



# Whitby PAR Options Appraisal Report

Scarborough Borough Council

17 May 2012

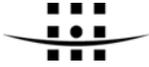
Final Report

9W5572



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## SUMMARY

This report evaluates a range of options for achieving the Condition and Performance Improvements identified and recommended within the Whitby Coastal Strategy 2 Strategy Appraisal Report (StAR) (2012) for Management Units 17 (West Pier) and 18 (East Pier).

The recommendation of the StAR was to implement a capital funded project to improve the condition of the Main Piers and the condition and performance of the Pier Extensions.

This Options Appraisal Report does not include a comparative assessment of the Do Nothing and Do Minimum options, as these have been evaluated and eliminated in the StAR. The PAR is to be presented as a Supported Change Project delivering the recommended outcomes of the StAR, and therefore the option evaluation process compares and contrasts a range of Do Something options that deliver the StAR objectives.

All Do Something options provide solutions that extend the life of the existing assets by a further 100 years. The whole life cost assessments for the options are based on carrying out the Main Pier works immediately with an allowance for further intervention on the Pier Extensions (typically 20 and 70 years after the completion of the capital scheme) within the 100 year benefit period.

The Preferred Option identified in this report is;

### **Option 6 – M1 + E4 (Main Piers Works & Pier Extensions Option E4)**

- Main Pier re-pointing and grout infilling, and surface repairs;
- Flood Gate installation at Battery slipway;
- Access barriers and warning signs;
- Scour protection to West Pier Bull-Nose;
- Half-height rock revetment to outer face of East Pier Extension;
- Sheet pile and concrete backfill scour protection to inner face of West Pier Extension;
- Void infilling on remaining two faces of the Pier Extensions;
- Concrete repairs to all faces of Extensions; and
- Scour protection to Extension Bull-Noses.





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## **1. INTRODUCTION**

### **1.1 Purpose of Report**

The purpose of this report is to record the option appraisal process carried out for implementing the preferred strategic option for management Units 17 (West Pier) and 18 (East Pier) from the Whitby Coastal Strategy 2.

This Options Appraisal Report will inform the Whitby Piers Project Appraisal Report (PAR) and will be included as an appendix.

The aim of the report is to explain how the options considered for the different sections of the asset system were derived, what the options include, how they have been combined, and how they have been assessed to determine the preferred option.

### **1.2 Background**

The Whitby Coastal Strategy 2 is a review and update of the original Whitby Coastal Strategy. The Strategic Appraisal Report (StAR) was submitted and approved in 2012. The Whitby Piers PAR covers two management units (MU) from the Strategy:

- Management Unit 17: West Pier and Extension; and
- Management Unit 18: East Pier and Extension.

Whitby harbour is situated on a north facing stretch of coastline and is protected from the severe wave climate by two historic masonry piers dating back to the 1500s and their mass concrete extensions which were constructed in the early 1900s. The piers and their extensions play a crucial role in the coastal erosion and flood risk management of the Whitby area. The piers act as a large groyne supporting the build-up of sand at Whitby Sands, without the piers the beach would be lost and the rate of coastal erosion would accelerate. The piers also shelter the harbour and town centre from the severe wave climate reducing the probability of flooding. The piers and their extensions are therefore of critical importance to Whitby.

The preferred strategic option for both management units was to carry out capital works to refurbish the Main Piers and Extensions, improving the structural condition of the Main Piers and the structural condition and performance of the Pier Extensions. The proposed capital works also include the installation of a flood gate at Battery Parade Slipway (which is at the boundary of MU 16 and 17) to prevent waves from running up the slipway and causing flooding to Pier Road.



## **2. MAIN PIERS**

### **2.1 Definition of the Problems**

#### *2.1.1 Structural Issues - Voiding and Movement of Blocks*

The Main Pier structures are formed from an outer face of large sandstone blocks, with a central core filled with what is assumed to be locally gained cliff or bed rock type material. The upper surfaces of the piers are formed from dressed sandstone blocks, which have subsequently been overlaid with a concrete promenade surface on the West Pier only.

The large sandstone blocks appear to be bedded directly onto the underlying bedrock material. On the inner (harbour) face of the West Pier, the blocks appear to have been placed onto dressed sandstone 'shoes'; long, relatively thin blocks, which form the base layer for the structure.

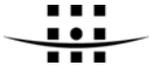
The Further Investigations Report of 2009 (FIR 2009) identified that there are areas of voiding where the inner fill material has been lost as a result of tidal ingress and subsequent wash-out of the fill material immediately behind the walls and beneath the upper surface. This was confirmed through use of ground radar scanning equipment used at the time of the investigations. The voiding appeared to be worse towards the seaward ends of the Piers.

There are sections of the piers where it appears that the 'shoes' at the toe of the structure have been lost through undercutting of the bedrock or erosion over the life of the structure. This loss of toe support has resulted in the facing stones directly above the missing blocks dropping in a 'cascade' type manner. The gaps between the stonework allows tidal water to wash out fill material from behind the walls and hence creates voiding and further destabilisation of the structure. This type of failure can be seen on both faces of the West Pier and also on the inner face of the East Pier.

The piers do not appear to have been constructed with mortared joints. Therefore, what appears to be open joints where mortar has been lost are more likely to be eroded joints due to weathering, or open joints as a result of movement of the blocks from the processes described above, and also possibly as a result of settlement of the structure over time. The original jointing can be seen at the lower sections of the pier where the blocks have been protected by marine growth and are not exposed to weathering – at these locations the joints can be seen as being flush and not formed from mortar beds.

Continued loss of inner fill material will result in;

- The collapse of the promenade surface as supporting material beneath the concrete/sandstone promenade areas is lost and large voids are formed.
- The breaching of the outer face as further instability occurs in the wall in areas where the toe support has been lost and tidal ingress results in further destabilisation. As the outer face is breached, tidal washout of the inner core will accelerate.



Both of the above scenarios will result in the collapse of the structure and the loss of the tidal defence asset, in addition to posing a significant risk to the general public using the structures and the loss of an historic listed asset.

The FIR 2009 identified scour holes and voiding beneath the West Pier Bull-Nose. The concrete structure has been undercut, either through erosion of the bedrock, or through damage to the lower section of concrete. The report did not find any scour or erosion on the East Pier Bull-Nose.

Continued undercutting of the West Pier Bull-Nose will result in its structural failure and will ultimately lead to undercutting of the West Pier itself.

### 2.1.2 *Performance Issues - Overtopping*

The public are at risk from wave overtopping that washes over the piers on high tides and in storm conditions. There are recorded incidents of near misses where members of the public and fishermen have been almost washed off the piers as they failed to appreciate the danger that they were in by being on the piers in these conditions.

Modelling undertaken for the Further Investigations Report and the Draft StAR has indicated that the rate of overtopping does not pose a structural risk to the piers.

## **2.2 Main Piers - Proposed Solutions**

### 2.2.1 *Structural Repairs*

The FIR 2009 recommended that the piers be repointed and the voids behind the walls and beneath the upper surface be filled with a cementitious grout. In addition, it recommended that the worst 75m length of undercutting/scouring be repaired using sheet piles with concrete backfill, to provide toe protection. Undercutting and scour occur predominantly on the east (inner) face of the West Pier, where the bed rock is more exposed to wave action.

Repointing of the pier is only required to infill voids prior to the placing of cementitious grout – to prevent it escaping from the structure. The extent of voiding varies along the lengths of the piers. Repointing will be required where new blocks and copings have been installed on mortar beds, which have subsequently lost jointing material and where actual repointing is required.

At locations where the outer face has dropped as a result of loss of toe support there are large, deep voids. These will need to be infilled with concrete or new sandstone pieces prior to cementitious grouting. In addition, stainless steel anchor bars may need to be installed to tie any un-bound blocks into the central core prior to placing the grout. The anchor bars may have load spreading plates on the outer face to anchor a group of blocks rather than individual blocks.

Cementitious grout could also be used to flood voids at the toe of the structure, rather than installing sheet piles and concrete backfill. This would require some form of temporary shuttering, clay bund or other temporary measure to prevent grout escaping at low level, prior to curing. The positioning and number of grout tube locations will depend upon the technique used.



Based on the findings of the geophysical survey it has been assumed that the total void area to be filled with grout is approximately 12,000m<sup>3</sup>, this represents approximately 10% of the total structure volume. This value is based on 500mm depth voids behind the walls and beneath the upper surfaces and assumes that there are no significant voids in the central core of the structure.

The structural repairs therefore recommended for the Main Piers are to:

- Seal up any voids in the outer faces using mortar, concrete, sandstone insets or other temporary solutions.
- Stabilise any un-bound areas of outer blockwork using tie rods/plates.
- Use a cementitious grouting technique to infill voids immediately behind the wall face and beneath the upper surfaces, from bed rock level to below the surface level. Grout tubes to be installed through the walls and also the upper surface, at spacings to suit the technique and product used.

Other structural repairs required will include:

- Replacing badly eroded/weathered sandstone blocks and copings.
- Repairs to the concrete promenade surface of the West Pier.
- Sealing and repairs to the sandstone promenade surface of the East Pier.
- Refurbishment of the handrails on the West Pier.

It has been assumed that with appropriate maintenance the proposed structural repairs will extend the residual life of the Main Piers by 100 years.

Scour protection works for the West Pier Bull-Nose are proposed in the form of sheet pile toe protection with concrete backfill. The piles being placed in pre-augured trenches. It has been assumed that the residual life of these assets is 50 years and that further intervention would be required to replace them at that time.

### 2.2.2 *Performance Improvements*

The FIR 2009 investigated options for installing rock revetments on the faces of the piers to reduce overtopping to safe limits for pedestrians. The proposal to install rock revetments on the outer faces proved to be unpopular with consultees due to the impact it would have visually and environmentally.

The StAR therefore proposed that the performance improvements be achieved through a safety management approach. This approach to include:

- Main Piers - Preferred Installation of access barriers at the entrance to both Main Piers and at the entrance to the West Pier Extension access bridge.
- Installation of a flood gate at the Battery Parade Slipway.
- Installation of warning signs at the access gates and flood gate locations.
- Implementing a new operational procedure for the piers whereby the Harbour Master's staff are responsible for the operation and maintenance of the access barriers and flood gate.



## 2.3 Option Capital Scheme Cost Comparisons

A cost certainty assessment exercise was carried out for the PAR by requesting quotes from three contractors for the works identified following development of the options. Appendix A shows the full cost comparison information from the three contractors.

The three contractors approached were:

- Birse;
- Bam Nuttall; and
- Volker Stevin.

Birse did not provide prices for all elements of the Main Piers cost estimate and where items were not priced the highest cost from either Bam Nuttall or Volker Stevin was used to allow a complete cost comparison.

The following table summarises the cost comparisons for the Main Piers and West Pier Bull-Nose – Option M1;

**Table 1. Main Pier Works: Contractor's Cost Estimates Comparisons**

Lowest Cost	Highest Cost	Average Cost	Adjusted Average Costs following English Heritage Feedback*
£3,672M	£4,178M	£3,913M	£3,788M

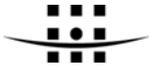
Notes: \* English Heritage stated that the installation of handrails on the East Pier was not acceptable – this cost has therefore been removed.

## 2.4 Main Piers – Technical Preferred Option Recommendation

The preferred option for achieving the Structural and Performance Improvements identified in the StAR is;

### **Do Something: Option M1 – Main Piers**

Option M1 has no variable elements and includes the works proposed for the West Pier Bull-Nose and Battery Parade Slipway flood gate.



### **3. PIER EXTENSIONS**

#### **3.1 Definition of the Problems**

##### *3.1.1 Structural Issues – Scour and Voids*

In the FIR 2009 it was assumed that when the initial cofferdam structure was constructed to allow the extensions to be cast, that a rubble infill layer was created at the bottom as a form of blinding for the mass concrete pour. The emergency works carried out in 2010/2011 found that the layer that was assumed to be rubble/granular fill was in fact weak concrete at the base of the extensions.

Corrosion to the sheet piles at the toe of the extensions had allowed the weak concrete to be eroded, resulting in voids and undercutting of the structure. The degree of voiding varied, and the worst section on the landward end of the East Pier Extension was repaired during the Emergency Works contract in 2010/2011.

Corrosion to the sheet pile toe and voiding occurs mainly on the east faces of the extensions. The FIR 2009 (Figure 21) identifies no significant issues on the west faces.

Continued voiding and loss of concrete at the toe of the structure will result in partial collapse and a breach of the structure. Once a section has breached, erosion and destabilisation of adjacent sections will accelerate, resulting in the eventual loss of the asset.

##### *3.1.2 Structural Issues – Erosion to Concrete Faces*

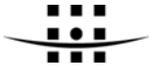
The FIR 2009 identified that the construction joints of the mass concrete structures had opened up as a result of weathering, tidal erosion and possible movement of the structure due to settlement or scour.

The continued erosion of the concrete faces will eventually have an impact on the integrity of the timber walkway superstructure, but not on the structural integrity of the extensions in their function as a coastal defence asset. Loss of overall thickness of the extensions does not reduce their effectiveness at reducing the wave climate within the harbour, until such time as the overall height or stability of the structure is impaired. As these are mass concrete structures, the reducing thickness does not pose a problem in terms of exposure of reinforcement cover.

Anecdotal evidence suggests that little or no maintenance has been carried out on the upper faces of the extensions since their construction, repairs being focused more on dealing with scour at the toe.

##### *3.1.3 Performance Issues – Overtopping*

The overtopping levels at the extensions are sufficient to result in damage to the mass concrete structure. This damage occurs in the form of erosion to the side and upper faces of the structure.



## 3.2 Pier Extensions - Proposed Solutions

### 3.2.1 Cost Development

A number of scour protection and rock revetment solutions were developed for pricing by the contractors to allow typical costs to be derived for carrying out structural and performance improvements for the Pier Extensions.

These solutions were carried forwards from those considered in the FIR 2009. Table 2 below identifies the range of solutions priced.

**Table 2.** Pier Extension Improvement Priced By Contractors

Description	Function	Comments
<b>Infilling of Voids with Concrete Bagwork or similar.</b>	To infill existing localised scour holes and prevent further scour at localised sections.	Carried forwards as an element of PAR Option development.
<b>Half Height Rock Revetment</b>	To prevent scour at the toe of the extensions and to reduce overtopping limits to prevent structural damage.	Carried forwards as an element of PAR Option development.
<b>Quarter Height Rock Revetment</b>	To prevent scour at the toe of the extensions.	Not carried forwards, as technically unlikely to be able to stabilise such a small revetment in the tidal conditions.
<b>Sheet Pile Revetment &amp; Concrete Backfill</b>	To prevent scour at the toe of the extensions.	Carried forwards as an element of PAR Option development.
<b>Concrete Panel &amp; Pile Scour Protection (as per emergency works)</b>	To prevent scour at the toe of the extensions.	Not carried forwards as too costly in comparison with sheet piles, and does not provide additional design life.
<b>Concrete Repairs to Faces and Top of Pier Extensions.</b>	To repair damaged areas of concrete and extend the overall asset life.	Carried forwards as an element of PAR Option development.
<b>Installation of Scour Protection to Extension Bull-Noses</b>	To prevent scour at the toe of the Bull-Noses.	Carried forwards as an element of PAR Option development.

### 3.2.2 Pier Extensions - Options Proposed

From the above elements a number of options were created that looked at various iterations of how these solutions could be combined.

The Options created for assessment and comparison in the PAR are as follows:

#### **Pier Extensions – Option E1**

- Sheet piles and concrete fill to all four (4) faces of the Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to faces of extensions.

#### **Pier Extensions – Option E2**

- Half-height rock revetment to outer face of East Pier Extension;
- Sheet pile and concrete backfill scour protection to remaining three (3) faces of the Pier Extensions;



- Scour protection to Extension Bull-Noses; and
- Concrete repairs to faces of extensions.

#### **Pier Extensions - Option E3**

- Half-height rock revetment to outer faces of East and West Pier Extensions;
- Sheet pile and concrete backfill scour protection to inner faces of East and West Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to faces of extensions.

#### **Pier Extensions – Option E4**

- Half-height rock revetment to outer face of East Pier Extension;
- Sheet pile and concrete backfill scour protection to inner face of West Pier Extension;
- Void infilling on remaining two faces of the Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to all faces of extensions.

### **3.2.3 Pier Extensions - Option Comparisons**

#### **Option E1**

- Provides scour protection to all four faces.
- Assumed residual life is 50 years.
- Does not reduce overtopping – maintenance costs not reduced compared to current situation.
- Has a high buildability risk as all four faces of the extension require works from jack-up barges.
- Construction cost £3.5M

#### **Option E2**

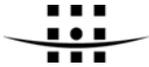
- Provides scour protection to all four faces.
- Assumed residual life of the sheet pile and concrete backfill scour protection is 50 years. Assumed residual life for rock revetment is 100 years.
- Reduces overtopping on one face – maintenance costs slightly reduced.
- Has a high buildability risk as all four faces of the extension require works from jack-up barges.
- Construction cost £4.8M

#### **Option E3**

- Provides scour protection to all four faces.
- Assumed residual life of the sheet pile and concrete backfill scour protection is 50 years. Assumed residual life for rock revetment is 100 years.
- Reduces overtopping on two faces – maintenance costs reduced.
- Has a high buildability risk as all four faces of the extensions require works from jack-up barges.
- Consultation has proven that rock placed on the outer face of the West Pier Extension would not be welcomed due to visual and environmental impact.
- Construction cost £6.0M

#### **Option E4**

- Provides scour protection to two east faces initially and localised infilling of voids on west faces only.



- Assumed residual life of the sheet pile and concrete backfill scour protection is 50 years. Assumed residual life for rock revetment is 100 years.
- It is assumed that scour protection works will be required to the west faces 40 years after the initial capital works are carried out for the east faces, and at this intervention (year 60) the sheet pile and concrete backfill works installed on the inner face of the West Pier Extension (year 20) shall also be replaced. Thus the date of next significant intervention for this option is 10 years earlier than the other options.
- Reduces overtopping on one face – maintenance costs slightly reduced.
- Has a lower buildability risk, as the void infill works will only be required at a limited number of locations – therefore construction works requiring barges will be reduced.
- Construction cost £3.7M

### **3.3 Pier Extensions – Option Evaluation**

All four options offer solutions that extend the existing asset life by preventing scour at the toe of the structure and through maintaining the exposed upper concrete superstructure.

To assess the best technical solutions for the Pier Extensions we should consider each of the faces and evaluate the condition of the face, the suitability of repair works and other factors specific to that face.

Figure 21 from FIR 2009 has been included in Appendix B of this report to support the option evaluation discussions presented below.

#### **3.3.1 West Pier Extension – Outer Face**

The FIR 2009 report identifies very few significant defects on this face of the Pier Extensions, therefore there is no technical reason to immediately install a rock revetment or sheet pile and concrete backfill scour protection.

The seaward end Bull-Nose does however require scour protection works and repair. For navigational reasons it is not desirable to have a rock revetment installed on the Bull-Nose and therefore the most appropriate technical solution is to install sheet pile and concrete backfill scour protection.

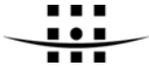
#### **3.3.2 West Pier Extension – Inner Face**

The FIR 2009 indicates extensive corrosion of the sheet piles and voiding. For navigational reasons it is not desirable to have a rock revetment installed on the inner face of the harbour and therefore the most appropriate technical solution is to install sheet pile and concrete backfill scour protection.

#### **3.3.3 East Pier Extension – Inner Face**

The FIR 2009 report identifies very few significant defects on this face of the Pier Extensions, therefore there is no technical reason to immediately install a rock revetment or sheet pile and concrete backfill scour protection.

The seaward end Bull-Nose does however require scour protection works and repair. For navigational reasons it is not desirable to have a rock revetment installed on the



Bull-Nose and therefore the most appropriate technical solution is to install sheet pile and concrete backfill scour protection.

Emergency works were undertaken on the landward end in 2010/11. Therefore no further works are required at that location.

#### 3.3.4 *East Pier Extension – Outer Face*

The FIR 2009 indicates extensive corrosion of the sheet piles and voiding. Placement of concrete at this location would be very difficult due to the limited access available by land. Therefore a rock revetment solution that includes initial infilling of voids and provides a 100 year design life, is preferable to a solution that would require further capital intervention in 50 years.

This face is affected by the most severe wave conditions and therefore the installation of a rock revetment would also be beneficial in terms of reducing the rate of erosion of the exposed concrete faces.

### 3.4 **Pier Extensions – Technical Preferred Option Recommendation**

Taking into account the considerations above for each of the Pier Extension faces, Option E4 is the technically preferable solution and also has significantly less risk of maritime plant downtime in comparison to Options E1, E2 and E3.

Option E4 includes the provision of works/costs to carry out repairs and localised void filling on the west faces of the extensions as part of an initial capital project.

The Preferred Technical Option for achieving the structural and performance improvements identified in the StAR for the Pier Extensions is;

#### **Pier Extensions – Option E4**

- Half-height rock revetment to outer face of East Pier Extension;
- Sheet pile and concrete backfill scour protection to inner face of West Pier Extension;
- Void infilling on remaining two faces of the Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to all faces of extensions.



#### **4. COMBINED OPTION SUMMARY**

The issues relating to the Main Pier and Pier Extensions and the potential options for improvements have been considered in isolation in the preceding sections. Options for improvements to the whole assets therefore need to consider Combination Options.

This is straight forwards, as the Main Pier improvements are limited to a single option (that includes a number of proposed activities).

Therefore the combined Do Something Main Pier and Pier Extension options considered are;

- Option 3 – M1 + E1;
- Option 4 – M1 + E2;
- Option 5 – M1 + E3; and
- Option 6 – M1 + E4.

Option 1 is 'Do Nothing' and Option 2 is 'Do Minimum'. As previously stated, these options have not been re-evaluated in this report, but will be carried forwards in the Project Appraisal Report (PAR) hence the numbering sequence of the combined options.



## **5. PHASING OF THE WORKS**

### **5.1 Phasing Summary**

All four options offer solutions that extend the existing asset life by preventing scour at the toe of the structure and through maintaining the exposed upper concrete superstructure.

The FIR 2009 identified that the most urgent works required to the pier assets were the repairs to the undercut/eroded southern end of the East Pier Extension, as the structure was effectively cantilevering over a large void and was therefore exposed to the greatest risk of failure. A design and construct contract was subsequently awarded to Volker Stevin and the repair works were completed in 2010/2011.

The structural and performance improvements identified in the combined options have been assessed in terms of prioritisation of urgent works and also giving consideration to maximising the residual life of the existing assets.

The proposed phasing of the works for each option is described below;

- Year 1: Procurement & Tender Award;
- Year 2: Site Investigation & Design Phase for Main Piers;
- Years 3 & 4: Construction Phase for Main Piers;
- Year 20 (commencing): Design & Construction Phases for Pier Extensions;
- Replacement of all flood gates and barriers every 20 years; and
- Year 70 (commencing): Capital scheme to replace Pier Extension works.

For Option E4 the phasing differs as follows;

- Year 1: Procurement & Tender Award;
- Year 2: Site Investigation & Design Phase for Main Piers;
- Years 3 & 4: Construction Phase for Main Piers;
- Year 20 (commencing): Design & Construction Phases for Pier Extensions;
- Replacement of all flood gates and barriers every 20 years;
- Year 60 (commencing): Capital scheme to install scour protection works to 2nr Pier Extension faces and to replace scour protection works installed on 1nr face (in year 20).

It has been assumed that a residual life (with appropriate maintenance) for the Main Piers of 100 years can be achieved.

It has been assumed that a residual life of 50 years is achievable for the Pier Extensions due to the more hostile environment and the nature of the proposed works, with the exception of the rock revetments which are anticipated to have a 100 year design life.

### **5.2 Main Piers – Phasing Priority Justification**

The Main Piers have been assessed as being the most vulnerable of the assets due to their current condition and the likelihood of failure.

There are areas of the Main Piers where structural instability and voiding is visibly apparent. The loss of toe support, the 'cascading' collapse of sandstone blocks and the existing large voids in these locations is allowing continued washing out of the central, granular core material. If no improvement works are carried out then the loss of core



material and further destabilisation of the outer blocks will result in a partial collapse and a breach of the Main Piers.

The potential collapse of the Main Piers poses a significant health and safety risk to members of the public and also for ships using the harbour.

Emergency repair costs following a collapse/breach are likely to be greater than the costs of a planned capital repair project.

For the above reasons the Main Pier works have been prioritised and have been identified with a procurement and tender award in year 1, site investigation and design programme commencing in Year 2 and construction works commencing in Year 3 for a two year period. It has been assumed that works would be carried out on one pier at a time (to avoid the need to close both piers and the potential adverse impact on tourism). During the ECI Design stage the Designers and the Contractor should explore the most cost effective sequencing for these works, taking into consideration the impact on tourism.

### **5.3 Pier Extensions – Phasing Delay Justification**

The Pier Extensions have been identified as having scour protection works delayed until Year 20.

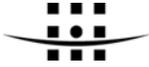
The urgent works identified in the FIR 2009 have been completed, therefore it has been considered that any remaining issues do not require immediate attention. The Pier Extensions consist of a large bulk of mass concrete poured onto the sea bed. Therefore for them to become unstable to the point of affecting their performance, or to reduce their effective residual life, a significant amount of undercutting/voiding would need to occur.

Loss of concrete thickness and opening up of the joints on the upper surfaces (i.e. those visible above the water) are not considered to be significant structural issues in terms of the asset's performance as a coastal defence structure. However, continued loss of thickness will result in a risk to the timber superstructure that supports the upper walkways.

£30k costs have been included within the asset inspection costs for dive surveys every 5 years from year 1 to 19, to continue to assess the condition of the toe of the Pier Extensions to ensure that any significant deterioration in condition (such as the development of a large void) is reported to allow the timing of the repair works to be re-evaluated if required.

For the above reasons the proposed scour protection works and repairs to the Pier Extensions have been deferred until Year 20. It should be noted that further intervention has been included for further works (of the same nature) in Year 70 to allow for a 50 year design life for the works proposed.

From the information obtained during the emergency works, the undercutting and loss of material at the toe of the Pier Extensions appears to be more complex than just the loss of bed material through on-going erosion processes. The issue appears to be more related to the poor quality concrete at the lower levels of the Pier Extensions, possibly as a result of it being placed underwater. The corrosion of the sheet piles surrounding this poor quality concrete allowed the loose granular material to be washed out, resulting in a large void occurring. This void was not solely in the seabed, but also in the actual toe of the Pier Extension itself.



It is therefore recommended that further investigations of the form and condition of the Pier Extension toe be carried out during the design phase of the Main Piers, to ensure that the risk is understood in terms of the relationship between voiding due to erosion of the seabed at the junction of the structure and voiding as a result of the poor quality of the concrete structure.

Horizontal cores through the toe will identify the condition of the concrete as placed during the repair works in the 1960's and also the condition of the original pour. This will help to provide an understanding as to why the repair works in the 1960's were carried out – was it as a result of erosion of the sea bed or was it as a result of low strength concrete at the base of the original structure?



## **6. RISKS**

### **6.1 Risk Evaluation**

This section assesses what the key technical risks are in terms of levels of uncertainty regarding the proposed works, then assesses optimism bias levels for each of the Do Something options, to allow the risk assessment process to feed into the Whole Life Cost evaluation and hence to feed into the preferred option selection process.

### **6.2 Key Technical Risks**

The FIR 2009 provides detailed information in the form of topographic surveys, non-intrusive ground penetration radar surveys, non-intrusive micro gravity surveys, intrusive ground investigation surveys, diving surveys, wave modelling and visual inspection surveys.

The emergency works carried out in 2010/2011 provided further information on the issues that resulted in substantial erosion to the toe of the East Pier Extension as a result of tidal erosion of the weak concrete exposed by the corroded sheet piles.

The emergency works also highlighted a significant cost risk in terms of the amount of downtime or standing time that occurred as a result of the wave climate. Due to the location and nature of the works, floating barges and divers were required to perform and oversee the construction works. A wave climate of greater than 1m typical wave height resulted in standing time of almost 50% and the costs almost doubling from the anticipated costs as a result.

The information gained from the FIR 2009 and the experience gained from the emergency works significantly reduces risk uncertainty by defining the problems and understanding the difficulties of working in the wave climate. There are key technical risks that need to be considered when setting initial optimum bias levels and for evaluating the outputs from the Monte Carlo analysis contingency allowance for the Preferred Option. The key technical risks are identified in Table 3 below. A more detailed Risk Register has been created and full Monte Carlo analysis has been undertaken, the output of which has been used to inform the contingency value included within the PAR.



**Table 3. Key Technical Risks**

Risk	Description	Potential Impacts	
1	Tidal conditions results in standing time for marine plant @ approx. £5k per day.	20% downtime could result in additional costs of £1M	40% downtime could result in additional costs of £2M
2	Extent of voiding in Main Piers is greater than anticipated.	20% additional increase in voiding results in additional costs of £0.56M	40% additional increase in voiding results in additional costs of £1.1M
3	Extent of scour at toe of Main Piers has increased requiring additional length of sheet pile and concrete backfill.	Additional 100m costs £0.5M	Additional 200m costs £1M
4	English Heritage requires areas of concrete repair on West Pier to be replaced with sandstone, to match existing, as part of conditions for compliance with licence/applications.	Cost for replacing 25% of surface area with new sandstone blocks – based on Volker Stevin estimate £175k	Cost for replacing 25% of surface area with new – based on Bam Nuttall estimate £400k
5	Extent of concrete repairs required for Pier Extension faces is greater than anticipated.	20% increase in concrete repairs required costs £21.3k	40% increase in concrete repairs required costs £42.6k
6	Extent of concrete repairs required for West Pier deck slab is greater than anticipated.	20% increase in concrete repairs required costs £7.5k	40% increase in concrete repairs required costs £15k
7	Proportion of Main Pier walls requiring repairs and replacement of sandstone blocks is greater than anticipated (estimated at 2%).	3% increase (to 5%) costs £445k	8% increase to (10%) costs £1.18M

These potential risks provide a guide as to the range of contingency allowance that would need to be considered. The total additional costs identified above range from £2.6M to £5.6M (approximately 26% to 51% of capital scheme value). These risks/costs form part of the overall Risk Register and contingency valuation

### 6.3 Optimism Bias Assessment

A typical starting (upper bound) optimism bias factor for a scheme at Pre-Feasibility Stage is 60% and for a Detailed Design stage 30%.

The Whitby PAR has been developed to an Outline Design stage and it has been assumed that the starting point for the initial assessment is 45%, as the scope of works is significantly developed from the initial Strategy stage, but not to a level of cost/risk certainty that could be determined at a Detailed Design stage as part of a Design and Build contract.

Each of the options has been considered to evaluate how the risk elements vary, depending upon the solutions proposed.

A detailed explanation of the adjustments made to the average % risk components is provided on the pages following Table 4.



A summary of the key differences in applied risk components for the options is provided below:

- Design Complexity / Degree of innovation – Option 3 only has one design for the scour protection works and hence a reduction in the adjusted value compared to the other options.
- Potential Environmental Impact – Option 6 involves less scour protection work and therefore has a shorter construction programme and less sediment arisings. Option 5 has a rock revetment on the west face of the West Pier Extension, which would have a significant impact on the Conservation Area.
- Other – Wave Climate / Maritime Plant Downtime – Options 3, 4 & 5 involve some works to all four faces of the Pier Extensions and hence have the largest risk in terms of downtime. Option 6 has a reduced risk as although long term scour protection is proposed to two faces, the scope of works on the other two is reduced to void filling only initially.
- Public Relations / Site Characteristics – Option 5 has the greatest visual impact and the largest footprint, hence poses the greater risk.

All other risks are identical (or very similar) across the options.

The adjusted Optimism Bias values obtained have been used to inform the Whole Life Cost Comparisons (see Section 7).

## **6.4 Key Environmental Constraints**

The following environmental constraints have been identified that could affect the options being considered:

- the foreshore area to the east and west of the piers is known to be well used by the public for tourism and recreational uses, therefore the proposed works have the potential to affect the tourism and recreational value of the area;
- critical infrastructure and material assets, in particular waste water services, car parks, harbour defences and lifeboat station;
- the River Esk is locally designated as a SINC. In addition, UK BAP habitats are present within the study area, including maritime cliff and slope, mudflat and saltmarsh habitats;
- the Esk is important habitat for migratory fish including sea trout and salmon;
- Whitby Harbour provides the base for long established coastal fisheries;
- Whitby Harbour provides foraging areas for bird species of European and national importance, whilst the piers provide high tide roosts for these species;
- there are five WFD waterbodies that could be affected by the proposed works. In addition, West Cliff beach is a designated bathing water;
- the proposed works have the potential to affect the local landscape / seascape character;

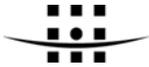


- the site is located adjacent to the Yorkshire and Cleveland Heritage Coast; as such, the proposed scheme will need to consider the Heritage Coast's objectives;
- there are a large number of features of archaeological importance within the study area. There is therefore potential to cause disturbance to these known features of interest during construction. There is also the potential to encounter unknown features of archaeological interest during any rock stockpiling and excavation works;
- Whitby to Saltwick geological SSSI is located to the immediate east of East Pier. Any works that are within the site boundary of the SSSI or that would alter the existing coastal processes have the potential to impact on this designated site;
- a construction method statement will be required to ensure suitable mitigation for construction works (e.g. materials to be used, timing of works, prevention of pollution etc.); and,
- any construction project in England which started after 6<sup>th</sup> April 2008 and has a value of over £300,000 has a legal requirement to have a Site Waste Management Plan (SWMP) in place. The SWMP will detail how resources will be managed, and waste materials controlled, at all stages during the construction period.



**Table 4.** Optimism Bias Assessment

<i>Risk Components – based on 45% Starting (upper bound) Optimism Bias scheme costs (detailed design stage)</i>		<i>Average % for FCD projects (summing to 45%)</i>	<i>Applied adjusted % for Option 3 M1 + E1</i>	<i>Applied adjusted % for Option 4 M1 + E2</i>	<i>Applied adjusted % for Option 5 M1 + E3</i>	<i>Applied adjusted % for Option 6 M1 + E4</i>
Procurement	Late contractor involvement in design	0.45	0.10	0.10	0.10	0.10
	Dispute and claims occurred	4.95	2.45	2.45	2.45	2.45
	Other	0.45	0.50	0.50	0.50	0.50
Project specific	Design complexity	1.8	3.0	4.0	4.0	4.0
	Degree of innovation	1.8	3.0	4.0	4.0	4.0
	Environmental impact	5.85	2.0	3.0	5.0	2.4
	Other – Wave Climate / Maritime Plant Downtime	4.05	20	20	20	15
Client specific	Inadequacy of the business case	10.35	0.1	0.1	0.1	0.1
	Funding availability	0.9	0	0	0	0
	Project management team	0.45	0.1	0.1	0.1	0.1
	Poor project intelligence	3.6	1.0	1.0	1.0	1.0
Environment	Public relations	2.25	1.5	2.5	5.0	2.5
	Site characteristics	1.8	1.2	1.7	2.4	1.7
External influences	Economic	2.25	2.25	2.25	2.25	2.25
	Legislation/regulations	1.8	1.8	1.8	1.8	1.8
	Technology	1.8	1.8	1.8	1.8	1.8
	Other	0.45	0	0	0	0
<b>Totals</b>		<b>45.0</b>	<b>40.8</b>	<b>45.3</b>	<b>50.5</b>	<b>39.7</b>



### Description of Risk Adjustments

The descriptions below provide commentary on the key adjustments made to the Average %.

#### **Procurement**

- *Late contractor involvement in design:* Detailed Design stage has yet to be undertaken and will be carried out on a Design & Build basis, with the Contractor leading the project design.
- *Dispute and claims occurred:* Assets are entirely owned by SBC. Potential for claims could arise from plant and materials access to the site and from potential disruption to tourism related trades. Close liaison with all stakeholders has been carried out at key stages of the Strategy and Strategy Appraisal Report and will continue to be an integral part of the PAR process.
- *Other:* Procurement route through the democratic processes of SBC will result in a slight increase of costs to tender award, in comparison to an EA delivered project.

#### **Project Specific**

- *Design complexity:* The design concept for the Main Piers is relatively simple. Coming up with a cost effective, low risk, high residual life option for the Pier Extensions could entail a further stage of option evaluation to obtain best value for money, based on detailed design analysis of innovative options.
- *Degree of innovation:* Innovative designs and integrated effective construction methodologies will be required to ensure that the works carried out on the Pier Extensions are delivered to the anticipated budget, taking into account the risks, issues and lessons learnt from the emergency repair project.
- *Environmental impact:* Early liaison with English Heritage, Natural England, the Harbour Master, Whitby Town Council and the public has been on-going throughout Strategy, Strategy Appraisal Report and PAR stages. Therefore the proposed works already take into account comments and concerns from external stakeholders and this risk is therefore reduced in comparison to a typical project.
- *Other - Wave Climate / Maritime Plant Downtime:* The local wave climate at the piers results in waves which are in excess of allowable heights for safe working for divers and marine plant. This resulted in a significant cost increase in the emergency works project. Therefore an anticipated downtime allowance of 20% has been included within this assessment.

#### **Client Specific**

- *Inadequacy of business case:* The business case for the project has been developed in the initial Strategy and confirmed in the StAR. The extensive, detailed Investigations carried out that culminated in the FIR 2009 provide a clear indication of the need for the works. The cost certainty exercise carried out provides a reasonable level of assurance for the basis for the construction cost estimates. Therefore the requirement specifications and scope definition are very clear and there is little risk of project delays as a result of scope changes.



- *Funding availability:* SBC have confirmed the commitment to provide the identified contribution, apart from the GIA funding request, there are no other funding contributors - therefore risk value has been reduced to 0%.
- *Project management team* – SBC project management team will be supported by an ECC PM to act as Employers Agent throughout the procurement process and for the duration of the construction phase. This post will be appointed through a procurement process using the YOR Consult Framework and a careful assessment of the CV's of staff proposed by the consultants tendering for the role will be carried out by SBC's Technical Delivery team.
- *Poor project intelligence.* There is extensive information on all aspects of the condition of the assets from the FIR 2009. There is a residual risk that the condition may have deteriorated since then, and this has been reflected in adjusted allowance.

### **Environment**

- *Public relations:* Public relations have been an on-going part of the consultation process and the evolution of the options from the initial Strategy, to the options proposed in the PAR. The commitment to further public relations work will be an integral part of the Detailed Design process.
- *Site characteristics:* The site characteristics are described in Section 6.4. Consultation has been undertaken with Natural England, the Environment Agency and English Heritage and their comments incorporated into the option evaluation process.

### **External Influences**

- *Economic:* Therefore there are no unusual economic factors, the project will be sensitive to oil prices and material costs, but no more so than other projects.
- *Legislation/regulations:* The project will be subject to an application for Planning Permission (from SBC) and a Marine Licence (from the Marine Management Organisation). The proposed works will require Crown Estates Consent and may require consent from the Environment Agency for works on or near a watercourse.
- *Technology:* There project is not sensitive to technological advancements. It is anticipated that further intervention will be required after 50 years and this obsolescence has been factored into the whole life costs.
- *Other:* There may be pressure for SBC to replace the East Pier bridge which allows access to the East Pier Extensions. This is however outside of the scope of this project and therefore would require a funding contribution top-up to include this work within the design and construction phase activities.



## 7. ECONOMIC ASSESSMENT

### 7.1 Whole Life Cost Comparison

Table 5 below assesses the whole life cost comparisons for the Do Something options, to evaluate how the options compare in terms of the costs of the initial design and construction phase, but also the future interventions and long term maintenance.

All the Do Something options have the same initial phase of works on the Main Piers, and therefore they have the same initial design, post-PAR, and construction costs. The difference in the whole life costs between the options derive from the differences in the future works to the Pier Extensions, maintenance required, and the level of risk contingency.

Appendix C contains the Cost Derivation information, upon which the Whole Life Cost Comparisons were based and the discounting spreadsheet.

**Table 5.** Whole Life Cost Comparisons

Costs		Phased Approach			
		Option 3 (M1+E1)	Option 4 (M1+E2)	Option 5 (M1+E3)	Option 6 (M1+E4)
Initial Design Costs	Cash	£235,453	£235,453	£235,453	£235,453
	<i>PV (discounted)</i>	£227,491	£227,491	£227,491	£227,491
Post-PAR Costs (SI, surveys, SBC, Site Supervision)	Cash	£824,087	£824,087	£824,087	£824,087
	<i>PV (discounted)</i>	£761,991	£761,991	£761,991	£761,991
Construction Costs (Construction, Prelims, OH&P)	Cash	£6,004,054	£6,004,054	£6,004,054	£6,004,054
	<i>PV (discounted)</i>	£5,510,081	£5,510,081	£5,510,081	£5,510,081
Maintenance Costs over 100 years	Cash	£1,437,000	£1,317,000	£1,197,000	£1,317,000
	<i>PV (discounted)</i>	£460,348	£437,694	£415,040	£437,694
Future Costs (design, construction, strategic)	Cash	£10,722,577	£11,541,283	£12,359,965	£9,888,055
	<i>PV (discounted)</i>	£2,967,030	£3,716,284	£4,465,531	£3,109,122
	Year of Next Intervention	20	20	20	20
Risk Contingency		40.8%	45.3%	50.5%	39.7%
		£4,050,192	£4,826,054	£5,746,968	£3,988,412
<b>WHOLE LIFE COST</b>	<b>Cash</b>	<b>£23,273,363</b>	<b>£24,747,931</b>	<b>£26,367,527</b>	<b>£22,257,061</b>
	<i><b>PV (discounted)</b></i>	<i><b>£13,977,133</b></i>	<i><b>£15,479,595</b></i>	<i><b>£17,127,102</b></i>	<i><b>£14,034,791</b></i>
<b>Benefit-Cost Ratio (Benefits = £128,527,000*)</b>		<b>9.20</b>	<b>8.30</b>	<b>7.50</b>	<b>9.16</b>

\* All Do Something options will have the same benefits as all options will ensure the presence of the Main Piers and their extensions for the full 100 year appraisal period and so avoid the Do Nothing damages.

#### 7.1.1 Main Pier & Pier Extensions – Economic Preferred Option

Option 3 has the lowest present value whole life costs of £13,977k. However Option 6 is only marginally more expensive, by £58k, this is just 0.4% of the overall whole life cost, and can therefore be considered insignificant.

Option 3 and Option 6 have similar benefit-cost ratios of greater than 9. Options 4 and 5 are significantly more expensive, by £1.5M and £3.1M respectively, and can therefore be eliminated.

As the difference between Option 3 and Option 6 in benefit-cost ratio and whole life costs is negligible both options are considered to be economically acceptable. The choice of preferred option between Option 3 and 6 should therefore be made on a technical and environmental basis.



The economically preferred options are:

**Option 3: Main Piers – M1 + Pier Extensions – Option E1**

- Main Pier re-pointing and grout infilling, and surface repairs;
- Scour protection to West Pier Bull-Nose;
- Sheet piles and concrete fill to all four (4) faces of the Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to faces of extensions.

**Option 6: Main Piers – M1+ Pier Extensions – Option E4**

- Main Pier re-pointing and grout infilling, and surface repairs;
- Scour protection to West Pier Bull-Nose;
- Half-height rock revetment to outer face of East Pier Extension;
- Sheet pile and concrete backfill scour protection to inner face of West Pier Extension;
- Void infilling on remaining two faces of the Pier Extensions;
- Scour protection to Extension Bull-Noses; and
- Concrete repairs to all faces of Extensions.



## 8. ENVIRONMENTAL ASSESSMENT

All options have the potential to affect navigation, foraging and roosting overwintering birds, and tourism and recreation during the construction works. Over topping issues to the Main Piers are to be managed through the use of warning signs and barrier gates; these have the potential to affect the character and appearance of the Conservation Area. It should be noted that English Heritage was consulted inform the optioneering process. Their requirements have been used to inform the design of the works and to identify suitable mitigation measures, where required.

It is understood that where sheet piling is to be installed that the method of installation would be to use pre-augured trenches rather than percussive piling methods. Consequently, this will significantly reduce the level of airborne and underwater noise effects that would otherwise have arisen should percussive methods been used. In order to prevent damage to the Pier Extension(s) during the construction of the rock revetment(s), where proposed, it is assumed that the rock will be put in place using, for example, an excavator, rather than being tipped from a barge. This reduces the noise and vibration effects that could arise from tipping and also minimises the potential to injure and kill fish, in particular migratory fish.

The potential key positive and negative environmental impacts of the detailed options being considered are presented in **Table 4.1**. Only the potential impacts that differ between the options are presented here allowing for a comparison of each option's positive and negative impacts against each other. Mitigation measures and enhancement opportunities have also been proposed, where required.

**Table 4.1 Key positive and negative environmental impacts of short listed options**

Key Positive Impacts	Key Negative Impacts	Mitigation / Enhancement Opportunity
<b>Option 3 – Do Something M1 + E1</b>		
No rock revetment on the west face of the West Pier, whose visibility could affect the character and appearance of the Conservation Area.	Works have no potential to reduce over topping issues. This issue is to be managed using warning signs and closing the piers.	Construction works should follow industry best practice guidance (i.e. CIRIA).
No rock temporarily stored on the beach.	All four faces of the Pier Extensions have an estimated residual life of only 50 years.	Works should be undertaken so as to be considerate of sensitive periods for tourism, migratory fish and birds.
	This option requires the most pre-auguring to place the sheet piling, extending the programme of around four years.	Production of a construction method statements will ensure suitable mitigation for construction works (e.g. materials to be used, timing of works, prevention of pollution, prevention etc.).
	Pre-auguring works will disturb sediments, which may have associated contaminants. This potential issue is considered to be the highest for this option.	A Site Waste Management Plan (SWMP) will be implemented prior to the commencement of works.
	Pre-auguring works will result in arisings. Beneficial use will need to be considered	Liaise with harbour master to avoid / mitigate any effects to navigation.



Key Positive Impacts	Key Negative Impacts	Mitigation / Enhancement Opportunity
	or, if this is not possible, disposal options. Should the sediments be contaminated, this will affect the cost and the beneficial use and disposal options that can be considered. This option would produce the most arisings.	
<b>Option 4 – Do Something M1 + E2</b>		
Reduced overtopping to East Pier Extension resulting from the placement of rock revetments.	This option involves more sheet piling, and associated pre-auguring, than Option 6, extending the programme to around three years.	As for Option 3,
The east face of the East Pier Extension will have an estimated residual life of 100 years, thus reducing the level of intervention required to maintain this side of the pier.	Rock to be used for the revetment may need to be unloaded on the beach prior to being put in place.	Works should be designed so as to minimise the visibility of the rock revetment.
No rock revetment on the west face of the West Pier Extension, whose visibility would affect the character and appearance of the Conservation Area.	Works have no potential to reduce overtopping to West Pier Extension. This issue is to be managed using warning signs and closing the piers.	
	Pre-auguring works will disturb sediments, which may have associated contaminates.	
	Pre-auguring works will result in arisings. Beneficial use will need to be considered or, if this is not possible, disposal options. Should the sediments be contaminated, this will affect the cost and the beneficial use and disposal options that can be considered.	
<b>Option 5 – Do Something M1 + E3</b>		
Reduced overtopping to East and West Pier Extensions resulting from the placement of rock revetments	Rock on outer face of West Pier considered to be unsuitable by English Heritage due to the visibility of the rock affecting the character and appearance of the Conservation Area.	As for Option 4.
The outer faces of the Pier Extensions will have an estimated residual life of 100 years, thus reducing the level of intervention required to maintain these sides of the piers.	Rock revetment along the seaward face of the West Pier Extension would affect local anglers.	
	Rock to be used for the revetment may need to be unloaded on the beach prior to being put in place.	
	Pre-auguring works will disturb sediments, which may have associated contaminates.	



Key Positive Impacts	Key Negative Impacts	Mitigation / Enhancement Opportunity
	Pre-auguring works will result in arisings. Beneficial use will need to be considered or, if this is not possible, disposal options. Should the sediments be contaminated, this will affect the cost and the beneficial use and disposal options that can be considered.	
<b>Option 6 – Do Something M1 + E4</b>		
Reduced overtopping to East Pier Extension resulting from the placement of rock revetments.	Rock to be used for the revetment may need to be unloaded on the beach prior to being put in place.	As for Option 4.
The east face of the East Pier Extension will have an estimated residual life of 100 years, thus reducing the level of intervention required to maintain this side of the pier.	The proposed approach of localised infilling of voids would, whilst reducing the level of capital works required for year 2, reduce the time for the next capital works are required by 10 years (to Year 60), compared to the other three options (year 70).	
No rock revetment on the west face of the West Pier Extension, whose visibility would affect the character and appearance of the Conservation Area.	Works have no potential to reduce overtopping to West Pier Extension. This issue is to be managed using warning signs and closing the piers.	
Anticipated shortest construction programme of around two years.	Pre-auguring works with disturb sediments, which may have associated contaminants. This potential issue is considered to be the lowest for this option.	
	Pre-auguring works will result in arisings. Beneficial use will need to be considered or, if this is not possible, disposal options. Should the sediments be contaminated, this will affect the cost and the beneficial use and disposal options that can be considered. This option would produce the least arisings.	

Option 5 is considered to be environmentally unacceptable due to the presence of rock along the outer face of the West Pier Extension, which would affect the character and appearance of the Conservation Area.

Whilst Option 3 does not include a rock revetment, with its associated effects, this option is considered to have the longest programme, at around four years, as a result of the sheet piling works that are required. These works would result in the largest amount of arisings, produced during the pre-auguring works, which would need to be suitably disposed of and which have the potential to be contaminated. Option 3 would require the highest level of capital intervention as all four faces of the Pier Extensions would have residual lives of only 50 years. Furthermore, Option 3 does not provide any reduction to the effects of wave overtopping of the Pier Extensions, resulting in the



requirement for higher levels of maintenance works, should over-topping damage the surface of the piers.

Option 4 involves significantly more sheet piling works compared to Option 6, which would extend the programme by an estimated 12 months. This option would also result in more arisings as a result of the pre-auguring works, which have the potential to be contaminated. As such Option 6 is preferred over Option 4 and is the environmentally preferred option.



## 9. RECOMMENDED PREFERRED OPTION

### 9.1.1 *Summary of Preferred Technical, Economic & Environmental Options*

The recommended Do Something **Technical Options** are **M1** (Main Piers) and **E4** (Half Height Rock Revetment to Outer Face of East Pier Extension + Sheet Pile and Concrete Backfill Scour Protection to Inner Face of West Pier Extension and Void Infilling on Remaining Two Faces of the Pier Extensions + Scour Protection to Bull-Noses + Concrete Repairs to All Faces of Extensions). (**Option 6 - M1 + E4**).

The recommended Do Something **Economic Options** are **M1** (Main Piers) and either **E1** (Sheet Piles and Concrete Fill to all Four (4) Faces of the Pier Extensions + Scour Protection to Bull-Noses + Concrete Repairs to Faces of Extensions) or **E4** (Half Height Rock Revetment to Outer Face of East Pier Extension + Sheet Pile and Concrete Backfill Scour Protection to Inner Face of West Pier Extension and Void Infilling on Remaining Two Faces of the Pier Extensions + Scour Protection to Bull-Noses + Concrete Repairs to All Faces of Extensions). (**Option 3 – M1 + E1 or Option 6 - M1 + E4**).

The recommended Do Something **Environmental Options** are **M1** (Main Piers) and **E4** (Half Height Rock Revetment to Outer Face of East Pier Extension + Sheet Pile and Concrete Backfill Scour Protection to Inner Face of West Pier Extension and Void Infilling on Remaining Two Faces of the Pier Extensions + Scour Protection to Bull-Noses + Concrete Repairs to All Faces of Extensions). (**Option 6 - M1 + E4**).

### 9.1.2 *Recommended Preferred Option*

As Option 6 is the Technical and Environmental Preferred Option, and there is no clear Economic Preferred Option (between Options 3 and 6), we recommend that **Option 6 (M1 + E4)** be considered as the Preferred Option to take forwards for funding within the PAR submission.



## APPENDIX A – CONTRACTOR’S COST ESTIMATES

- Bam Nuttall
- Birse
- Volker Stevin



MAIN  
PIERS -  
COST  
ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate	Unit Rate Cost	Contractor's Comments
1	Fabrication and Installation of Flood Gate across the slipway adjacent to Battery Parade, adjacent to the West Main Pier.	Flood Gate will need to be robust to withstand direct wave impact from wave run-up forces. Assume that telemetry feed will be required.	1nr Flood Gate required. Width of slipway is approximately 5m. Height of gate is approximately 1.5m.	£20,000	na	
2	Fabrication and installation of 3nr Access Barriers					
2.1	Access Barrier at entrance to West Pier	Assume that barriers are to include illuminated warning sign/message and a telemetry link.	West Pier entrance width is approx 12m.	£15,000	na	
2.2	Access Barrier at entrance to East Pier		East Pier entrance width approx 16m.	£20,000	na	
2.3	Access Barrier at entrance to West Pier Extension Bridge.		West Pier Extension Bridge entrance is approx 5m.	£7,500	na	
3	Repairs and painting of Hand Rails on West Pier.	Handrails appear to be in reasonable condition. Cost on the basis of repainting with a contingency for some repairs.	Approximately 420m length in total for both sides.	£6,300	£15 per m	Rate for mechanical prep and painting insitu. Assumes no lead paint. All works carried out insitu. No shot blasting required.
4	Installation of new handrails on East Pier to match those on West Pier.	Include costs for removal and disposal of existing handrails - approx 200m length.	Approximately 550m length in total for both sides.	£181,500	£330 per l/m	
5	Repointing and repairs to masonry walls.	Assume all joints to be raked at to a minimum depth of 25mm. Assume restoration mortar (i.e. lime based) is required. Assume that marine mortar (gelling additives or similar) are required for 25% of the works for area at risk of tidal washout prior to curing. Assume a contingency sum for providing replacement sandstone blocks for areas where erosion or damage requires removal and reinstatement of block. Assume no more than 2% of the wall area needs to be replaced.	Area of walls 11,180m2. Total length of joints 22,360m. Volume of mortar reqd approx 11.18m3.	£419,250	£10 per m2 (normal) £12 per m2 (marine) £1350 per m2 for replacing sandstone blocks.	No cleaning or removal of marine growth included for. Includes cherry picker for access for pointing. No allowance for access or lifting equipment for Sandstone blocks.
6	Cementitious Grouting of the Rubble Fill inner core.	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)	1,200m3 volume of cementitious grout (based on 10% of total pier volume).	£800,000	£650 per m3.	Assumes we do not need to bring in plant and materials by sea.
7	Scour Protection Works to the Bull noses of the East and West Main Piers.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 100m on West Pier Bull nose and 50m on East Pier Bull nose.	£918,450	£6123 per m	
8	Repairs to concrete promenade surface on the West Pier.	The whole promenade surface of the West Pier is formed from concrete. Repairs will be required to infill grout holes, replace existing damaged sections and sections where poor repairs have been carried out for service trenches and also to make good after construction works.	Total West Pier surface area is approx 4,500m2	£297,000	£66 per m2	Assumed 150mm thick slabs and includes for all joints. Assumes we do not need to bring in plant and materials by sea.
9	Re-setting of sandstone blocks that form the promenade surface for the East Pier.	The current surface is very uneven as a result of settlement of the inner core, erosion of the sandstone blocks, overtopping and numerous previous repairs. As this is a Listed Structure we are assuming that the surface will need to be reinstated on a like for like basis. A small area of the Pier has a concrete deck (where repairs have been carried out) - assume that this is about 5% of the total surface area. Some of the sandstone blocks will not be suitable for re-use. Therefore assume that 25% of the surface area will require new blocks to be provided - to match the existing. Assume that all blocks in the remaining surface area will need to be lifted and re-set on a new mortar bed (in terms of sequencing the blocks will probably need to be lifted prior to grout infill - this will avoid coring through the blocks and also give an indication of the extent of voiding or deterioration of the inner core.	Total East Pier surface area is approx 46,000m2	£1,582,975	£32.75 per m2 (lift & re-set sandstone blocks) £66 per m2 (reinstate concrete decking)	Sandstone block rate allows for lifting existing prior to grouting and resetting on mortar following completion of grouting. Concrete decking assumed 150mm thick. No allowance for new slabs.

Marine Plant Mobilisation/Demob (Each Season)

£150,000

£4,417,975

PIER EXTENSIONS- COST ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate	Unit Rate Cost	Contractor's Comments
<b>OPTION E1 - (See Sketch: Option 3)</b>						
E1.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	£122,460	£2041 per m	
E1.2	Raising of the concrete shoulder to allow key in for future repairs.	Assume that concrete shoulder will be formed from fibre reinforced concrete, dowelled into the existing structure.	Assume total volume of concrete required is 2.220m3.	£2,173,380		
E1.3	Installation of rock revetment to MHWS height.	Note that excavation of the seabed is required for forming the toe detail. Note that the sea bed is sandstone bed rock. Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		£7,900,920	£11,619 per m	Excavation of seabed not included as advised as not required during meeting with Paul Knight on 22/02/12. Filter material replaced with secondary rock to avoid loss of material from tidal action.
E1.4	Installation of scour protection to northern and southern ends of bullnoses of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	£765,375	£6123 per m	
E1.5	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions that remain exposed above the raised shoulders - inc top face.	Assume 2,700m2 of minor repairs to concrete surfaces.	£729,000	£250 per m2	All repairs less than 50mm deep. Includes scaffold access
<b>Total Cost</b>				<b>£11,691,135</b>		
Marine Plant Mobilisation - Each Season					250,000 Each Way	
<b>OPTION E2 - Scour Protection Variants</b>						
<b>Void Infill &amp; Rock Revetment - Sketch Option 2</b>						
E2.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	£122,460	£2041 per m	
E2.2	Installation of rock revetment to MLWN height.	Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		£3,320,440	£4883 per m	Filter material replaced with secondary rock to avoid loss of material from tidal action.
E2.3	Installation of scour protection to northern and southern ends of bullnoses of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	£765,375	£6123 per m	
E2.4	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m2 of minor repairs to concrete surfaces.	£1,328,400	£270 per m2	All repairs less than 50mm deep. Includes scaffold access
<b>Total Cost</b>				<b>£5,536,675</b>		
Marine Plant Mobilisation - Each Season					£250,000 Each Way	
<b>Steel Sheet Piles &amp; Concrete Backfill - Sketch Option 1</b>						
E2.5	Pre augering and installation of sheet piles.	To be used for whole length of Pier Extension bases.	680m of interlocking sheet piles; 8m high driven 2m into ground. Pre-excavation for piling 1360m3 Backfill with concrete 680m3	1,115,200	£1640/m	No pre-augering allowed. Alternative solution priced as discussed during meeting with Paul Knight on 22/02/12
E2.6	Concrete backfill.		Mass concrete backfill 5,000m3	£1,550,000	£310 per m3	
E2.6.1	Install dowels to existing pier and install top tie			£291,040	£428/m	Part of alternative solution.
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,260m2 of minor repairs to concrete surfaces.	£1,150,200	£270 per m2	All repairs less than 50mm deep. Includes scaffold access
<b>Total Cost</b>				<b>£4,106,440</b>		
Marine Plant Mobilisation - Each Season					£150,000 Each Way	
<b>Concrete repairs as per Emergency Works - See Drawings 9W0160-100C2 and C-8427-013B</b>						
E2.9	Installation of UC and PCC Panels.	See drawings for details.	Assume total length of repair is 680m.	£3,366,000	£4950 per m	
E2.10	Concrete backfill and capping.	See drawings for details.	Mass concrete backfill 5,000m3	£1,585,000	£317 per m3	
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m2 of minor repairs to concrete surfaces.	£1,328,400	£270 per m2	All repairs less than 50mm deep. Includes scaffold access
<b>Total Cost</b>				<b>£6,279,400</b>		
Marine Plant Mobilisation - Each Season					150,000 Each Way	

NOTE - Options E3 and E4 are variants of E1 and E2 and therefore costs can be extracted for them from the above tables.

<b>East Pier Bridge Replacement - see photos for details</b>						
B1	Replace East Pier Bridge with new clear spanning structure.	Assume that no works are required to remove the existing abutment and that the new bridge will arch above it. Costs to include works to structures to act as abutments / to receive bridge.	Gap to bridge is approx 25m.	£50,000	Cost for fabrication £40000 Cost for installation £10000	
B2	Replace the East Pier Bridge with a like for like replacement of the historic bridge and a new central pier.		Gap to bridge is approx 25m.		Cost for central pier Exx Cost for construction of bridge Exx	Not priced as insufficient information on the reconstruction/construction of new pier

Management Unit 17A West Pier Main	Estimated	Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 4					Major Refurbish ment Required Yr 41					Major Refurbish ment Required Yr 81	
			0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Pointing	350,658		149,854					100,402					100,402	
Grouting	187,200		80,000					53,600					53,600	
Sheet Pile Toe Protection	255,090		85,030					85,030					85,030	
Half Height Revetment	0		0					0					0	
Preliminaries @ 15%	118,942		47,233					35,855					35,855	
OH & P @ 12.5%	99,119		39,361					29,879					29,879	
Design & Supervision @ 20%	158,590		62,977					47,806					47,806	
Site Investigation @ 5%	39,647		15,744					11,952					11,952	
SBC Costs @ 5%	39,647		15,744					11,952					11,952	
	<b>1,248,894</b>		<b>495,942</b>	<b>0</b>	<b>0</b>		<b>0</b>	<b>376,476</b>	<b>0</b>	<b>0</b>	<b>0</b>		<b>376,476</b>	<b>0</b>

Management Unit 17B West Pier Extension	Estimated	Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 5 & 6					Major Refurbish ment Required Yr 41					Major Refurbish ment Required Yr 81	
			0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Pointing	124,878		74,927					24,976					24,976	
Grouting	66,667		40,000					13,333					13,333	
Sheet Piling & Fill to Pier Extensions outer face	1,109,525		1,109,525					0					0	
Steel Pile, Pre cast panels and concrete back fill to inner harbour face.	10,650,000		10,650,000					0					0	
Half Height Revetment	420,300		420,300					0					0	
Preliminaries @ 15%	93,149		31,839					30,655					30,655	
OH & P @ 12.5%	82,544		31,453					25,545					25,545	
Design & Supervision @ 20%	208,258		126,513					40,873					40,873	
Site Investigation @ 5%	52,065		31,628					10,218					10,218	
SBC Costs @ 5%	52,065		31,628					10,218					10,218	
	<b>12,859,449</b>		<b>189,769</b>	<b>12,358,044</b>	<b>0</b>		<b>0</b>	<b>155,818</b>	<b>0</b>	<b>0</b>	<b>0</b>		<b>155,818</b>	<b>0</b>

Management Unit 18A East Pier Main	Estimated	Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 3					Major Refurbish ment Required Yr 41					Major Refurbish ment Required Yr 81	
			0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Pointing	249,757		149,854					49,951					49,951	
Grouting	133,333		80,000					26,667					26,667	
Sheet Pile Toe Protection	85,030		85,030					0					0	
Half Height Revetment	488,400		488,400					0					0	
Preliminaries @ 15%	107,170		84,185					11,493					11,493	
OH & P @ 12.5%	89,309		70,154					9,577					9,577	
Design & Supervision @ 20%	142,894		112,246					15,324					15,324	
Site Investigation @ 5%	35,723		28,062					3,831					3,831	
SBC Costs @ 5%	35,723		28,062					3,831					3,831	
	<b>1,367,339</b>		<b>1,125,993</b>	<b>0</b>	<b>0</b>		<b>0</b>	<b>120,673</b>	<b>0</b>	<b>0</b>	<b>0</b>		<b>120,673</b>	<b>0</b>

Management Unit 18B East Pier Extension	Estimated	Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 6 & 7					Major Refurbish ment Required Yr 41					Major Refurbish ment Required Yr 81	
			0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Pointing	124,878		74,927					24,976					24,976	
Grouting	66,667		40,000					13,333					13,333	
Sheet Piling & Fill to Pier Extensions outer face	1,109,525		1,109,525					0					0	
Steel Pile, Pre cast panels and concrete back fill to inner harbour face.	10,650,000		10,650,000					0					0	
Half Height Revetment	420,300		420,300					0					0	
Preliminaries @ 15%	93,149		31,839					30,655					30,655	
OH & P @ 12.5%	82,544		31,453					25,545					25,545	
Design & Supervision @ 20%	208,258		126,513					40,873					40,873	
Site Investigation @ 5%	52,065		31,628					10,218					10,218	
SBC Costs @ 5%	52,065		31,628					10,218					10,218	
	<b>12,859,449</b>		<b>189,769</b>	<b>12,358,044</b>	<b>0</b>		<b>0</b>	<b>155,818</b>	<b>0</b>	<b>0</b>	<b>0</b>		<b>155,818</b>	<b>0</b>

<b>2nd March 2012 ~ Birse Coastal Notes: Whitby Harbour Budget Rates</b>	
<b>1</b>	The budget rates and comments on this spreadsheet relate to various option sketches, drawings & other information provided by Paul Knight (Haskoning) on a series of 10 No. E mails to Brian Farrington (Birse Coastal) dated 19.01.12
<b>2</b>	Rates are based on budget quotes and rates from sub-contractors, and additionally priced by ourselves as a check where possible
<b>3</b>	Most of the items have been priced individually or 'stand alone'. There could be some saving in plant and equipment if the works were done concurrently
<b>4</b>	We have tried to show work item durations wherever possible, but again these could be concurrent depending on the phasing
<b>5</b>	All of the marine work has been priced on an assumption that it would be done in the summer season, but you could still expect around 20% downtime, particularly due to swell – which we haven't included.
<b>6</b>	The phasing of the work has not been optimised, for example there may be an advantage in doing the rock armour first in order to utilise the rock for temporary access, but there is also an advantage in running some of the marine operations concurrently to maximise plant use.
<b>7</b>	As has been shown on the recent works a significant risk is downtime of marine plant due to weather; how this risk is shared or allocated should be carefully considered as it is likely to have a significant bearing on how contractors will approach any future tender opportunity.

MAIN PIERS - COST ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate £	Unit Rate Cost	Contractor's Comments
1	Fabrication and Installation of Flood Gate across the slipway adjacent to Battery Parade adjacent to the West Main Pier.	Flood Gate will need to be robust to withstand direct wave impact from wave run-up forces. Assume that telemetry feed will be required.	1nr Flood Gate required. Width of slipway is approximately 5m. Height of gate is approximately 1.5m.	11,000	na	Based on similar gates installed at Stallingborough by Dam Structures. Gates cost £6k, £3k to install, plus £5k for telemetry. Gates at Morecambe £8k supply and install
2	Fabrication and installation of 3nr Access Barriers					
2.1	Access Barrier at entrance to West Pier		West Pier entrance width is approx 12m.	15000	na	Did not price at this time.
2.2	Access Barrier at entrance to East Pier	Assume that barriers are to include illuminated warning sign/message and a telemetry link.	East Pier entrance width approx 16m.	20000	na	Did not price at this time.
2.3	Access Barrier at entrance to West Pier Extension Bridge.		West Pier Extension Bridge entrance is approx 5m.	7500	na	Did not price at this time.
3	Repairs and painting of Hand Rails on West Pier.	Handrails appear to be in reasonable condition. Cost on the basis of repainting with a contingency for some repairs.	Approximately 420m length in total for both sides.	6300	£xx per m	Did not price at this time.
4	Installation of new handrails on East Pier to match those on West Pier.	Include costs for removal and disposal of existing handrails - approx 200m length.	Approximately 550m length in total for both sides.	110,000	£200 per l/m	Marshalls heritage 3 rail system £120 -150/m supply only
5	Repointing and repairs to masonry walls.	Assume all joints to be raked at to a minimum depth of 25mm. Assume restoration mortar (i.e. lime based) is required. Assume that marine mortar (gelling additives or similar) are required for 25% of the works for area at risk of tidal washout prior to curing. Assume a contingency sum for providing replacement sandstone blocks for areas where erosion or damage requires removal and reinstatement of block. Assume no more than 2% of the wall area needs to be replaced.	Area of walls 11,180m <sup>2</sup> . Total length of joints 22,360m. Volume of mortar reqd approx 11,18m <sup>3</sup> .	693,160	£13 per m (normal) £18 per m (marine) £xx per m <sup>2</sup> for replacing sandstone blocks.	Based on Berwick Breakwater estimates, may be some saving as a consequence of scale
6	Cementitious Grouting of the Rubble Fill inner core.	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)	1,200m <sup>3</sup> volume of cementitious grout (based on 10% of total pier volume).	800000	£xx per m <sup>3</sup> .	Did not price at this time.
7	Scour Protection Works to the Bull noses of the East and West Main Piers.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 100m on West Pier Bull nose and 50m on East Pier Bull nose.	3450000	£23,000 per m	Based on a sub contract price. Includes mobilisation, moves attendances etc. Assumes both piers are done in one visit. Ab to work in swells up to 0.5m, standing time per day £ 17,000. If 2 visits add £ 340,000
8	Repairs to concrete promenade surface on the West Pier.	The whole promenade surface of the West Pier is formed from concrete. Repairs will be required to infill grout holes, replace existing damaged sections and sections where poor repairs have been carried out for service trenches and also to make good after construction works.	Total West Pier surface area is approx 4,500m <sup>2</sup>	787,500	£175 per m <sup>2</sup>	Assumes concrete delivery by road, 300mm slab with 2 layers A393
9	Re-setting of sandstone blocks that form the promenade surface for the East Pier.	The current surface is very uneven as a result of settlement of the inner core, erosion of the sandstone blocks, overtopping and numerous previous repairs. As this is a Listed Structure we are assuming that the surface will need to be reinstated on a like for like basis. A small area of the Pier has a concrete deck (where repairs have been carried out) - assume that this is about 5% of the total surface area. Some of the sandstone blocks will not be suitable for re-use. Therefore assume that 25% of the surface area will require new blocks to be provided - to match the existing. Assume that all blocks in the remaining surface area will need to be lifted and re-set on a new mortar bed (in terms of sequencing the blocks will probably need to be lifted prior to grout infill - this will avoid coring through the blocks and also give an indication of the extent of voiding or deterioration of the inner core.	Total East Pier surface area is approx 4,600m <sup>2</sup>		£xx per m <sup>2</sup> (re-set sandstone blocks) £xx per m <sup>2</sup> (reinstated concrete decking)	Did not price at this time.

5,900,460

MAIN PIERS - COST ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate £	Unit Rate Cost	Contractor's Comments
<b>OPTION E1 - (See Sketch: Option 3)</b>						
E1.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	780,000.00	£13,000 per lin m	From the ultrabeam bathy survey we have identified 9 voids, each of approximately 2m each. Price is based on a dive team of 5 men for 6 weeks total £125,000. Briggs estimate. However this is priced as a stand alone operation and the reality is it could be done in conjunction with other works to make best use of equipment.
E1.2	Raising of the concrete shoulder to allow for future repairs.	Assume that concrete shoulder will be formed from fibre reinforced concrete, dowelled into the existing structure.	Assume total volume of concrete required is 2,220m <sup>3</sup> .	1,557,000.00		Assumes 4no. visits of approx 8 weeks per face, using jack up mounted crane. Work to coincide with rock armour placing to provide working platform. Concrete pumped from land batched mixers (may require additional temp works to access E piers)
E1.3	Installation of rock revetment to MHWS height.	Note that excavation of the seabed is required for forming the toe detail. Note that the sea bed is sandstone bed rock. Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		4,894,880.00	Primary Rock £3268 per m of extension Secondary Rock £570 per m of extension Filter Rock £4320 per m of extension	Assumes rock armour to extensions only - total 600 lin metres. Approx 13,500m <sup>3</sup> primary, 2000m <sup>3</sup> secondary, 17,500m <sup>3</sup> filter & 2500m <sup>3</sup> excavated at toe. Based on all material imported by sea from Norway in approx 20,000t loads. Approx 8wks per face.
E1.4	Installation of scour protection to northern and southern ends of bullnoses of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	2,875,000.00	£23,000 per m	Based on a sub contract price. Includes mobilisation, moves attendances etc. Assumes both piers are done in one visit. Total duration approximately 30 weeks. Able to work in swells up to 0.5m, standing time per day £ 17,000
E1.5	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions that remain exposed above the raised shoulders - inc top face.	Assume 2,700m <sup>2</sup> of minor repairs to concrete surfaces.	729,000.00	Exx per m <sup>2</sup>	Insufficient information to price at this stage.
<b>Total Cost</b>				<b>10,835,880.00</b>		
<b>OPTION E2 - Scour Protection Variants</b>						
<b>Void Infill &amp; Rock Revetment - Sketch Option 2</b>						
E2.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	780,000.00	£13,000 per lin m	As above
E2.2	Installation of rock revetment to MLWN height.	Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		1,682,400.00	Primary Rock £1633 per m of extension Secondary Rock £667 per m of extension Filter Rock £504 per m of extension	Assumes rock armour to extensions only - total 600 lin metres. Approx 6840m <sup>3</sup> primary, 2700m <sup>3</sup> secondary, 2,000m <sup>3</sup> filter. Based on all material imported by sea from Norway in approx 20,000t loads. Approx 2 - 3wks per face. Briggs quoted £1.5m i.e. 10% less.
E2.3	Installation of scour protection to northern and southern ends of bullnoses of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	2,875,000.00	£23,000 per m	Based on a sub contract price. Includes mobilisation, moves attendances etc. Assumes both piers are done in one visit. Able to work in swells up to 0.5m, standing time per day £ 17,000
E2.4	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m <sup>2</sup> of minor repairs to concrete surfaces.	1,328,400.00	Exx per m <sup>2</sup>	Insufficient information to price at this stage.
<b>Total Cost</b>				<b>6,665,800.00</b>		
<b>Steel Sheet Piles &amp; Concrete Backfill - Sketch Option 1</b>						
E2.5	Pre augering and installation of sheet piles.	To be used for whole length of Pier Extension bases.	680m of interlocking sheet piles; 8m high driven 2m into ground. Pre-excavation for piling 1360m <sup>3</sup> Backfill with concrete 680m <sup>3</sup>			Two subcontractors unwilling to price this, they don't think it can be done.
E2.6	Concrete backfill.		Mass concrete backfill 5,000m <sup>3</sup>		Exx per m <sup>3</sup>	
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,260m <sup>2</sup> of minor repairs to concrete surfaces.		Exx per m <sup>2</sup>	
<b>Total Cost</b>						
<b>Concrete repairs as per Emergency Works - See Drawings 9W0160-100C2 and C-8427-013B</b>						
E2.9	Installation of UC and PCC Panels.	See drawings for details.	Assume total length of repair is 680m.	12,920,000.00	£19,000 per m	Based on a sub contract price. Includes mobilisation, moves attendances etc. Assumes both piers are done in one visit. Able to work in swells up to 0.5m, standing time per day £ 17,000
E2.10	Concrete backfill and capping.	See drawings for details.	Mass concrete backfill 5,000m <sup>3</sup>	2,800,000.00	£560 per m <sup>3</sup>	If included as part of above works
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m <sup>2</sup> of minor repairs to concrete surfaces.	1,328,400.00	Exx per m <sup>2</sup>	
<b>Total Cost</b>				<b>17,048,400.00</b>		

NOTE - Options E3 and E4 are variants of E1 and E2 and therefore costs can be extracted for them from the above tables.

<b>East Pier Bridge Replacement - see photos for details</b>						
B1	Replace East Pier Bridge with new clear spanning structure.	Assume that no works are required to remove the existing abutment and that the new bridge will arch above it. Costs to include works to structures to act as abutments / to receive bridge.	Gap to bridge is approx 25m.		Cost for fabrication £90,000 Cost for installation £50,000 plus	Brooks budget quote for supply of bridge. Installation - assume £10,000 for bankseat preparation, craneage by barge very difficult to assess, if done stand alone anything from £40,000 to £90,000, depending on what's available. Maybe able to tie in with use of marine plant already on site for other works. Or possible land access if tied in with other work on E Pier
B2	Replace the East Pier Bridge with a like for like replacement of the historic bridge and a new central pier.		Gap to bridge is approx 25m.		Cost for central pier £77,000 Cost for construction of bridge £110,000	Assumes possible replacement monopile pier using equipment on site for scour protection Supply of 2 piece bridge as above £90,000

Management Unit 17A West Pier Main	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 4					Major Refurbishm ent Required Yr 41				Major Refurbishm ent Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
		<b>Capital Scheme Costs</b> (Stand Alone Scheme)										
Pointing	350,658	149,854					100,402					100,402
Grouting	187,200	80,000					53,600					53,600
Sheet Pile Toe Protection	255,090	85,030					85,030					85,030
Half Height Revetment	0	0					0					0
Preliminaries @ 15%	118,942	47,233					35,855					35,855
OH & P @ 12.5%	99,119	39,361					29,879					29,879
Design & Supervision @ 2	158,590	62,977					47,806					47,806
Site Investigation @ 5%	39,647	15,744					11,952					11,952
SBC Costs @ 5%	39,647	15,744					11,952					11,952
	<b>1,248,894</b>	<b>495,942</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>376,476</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>376,476</b>

Management Unit 17B West Pier Extension	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 5 & 6					Major Refurbishm ent Required Yr 41				Major Refurbishm ent Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
		<b>Capital Scheme Costs</b> (Stand Alone Scheme)										
Pointing	124,878	74,927					24,976					24,976
Grouting	66,667	40,000					13,333					13,333
Sheet Piling & Fill to Pier	1,109,525	1,109,525					0					0
Steel Pile, Pre cast panels	10,650,000	10,650,000					0					0
Half Height Revetment	420,300	420,300					0					0
Preliminaries @ 15%	93,149	31,839					30,655					30,655
OH & P @ 12.5%	82,544	31,453					25,545					25,545
Design & Supervision @ 2	208,258	126,513					40,873					40,873
Site Investigation @ 5%	52,065	31,628					10,218					10,218
SBC Costs @ 5%	52,065	31,628					10,218					10,218
	<b>12,859,449</b>	<b>189,769</b>	<b>12,358,044</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>155,818</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>155,818</b>

Management Unit 18A East Pier Main	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 3					Major Refurbishm ent Required Yr 41				Major Refurbishm ent Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
		<b>Capital Scheme Costs</b> (Stand Alone Scheme)										
Pointing	249,757	149,854					49,951					49,951
Grouting	133,333	80,000					26,667					26,667
Sheet Pile Toe Protection	85,030	85,030					0					0
Half Height Revetment	488,400	488,400					0					0
Preliminaries @ 15%	107,170	84,185					11,493					11,493
OH & P @ 12.5%	89,309	70,154					9,577					9,577
Design & Supervision @ 2	142,894	112,246					15,324					15,324
Site Investigation @ 5%	35,723	28,062					3,831					3,831
SBC Costs @ 5%	35,723	28,062					3,831					3,831
	<b>1,367,339</b>	<b>1,125,993</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>120,673</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>120,673</b>

Management Unit 18B East Pier Extension	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 6 & 7					Major Refurbishm ent Required Yr 41				Major Refurbishm ent Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
		<b>Capital Scheme Costs</b> (Stand Alone Scheme)										
Pointing	124,878	74,927					24,976					24,976
Grouting	66,667	40,000					13,333					13,333
Sheet Piling & Fill to Pier	1,109,525	1,109,525					0					0
Steel Pile, Pre cast panels	10,650,000	10,650,000					0					0
Half Height Revetment	420,300	420,300					0					0
Preliminaries @ 15%	93,149	31,839					30,655					30,655
OH & P @ 12.5%	82,544	31,453					25,545					25,545
Design & Supervision @ 2	208,258	126,513					40,873					40,873
Site Investigation @ 5%	52,065	31,628					10,218					10,218
SBC Costs @ 5%	52,065	31,628					10,218					10,218
	<b>12,859,449</b>	<b>189,769</b>	<b>12,358,044</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>155,818</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>155,818</b>

MAIN PIERS - COST ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate	Unit Rate Cost	Contractor's Comments	Duration inc. downtime
1	Fabrication and Installation of Flood Gate across the slipway adjacent to Battery Parade, adjacent to the West Main Pier.	Flood Gate will need to be robust to withstand direct wave impact from wave run-up forces. Assume that telemetry feed will be required.	1nr Flood Gate required. Width of slipway is approximately 5m. Height of gate is approximately 1.5m.	15,000.00	na		2 weeks (5d wk)
2	Fabrication and installation of 3nr Access Barriers						
2.1	Access Barrier at entrance to West Pier		West Pier entrance width is approx 12m.	10,302.00	na		8 weeks (5d wk)
2.2	Access Barrier at entrance to East Pier	Assume that barriers are to include illuminated warning sign/message and a telemetry link.	East Pier entrance width approx 16m.	10,732.00	na		
2.3	Access Barrier at entrance to West Pier Extension Bridge.		West Pier Extension Bridge entrance is approx 5m.	9,336.00	na		
3	Repairs and painting of Hand Rails on West Pier.	Handrails appear to be in reasonable condition. Cost on the basis of repainting with a contingency for some repairs.	Approximately 420m length in total for both sides.	17,600.00	41.90 per m		4 weeks (5d wk)
4	Installation of new handrails on East Pier to match those on West Pier.	Include costs for removal and disposal of existing handrails - approx 200m length.	Approximately 550m length in total for both sides.	82,500.00	150.00 per m		6 weeks (5d wk)
5	Repointing and repairs to masonry walls.	Assume all joints to be raked at to a minimum depth of 25mm.  Assume restoration mortar (i.e. lime based) is required.  Assume that marine mortar (gelling additives or similar) are required for 25% of the works for area at risk of tidal washout prior to curing.  Assume a contingency sum for providing replacement sandstone blocks for areas where erosion or damage requires removal and reinstatement of block. Assume no more than 2% of the wall area needs to be replaced.	Area of walls 11,180m <sup>2</sup> . Total length of joints 22,360m. Volume of mortar reqd approx 11.18m <sup>3</sup> .	693,160.00	30.00 per m	Normal	23 weeks (5d wk)
					30.00 per m	Marine	
					1,326.67 per m <sup>2</sup>	Replacing sandstone blocks	
6	Cementitious Grouting of the Rubble Fill inner core.	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)	1,200m <sup>3</sup> volume of cementitious grout (based on 10% of total pier volume).	660,000.00	550.00 per m <sup>3</sup>		8 weeks (5d wk)
7	Scour Protection Works to the Bull noses of the East and West Main Piers.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates.  Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 100m on West Pier Bull nose and 50m on East Pier Bull nose.	2,031,515.29	13,543.44 per m		332 days (7d wk)
8	Repairs to concrete promenade surface on the West Pier.	The whole promenade surface of the West Pier is formed from concrete. Repairs will be required to infill grout holes, replace existing damaged sections and sections where poor repairs have been carried out for service trenches and also to make good after construction works.	Total West Pier surface area is approx 4,500m <sup>2</sup>	45,000.00	10.00 per m <sup>2</sup>		18 weeks (5d wk)
9	Re-setting of sandstone blocks that form the promenade surface for the East Pier.	The current surface is very uneven as a result of settlement of the inner core, erosion of the sandstone blocks, overtopping and numerous previous repairs.  As this is a Listed Structure we are assuming that the surface will need to be reinstated on a like for like basis.  A small area of the Pier has a concrete deck (where repairs have been carried out) - assume that this is about 5% of the total surface area.  Some of the sandstone blocks will not be suitable for re-use. Therefore assume that 25% of the surface area will require new blocks to be provided to match the existing.  Assume that all blocks in the remaining surface area will need to be lifted and re-set on a new mortar bed (in terms of sequencing the blocks will probably need to be lifted prior to grout infill - this will avoid coring through the blocks and also give an indication of the extent of voiding or deterioration of the inner core.	Total East Pier surface area is approx 4,600m <sup>2</sup>	692,686.53	153.24 per m <sup>2</sup>	Re-set sandstone blocks	40 weeks (5d wk) using 3 gangs
					82.80 per m <sup>2</sup>	Reinstate concrete decking	6 weeks (5d wk)

PIER EXTENSIONS - COST ESTIMATE

Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate	Unit Rate Cost	Contractor's Comments	Duration (days) inc. downtime
<b>OPTION E1 - (See Sketch: Option 3)</b>							
E1.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	978,498.00	8,154.15 per m		0.4m/day X 600 = 150
E1.2	Raising of the concrete shoulder to allow key in for future repairs.	Assume that concrete shoulder will be formed from fibre reinforced concrete, dowelled into the existing structure.	Assume total volume of concrete required is 2,220m <sup>3</sup> .	5,216,700.00	8,694.50 per m <sup>3</sup>		2220 @ 3.2m <sup>2</sup> /day = 694
E1.3	Installation of rock revetment to MHWS height.	Note that excavation of the seabed is required for forming the toe detail. Note that the sea bed is sandstone bed rock. Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		10,741,396.33	10,500.10 per m	Primary Rock + toe excavation. Assumed 2m layer thickness	63,000m <sup>3</sup> @ 280m <sup>3</sup> /day + 50% downtime= 337 days
					1,496.14 per m	Secondary Rock, assumed 600mm layer thickness	
					6,209.51 per m	Filter rock inc geotextile	
E1.4	Installation of scour protection to northern and southern ends of bulkheads of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	1,692,929.41	13,543.44 per m	As per E2.9 and E2.10	40 piles @ 1.1/day + 125no panels @ 0.9/day + 919m <sup>3</sup> concrete @ 30/day = 44 + 139 + 31 = 214
E1.5	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions that remain exposed above the raised shoulders - inc top face.	Assume 2,700m <sup>2</sup> of minor repairs to concrete surfaces.	293,717.57	108.78 per m <sup>2</sup>		33m <sup>2</sup> /day = 82 days
<b>Total Cost</b>				<b>18,923,241.31</b>			
<b>OPTION E2 - Scour Protection Variants</b>							
<b>Void Infill &amp; Rock Revetment - Sketch Option 2</b>							
E2.1	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.	978,498.00	8,154.15 per m		150
E2.2	Installation of rock revetment to MLWN height.	Primary Rock is 10T. Secondary Rock 1T. Slope angle is 1 in 3. Berm width is 4.5m.		1,108,193.70	1,423.12 per m	Primary Rock	77
					226.06 per m	Secondary Rock	
					196.89 per m	Filter rock inc geotextile	
E2.3	Installation of scour protection to northern and southern ends of bulkheads of the Pier Extensions.	Cost estimate to be based on design used for emergency works on East Pier Extension. Drawings C-8427-013(B) and 9W0160-100(C2) have been provided for cost estimates. Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 60m on West Pier Bull noses and 65m on East Pier Bull nose.	1,692,929.41	13,543.44 per m	As per E2.9 and E2.10	170
E2.4	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m <sup>2</sup> of minor repairs to concrete surfaces.	535,218.69	108.78 per m <sup>2</sup>		149
<b>Total Cost</b>				<b>4,314,839.78</b>			
<b>Steel Sheet Piles &amp; Concrete Backfill - Sketch Option 1</b>							
E2.5	Pre augering and installation of sheet piles.	To be used for whole length of Pier Extension bases.	680m of interlocking sheet piles; 8m high driven 2m into ground. Pre-excavation for piling 1360m <sup>3</sup> Backfill with concrete 680m <sup>3</sup>	2,026,400.00	2,980.00 per m	Excavation and backfilling not required using Giken Supercrush Pile Press (which is able to straddle the piles and pre-bore ahead of the pile within the in-pan). Assumed 10m long piles to maximise working time.	100
E2.6	Concrete backfill.		Mass concrete backfill 5,000m <sup>3</sup>	1,772,928.57	354.59 per m <sup>3</sup>		167
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,260m <sup>2</sup> of minor repairs to concrete surfaces.	463,421.06	108.78 per m <sup>2</sup>		129
<b>Total Cost</b>				<b>4,262,749.63</b>			
<b>Concrete repairs as per Emergency Works - See Drawings 9W0160-100C2 and C-8427-013B</b>							
E2.9	Installation of UC and PCC Panels.	See drawings for details.	Assume total length of repair is 680m.	7,436,607.40	10,936.19 per m		227 piles @ 1.1/day + 680 panels @ 0.9/day = 250 + 612 = 862
E2.10	Concrete backfill and capping.	See drawings for details.	Mass concrete backfill 5,000m <sup>3</sup>	1,772,928.57	354.59 per m <sup>3</sup>		167
E2.8	Concrete repairs.	Allow a contingency sum for carrying out repairs to the concrete faces of the extensions.	Assume 4,920m <sup>2</sup> of minor repairs to concrete surfaces.	535,218.69	108.78 per m <sup>2</sup>		149
<b>Total Cost</b>				<b>9,744,754.65</b>			
NOTE - Options E3 and E4 are variants of E1 and E2 and therefore costs can be extracted for them from the above tables.							
<b>East Pier Bridge Replacement - see photos for details</b>							
B1	Replace East Pier Bridge with new clear spanning structure.	Assume that no works are required to remove the existing abutment and that the new bridge will arch above it. Costs to include works to structures to act as abutments / to receive bridge.	Gap to bridge is approx 25m.	125,000.00	125,000.00	Fabrication	8 weeks
				65,706.43	65,706.43	Installation	
B2	Replace the East Pier Bridge with a like for like replacement of the historic bridge and a new central pier.		Gap to bridge is approx 25m.	115,000.00	115,000.00	Fabrication	20 weeks
				165,706.43	165,706.43	Installation - includes central pier cost	

Management Unit 17A West Pier Main	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 4						Major Refurbish ment Required Yr 41				Major Refurbish ment Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
		Capital Scheme Costs (Stand Alone Scheme)											
Pointing	350,658	149,854					100,402					100,402	
Grouting	187,200	80,000					53,600					53,600	
Sheet Pile Toe Protection	255,090	85,030					85,030					85,030	
Half Height Revetment	0	0					0					0	
Preliminaries @ 15%	118,942	47,233					35,855					35,855	
OH & P @ 12.5%	99,119	39,361					29,879					29,879	
Design & Supervision @ :	158,590	62,977					47,806					47,806	
Site Investigation @ 5%	39,647	15,744					11,952					11,952	
SBC Costs @ 5%	39,647	15,744					11,952					11,952	
	<b>1,248,894</b>	495,942	0	0	0	0	376,476	0	0	0		376,476	0

Management Unit 17B West Pier Extension	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 5 & 6						Major Refurbish ment Required Yr 41				Major Refurbish ment Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
		Capital Scheme Costs (Stand Alone Scheme)											
Pointing	124,878	74,927					24,976					24,976	
Grouting	66,667	40,000					13,333					13,333	
Sheet Piling & Fill to Pier	1,109,525	1,109,525					0					0	
Steel Pile, Pre cast panels	10,650,000	10,650,000					0					0	
Half Height Revetment	420,300	420,300					0					0	
Preliminaries @ 15%	93,149	31,839					30,655					30,655	
OH & P @ 12.5%	82,544	31,453					25,545					25,545	
Design & Supervision @ :	208,258	126,513					40,873					40,873	
Site Investigation @ 5%	52,065	31,628					10,218					10,218	
SBC Costs @ 5%	52,065	31,628					10,218					10,218	
	<b>12,859,449</b>	189,769	12,358,044	0	0	0	155,818	0	0	0		155,818	0

Management Unit 18A East Pier Main	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yr 3						Major Refurbish ment Required Yr 41				Major Refurbish ment Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
		Capital Scheme Costs (Stand Alone Scheme)											
Pointing	249,757	149,854					49,951					49,951	
Grouting	133,333	80,000					26,667					26,667	
Sheet Pile Toe Protection	85,030	85,030					0					0	
Half Height Revetment	488,400	488,400					0					0	
Preliminaries @ 15%	107,170	84,185					11,493					11,493	
OH & P @ 12.5%	89,309	70,154					9,577					9,577	
Design & Supervision @ :	142,894	112,246					15,324					15,324	
Site Investigation @ 5%	35,723	28,062					3,831					3,831	
SBC Costs @ 5%	35,723	28,062					3,831					3,831	
	<b>1,367,339</b>	1,125,993	0	0	0	0	120,673	0	0	0		120,673	0

Management Unit 18B East Pier Extension	Estimated Costs 0- 100 years	Detailed Design Yrs 1 -2 Capital Scheme Constructed Yrs 6 & 7						Major Refurbish ment Required Yr 41				Major Refurbish ment Required Yr 81	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
		Capital Scheme Costs (Stand Alone Scheme)											
Pointing	124,878	74,927					24,976					24,976	
Grouting	66,667	40,000					13,333					13,333	
Sheet Piling & Fill to Pier	1,109,525	1,109,525					0					0	
Steel Pile, Pre cast panels	10,650,000	10,650,000					0					0	
Half Height Revetment	420,300	420,300					0					0	
Preliminaries @ 15%	93,149	31,839					30,655					30,655	
OH & P @ 12.5%	82,544	31,453					25,545					25,545	
Design & Supervision @ :	208,258	126,513					40,873					40,873	
Site Investigation @ 5%	52,065	31,628					10,218					10,218	
SBC Costs @ 5%	52,065	31,628					10,218					10,218	
	<b>12,859,449</b>	189,769	12,358,044	0	0	0	155,818	0	0	0		155,818	0

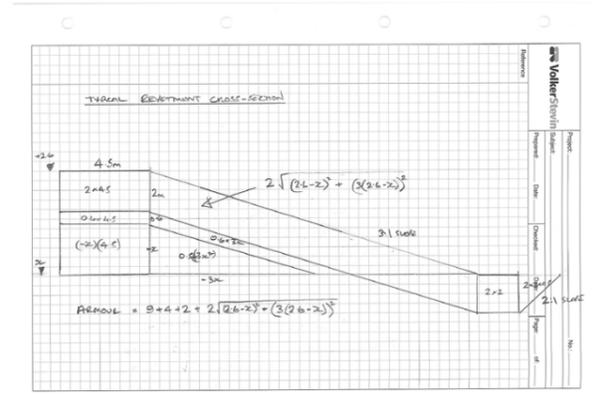


**Quantity (m3) per m run**                      **Totals (m3)**

**Revetment up to MHWS**

Geotextile

Cross section Ref	Bed Level	Primary Armour	Secondary Armour	Filter Rock	Chainage	Length	Primary Armour	Secondary Armour	Filter Rock	
<b>East arm East face</b>										
0EE	-5.3	64.96	13.89	65.99	0-12.5	12.5	812.05	173.68	824.81	109.98
25EE	-5.2	64.33	13.70	63.96	12.5-37.5	25	1,608.29	342.62	1,599.00	106.60
50EE	-4	56.74	11.43	42.00	37.5-62.5	25	1,418.55	285.70	1,050.00	70.00
75EE	-3.3	52.31	10.10	31.19	62.5-87.5	25	1,307.87	252.49	779.63	51.98
100EE	-3.2	51.68	9.91	29.76	87.5-112.5	25	1,292.06	247.75	744.00	49.60
125EE	-3	50.42	9.53	27.00	112.5-137.5	25	1,260.44	238.26	675.00	45.00
150EE	-2.7	48.52	8.96	23.09	137.5-150	12.5	606.50	112.02	288.56	38.48
<b>N Roundhead</b>										
<b>East arm West face</b>										
0EW	-4.7	61.17	12.76	54.29	0-12.5	12.5	764.62	159.45	678.56	90.48
25EW	-4.2	58.01	11.81	45.36	12.5-37.5	25	1,450.17	295.18	1,134.00	75.60
50EW	-4.2	58.01	11.81	45.36	37.5-62.5	25	1,450.17	295.18	1,134.00	75.60
75EW	-3.7	54.84	10.86	37.19	62.5-87.5	25	1,371.12	271.47	929.63	61.98
100EW	-3.4	52.95	10.29	32.64	87.5-112.5	25	1,323.68	257.24	816.00	54.40
125EW	-3.2	51.68	9.91	29.76	112.5-137.5	25	1,292.06	247.75	744.00	49.60
150EW	-3.5	53.58	10.48	34.13	137.5-150	12.5	669.75	130.99	426.56	56.88
<b>S Roundhead</b>										
<b>West Arm East face</b>										
0WE	-4.8	61.80	12.95	56.16	0-12.5	12.5	772.52	161.82	702.00	93.60
25WE	-4.6	60.54	12.57	52.44	12.5-37.5	25	1,513.42	314.16	1,311.00	87.40
50WE	-4.5	59.90	12.38	50.63	37.5-62.5	25	1,497.61	309.41	1,265.63	84.38
75WE	-4.5	59.90	12.38	50.63	62.5-87.5	25	1,497.61	309.41	1,265.63	84.38
100WE	-4.8	61.80	12.95	56.16	87.5-112.5	25	1,545.04	323.64	1,404.00	93.60
125WE	-4.7	61.17	12.76	54.29	112.5-137.5	25	1,529.23	318.90	1,357.13	90.48
145WE	-4.3	58.64	12.00	47.09	137.5-145	7.5	439.80	89.98	353.14	78.48
<b>N Roundhead</b>										
<b>West arm West Face</b>										
0WW	-4.7	61.17	12.76	54.29	0-12.5	12.5	764.62	159.45	678.56	90.48
25WW	-4	56.74	11.43	42.00	12.5-37.5	25	1,418.55	285.70	1,050.00	70.00
50WW	-3.1	51.05	9.72	28.37	37.5-62.5	25	1,276.25	243.01	709.13	47.28
75WW	-2.8	49.15	9.15	24.36	62.5-87.5	25	1,228.81	228.78	609.00	40.60
100WW	-2.7	48.52	8.96	23.09	87.5-112.5	25	1,213.00	224.03	577.13	38.48
125WW	-2.4	46.62	8.39	19.44	112.5-137.5	25	1,165.57	209.80	486.00	32.40
145WW	-2.4	46.62	8.39	19.44	137.5-145	7.5	349.67	62.94	145.80	32.40
<b>Totals</b>							<b>32,839</b>	<b>6,551</b>	<b>23,738</b>	<b>1,900</b>
Toe excavation										590 m 12 m3/m <b>7080</b> Toe Excavation
										<b>2,280</b> inc 20% waste



**Revetment up to MLWN**

Cross section Ref	Bed Level	Primary Armour	Secondary Armour	Filter Rock	Chainage	Length	Primary Armour	Secondary Armour	Filter Rock	
<b>East arm East face</b>										
0EE	-5.3	29.24	6.87	11.04	0-12.5	12.5	365.48	85.93	138.00	18.40
25EE	-5.2	28.61	6.68	10.13	12.5-37.5	25	715.15	167.11	253.13	16.88
50EE	-4	21.02	4.41	1.49	37.5-62.5	25	525.42	110.19	37.13	2.48
75EE	-3.3	16.59	-	-	62.5-87.5	25	414.74	-	-	-
100EE	-3.2	15.96	-	-	87.5-112.5	25	398.93	-	-	-
125EE	-3	8.55	-	-	112.5-137.5	25	213.75	-	-	-
150EE	-2.7	7.20	-	-	137.5-150	12.5	90.00	-	-	-
<b>N Roundhead</b>										
<b>East arm West face</b>										
0EW	-4.7	25.44	5.74	6.00	0-12.5	12.5	318.05	71.70	75.00	10.00
25EW	-4.2	22.28	4.79	2.63	12.5-37.5	25	557.04	119.68	65.63	4.38
50EW	-4.2	22.28	4.79	2.63	37.5-62.5	25	557.04	119.68	65.63	4.38
75EW	-3.7	19.12	3.84	-	62.5-87.5	25	477.98	95.96	-	-
100EW	-3.4	17.22	-	-	87.5-112.5	25	430.55	-	-	-
125EW	-3.2	15.96	-	-	112.5-137.5	25	398.93	-	-	-
150EW	-3.5	17.85	-	-	137.5-150	12.5	223.18	-	-	-
<b>S Roundhead</b>										
<b>West Arm East face</b>										
0WE	-4.8	26.08	5.93	6.77	0-12.5	12.5	325.95	74.07	84.56	11.28
25WE	-4.6	24.81	5.55	5.27	12.5-37.5	25	620.28	138.65	131.63	8.77
50WE	-4.5	24.18	5.36	4.56	37.5-62.5	25	604.47	133.91	114.00	7.60
75WE	-4.5	24.18	5.36	4.56	62.5-87.5	25	604.47	133.91	114.00	7.60
100WE	-4.8	26.08	5.93	6.77	87.5-112.5	25	651.91	148.14	169.13	11.28
125WE	-4.7	25.44	5.74	6.00	112.5-137.5	25	636.10	143.39	150.00	10.00
145WE	-4.3	22.91	4.98	3.24	137.5-145	7.5	171.86	37.33	24.30	5.40
<b>N Roundhead</b>										
<b>West arm West Face</b>										
0WW	-4.7	25.44	5.74	6.00	0-12.5	12.5	318.05	71.70	75.00	10.00
25WW	-4	21.02	4.41	1.49	12.5-37.5	25	525.42	110.19	37.13	2.48
50WW	-3.1	15.32	-	-	37.5-62.5	25	383.11	-	-	-
75WW	-2.8	7.65	-	-	62.5-87.5	25	191.25	-	-	-
100WW	-2.7	7.20	-	-	87.5-112.5	25	180.00	-	-	-
125WW	-2.4	5.85	-	-	112.5-137.5	25	146.25	-	-	-
145WW	-2.4	5.85	-	-	137.5-145	7.5	43.88	-	-	-
<b>Totals</b>							<b>11,089</b>	<b>1,762</b>	<b>1,534</b>	<b>131</b>
										<b>157</b> inc 20% waste



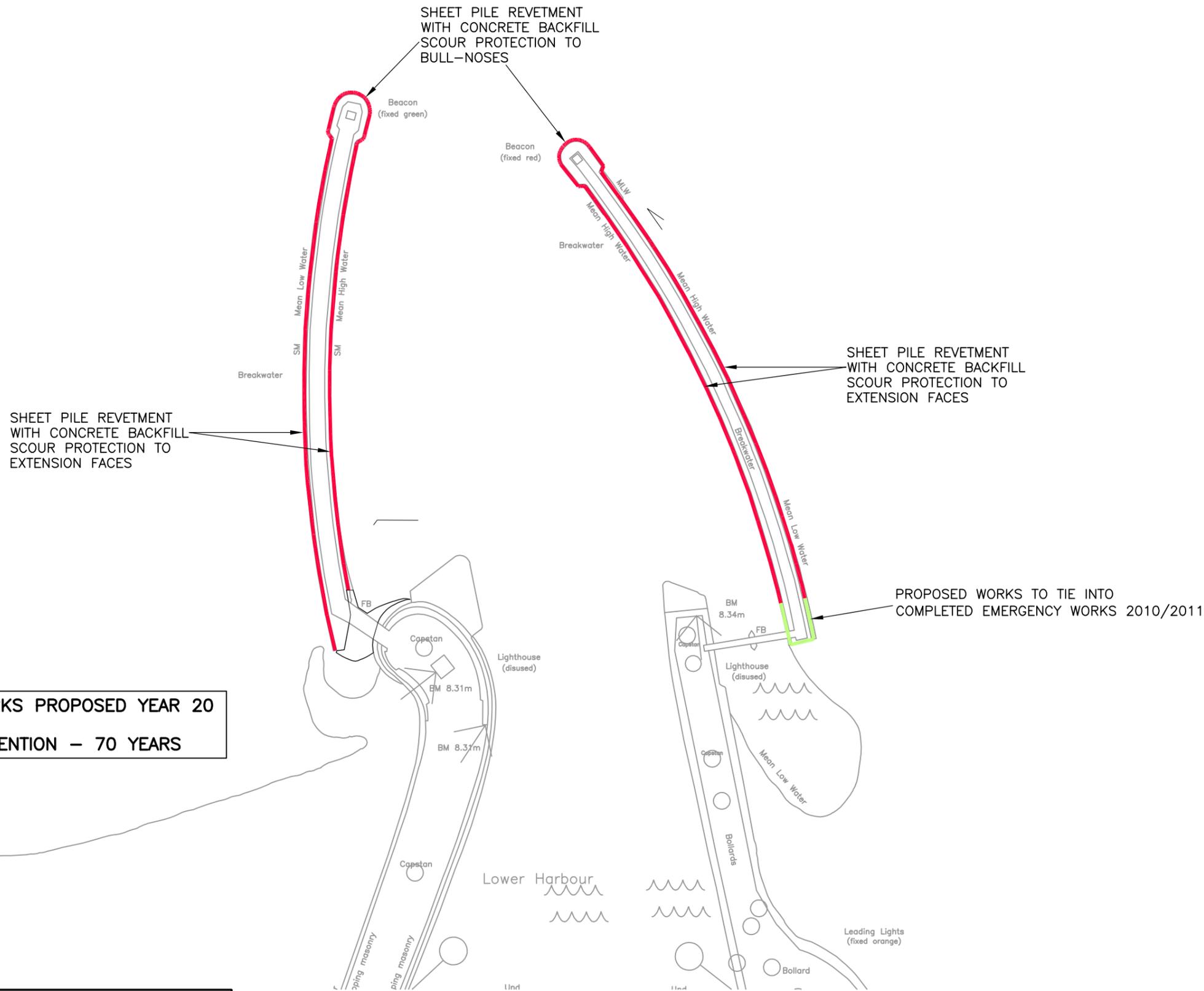
## APPENDIX B – FIGURES

- Figure 1 – Option M1
- Figure 2 – Option E1
- Figure 3 – Option E2
- Figure 4 – Option E3
- Figure 5 – Option E4
- Figure 21 (FIR 2009); Whitby Piers – Overview Condition





DO NOT SCALE

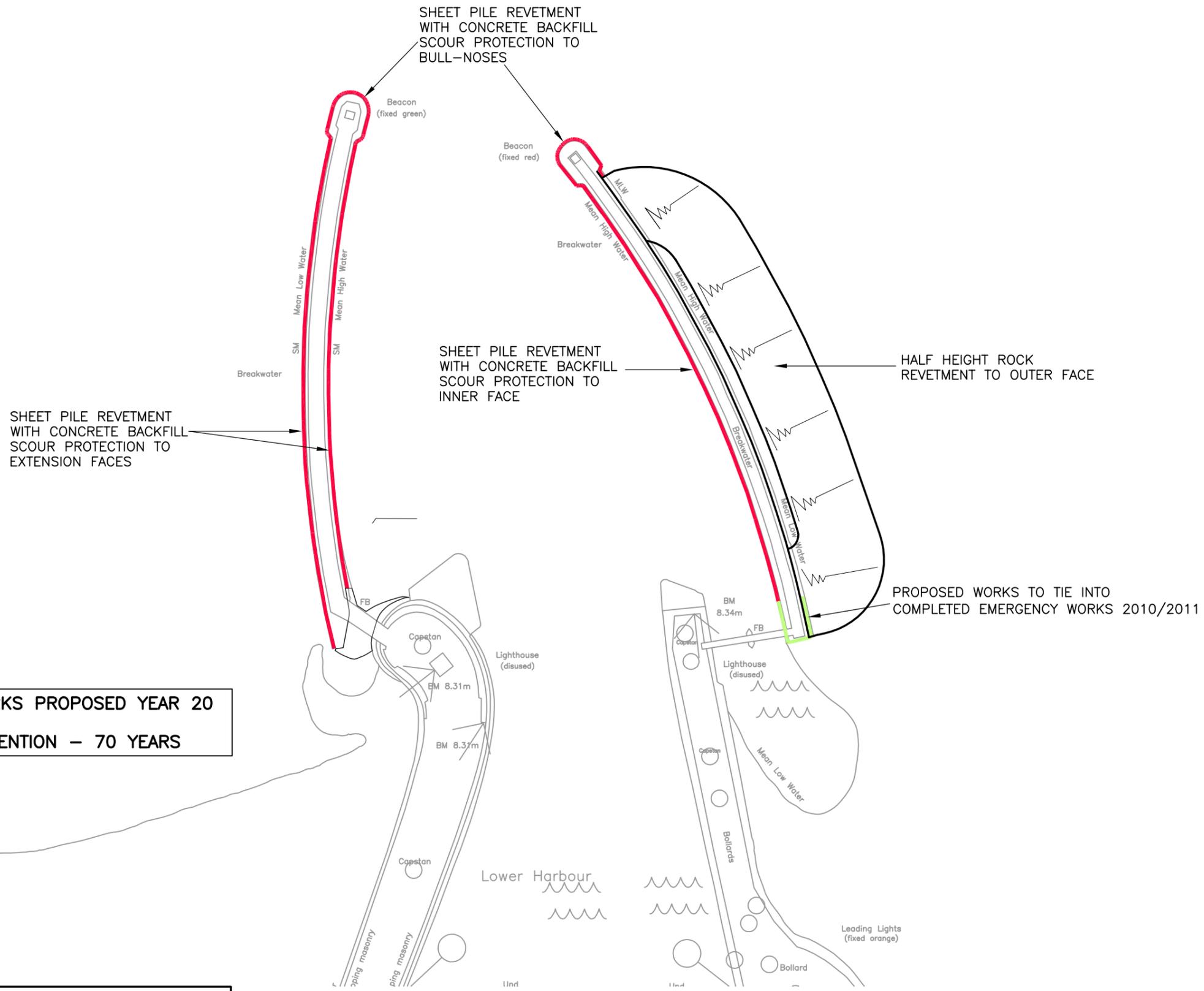


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TITLE <b>WHITBY PIERS OPTIONS</b>	PROJECT <b>OPTION E1 PIER EXTENSIONS PLAN VIEW</b>	 <b>ROYAL HASKONING</b> <small>A COMPANY OF</small> <b>HASKONING UK LTD</b> <b>COASTAL AND RIVERS DIVISION</b> <small>Rightwell House          Breilton          Peterborough PE3 8DW          +44 (0)1733 394455          +44 (0)1733 282243          info@peterborough.royalhaskoning.com          www.royalhaskoning.com</small>	Job No.	IL	DATE	MARCH 2012	SCALE	NO SCALE
			ACAD Ref.		CHECKED	PK	PASSED	PK
			DRAWN	IL	DRG No.	<b>FIGURE 2</b>		REV

DO NOT SCALE

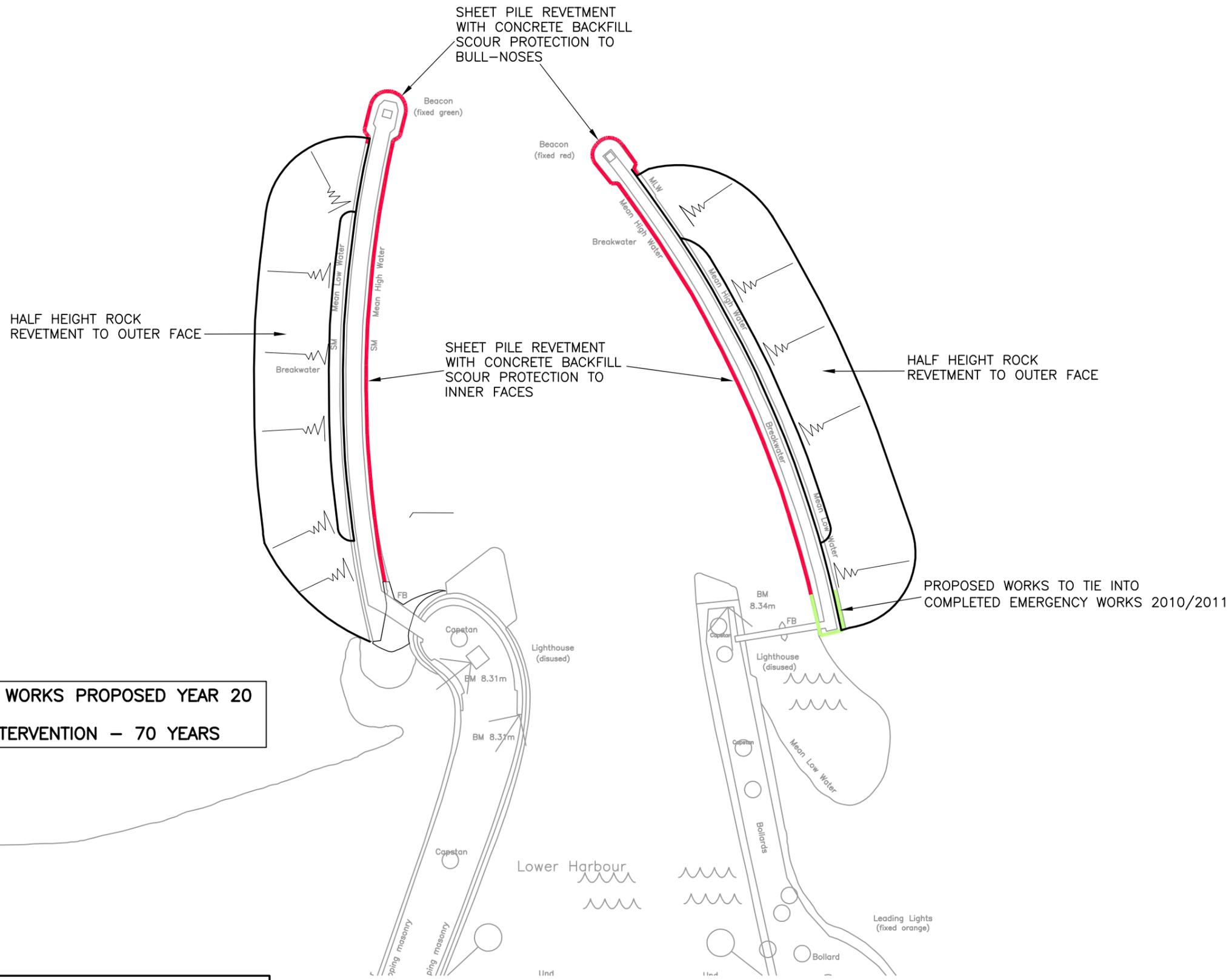


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			ACAD Ref.		CHECKED	PK	PASSED	PK
			DRAWN	IL	DRG No.	<b>FIGURE 3</b>		REV

DO NOT SCALE



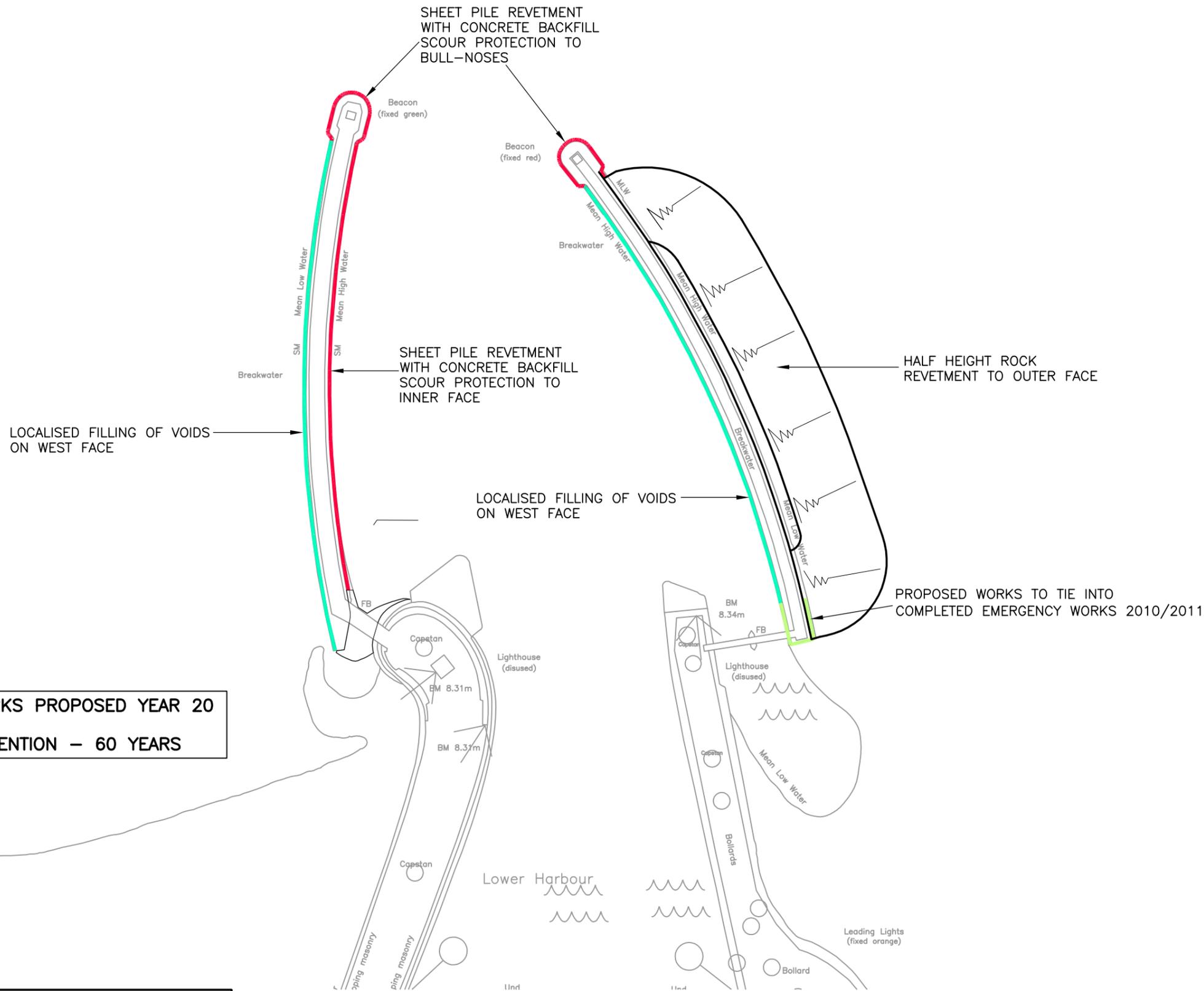
CAPITAL WORKS PROPOSED YEAR 20  
NEXT INTERVENTION - 70 YEARS

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			ACAD Ref.		CHECKED	PK	PASSED	PK
			DRAWN	IL	DRG No.	<b>FIGURE 4</b>		REV

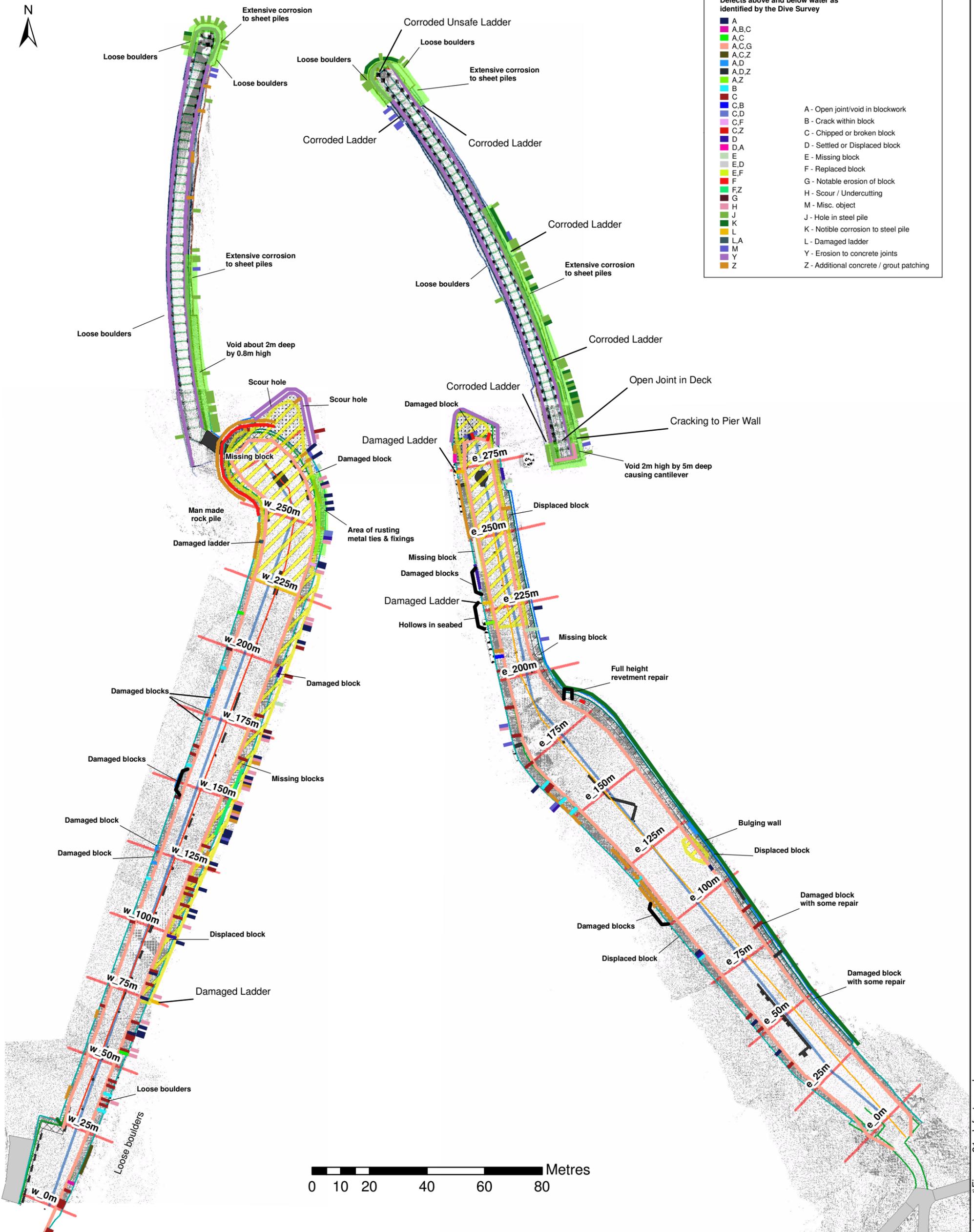
DO NOT SCALE



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TITLE <b>WHITBY PIERS OPTIONS</b>	PROJECT <b>OPTION E4 PIER EXTENSIONS PLAN VIEW</b>	 <b>ROYAL HASKONING</b> <small>A COMPANY OF</small> <b>HASKONING UK LTD</b> <b>COASTAL AND RIVERS DIVISION</b> <small>Rightwell House          Breitan          Peterborough PE3 8DW          +44 (0)1733 334455          +44 (0)1733 282243          info@peterborough.royalhaskoning.com          www.royalhaskoning.com</small>	Job No.	IL	DATE	MARCH 2012	SCALE	NO SCALE
			ACAD Ref.		CHECKED	PK	PASSED	PK
			DRAWN	IL	DRG No.	<b>FIGURE 5</b>		REV



**Defects above and below water as identified by the Dive Survey**

A	A - Open joint/void in blockwork
A,B,C	B - Crack within block
A,C	C - Chipped or broken block
A,C,G	D - Settled or Displaced block
A,C,Z	E - Missing block
A,D	F - Replaced block
A,D,Z	G - Notable erosion of block
A,Z	H - Scour / Undercutting
B	M - Misc. object
C	J - Hole in steel pile
C,B	K - Notable corrosion to steel pile
C,D	L - Damaged ladder
C,F	Y - Erosion to concrete joints
C,Z	Z - Additional concrete / grout patching
D	
D,A	
E	
E,D	
E,F	
F	
F,Z	
G	
H	
J	
K	
L	
L,A	
M	
Y	
Z	

**Key:**

	Corrosion to sheet piles
	Damage to external face of block walls
	Areas of potential voids
	Section Baseline
	Cross-Sections

**Title:**  
Whitby Piers - Overview Condition

**Project:**  
Whitby Coastal Strategy Further Investigations at Whitby Harbour

**Client:**  
Scarborough Council

<b>Date:</b> Jan 2009	<b>Scale:</b> 1 : 1,200
<b>Figure:</b> 21	<b>Drawn:</b> TC
	<b>Checked:</b> CG





## APPENDIX C – ECONOMICS

- Whole Life Costs – Phased Approach
- Options Costs Derivations
- Present Value Costs
- Cost Comparisons

Option 3 - Description

- Main Piers Procurement & Tender Award Year 1
- Main Piers Site Investigation & Design Year 2
- Main Pier Works delivered in Years 3 & 4
- Extensions Design Year 21 to 22
- Extensions Works delivered in Year 23 to 25

Option Evaluation M1 + E1	Estimated Costs	Main Piers Procurement & Tender Award Year 1, SI & Detailed Design Yr 2, Constructed Yrs 3 & 4				Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years		Replacement of West Pier Bull Nose Scour Protection Works		Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years		Replacement of flood gates & barriers every 20 years	
	0- 100 years	0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
<b>Capital Scheme Costs</b>													
M1 - Design Life 100 yrs	4,410,553	3,787,960	0	0	30,370	0	30,370	501,113	30,370	0	30,370	0	
E1 Capital Works Years 21 to 25 and 70	7,027,924	0	0	0	3,513,962	0	0	0	0	3,513,962	0	0	
Preliminaries @ 15%	1,697,550	568,194	0	0	527,094	0	0	75,167	0	527,094	0	0	
OH & P @ 12.5%	1,414,625	473,495	0	0	439,245	0	0	62,639	0	439,245	0	0	
Supervision @ 10%	1,131,699	378,796	0	0	351,396	0	0	50,111	0	351,396	0	0	
SBC Costs @ 5%	565,850	189,398	0	0	175,698	0	0	25,056	0	175,698	0	0	
	<b>16,248,201</b>	5,397,843	0	0	5,037,766	0	30,370	714,086	30,370	5,007,396	30,370	0	
<b>Maintenance Costs</b>													
Maintenance Existing Coastal Defences	1,190,000	50,000	60,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	
Modifications to structures/railings, signing closure, monitoring etc	97,000	2,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
	<b>1,287,000</b>	52,000	65,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	
<b>Other Costs</b>													
10 yearly strategy review	59,211	0	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	
Design @ 5%	565,850	189,398	0	0	175,698	0	0	25,056	0	175,698	0	0	
Site Investigation @ 2.5%	282,925	94,699	0	0	87,849	0	0	12,528	0	87,849	0	0	
Inspection	150,000	33,000	33,000	36,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	
	<b>1,057,986</b>	317,097	38,921	41,921	275,468	11,921	11,921	49,505	11,921	275,468	11,921	11,921	
	<b>18,593,187</b>	<b>5,766,940</b>	<b>103,921</b>	<b>171,921</b>	<b>5,443,234</b>	<b>141,921</b>	<b>172,291</b>	<b>893,591</b>	<b>172,291</b>	<b>5,412,864</b>	<b>172,291</b>	<b>141,921</b>	

Notes:

1. Costs are based on current day prices and have not been inflated up to the year of implementation
2. 10 yearly strategy review costs includes coastal and river management units.

Option 4- Description

- Main Piers Procurement & Tender Award Year 1
- Main Piers Site Investigation & Design Year 2
- Main Pier Works delivered in Years 3 & 4
- Extensions Design Year 21 to 22
- Extensions Works delivered in Year 23 to 25

Option Evaluation M1 + E2	Estimated Costs	Main Piers Procurement & Tender Award Year 1, SI & Detailed Design Yr 2, Constructed Yrs 3 & 4	0-5	5-10	10-20	Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years	20-30	30-40	Replacement of flood gates & barriers every 20 years	40-50	Replacement of West Pier Bull Nose Scour Protection Works	50-60	Replacement of flood gates & barriers every 20 years	60-70	Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years	70-80	Replacement of flood gates & barriers every 20 years	80-90	90-100
	0- 100 years																		
<b>Capital Scheme Costs</b>																			
M1	4,410,553	3,787,960	0	0	0	30,370	0	0	30,370	501,113	30,370	0	30,370	0	2,806,147	0	30,370	0	
E2 Capital Works Years 21 to 25 and 70	7,573,727	0	0	0	0	4,767,580	0	0	0	0	0	0	0	0	2,806,147	0	0	0	
Preliminaries @ 15%	1,779,420	568,194	0	0	0	715,137	0	0	0	75,167	0	0	0	0	420,922	0	0	0	
OH & P @ 12.5%	1,482,850	473,495	0	0	0	595,948	0	0	0	62,639	0	0	0	0	350,768	0	0	0	
Supervision @ 10%	1,186,280	378,796	0	0	0	476,758	0	0	0	50,111	0	0	0	0	280,615	0	0	0	
SBC Costs @ 5%	593,140	189,398	0	0	0	238,379	0	0	0	25,056	0	0	0	0	140,307	0	0	0	
	<b>17,025,970</b>	5,397,843	0	0	0	6,824,172	0	0	30,370	714,086	30,370	0	30,370	0	3,998,759	0	30,370	0	
<b>Maintenance Costs</b>																			
Maintenance Existing Coastal Defences	1,070,000	50,000	60,000	120,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	
Modifications to structures/railings, signing closure, monitoring etc	97,000	2,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
	<b>1,167,000</b>	52,000	65,000	130,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	115,000	
<b>Other Costs</b>																			
10 yearly strategy review	59,211	0	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	
Design @ 5%	593,140	189,398	0	0	0	238,379	0	0	0	25,056	0	0	0	0	140,307	0	0	0	
Site Investigation @ 2.5%	296,570	94,699	0	0	0	119,190	0	0	0	12,528	0	0	0	0	70,154	0	0	0	
Inspection	150,000	33,000	33,000	36,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	
	<b>1,098,921</b>	317,097	38,921	41,921	369,490	11,921	11,921	11,921	11,921	49,505	11,921	11,921	11,921	11,921	222,382	11,921	11,921	11,921	
	<b>19,291,891</b>	<b>5,766,940</b>	<b>103,921</b>	<b>171,921</b>	<b>7,308,661</b>	<b>126,921</b>	<b>157,291</b>	<b>157,291</b>	<b>878,591</b>	<b>157,291</b>	<b>4,336,142</b>	<b>157,291</b>	<b>157,291</b>	<b>4,336,142</b>	<b>157,291</b>	<b>157,291</b>	<b>126,921</b>	<b>126,921</b>	

Notes:

1. Costs are based on current day prices and have not been inflated up to the year of implementation
2. 10 yearly strategy review costs includes coastal and river management units.

Option 5- Description

- Main Piers Procurement & Tender Award Year 1
- Main Piers Site Investigation & Design Year 2
- Main Pier Works delivered in Years 3 & 4
- Extensions Design Year 21 to 22
- Extensions Works delivered in Year 23 to 25

Option Evaluation M1 + E3	Estimated Costs 0- 100 years	Main Piers Procurement & Tender Award Year 1, SI & Detailed Design Yr2, Constructed Yrs 3 & 4			Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years		Replacement of flood gates & barriers every 20 years		Replacement of West Pier Bull Nose Scour Protection Works		Replacement of flood gates & barriers every 20 years		Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years		Replacement of flood gates & barriers every 20 years	
		0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100				
<b>Capital Scheme Costs</b>																
M1	4,410,553	3,787,960	0	0	30,370	0	30,370	501,113	30,370	0	30,370	0	30,370	0	0	0
E3 Capital Works Years 21 to 25 & 70	8,119,516	0	0	0	6,021,191	0	0	0	0	2,098,325	0	0	0	0	0	0
Preliminaries @ 15%	1,861,288	568,194	0	0	903,179	0	0	75,167	0	314,749	0	0	0	0	0	0
OH & P @ 12.5%	1,551,074	473,495	0	0	752,649	0	0	62,639	0	262,291	0	0	0	0	0	0
Supervision @ 10%	1,240,859	378,796	0	0	602,119	0	0	50,111	0	209,833	0	0	0	0	0	0
SBC Costs @ 5%	620,430	189,398	0	0	301,060	0	0	25,056	0	104,916	0	0	0	0	0	0
	<b>17,803,720</b>	5,397,843	0	0	8,610,567	0	30,370	714,086	30,370	2,990,113	30,370	0	30,370	0	0	0
<b>Maintenance Costs</b>																
Maintenance Existing Coastal Defences	950,000	50,000	60,000	120,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
Modifications to structures/railings, signing closure, monitoring etc	97,000	2,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
	<b>1,047,000</b>	52,000	65,000	130,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
<b>Other Costs</b>																
<b>10 yearly strategy review</b>	59,211	0	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921	5,921
Design @ 5%	620,430	189,398	0	0	301,060	0	0	25,056	0	104,916	0	0	0	0	0	0
Site Investigation @ 2.5%	310,215	94,699	0	0	150,530	0	0	12,528	0	52,458	0	0	0	0	0	0
Inspection	150,000	33,000	33,000	36,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
	<b>1,139,855</b>	317,097	38,921	41,921	463,510	11,921	11,921	49,505	11,921	169,295	11,921	11,921	11,921	11,921	11,921	11,921
	<b>19,990,575</b>	<b>5,766,940</b>	<b>103,921</b>	<b>171,921</b>	<b>9,174,078</b>	<b>111,921</b>	<b>142,291</b>	<b>863,591</b>	<b>142,291</b>	<b>3,259,409</b>	<b>142,291</b>	<b>142,291</b>	<b>142,291</b>	<b>142,291</b>	<b>111,921</b>	<b>111,921</b>

Notes:

1. Costs are based on current day prices and have not been inflated up to the year of implementation
2. 10 yearly strategy review costs includes coastal and river management units.

Option 6 - Description

- Main Piers Procurement & Tender Award Year 1
- Main Piers Site Investigation & Design Year 2
- Main Pier Works delivered in Years 3 & 4
- Extensions Design Year 21 to 22
- Extensions Works delivered in Year 23 to 25

Option Evaluation M1 + E4	Estimated Costs 0- 100 years	Main Piers Procurement & Tender Award Year 1, SI & Detailed Design Yr2, Constructed Yrs 3 & 4			Capital scheme to install scour protection works to Extensions. Replacement of flood gates & barriers every 20 years		Replacement of flood gates & barriers every 20 years	Replacement of West Pier Bull Nose Scour Protection Works	Capital scheme to install sheet piles to 3 faces and scour repairs. Replacement of flood gates & barriers every 20 years		Replacement of flood gates & barriers every 20 years	90-100
		0-5	5-10	10-20	20-30	30-40			60-70	70-80		
<b>Capital Scheme Costs</b>												
M1	4,410,553	3,787,960	0	0	30,370	0	30,370	501,113	30,370	0	30,370	0
E4 Capital Works Yrs 21 to 25 & 70	6,471,576	0	0	0	3,665,429	0	0	0	2,806,147	0	0	0
Preliminaries @ 15%	1,614,097	568,194	0	0	549,814	0	0	75,167	420,922	0	0	0
OH & P @ 12.5%	1,345,081	473,495	0	0	458,179	0	0	62,639	350,768	0	0	0
Supervision @ 10%	1,076,065	378,796	0	0	366,543	0	0	50,111	280,615	0	0	0
SBC Costs @ 5%	538,033	189,398	0	0	183,271	0	0	25,056	140,307	0	0	0
	<b>15,455,405</b>	<b>5,397,843</b>	<b>0</b>	<b>0</b>	<b>5,253,606</b>	<b>0</b>	<b>30,370</b>	<b>714,086</b>	<b>4,029,130</b>	<b>0</b>	<b>30,370</b>	<b>0</b>
<b>Maintenance Costs</b>												
Maintenance Existing Coastal Defences	1,070,000	50,000	60,000	120,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000
Modifications to structures/railings, signing closure, monitoring etc	97,000	2,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
	<b>1,167,000</b>	<b>52,000</b>	<b>65,000</b>	<b>130,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>	<b>115,000</b>
<b>Other Costs</b>												
<b>10 yearly strategy review</b>	<b>59,211</b>	<b>0</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>	<b>5,921</b>
Design @ 5%	538,033	189,398	0	0	183,271	0	0	25,056	140,307	0	0	0
Site Investigation @ 2.5%	269,016	94,699	0	0	91,636	0	0	12,528	70,154	0	0	0
Inspection	150,000	33,000	33,000	36,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
	<b>1,016,260</b>	<b>317,097</b>	<b>38,921</b>	<b>41,921</b>	<b>286,828</b>	<b>11,921</b>	<b>11,921</b>	<b>49,505</b>	<b>222,382</b>	<b>11,921</b>	<b>11,921</b>	<b>11,921</b>
	<b>17,638,665</b>	<b>5,766,940</b>	<b>103,921</b>	<b>171,921</b>	<b>5,655,434</b>	<b>126,921</b>	<b>157,291</b>	<b>878,591</b>	<b>4,366,512</b>	<b>126,921</b>	<b>157,291</b>	<b>126,921</b>

Notes:

1. Costs are based on current day prices and have not been inflated up to the year of implementation
2. 10 yearly strategy review costs includes coastal and river management units.

MAIN PIERS - COST ESTIMATE - Option M1

				Volker Stevin	Bam Nuttall	Birse	Average	With EH Feedback Included	PAR Scope Recommended Minimum Cost Provision
Item	Description	Comments	Dimensions / Units / Quantities	Contractor's Cost Estimate £	Contractor's Cost Estimate £	Contractor's Cost Estimate £	Average Estimate £	Average Estimate £	Recommended Estimate £
M.01	Fabrication and Installation of Flood Gate across the slipway adjacent to Battery Parade, adjacent to the West Main Pier.	Flood Gate will need to be robust to withstand direct wave impact from wave run-up forces. Assume that telemetry feed will be required.	1nr Flood Gate required. Width of slipway is approximately 5m. Height of gate is approximately 1.5m.	£15,000.00	£20,000.00	11,000.00	£15,333.33	£15,333.33	£15,333.33
M.02	Fabrication and installation of 3nr Access Barriers								
M.02.1	Access Barrier at entrance to West Pier		West Pier entrance width is approx 12m.	£10,302.00	£15,000.00	15,000.00	£13,434.00	£13,434.00	£13,434.00
M.02.2	Access Barrier at entrance to East Pier	Assume that barriers are to include illuminated warning sign/message and a telemetry link.	East Pier entrance width approx 16m.	£10,732.00	£20,000.00	20,000.00	£16,910.67	£16,910.67	£16,910.67
M.02.3	Access Barrier at entrance to West Pier Extension Bridge.		West Pier Extension Bridge entrance is approx 5m.	£9,336.00	£7,500.00	9,336.00	£8,724.00	£8,724.00	£8,724.00
M.03	Repairs and painting of Hand Rails on West Pier.	Handrails appear to be in reasonable condition. Cost on the basis of repainting with a contingency for some repairs.	Approximately 420m length in total for both sides.	£17,600.00	£6,300.00	17,600.00	£13,833.33	£13,833.33	£13,833.33
M.04	Installation of new handrails on East Pier to match those on West Pier.	Include costs for removal and disposal of existing handrails - approx 200m length.	Approximately 550m length in total for both sides.	£82,500.00	£181,500.00	110,000.00	£124,666.67	£0.00	£0.00
M.05	Repointing and repairs to masonry walls.	Assume 50% of joints to be raked at to a minimum depth of 25mm. Assume restoration mortar (i.e. lime based) is required. Assume that marine mortar (gelling additives or similar) are required for 25% of the works for area at risk of tidal washout prior to curing. Assume a contingency sum for providing replacement sandstone blocks for areas where erosion or damage requires removal and reinstatement of block. Assume no more than 2% of the wall area needs to be replaced.	Area of walls 11,180m2. Total length of joints 22,360m. Volume of mortar reqd approx 11.18m3 x 50%	£346,580.00	£209,625.00	346,580.00	£300,928.33	£300,928.33	£300,928.33
M.06	Cementitious Grouting of the Rubble Fill inner core.	Assume that a 0.5m wide x 10m high x 1,200m long 'wall' of grout will be poured into the voids behind the facing stones. Assume that a 0.5m deep x 15m wide grout pour is required to infill voids beneath the concrete slabs of the west pier and the sandstone promenade of the east pier, 2 x 50m lengths at the seaward ends of the piers.	6,000m3 volume of cementitious grout for rcintuous grout wall. + 1500m3 volume of cementitious grout beneath upper surfaces.	£2,475,000.00	£2,925,000.00	2,925,000.00	£2,775,000.00	£2,775,000.00	£2,775,000.00
M.07	Scour Protection Works to the Bull nose of the West Main Piers.	Cost estimates based on installation of sheet piles toe protection with concrete backfill. Piles placed into pre-augered trenchholes.	Assume scour repair lengths of 100m on West Pier Bull nose.	£558,724.79	£385,889.64	558,724.79	£501,113.07	£501,113.07	£501,113.07
M.08	Repairs to concrete promenade surface on the West Pier.	The whole promenade surface of the West Pier is formed from concrete. Repairs will be required to infill grout holes, replace existing damaged sections and sections where poor repairs have been carried out for service trenches and also to make good after construction works.	Total West Pier surface area is approx 4,500m2 - assume repairs are required to 10% of the surface area only.	£4,500.00	£29,700.00	78,750.00	£37,650.00	£37,650.00	£37,650.00
M.09	Re-setting of sandstone blocks that form the promenade surface for the East Pier.	The current surface is very uneven as a result of settlement of the inner core, erosion of the sandstone blocks, overtopping and numerous previous repairs. Feedback from EH has stated that re-setting of the blocks is not appropriate and therefore costs for simply sealing the joints has been allowed for. No costs for removing the existing concrete repairs and replacing with new sandstone blocks have been allowed for. Cost has been derived based on proportional rates from item M.05.	Total East Pier surface area is approx 4,600m2	£142,600.00	£86,250.00	86,250.00	£105,033.33	£105,033.33	£105,033.33
<b>Total</b>				<b>£3,672,874.79</b>	<b>£3,886,764.64</b>	<b>£4,178,240.79</b>	<b>£3,912,626.74</b>	<b>£3,787,960.07</b>	<b>£3,787,960.07</b>

**PIER EXTENSIONS - COST ESTIMATE - Option E1 to E4  
Broken Down Into Elements E.01 to E.06**

					Volker Stevin	Bam Nuttall	Birse	Average
Item	Description	Comments	Dimensions / Units / Quantities		Contractor's Cost Estimate £	Contractor's Cost Estimate £	Contractor's Cost Estimate £	Average Estimate £
E.01	Infilling of voids in the concrete structure with concrete filled fabric bags or similar.	Assume that 10% of the total length of the extensions will require placement of concrete filled bags (or similar) to infill voids. Max void size 2m deep by 1m high.	Approx total length of extensions is 600m.		£978,498.00	£122,460.00	£780,000.00	£626,986.00
E.02	Installation of rock revetment to MHWS height.	Note that excavation of the seabed is required for forming the toe detail.  Note that the sea bed is sandstone bed rock.  Primary Rock is 10T. Secondary Rock 1T.  Slope angle is 1 in 3. Berm width is 4.5m.			£10,741,396.33	£7,900,920.00	£4,894,880.00	£7,845,732.11
E.03	Concrete repairs.	Allow a contingency sum for carrying out patch repairs to 10% of the concrete faces of the extensions.	Assume 492m <sup>2</sup> of minor repairs to concrete surfaces.		£53,521.87	£132,840.00	£132,840.00	£106,400.62
E.04	Pre augering and installation of sheet piles.	To be used for whole length of Pier Extension bases.	565m of interlocking sheet piles; 8m high driven 2m into ground. (excludes west pier bullnoses of 75m and east pier bullnoses of 40m).  Pre-excavation for piling 1360m <sup>3</sup> Backfill with concrete 680m <sup>3</sup>		£1,683,700.00	£926,600.00	£1,683,700.00	£1,431,333.33
E.05	Concrete backfill.		Mass concrete backfill 4,155m <sup>3</sup>		£1,473,095.06	£1,253,676.47	£1,473,095.06	£1,399,955.53
E.06	Installation of scour protection to northern and southern ends of bullnoses of the Pier Extensions.	Cost estimate is based on rates provided for sheet pile and concrete backfill (items E.4 + E.5).  Please note that the swell conditions and the difficulty in delivering concrete to the East Pier Extension resulted in significant delays and additional costs for this contract - please bear this in mind when pricing.	Assume scour repair lengths of 75m on West Pier Bull noses and 40m on East Pier Bull nose.		£642,533.51	£443,773.09	£642,533.51	£576,280.03

**PAR OPTIONS COST ELEMENTS - Using Average Prices Derived Above**

Extension Option - Construction Costs	Description	Comprised of cost elements:-	Capital Scheme In Yr 20	Yr 60 Intervention Costs	Yr 70 Intervention Costs
Option E1	Sheet Piles and Concrete Fill to all 4 faces of the Pier Extensions + Scour Protection to Bull Noses + Concrete Repairs to faces of Extensions.	E.04 + E.05 + E.06 + E.03	£3,513,969.52	£0.00	£3,513,969.52
Option E2	Half Height Rock Revetment to the east face of the east pier extension + Sheet Pile and Concrete Backfill Scour Protection to remaining 3 faces of the Pier Extensions + Scour Protection to Bull Noses + Concrete Repairs to faces of Extensions.	E.0.2 * (150/600) + (E.0.4 + E.0.5) * 0.75 + E.0.6 + E.0.3	£4,767,580.33	£0.00	£2,806,147.31
Option E3	Half Height Rock Revetment to 2 Extension faces; the east face of the east pier extension and the west face of the west pier extension. Sheet Pile and Concrete Backfill Scour Protection to remaining 2 faces of the Pier Extensions + Scour Protection to Bull Noses + Concrete Repairs to faces of Extensions.	E.0.2 * (300/600) + (E.0.4 + E.0.5) * 0.5 + E.0.6 + E.0.3	£6,021,191.15	£0.00	£2,098,325.09
Option E4	Half Height Rock Revetment to the east face of the east pier extension & Sheet Pile and Concrete Backfill Scour Protection to the east face of the west pier extension and Void Infilling on 2 remaining faces of the Pier Extensions + Scour Protection to Bull Noses + Concrete Repairs to Faces of Extensions.	E.0.2 * (150/600) + (E.0.4 + E.0.5) * 0.25 + E.0.1*0.5 + E.0.6 + E.0.3 + E.0.1 * 0.5	£3,665,428.90	£2,806,147.31	£0.00

Present Value Costs for all options

Client/Authority Scarborough Borough Council		Project name Whitby Harbour Piers Coast Protection Scheme P.		Project reference 9X1732		Base date for estimates (year 0) 04/2011		Scaling factor (e.g. Em, Ek, £) Ek		Initial discount rate 0.035		Results Ek												Prepared (date) 31/05/2012		Printed 31/05/2012		Prepared by Emma Hick		Checked by		Checked date					
PV total costs												Option 1 8,822.646				Option 2 9,549.246				Option 3 10,275.838				Option 4 8,942.084													
		Option 3				Option 4				Option 5				Option 6																							
		Capital	Maint.	Other	Negative costs	Cash	Capital	Maint.	Other	Negative costs	Cash	Capital	Maint.	Other	Negative costs	Cash	Capital	Maint.	Other	Negative costs	Capital	Maint.	Other	Negative costs	Cash	Capital	Maint.	Other	Negative costs	Cash	Capital	Maint.	Other	Negative costs			
cash sum	Discount																																				
year	Factor																																				
0	1.000					13,600				13,600				13,600				13,600				13,600				13,600				13,600				13,600			
1	0.966	284,097	13,600			297,697	274,490	13,140	0.000	284,097	13,600			297,697	274,490	13,140	0.000	284,097	13,600			297,697	274,490	13,140	0.000	284,097	13,600			297,697	274,490	13,140	0.000				
2	0.934	2,698,922	8,600			2,707,522	2,519,473	8,028	0.000	2,698,922	8,600			2,707,522	2,519,473	8,028	0.000	2,698,922	8,600			2,707,522	2,519,473	8,028	0.000	2,698,922	8,600			2,707,522	2,519,473	8,028	0.000				
3	0.902	2,728,922	8,600			2,737,522	2,461,331	7,757	0.000	2,728,922	8,600			2,737,522	2,461,331	7,757	0.000	2,728,922	8,600			2,737,522	2,461,331	7,757	0.000	2,728,922	8,600			2,737,522	2,461,331	7,757	0.000				
4	0.871		40,600			40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000	40,600	0.000	35,381	0.000				
5	0.842		13,600			13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000	13,600	0.000	11,451	0.000				
6	0.814		13,600			13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000	13,600	0.000	11,064	0.000				
7	0.786		13,600			13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000	13,600	0.000	10,689	0.000				
8	0.759		13,600			13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000	13,600	0.000	10,328	0.000				
9	0.734		43,600			43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000	43,600	0.000	31,991	0.000				
10	0.709		13,600	5,921		19,521	0.000	9,641	4,198	13,600	5,921	19,521	0.000	9,641	4,198	13,600	5,921	19,521	0.000	9,641	4,198	13,600	5,921	19,521	0.000	9,641	4,198	13,600	5,921	19,521	0.000	9,641	4,198				
11	0.685		13,600			13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000	13,600	0.000	9,315	0.000				
12	0.662		13,600			13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000	13,600	0.000	9,000	0.000				
13	0.639		13,600			13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000	13,600	0.000	8,696	0.000				
14	0.618		43,600			43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000	43,600	0.000	26,935	0.000				
15	0.597		13,600			13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000	13,600	0.000	8,118	0.000				
16	0.577		13,600			13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000	13,600	0.000	7,843	0.000				
17	0.557		13,600			13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000	13,600	0.000	7,578	0.000				
18	0.538		13,600			13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000	13,600	0.000	7,322	0.000				
19	0.520		13,600			13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000	13,600	0.000	7,074	0.000				
20	0.503		13,600	5,921		19,521	0.000	6,835	2,976	12,100	5,921	18,021	0.000	6,081	2,976	10,600	5,921	16,521	0.000	5,327	2,976	12,100	5,921	18,021	0.000	6,081	2,976	10,600	5,921	16,521	0.000	5,327	2,976				
21	0.486	263,547	13,600			277,147	127,971	6,604	0.000	357,569	12,100	369,669	173,625	5,875	0.000	451,590	10,600	462,190	219,279	5,147	0.000	274,907	12,100	287,007	133,487	5,875	0.000	1,753,179	816,828	5,677	0.000						
22	0.469	1,669,132	13,600			1,682,732	783,074	6,380	0.000	2,264,601	12,100	2,276,701	1,062,439	5,677	0.000	2,860,066	10,600	2,870,666	1,341,802	4,973	0.000	1,741,079	12,100	1,753,179	816,828	5,677	0.000	1,753,179	816,828	5,677	0.000						
23	0.453	1,669,132	13,600			1,682,732	756,593	6,165	0.000	2,264,601	12,100	2,276,701	1,026,511	5,485	0.000	2,860,066	10,600	2,870,666	1,296,427	4,805	0.000	1,741,079	12,100	1,753,179	783,206	5,485	0.000	1,753,179	783,206	5,485	0.000						
24	0.438	1,669,132	13,600			1,682,732	731,008	5,956	0.000	2,264,601	12,100	2,276,701	991,796	5,299	0.000	2,860,066	10,600	2,870,666	1,252,586	4,642	0.000	1,741,079	12,100	1,753,179	762,518	5,299	0.000	1,753,179	762,518	5,299	0.000						
25	0.423		13,600			13,600	0.000	5,755	0.000	12,100		12,100	0.000	5,120	0.000	10,600		10,600	0.000	4,485	0.000	12,100		12,100	0.000	5,120	0.000	10,600		10,600	0.000	4,485	0.000				
26	0.409	30,370	13,600			43,970	12,416	5,560	0.000	30,370	12,100	42,470	12,416	4,947	0.000	30,370	10,600	40,970	12,416	4,334	0.000	30,370	12,100	42,470	12,416	4,947	0.000	30,370	12,100	42,470	12,416	4,947	0.000				
27	0.395		13,600			13,600	0.000	5,372	0.000	12,100		12,100	0.000	4,780	0.000	10,600		10,600	0.000	4,187	0.000	12,100		12,100	0.000	4,780	0.000	10,600		10,600	0.000	4,187	0.000				
28	0.382		13,600			13,600	0.000	5,190	0.000	12,100		12,100	0.000	4,618	0.000	10,600		10,600	0.000	4,046	0.000	12,100		12,100	0.000	4,618	0.000	10,600		10,600	0.000	4,046	0.000				
29	0.369		13,600			13,600	0.000	5,015	0.000	12,100		12,100	0.000	4,462	0.000	10,600		10,600	0.000	3,909	0.000	12,100		12,100	0.000	4,462	0.000	10,600		10,600	0.000	3,909	0.000				
30	0.356		13,600	5,921		19,521	0.000	4,845	2,110	12,100	5,921	18,021	0.000	4,311	2,110	10,600	5,921	16,521	0.000	3,777	2,110	12,100	5,921	18,021	0.000	4,311	2,110	10,600	5,921	16,521	0.000	3,777	2,110				
31	0.346		13,600			13,600	0.000	4,704	0.000	12,100		12,100	0.000	4,185	0.000	10,600		10,600	0.000	3,667	0.000	12,100		12,100	0.000	4,185	0.000	10,600		10,600	0.000	3,667	0.000				
32	0.336		13,600			13,600	0.000	4,567	0.000	12,100		12,100	0.000	4,064	0.000	10,600		10,600	0.000	3,560	0.000	12,100		12,100	0.000	4,064	0.000	10,600		10,600	0.000	3,560	0.000				
33	0.326		13,600																																		

Costs		Phased Approach			
		Option 3 (M1+E1)	Option 4 (M1+E2)	Option 5 (M1+E3)	Option 6 (M1+E4)
Initial Design Costs	Cash	£189,398	£189,398	£189,398	£189,398
	<i>PV (discounted)</i>	£182,993	£182,993	£182,993	£182,993
Post-PAR Costs (SI, surveys, SBC, Site Supervision)	Cash	£662,893	£662,893	£662,893	£662,893
	<i>PV (discounted)</i>	£612,943	£612,943	£612,943	£612,943
Construction Costs (Construction, Prelims, OH&P)	Cash	£4,829,650	£4,829,650	£4,829,650	£4,829,650
	<i>PV (discounted)</i>	£4,432,299	£4,432,299	£4,432,299	£4,432,299
Environmental Mitigation	Cash	£30,000	£30,000	£30,000	£30,000
	<i>PV (discounted)</i>	£27,058	£27,058	£27,058	£27,058
Maintenance Costs over 100 years	Cash	£1,437,000	£1,317,000	£1,197,000	£1,317,000
	<i>PV (discounted)</i>	£460,348	£437,694	£415,040	£437,694
Future Costs (design, construction, strategic)	Cash	£11,474,247	£12,292,953	£13,111,635	£10,639,725
	<i>PV (discounted)</i>	£3,107,005	£3,856,258	£4,605,505	£3,249,096
	Year of Next Intervention	20	20	20	20
Risk Contingency		40.8%	45.3%	50.5%	39.7%
		£3,599,640	£4,325,808	£5,189,298	£3,550,007
<b>TOTAL COST</b>	<b>Cash</b>	<b>£22,222,828</b>	<b>£23,647,702</b>	<b>£25,209,874</b>	<b>£21,218,673</b>
	<b><i>PV (discounted)</i></b>	<b>£12,422,286</b>	<b>£13,875,053</b>	<b>£15,465,136</b>	<b>£12,492,090</b>
<b>Benefit-Cost Ratio (Benefits = £128,082,000)</b>		<b>10.31</b>	<b>9.23</b>	<b>8.28</b>	<b>10.25</b>

Note: PV = Present Value (costs discounted over the 100 year appraisal period in line with HM Treasury guidelines)