareness of PAR processes through discussions with Environment Agency staff. Aim to deliver Whitby Harbour PAR before the (phased) implementation of the streamlining process in April 2009. | Medium | Low |

# Appendix J

# Implementation Programme

# Whitby Coastal Strategy: Further Investigations - Implementation Programme

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 0 | **Whitby Coastal Strategy: Further Investigations** | **1560 days** | **Mon 01/06/09** | **Fri 14/08/15** |
| 1 | | | | |
| 2 | Detailed Design of East Pier Extension (EPE) Urgent Works | 27 wks | Mon 01/06/09 | Fri 04/12/09 |
| 3 | EPE Urgent Works Procurement | 10 wks | Mon 07/12/09 | Fri 12/02/10 |
| 4 | EPE Urgent Works Mobilisation | 4 wks | Mon 01/03/10 | Fri 26/03/10 |
| 5 | | | | |
| 6 | **EPE UrgentConstruction Works** | **102 days** | **Mon 19/04/10** | **Tue 07/09/10** |
| 7 | Site Mobilisation | 15 days | Mon 19/04/10 | Fri 07/05/10 |
| 8 | Pre-excavation | 6 days | Mon 10/05/10 | Mon 17/05/10 |
| 9 | Sheet Piling | 20 days | Tue 18/05/10 | Mon 14/06/10 |
| 10 | Grouting to Pre-bores | 15 days | Tue 15/06/10 | Mon 05/07/10 |
| 11 | Anchors | 6 days | Tue 06/07/10 | Tue 13/07/10 |
| 12 | Concrete Filling | 30 days | Wed 14/07/10 | Tue 24/08/10 |
| 13 | Demobilisation | 10 days | Wed 25/08/10 | Tue 07/09/10 |
| 14 | | | | |
| 15 | NRG Approval Process and Funding Application | 16 wks | Mon 01/06/09 | Fri 18/09/09 |
| 16 | Detailed Design of Improvement Works to All Piers | 62 wks | Mon 21/09/09 | Fri 26/11/10 |
| 17 | Construction Works Procurement | 12 wks | Mon 29/11/10 | Fri 18/02/11 |
| 18 | Construction Works Mobilisation | 30 days | Mon 21/02/11 | Fri 01/04/11 |
| 19 | | | | |
| 20 | **Construction Works to All Piers** | **1080 days** | **Mon 04/04/11** | **Fri 14/08/15** |
| 21 | Site Mobilisation | 30 days | Mon 04/04/11 | Fri 13/05/11 |
| 22 | **East Main Pier** | **180 days** | **Mon 16/05/11** | **Fri 03/02/12** |
| 23 | Pointing | 140 days | Mon 16/05/11 | Fri 25/11/11 |
| 24 | Grouting | 50 days | Mon 03/10/11 | Fri 09/12/11 |
| 25 | Pre-excavation | 1 wk | Mon 12/12/11 | Fri 16/12/11 |
| 26 | Sheet Piling | 2 wks | Mon 02/01/12 | Fri 13/01/12 |
| 27 | Grouting to Pre-bores | 1 wk | Mon 16/01/12 | Fri 20/01/12 |
| 28 | Concrete Filling | 2 wks | Mon 23/01/12 | Fri 03/02/12 |
| 29 | **West Main Pier** | **180 days** | **Mon 06/02/12** | **Fri 19/10/12** |
| 30 | Pointing | 140 days | Mon 06/02/12 | Fri 24/08/12 |
| 31 | Grouting | 50 days | Mon 02/07/12 | Fri 07/09/12 |
| 32 | Pre-excavation | 1 wk | Mon 10/09/12 | Fri 14/09/12 |
| 33 | Sheet Piling | 2 wks | Mon 17/09/12 | Fri 28/09/12 |
| 34 | Grouting to Pre-bores | 1 wk | Mon 01/10/12 | Fri 05/10/12 |
| 35 | Concrete Filling | 2 wks | Mon 08/10/12 | Fri 19/10/12 |
| 36 | **West Pier Extension** | **136 days** | **Mon 01/04/13** | **Mon 14/10/13** |
| 37 | Pre-excavation | 21 days | Mon 01/04/13 | Mon 06/05/13 |
| 38 | Sheet Piling | 58 days | Mon 08/04/13 | Wed 03/07/13 |
| 39 | Grouting to Pre-bores | 21 days | Wed 12/06/13 | Wed 10/07/13 |
| 40 | Anchors | 47 days | Tue 14/05/13 | Wed 17/07/13 |
| 41 | Concrete Filling | 84 days | Wed 19/06/13 | Mon 14/10/13 |
| 42 | **East Pier Extension** | **125 days** | **Mon 31/03/14** | **Fri 26/09/14** |
| 43 | Pre-excavation | 21 days | Mon 31/03/14 | Mon 05/05/14 |
| 44 | Sheet Piling | 52 days | Mon 14/04/14 | Tue 24/06/14 |
| 45 | Grouting to Pre-bores | 18 days | Fri 06/06/14 | Tue 01/07/14 |
| 46 | Anchors | 42 days | Mon 12/05/14 | Tue 08/07/14 |
| 47 | Concrete Filling | 76 days | Fri 13/06/14 | Fri 26/09/14 |
| 48 | **Rock Revetment Works** | **570 days** | **Mon 01/04/13** | **Fri 24/07/15** |
| 49 | Main Piers | 55 days | Mon 01/04/13 | Fri 21/06/13 |
| 50 | Pier Extensions | 155 days | Mon 31/03/14 | Fri 24/07/15 |
| 51 | Site Demobilisation | 15 days | Mon 27/07/15 | Fri 14/08/15 |




Project: Whitby Coastal Strategy: Furt
Date: Tue 14/04/09

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

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