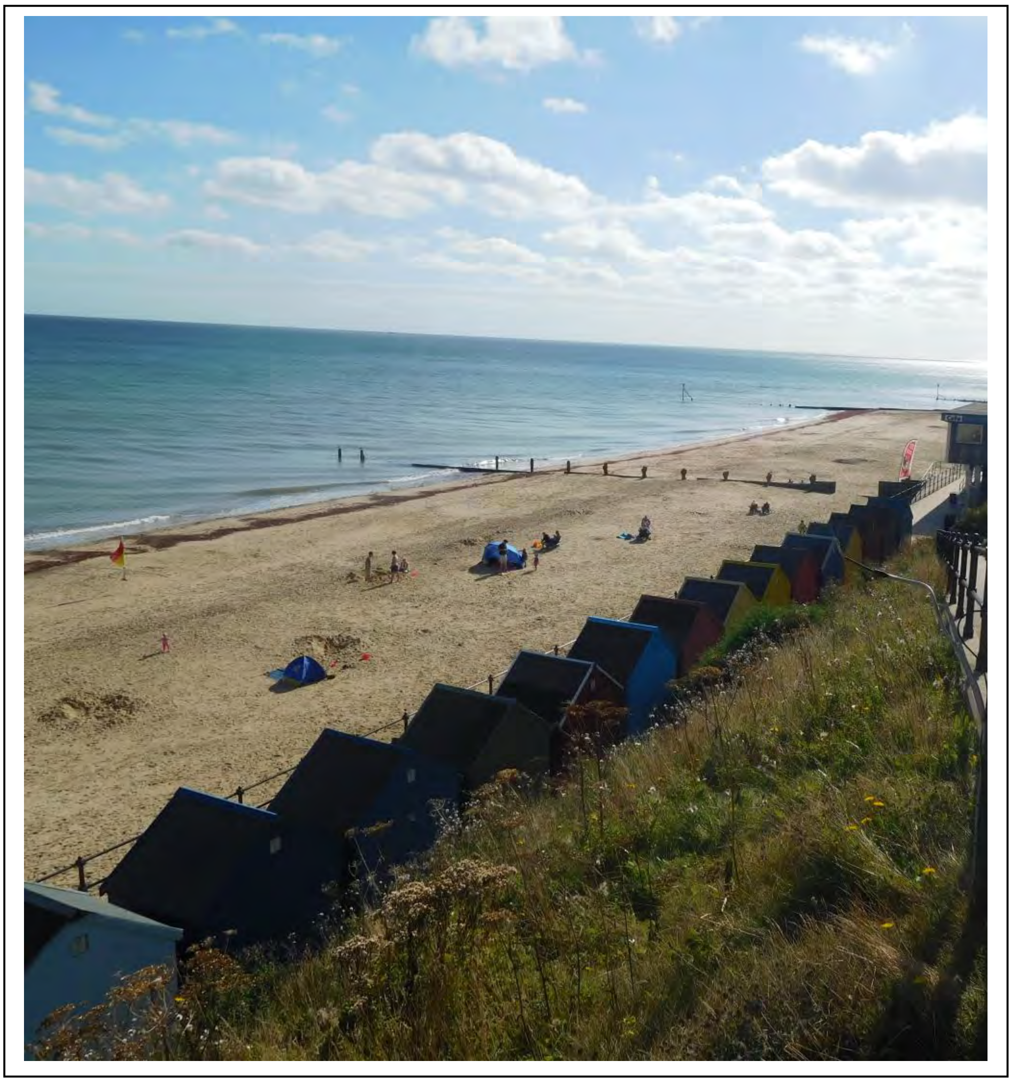
North Norfolk District Council Project

Mundesley Coastal Management Outline Business Case



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Date: June 2018

BUSINESS CASE APPROVAL SHEET

1 Review and Technical Approval

Project title	Mundesley Coastal Protection		
Authority project reference		EA reference	
Lead authority	North Norfolk District Council	Date of submission	
Consultant	AECOM	Document stage (SOC/OBC/FBC)	OBC
Previous document	SOC	Previous doc ref	
Job title	**Name**	**Signature**	**Date**
'I confirm that this project meets our quality assurance requirements, environmental obligations and Defra investment appraisal conditions and that all internal approvals, including member approval, have been completed and recommend we apply to the Environment Agency for capital grant and local levy in the sum of £			
Authority Project Executive			
'I have reviewed this document and confirm that it meets the current business case guidelines for local authority and Internal Drainage Board applications.'			
Business case reviewer			
'I confirm that the project is ready for assurance and that I have consulted with the Director of Business Finance'			
Area Flood and Coastal Risk Manager			
NPAS Assurance (Tick the appropriate box)	☐ Projects £100k - £10m	Large project review group (LPRG)	☐ Projects >£10m
Recommended for approval			Date
NPAS or LPRG Chair			
Project total as approved £		Version number	
Project total made up of :	Capital Grant (£k)		
	Levy (£k)		
	Other Contributions (£k)		

2 Project Financial approval

Financial scheme of approval	Project total	Name	Signature	Date
Director of Business Finance	All >£100k			
Director of Operations	£1m -£10m			
Executive Director of Operations	>£10m	N/A		N/A
Chief Executive	>£20m	N/A		N/A

3 Defra approval

Date sent to Defra (or N/A)		Version number (if different)	
Date approved by Defra (or N/A)			
Comments			

For FSoD Coordinator use only:

Table of Contents

1 Review and Technical Approval 2
2 Project Financial approval 2
3 Defra approval 2
1. Executive Summary 5
1.1. Introduction 5
1.2. Strategic case 5
1.3. Economic case 6
1.4. Commercial case 9
1.5. Financial case 10
1.6. Management case 11
1.7. Recommendation 13
1.8. Location plan 13
2. The Strategic case 14
2.1. Introduction 14
2.2. Business strategies 18
2.3. Environmental and other considerations 19
2.4. Investment objectives 22
2.5. Current arrangements 22
2.6. Main benefits 22
2.7. Main risks 23
2.8. Constraints 24
2.9. Dependencies 24
3. The Economic Case 25
3.1. Introduction 25
3.2. Critical success factors 25
3.3. Longlist options 26
3.4. Shortlist options 31
3.5. Scheme Options 34
3.6. Economic appraisal 35
3.7. Non-financial benefits appraisal 38
3.8. Preferred Scheme option 40
3.9. Sensitivity analysis 41
4. The Commercial case 44
4.1. Introduction and Procurement Strategy 44
4.2. Key contractual terms and risk allocation 44
4.3. Procurement route and timescales 45
4.4. Efficiencies and commercial issues 47
5. The Financial case 48
5.1. Financial summary 48
5.2. Funding sources 49
5.3. Impact on revenue and balance sheet 49
5.4. Overall affordability 50
6. The Management case 51
6.1. Project management 51
6.2. Communications and Stakeholder engagement 55
6.3. Change management 55
6.4. Benefits realisation 55
6.5. Risk management 56
6.6. Contract management 56
6.7. Assurance 56
6.8. Post project evaluation 56
6.9. Contingency plans 56

Appendices

Appendix A – PF Calculator
Appendix B – Shortlisted Option Outline Designs
Appendix C – Economic Assessment Report
Appendix D – Cost Report
Appendix E – Option Appraisal Report
Appendix F – Natural England Correspondence
Appendix G – Third Party Funding Correspondence
Appendix H – NNDC Funding Correspondence
Appendix I – Project Efficiency Register
Appendix J – Project Risk Register
Appendix K – Initial Designer's Risk Assessment

1. Executive Summary

1.1. Introduction

The Mundesley Coastal Management scheme seeks to implement erosion risk management measures to reduce the risk of erosion of the vulnerable cliffs along almost 2km of the Mundesley coastline. This report sets out the outline business case for funding the scheme. A location plan of the scheme extent is included in Section 1.8.

1.2. Strategic case

1.2.1 Strategic context

The need for improvements to the erosion risk infrastructure along the Mundesley frontage is detailed in several different strategic documents. A high level summary of these is provided in Table 1.1 with further details on each of the business strategies provided in Section 2.2.

Table 1.1: Summary of business strategies relating to the scheme frontage

Business strategy	Recommendation(s) relevant to the scheme frontage	Key driver(s)
Kelling to Lowestoft Ness Shoreline Management Plan' (SMP6)	Holding the Line (HTL) until 2055 before transitioning to a policy of Managed Realignment (MR).	To manage coastal erosion by reducing the risk to people and property thus avoiding future erosion damages.
The Cromer to Winterton Ness Coastal Management Study (Strategy)	Found that a Holding the Line policy could be technically and economically justified for the Mundesley frontage for both the SMP6 recommended 50years or a modified 100 year	To manage coastal erosion by reducing the risk to people and property thus avoiding future erosion damages.

Although only 37 years remain until 2055 and the start of the transition from the SMP6 'Hold the Line' (HTL) policy to a 'Managed Realignment' policy, the Cromer to Winterton Ness Coastal Management Study found that the original SMP policy (first drafted in 2005) of HTL for 50 years is still economically justified if commenced in the present day. Consequently, NNDC have assumed that both the appraisal period and the 50 year HTL policy commenced in 2017/18, however, the transition to a policy of 'Managed Realignment' (MR) is still expected to take place in line with SMP policy, as the transition from HTL to MR will still take place between 2055 to 2105.

1.2.2 The case for change

Without intervention the existing defences will progressively deteriorate over time until they eventually fail, resulting in the increased exposure of the cliffs to wave action (the primary driver of erosion). This coupled with future climate predictions, which forecasts increases in both sea levels and the frequency of large storm events, will result in the rate of erosion (currently 0.2 – 0.5 m / year) increasing. Therefore, in a No Active Intervention situation, over the course of the next 100 years the cliffs will be expected to recede by up to approximately 245 m due to erosion.

As the cliff recedes all of the assets situated on top of the cliffs (including properties) will also be expected to be lost, generating significant financial damages, disruption to the community, impacts on local business and tourism and placing the general public and local residents at risk of injury or death.

A coastal protection scheme at Mundesley will prolong the useful life of the existing defences or replace them where necessary in order to uphold the approved SMP6 policy of Hold the Line for the next 50 years and therefore prevent the increased rates of erosion expected in a No Active Intervention situation.

The people and key assets that will benefit from a scheme throughout the appraisal period would include:

- Approximately 600-700 local residents (based on the Norfolk average of 2.3 people per residential property)
- 297 residential properties
- 96 commercial properties
- Various historic monuments or listed sites
- Community facilities (including a library and museum)
- Electricity substations
- Anglian Water pumping station
- Various utility infrastructure
- The beach and foreshore
- Various roads (including the B1159)
- Several beach access points
- Local tourism and tourism related properties (holiday cottages, beach huts etc.)
- The Lifeboat station

- Environmental habitats

Additional benefits of the scheme will include:

- Improved safety of residents and users of the sites along the frontage;
- Strategic infrastructure with scheduled future maintenance;
- Reduces the burden on the reactive emergency response to future storm events;
- Reduction in business disruption due to erosion damage with positive impacts for the local economy; and
- Safeguarding existing employment areas and facilitating future growth.

1.2.3 Objectives

The investment objectives have been set to reflect the importance of delivering robust and sustainable erosion risk management infrastructure for existing communities, acknowledging the importance of the area for both tourism and future development opportunities as identified in the Council's Core Development Strategy (see Section 2.2.4).

The key investment objectives for the project are:

- To reduce erosion risk to people, property and infrastructure for the duration of the scheme
- To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable;
- To enhance the frontage's resilience to climate change impacts;
- To maintain and where possible enhance natural, historic and built environments;
- To avoid disruption to and where possible enhance local tourism; and
- To facilitate sustainable growth in the village of Mundesley by enabling development opportunities for employment and residential purposes along with the associated infrastructure.

These objectives also comprise the critical success factors for the scheme (see Section 3.2).

1.3. Economic case

1.3.1 Options considered

Flood and Coastal Erosion Risk Management (FCERM) Appraisal Guidance sets out the option development and appraisal process which was followed in order to determine the preferred option for the scheme. The longlist of options was developed in collaboration with NNDC, with a further detailed appraisal undertaken of the shortlisted options during development of this business case.

A summary is provided in Table 1.2 and Table 1.3. Please refer to Section 3.3 and Section 3.4 for further details on the option appraisal.

Table 1.2 - Longlist of options

Option name	Short-listed?
No Active Intervention	
Do Nothing	Yes
Do Minimum	Yes
Active Intervention	
Option 1 – Seawall	
Option 1A: Maintain the existing seawall and construct new seawall along the rest of the frontage	No
Option 1B: Maintain the existing seawall and apron through concrete encasement	Yes
Option 1C: Concrete Sea wall and apron encasement with additional rock armour protection	Yes
Option 1D: Raise the existing seawall in line with climate change	No
Options 2-5	
Option 2 - Off-shore Rock Armour Breakwater	No
Option 3 - Rock Armour Revetment	Yes
Option 4 - Concrete Block Revetment	No
Option 5 - Rock Armour Protection Sill (placed on beach)	Yes
Option 6 – Timber Revetment	
Option 6A - Replace Timber Revetment with Oak	No
Option 6B - Replace Timber Revetment with tropical hardwood	No

Option 6C – Refurbish existing revetment with oak	Yes
Option 6D – Refurbish existing revetment with tropical hardwood	Yes
Option 7 – Steel Framed Structure	
Option 7A: Reinforce existing Steel Framed structure - Concrete Blocks	Yes
Option 7B: Reinforce existing Steel Framed structure - Rock Armour	Yes
Option 7C: Reinforce and raise existing structure – Concrete Blocks	No
Option 7D: Reinforce and raise existing structure – Rock Armour	No
Option 7E: New steel framed structure – Concrete Blocks	No
Option 7F: New steel framed structure – Rock Armour	No
Option 8 – Timber Groynes	
Option 8A: Maintain through refurbishment	Yes
Option 8B: Replace with like for like	No
Option 8C: Refurbish and enhance to impermeable structure	No
Option 8D: Replace with an impermeable structure	No
Option 8E: Maintain through refurbishment with rock protection	Yes
Options 9-11	
Option 9 - Rock Armour Groynes	No
Option 10 - Gabion Toe Protection	No
Option 11 - Beach Nourishment	Yes
Option 12 - Cliff Stabilisation	No
Option 13 - Embankment Scour Protection	
A - Scour protection gabions	No
B - Upstand wall	Yes
C - Interlocking porous concrete block/ mattress revetment	Yes
D - Scour protection concrete canvas	No
E - erosion control mat	No
F - Sprayed concrete protection	No

Table 1.3 – Shortlist of options

Option name	Taken forward for Economic Appraisal
No Active Intervention	
Do Nothing	Yes
Do Minimum	Yes
Active Intervention	
Option 1 – Seawall	
Option 1B: Maintain the existing seawall and apron through concrete encasement	No
Option 1C: Concrete Sea wall and apron encasement with additional rock armour protection	Yes
Options 3 and 5	
Option 3 - Rock Armour Revetment	Yes
Option 5 - Rock Armour Protection Sill (placed on beach)	Yes
Option 6 – Timber Revetment	
Option 6C – Refurbish existing revetment with oak	No
Option 6D – Refurbish existing revetment with tropical hardwood	Yes
Option 7 – Steel Framed Structure	
Option 7A: Reinforce existing Steel Framed structure - Concrete Blocks	No
Option 7B: Reinforce existing Steel Framed structure - Rock Armour	Yes

Option 8 – Timber Groynes	
Option 8A: Maintain through refurbishment	No
Option 8E: Maintain through refurbishment with rock protection	Yes
Option 11	
Option 11 - Beach Nourishment	Yes
Option 13 - Embankment Scour Protection	
B - Upstand wall	No
C - Interlocking porous concrete block/ mattress revetment	Yes

One thing that is common to all of the shortlisted options is that none of them can be adopted to protect the entire frontage. It is necessary, due to the nature of the coastline, the existing defences and for reasons of affordability that a coastal protection scheme will need to comprise a combination of interventions from the shortlisted options.

Having assessed and costed all of the potential defence options it has been possible to develop a number of different combinations for a scheme to deliver a 'Hold the Line' Policy for the next 50 years. 9 different combinations of the various shortlisted options, each compiled to ensure that the entire frontage is protected, have been considered over a 50 year appraisal period.

Table 1.4 below summarises the resulting 9 combinations of shortlisted options that have been joined together to form complete defence solutions for a scheme for the whole frontage.

Table 1.4 – Scheme options

Scheme Option	Description
1	**Do Nothing**; Stop all funding, no further capital works or maintenance.
2	**Do Minimum**; No capital spend, only routine maintenance until the defences reach the end of their residual life, then stop maintenance
3	**Rock Revetment**; Includes for a rock armour revetment along the toe of the cliff for the entire frontage except along the existing seawall. This option also Includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
4	**Maintain Existing**: This option is to maintain all of the existing defences, this will including reinforcing the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
5	**Partial Rock placement A**: Includes for rock armour protection along the length of the existing timber revetment, to reinforce the existing steel structure and to undertake seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
6	**Partial Rock placement B**: Includes for rock armour protection along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
7	**Full Rock Placement:** Includes for the placement of rock armour protection along the length of the frontage except along the existing seawall. This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
8	**Beach Re-Nourishment**; Including a significant quantity of beach re-nourishment to raise the level of the beach. This option also includes for seawall (not apron) and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
9	**Adaptive Option**: Similar to Option 7 as it also includes for the placement of rock armour along the remainder of the frontage, but is limited to 1 shipment of rock (i.e. 25,000 tonnes). This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

1.3.2 Key findings

Economic Appraisal

The economic appraisal shows that when assessed against the FCERM decision rules the economically preferred option for a scheme for the 50 year period is Option 9 (the Adaptive Option) as it has the best benefit to cost ratio (BCR) of 8.26:1. Although the Do Minimum (Option 2) has a higher BCR of 16.38, when Option 9 is compared incrementally against the Do Minimum option it achieves an incremental benefit cost ratio of 7.42:1, which robustly justifies the additional spend of Option 9 over that of the Do Minimum.

The results also showed that the economically preferred active intervention option over a 100 year period remains the Adaptive Option (Option 9), with a benefit to cost ratio of 8.76:1. In addition, the appraisal found that when Scheme Option 9 is compared to 'Do Minimum' over a 100 year period it achieves an incremental benefit cost ratio of 8.18:1, which clearly demonstrates that if the 'hold the line' policy was to be extended to 100 years then the additional spend would be economically justified and outweighed by the additional benefits. This therefore demonstrates that in future revisions of the SMP or Coastal Strategy, the case to extend a hold the line policy to year 100 should be revisited and reconsidered.

Critical Success Assessment

By utilising the assessment undertaken of all the constituent shortlisted options and the economic appraisal of the scheme options it has been possible to measure each of the scheme options against the critical success factors that have been identified for the scheme as summarised in Table 1.5 below.

Table 1.5 – Critical Success Assessment

Critical Success Factor	Scheme Options								
	1	2	3	4	5	6	7	8	9
To reduce erosion risk to people, property and infrastructure for the duration of the scheme	☹	☹	☺	☺	☺	☺	☺	😐	☺
To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable	☺	☺	☹	😐	😐	😐	😐	☹	☺
To maintain and where possible enhance natural, historic and built environments	☹	☹	😐	☺	☺	☺	☺	😐	☺
To maintain and where possible enhance the tourist industry in Mundesley	☹	☹	😐	😐	😐	😐	😐	☺	😐
To facilitate NNDC in meeting their Development goals for Mundesley including employment and residential properties and associated infrastructure over the life of the scheme.	☹	☹	☺	☺	☺	☺	☺	☺	☺

The results of this critical success assessment support the results of the economical appraisal, as Scheme Option 9 is again the preferred option. This is because Scheme Option 9:

- Successfully reduces the erosion risk to the people, property and infrastructure of Mundesley.
- Is the most cost effective of the active intervention options.
- Is both technically feasible and sustainable.
- Protects the natural, historic and built environments without any significant impacts on local designations, landscapes or coastal processes.
- Does not adversely impact and will help to maintain the existing tourism industry.
- Does not adversely impact and will help to facilitate NNDC's development plans for Mundesley.

1.3.3 Preferred way forward

Following the option appraisal process the technically, environmentally and economically preferred option is Scheme **Option 9 – Adaptive Option**, which is comprised of the following 4 elements of work (described in more detail in Section 3.8):

1. **Rock Works:** Placing rock armour (initially 25,000 tonnes) protection along the frontage (except along the existing seawall) on the beach in front of the cliffs, either supplementing or (in time) replacing the existing defences.
2. **Scour Protection:** Placing a cabled concrete solid block mattress over the lower end of the embankment (behind the seawall) to protect against overtopping scour.
3. **Timber Groynes:** Major refurbishment of the existing timber groynes by replacing 30% of the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. In addition, this option also includes placing rock armour protection around the more vulnerable seaward end of the existing groynes in order to reduce the future maintenance requirements.
4. **Seawall and apron**: Encasing the existing structure in reinforced concrete when necessary; initially this involves encasing only a limited number of sections of the existing wall/apron, ensuring that the residual life of the entire seawall is uniform. In addition, this option also includes additional rock armour protection for particularly vulnerable sections of the structure, therefore reducing the need for future works.

1.4. Commercial case

1.4.1 Procurement strategy

The preferred procurement strategy for the scheme is a traditional design-bid-build approach. This would allow for greater control over design and quality by procuring appropriate designers and contractors and allowing the opportunity to work as an integrated team. It would also provide the potential to maximise efficiency savings throughout the design process and still provide greater cost certainty through client led risk management.

Procurement of any services and works associated with delivery of the scheme will follow NNDC Contract Procedure Rules to ensure compliance with relevant EU Directives and UK legislation. The use of existing frameworks, where they exist and are applicable to the scheme, could be beneficial especially given the potential reduction in time and cost associated with procuring services and works through these vehicles whilst ensuring compliance with procurement rules.

NNDC has a number of frameworks available to utilise which contain suitable and appropriate suppliers to deliver construction related works and services (an overview of these is presented in Section 4.3).

The WEM Framework has been identified as a potential route to market for the scheme although it is considered that additional value for money can be achieved through local direct procurement for some aspects of the scheme. The WEM Framework could offer a low risk timely route to market which will optimise the potential for design control, cost certainty, risk reduction and efficiencies through an established framework with pre-determined terms and conditions. In addition, this Framework enables the user to appoint each supplier separately whilst still enabling early contractor involvement. This route also benefits from potential support from working with partner organisations, such as, NCPMS and NEAS within the Environment Agency. Alternative local procurement processes are well established with high quality efficient outputs delivered as demonstrated in the recently completed Sheringham West Coastal Management Scheme. Depending on the timescales of other local projects there may be some potential for various synergies resulting in opportunities for efficiencies through joint procurement and management of some aspects of the scheme.

1.4.2 Key contractual terms and risk allocation

Any services and works to be provided by a contractor shall be based on the terms of the relevant NEC contract, in accordance with the requirements set out in the framework agreement. The key contractual terms, and therefore risk allocation, of each contract will be dependent on the services/works to be delivered, any identified amendments set down within the overarching framework agreement and recommendations from the NNDC legal team in relation to secondary options and additional conditions. Contractual terms have not been developed as part of the outline business case but this will be undertaken at the next stage of the scheme.

1.4.3 Efficiencies

Approximately £836k of potential efficiency savings have been identified for the scheme equating to approximately 24% of the total PV capital cost which can be delivered or reinvested into the scheme.

Identifying and realising efficiencies will be an integral part of the delivery of the scheme, with an aim to deliver in excess of 15% efficiency savings on the overall scheme cost. NNDC will work closely alongside the Designer and Contractor(s) to ensure regular monitoring and forecasting of efficiency savings. These will be reported to NNDC and the Environment Agency as part of Project Management reporting.

1.5. Financial case

1.5.1 Summary of financial appraisal

A summary of the costs for the preferred option is provided in Table 1.6.

Table 1.6 - Financial summary of projected costs for the preferred option

	Economic appraisal (PV)	Whole-life cash cost	Total project cost (approval)
Costs up to OBC	N/a – sunk costs	£70,000	Exc. previous app
Costs after OBC			
Staff costs	£0	£0	£0
External fees	£205,534	£208,330	£206,313
Construction and site costs	£2,214,135	£2,291,630	£2,235,737
Environmental	£25,161	£26,041	£25,406
Land and compensation	£75,482	£78,124	£76,218
Other	£0	£0	£0
Risk - Optimism Bias (30%)			£763,102
Risk - Optimism Bias (30%)	£756,094	£781,237	
Inflation (at 2.5%APR)	N/a	N/a	£78,586
Future costs (construction + maintenance)	(PV) £1,321,640	(Cash) £2,934,909	N/a
Future optimism bias	£396,492	£880,473	
Project total costs	£4,994,538	£7,270,744	£3,385,362

1.5.2 Funding sources

The identified sources of funding for the scheme are shown in Table 1.7.

Table 1.7 - Overview of funding sources

	%	Description	Total £ (PV)	Total £ (Cash)
Raw partnership funding score	87			
Funding:				
Local Levy - Appraisal Costs		Received	£70,000	
Contributions - private (Parish Council)			£19,324	£20,000
Contributions - private (Anglian Water)			£241,546	£250,000
Contributions - public (NNDC)			£225,248	£227,414
Inflation (@2.5% APR) - NNDC			£75,928	£78,586
Non GiA contributions			**£632,046**	**£576,000**
Adjusted Partnership funding score	105			
Grant in Aid		Scheme is eligible for up to	£2,714,359	£2,809,362
Project total costs (approval)		Up-front costs	**£3,346,405**	**£3,385,362**

The risk contingency (optimism bias) allowance identified within the financial summary (see Table 1.6) will be split so that Grant in Aid (GiA) covers approximately 83% (cash), with the remaining 17% being covered by third party contributions. Any additional overspend or increases in cost will either be met through additional contributions or will be underwritten by NNDC (subject to an affordability assessment).

1.5.3 Overall affordability

The annualised spend profile showing the overall affordability for the scheme is provided in Table 1.8.

Table 1.8 - Financial summary of projected costs for the preferred option (PV)

Annualised spend profile (£k)	Pre 2018	Yr. 0 2017/18	Yr. 1 2018/19	Yr. 2 2019/20	Yr. 3 2020/21	Yr. 4+	Total
Construction and other costs	70.00	125.65	2,412.18	-	-	-	2,607.83
Optimism bias and risk	-	37.69	700.88	-	-	-	738.57
Project total costs	**70.00**	**163.34**	**3,113.06**	**-**	**-**	**-**	**3,346.40**
Less: Contributions	70.00	163.34	398.70	-	-	-	632.04
Capital Grant	-	-	2,714.36	-	-		2,714.36

1.6. Management case

1.6.1 Project management

Delivery of the scheme will follow the PRINCE2 methodology, overseen by a multi-agency Project Board comprising senior management representation from NNDC, the Environment Agency and the appointed supplier(s) and supported by a project team, which will be led by a Project Manager. An overview of the key roles and responsibilities are summarised in Table 1.9. Further detail on the project structure and governance arrangements is contained in Section 6.

Table 1.9 -: Key roles and responsibilities

Role	Person	Responsibility
Senior Responsible Officer	NNDC Director **Steve Blatch**	Enable linkage between the top level strategic direction of the organisation and the management activities required to achieve strategic objectives.
Project Executive	Head of Coastal Partnership East Director **Bill Parker**	The Project Executive represents NNDC/Coastal Partnership East and is ultimately responsible for the project, supported by the Senior User and Senior Supplier. The Project Executive's role is to ensure that the scheme is focused throughout its life cycle on achieving its objectives and delivering a product that will achieve the projected benefits. The Project Executive has to ensure that the scheme delivers value for money, ensuring a cost-conscious approach to the project, balancing the demands of business, user and supplier. The Project Executive is responsible for overall business assurance of the scheme.
Senior User(s)	NNDC Coastal Manager **Rob Goodliffe**	The Senior User is responsible for the specification of the needs of all those who will use the final product, for user liaison with the project team and for monitoring that the solution will meet those needs within the constraints of the Business Case in terms of quality, functionality and ease of use.
Senior Supplier	To Be Appointed	The Senior Supplier is responsible for the technical integrity of the elements of the project under their commissions.

Role	Person	Responsibility
Project Assurance	Project Board	Project Assurance provides an independent view of how the project is progressing. There are three views of assurance; business, user and supplier. Assurance is about checking that the project remains viable in terms of costs and benefits (business assurance), checking the user requirements are being met (user assurance) and that the project is delivering a suitable solution (supplier assurance).
Project Manager	Coastal Partnership East Engineering Manager **Tamzen Pope**	The Project Manager has the authority to run the project on a day-to-day basis on behalf of the Project Board within the constraints and tolerances laid down. The Project Manager's prime responsibility is to ensure that the project produces the required product, to the required standard of quality and within the specified constraints of time and cost. The Project Manager is also responsible for the project producing a result that is capable of achieving the benefits defined in the Business Case.

1.6.2 Programme

The key milestones for the scheme are provided in Table 1.10.

Table 1.10 - Key dates and milestones.

Activity	Target Completion Date	Comment
Anglian Water Funding Approval	April 2018	Confirmation Received
NNDC Approval	Spring/Summer 2018	-
Project Business Case Approval	Spring/Summer 2018	Includes Environment Agency (FCERM GiA)
Detailed Design (including surveys etc.)	Summer/Autumn 2018	Assumes a 4 month programme (including any investigations) following business case approval,
Obtain all necessary consents	Winter 2018	Assumes a 4 month programme following the detailed design to obtain all the various required consents.
Complete delivery agreement for the Construction Stage	Spring 2019	Allows 2-3 months for procurement activities following the receipt of all required consents.
Construction work to be started on site	Summer 2019	Allows for at least a 6 weeks mobilisation period following contract award.
Construction work completed	Winter 2019	Assumes a 6 month construction programme

1.6.3 Communications

Key future communications include:

- Continued landowner and stakeholder engagement and negotiations. Where possible maintaining continuity with established points of contact.
- Additional external communications with wider public through existing channels, as required.
- Regular dialogue between Contractor and Stakeholders via a dedicated communications representative.
- Statutory consultee input and liaison as and when required e.g. Marine Management Organisation, Planning, and Natural England etc.
- Additional consultation associated with a potential Planning Application for the scheme.

1.6.4 Benefits realisation

The realisation of benefits will be managed by NNDC in their capacity as the lead organisation overseeing delivery of the scheme. There are numerous benefits to the scheme but only the identified financial benefits need to be realised to justify the investment. All benefits will be realised when the construction works have been completed.

1.6.5 Risk management

The key risks for the scheme and the proposed mitigation for each is summarised in Table 1.11.

Table 1.11 - Key risks for delivery of the scheme

Key risks	Mitigation
Variation in material prices (particularly rock and timber)	Optimism bias of 30% has been applied to all estimated costs. NNDC will seek to bulk purchase most materials with beneficial prices and store locally.
Fluctuations in currency market (Value of £)	Optimism bias, seek to bulk purchase with beneficial prices and store locally.
Unforeseen specific technical issues identified during detailed design leading to redesign of sections of work	Designer's risk assessment to be undertaken during the detailed design process by suitably experienced personnel. Optimism Bias of 30% has also been applied to all cost estimates to cover all unforeseen risks. Detailed ground investigation following Eurocode standards prior to completion of detailed design.
Funding changes in delivery period due to multiple sources of contributions and third party funding either being delayed or not materialising.	Early engagement with potential third party funders has been on-going and written funding commitments have been obtained from NNCD, Mundesley Parish Council and Anglian Water. Continued engagement will ensure that legal agreements are completed and the funding arrives in a timely manner. Possible re-profiling of contributions with updates on the scheme.
Funding shortfall due to overspends	The scheme has been designed to be affordable, if unforeseen costs arise they will either be met by NNDC or the scope of works will be reduced, therefore works will be scheduled in order

	of priority.
Potential for damage to properties during construction	Condition survey of buildings prior to construction, monitoring during construction, avoiding potentially sensitive locations.
Accelerated deterioration of existing defences.	Condition of the existing defences to be regularly monitored, works to commence early in the programme.
Delays or objections in obtaining the required consents and approvals	Early and on-going engagement with the relevant approval authorities will identify any potential issues early in the detailed design process. Adequate time will also be allowed in the programme to obtain all the required consents.
Change of landowners/uses along the frontage	Continued engagement throughout detailed design and construction to work with landowners/operators to identify potential changes as early as possible.
Unexploded Ordnance	Appropriate UXO investigations will be undertaken during the detailed design process, and if required potential mitigation measures such as watching brief or probing can be adopted during construction. In addition, the construction programme will be designed to be flexible to minimise downtime on discovery of a UXO.
Changes in guidance or legislation	Major changes not foreseen, sensitivity analysis undertaken which demonstrates that the scheme is robust against a reasonable range of uncertainty.

1.6.6 Assurance, approval and post project evaluation

Project assurance and change management approval will be undertaken by the Project Board. The scheme will have to follow the relevant NNDC internal approval processes.

As part of the closedown of the project, there will be a post project evaluation to verify that all the objectives have been met, the intended benefits have been realised and lessons learnt during the project are captured and shared with the Project Board.

1.7. Recommendation

The recommendation of this outline business case is for the approval of the identified preferred option which is **Combinational Option 9 – Adaptive Option**, which is as described in Section 1.3.3, is comprised of the following 4 elements of work:

1. Rock works (limited to 25,000 tonnes).
2. Concrete mattress scour protection.
3. Timber Groynes, with rock armour protection for the exposed seaward end
4. Seawall and apron; with rock armour protection of exposed sections.

The total project cost for approval is **£3,385,362** (cash), of which approximately 83% is being sought from FCERM GiA and the remainder from other funding sources.

1.8. Location plan

A location plan is presented in Figure 1.1 below:

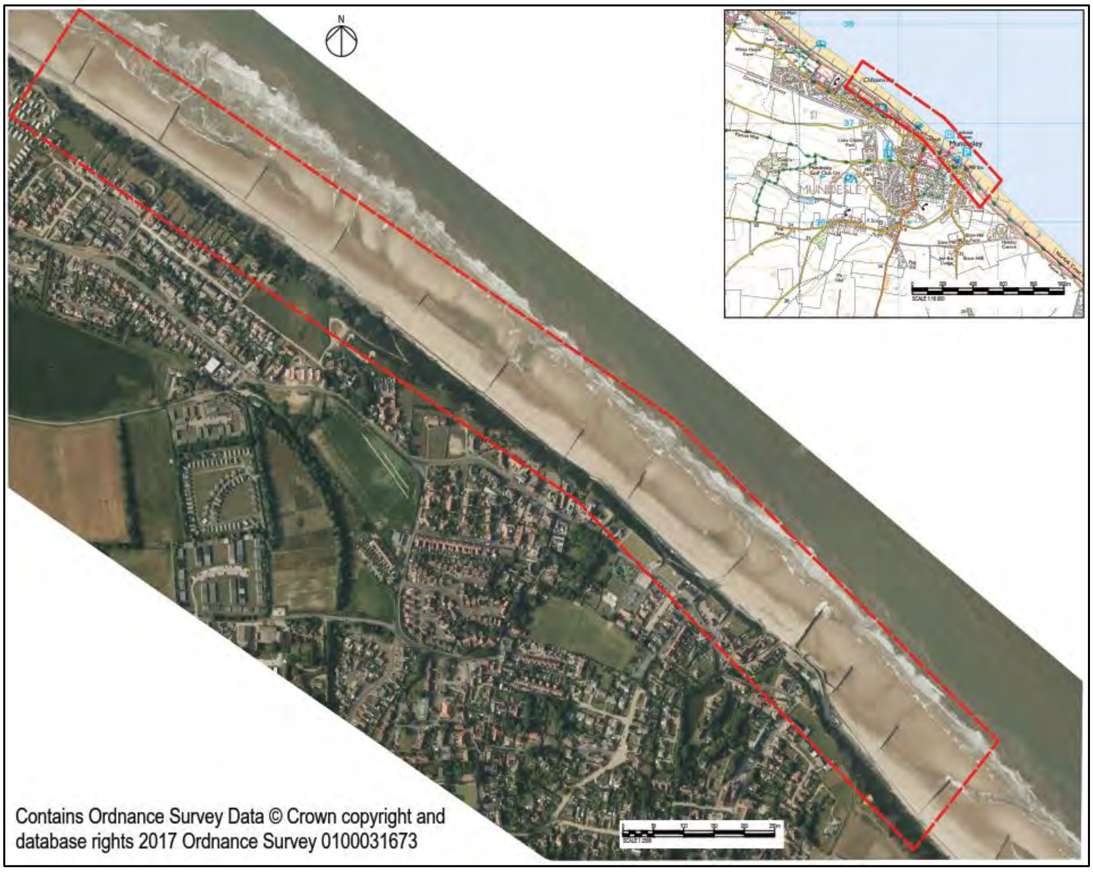

Figure 1.1: Site location plan (extent of site highlighted red)

2. The Strategic case

2.1. Introduction

2.1.1 Mundesley

Mundesley is a coastal village located on the Norfolk coastline that falls under the local governance of North Norfolk District Council. The vast majority of the village and associated infrastructure (including both residential and commercial properties) are situated on top of the Pleistocene sequence cliffs that dominate the shoreline. These cliffs are fronted by a natural sandy/shingle beach that can be directly accessed from the village centre, which helps to make Mundesley a popular tourist destination, with over 7000 visitors passing through the information centre each year.

2.1.2 Overview of the problem

Due to its north-easterly aspect, the coastline at Mundesley is exposed to coastal and weather conditions that originate in the North Sea, consequently, both the beach and cliffs are continuously subjected to attritional forces such as wave action and water level surges that act to erode the coastline.

Although the Mundesley frontage is currently protected by a range of coastal defences, which have successfully slowed the rate of cliff erosion, these defences are of mixed type, age and condition and in some cases are now approaching or have surpassed the end of their intended service lives.

Recent winter storm events have served to highlight the vulnerability of the existing defences, as significant damage was sustained in 2013, 2016 and 2018 (See Figure 2.1). During these recent storms, large waves overtopped the seawall and caused scour on the unprotected slope which resulted in the main beach access route from the village being undermined. In addition, the 2018 winter storms significantly lowered the level of the beach along the entire frontage.

With future climate predictions indicating increases in both sea levels and the frequency of large storm events this vulnerability is likely to be exacerbated leading to concerns that the rate of recession of the cliffs along the frontage will increase over time increasing the risk to both the people and assets of Mundesley.

Figure 2.1 – Typical Winter Storm Damage

2.1.3 Existing Defences

The Mundesley frontage (shown in Figure 1.1) spans nearly 2km and is currently protected by a number of different types of defences. These defences offer different levels of protection and are in varying conditions. As part of the appraisal process undertaken in preparation of this outline business case, all of the existing defences were inspected, their condition assessed and their residual life estimated.

The existing defences are summarised below and are illustrated in Figure 2.2:

Timber groynes - Timber groynes existing along the frontage act to trap sediment and increase beach levels. Typically they are 60-70 m long and permeable. The current condition is typically ‘Fair’, as although the groynes appear fairly robust and are functioning; many of the timbers are either missing or significantly impaired due to either rot or attritional damage (although it should be noted that there are a few exceptions where the condition is considered to be ‘Poor’). It is estimated that without further maintenance the residual life of most of the groynes will be approximately 5 years (or less, where the condition was found to be ‘Poor’), although their performance as a beach control structure will continue to deteriorate over that period.

Seawall - A concrete seawall protects approximately 580 m of the frontage. The area landward of this protection is the most heavily built-up part of Mundesley. The seawall varies in design with different types of recurve detail and finishing. At the time of the inspection, it was evident that much of the wall has been renovated and as a result the majority of the seawall was typically found to be in a ‘good’ condition (all except one section, which was found to be ‘Fair’). It is estimated that without further maintenance the residual life of most of the seawall will be at least 15 years.

Seawall Apron – The seawall is fronted by a concrete apron (of variable width) with a sheet piled toe, at the time of the inspection only limited sections of the apron and piling were accessible. However, information provided by NNDC indicates that the apron is typically intact, but the surface finish is deteriorating due to attrition and is in need of some maintenance to prevent the deterioration from progressing into a more serious failure. The condition of the apron is therefore believed to be in a ‘Fair’ condition. It is estimated that without further maintenance the residual life of most of the seawall will be at approximately 10 years.

Timber revetment - Two sections of hardwood timber revetment protect the frontage. The section southeast of the seawall measures approximately 315 m and the section northwest of the sea wall measures approximately 720 m. At the time of the inspection, significant emergency works were being undertaken to repair the timber revetment following storm damage, as a result the current condition of the structure was typically found to vary from ‘Poor’ to ‘Fair’ (depending how recently it had been repaired). It is estimated that without further maintenance the residual life of most of the timber revetment will be less than 5 years.

Steel framed structure - A steel framed structure filled with concrete blocks, rocks and rubble exists along approximately 465 m of the frontage. The current condition of the steel framed structure was found to be ‘Poor’, as although the structure is intact, there is evidence of both missing steel members and significant corrosion on those that remain. In places, due to falling beach levels the corroding steel structure was found to be retaining approximately a 2 m high pile of concrete blocks, rocks and rubble, therefore if the frame was to fail it would present a significant risk to public safety. It is estimated that without further maintenance the residual life of the steel structure will be less than 5 years.

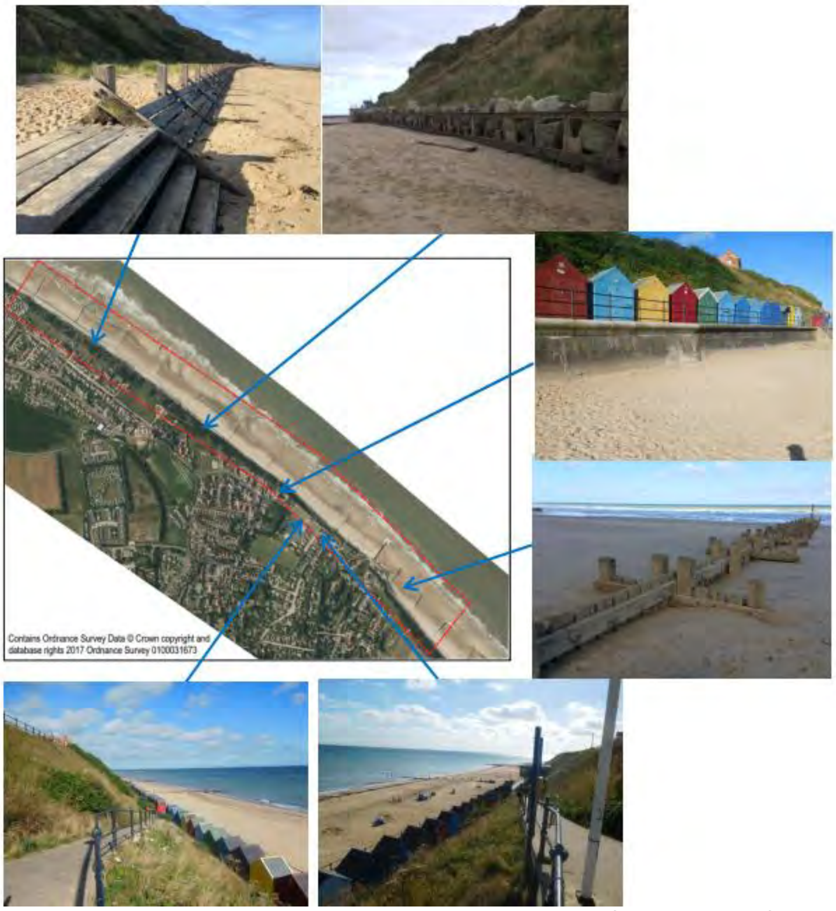

Figure 2.2: Photographs illustrating the nature of the existing frontage

2.1.4 Residual Life

Table 2.1 summarises the estimated residual life of the existing defences in 'Do Nothing' and 'Do Minimum' (routine maintenance only) scenarios. The estimates are based on the inspection completed during the 2016/17 condition survey and builds upon the previous assessments undertaken in 2003 and 2012.

Table 2.1 – Summary of the estimated residual lives of the existing defences.

Asset	Typical Condition	Typical estimated residual life with no maintenance (Do Nothing)	Typical estimated residual life with only routine maintenance (Do Minimum)
Seawall and Promenade	Good (with one Fair exception)	15 (10) Years	30 (20) Years
Concrete Apron	Fair*	10* Years	20* Years
Timber Revetment	Poor to Fair	<5 Years	8 Years
Steel Framed Structure	Poor	<5 Years	5 Years
Timber Groynes	Fair (with some poor exceptions)	5 (<5) Years	10 (5)Years

* Beach levels prevented the detailed inspection of all the concrete aprons – residual life estimate provided by NNDC

2.1.5 Consequences of Doing Nothing

Without intervention the existing defences will progressively deteriorate over time until they eventually fail, resulting in the increased exposure of the cliffs to wave action (the primary driver of erosion). This coupled with future climate predictions, which forecasts increases in both sea levels and the frequency of large storm events, will result in the rate of erosion (currently 0.2 – 0.5 m / year) increasing. Over the course of the 100 year appraisal period the cliffs will be expected to recede by up to approximately 245 m due to erosion (see section 2.1.7).

As the cliff recedes all of the assets situated on top of the cliffs (including properties) will also be expected to be lost, generating significant financial damages, disruption to the community, impacts on local business and tourism and placing the general public and local residents at risk of injury or death.

2.1.6 Management Options

There are different management options available to NNDC to address the erosion risk at Mundesley. They include:

Do Nothing - The Do Nothing option would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course. The Do Nothing option is the baseline against which all other options will be compared. This approach is discounted because it is not compliant with the 'Hold the Line' policy and will ultimately lead to large damages, but it will be used as a baseline to judge other options.

Do Minimum - The Do Minimum option involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works. In effect, the Do Minimum approach is a delayed Do Nothing, as it will also eventually allow the defences to fail and nature to take its course. This option will be discounted because it is not compliant with the 'Hold the Line' policy and will also lead to large damages, but it has been considered within this OBC in line with the FCERM guidance.

Maintain Existing Protection – This option involves the continued monitoring and maintenance of the existing defences, as well as allowing for the like-for-like replacement of failed or failing structures. However, this option does not include enhancing or improving the defences, and therefore accepts that the level of protection will fall over time due to climate change. This option may be suitable for some of the existing defences on the frontage and it warrants further investigation and appraisal.

Replace/Enhance Existing Protection – Like the maintain option as this approach also involves monitoring and maintaining existing defences, however, it also allows for either replacing or enhancing the existing defences to either improve the level of protection, maintain the level of protection (in line with climate change projections) or to make a defence more sustainable (i.e. more resilient). This option may also be suitable for some of the existing defences on the frontage and it warrants further investigation and appraisal.

2.1.7 Erosion

The primary concern along this frontage is the recession of the cliffs and although the centre of Mundesley is protected by a reinforced concrete sea wall, to either side the cliffs have been gradually receding over time. This recession of between 0.2 m and 0.5 m a year (Environment Agency, 2013) has occurred even with the presence of existing defences such as the timber revetments and rubble filled steel framed structures. However, as these structures deteriorate and/or fail the cliffs will be increasingly exposed to attritional forces (such as wave action) and the rate is expected to significantly increase.

As part of the 2013 Cromer to Winterton Coastal Study (NNDC, 2013), Soft Cliff and Platform Erosion (SCAPE) modelling of the Mundesley frontage was undertaken to determine the extent of the potential erosion in the following scenarios:

1. Do Nothing
2. Hold the line for 50 Years
3. Hold the line for 100 years

The modelling for each of these scenarios also incorporated climate change projections in accordance with the current FCERM recommended Change Factor (UKCP09 medium emission scenario 95%tile).

The modelling results indicate that over a 100 year period the cliff could recede up to 245 m in a 'Do nothing Scenario', whereas in the Hold the line for 50 and 100 year options the total recession was found to be up to 230 m and 50 m respectively. Using these modelled erosion extents it is possible to calculate the average erosion rates over the 100 year appraisal period. The modelled extents and calculated erosion rates are summarised in Table 2.2.

Table 2.2 – Summary of erosion analysis

Scenario	East of the seawall				Central seawall section				West of the seawall			
	Assumed Residual Life	Total Modelled Erosion	Pre failure * (m/yr.)	Post failure ** (m/yr.)	Assumed Residual Life	Total Modelled Erosion	Pre failure* (m/yr.)	Post failure ** (m/yr.)	Assumed Residual Life	Total Modelled Erosion	Pre failure * (m/yr.)	Post failure** (m/yr.)
Do Nothing	3	245	0.5	2.5	10	235	0	2.6	3	243	0.2	2.5
Do Minimum***	8	245	0.5	2.6	20	235	0	2.9	8	243	0.2	2.6
HTL (50 Years)	50	230	0.5	4.1	50	220	0	4.4	50	220	0.2	4.2
HTL (100 Years)	100	50	0.5	n/a	100	0	0	n/a	100	20m	0.2	n/a

*Pre-failure rates are based on observed trends taken from the Environment Agency's Coastal Trends Report 2013

**Post failure rates have been calculated from the modelled total erosion totals

***The Do Minimum scenario is assumed to have the same erosion extents as the Do Nothing scenario

2.1.8 Assets at Risk

As described in section 2.1.5 without intervention the existing defences will progressively deteriorate and eventually fail, and the rate of erosion will increase placing various assets on top of the cliffs at increased risk of erosion. The erosion modelling results summarised in Table 2.2 identify that under a 'Do Nothing' scenario it is estimated that up to 245 m could be lost to cliff erosion in the next 100 years as a result the assets summarised in Table 2.3 will also be at increased risk from coastal erosion.

Table 2.3 – Assets at risk of coastal erosion

Key features and associated issues	Why is the feature important
Residential Properties Potential loss of housing within the village through erosion, devaluation of neighbouring property and anxiety and stress to owners and occupiers facing losses.	Homes for people – represents substantial investment for individual property owners.
Commercial Properties Potential loss of businesses through erosion.	Local economy, community cohesion, social inclusion and investment of individual business owners.
Heritage Sites Potential loss of important monument sites and Grade II listed buildings.	Sites identified as high heritage value due to their unique nature or listed status.
Community facilities Potential loss of community facilities, including Mundesley library and Maritime Museum, through erosion.	Benefit to local residents, community cohesion and social inclusion.
Infrastructure Potential loss of or damage to services and amenities through erosion. Of particular concern are the Anglian Water outfall works.	Services and facilities for the local business and resident communities.
B1159 at Mundesley Potential loss of the road, which is the main thoroughfare in the village and forms the main coast road linking villages between Cromer and Caister. Loss of the cliff top section of the road would require significant diversions around the village.	Important link road for both locals and tourist trade and provides local access within Mundesley to properties and businesses. Provides main links to adjacent villages along the coast.
Mundesley Lifeboat station Potential impact on launching of the lifeboat.	Forms part of chain of lifeboats providing rescue services around the coast.
Beach and Foreshore The way in which the coastline is managed may have an adverse effect on the condition and appearance of the Blue flag beach and dredging of off-shore banks for aggregate – concern about potential impact on beach levels.	Important recreational feature of the village, that helps to attract many tourists.
General Public and Local Residents The continued erosion of the cliff will increase the potential for injuries or even death of the general public and local residents.	Injuries or even death of local residents or the wider general public resulting from coastal erosion will have a significantly detrimental impact on the local community.
Environmental Habitat The continued erosion of the cliff will impact on important locally designated habitats.	Important sensitive habitats could be irretrievably damaged through continued erosion significantly impacting important local flora and fauna.

2.1.9 Properties at Risk

Analysis of the predicted erosion under 'Do Nothing' scenario has identified that the cumulative number of residential and commercial properties at risk from coastal erosion over the next 100 years is 629, as shown in Table 2.4.

Table 2.4 – Properties at risk in 'Do Nothing' scenario

Epoch	Residential properties at risk	Commercial properties at risk	Total properties at risk
Short (0-20 years)	39	65	104
Medium (20-50 years)	297	96	393
Long (50-100 years)	510	119	629

2.2. Business strategies

2.2.1 Shoreline Management Plan

The Mundesley frontage is covered by the 'Kelling to Lowestoft Ness Shoreline Management Plan' (SMP6) which was completed in 2010 and fully adopted later in 2012. The preferred management policy for Mundesley, Unit 6.08, involves 'Holding the Line' (HTL) until 2055 before transitioning to a policy of 'Managed Realignment' (MR).

2.2.2 Coastal Strategy

Following the adoption of SMP6, NNDC with funding from the Environment Agency, commissioned the Cromer to Winterton Ness Coastal Management Study which was completed in 2013. The purpose of that strategic study was to provide recommendations for coastal management works to be taken forward to the OBC stage.

The Cromer to Winterton Ness Coastal Management Study found that coastal defence schemes could be technically and economically justified for the Mundesley frontage under each of the following three scenarios:

- The SMP6 policy (50 year HTL);
- The Modified SMP6 (100 year HTL);
- The SMP6 (50 year HTL) with Sediment Nourishment.

It was noted that the resulting 100-year coastline geometry under the Modified SMP6 and SMP6 through Sediment Nourishment scenarios are expected to result in a less stable coastline compared to that of the SMP6 Scenario, however, all scenarios were found to be technically and economically justified over the 100-year appraisal period.

2.2.3 Outline Business Case (OBC)

This OBC has built upon the Cromer to Winterton Ness Coastal Management Study and identifies the technically, economically and environmentally preferred option and aims to seek Grant in Aid (GiA) funding to implement the adopted SMP6 management policy.

Although only 37 years remain until 2055 and the start of the transition from the SMP6 'Hold the Line' policy to a 'Managed Realignment' policy, the Cromer to Winterton Ness Coastal Management Study found that the original SMP policy (first drafted in 2005) of HTL for 50 years is still economically justified if commenced in the present day. Consequently, at the request of NNDC both the appraisal period and the 50 year HTL policy will commence in 2017/18, therefore the transition to a policy of 'Managed Realignment' and the proposed scheme can both be achieved in line with SMP policy as the transition from HTL to MR will remain between 2055 and 2105.

2.2.4 Council's Strategic Development Strategy

Mundesley is identified in the North Norfolk Local Development Framework Core Strategy document (2008) as one of a number of Coastal Service Villages with the following moderate development plans (only policies that directly impact Mundesley have been listed):

Policy SS1- Spatial Strategy for North Norfolk; A small amount of new development in Mundesley will be focussed on supporting rural sustainability and will support local coastal communities in the face of coastal erosion and flood risk.

Policy SS3 - Housing; as a Coastal Service Village Mundesley has an allocation for 50 new dwellings between 2011 and 2021.

Policy SS4 – Environment; All development proposals will contribute to the delivery of sustainable development, ensure protection and enhancement of natural and built environmental assets and geodiversity and be located and designed so as to reduce carbon emissions and mitigate and adapt to future climate change. In addition, the Council will minimise exposure of people and property to the risks of coastal erosion and flooding and will plan for a sustainable shoreline in the long-term that balances the natural coastal processes with the environmental, social and economic needs of the area.

Policy SS5 – Economy; At least 4,000 additional jobs will be provided between 2001 and 2021 across North Norfolk. It is anticipated that job growth will be achieved via policies for tourism, retail and the rural economy as well as provision of employment land. A range of sites and premises will be made available for employment development, through the allocation of new sites and the designation of existing employment sites in all settlements including Coastal Service Villages in order to increase the choice of sites available and to address the self-containment of settlements in terms of homes / jobs balance.

Policy SS6 – Access and Infrastructure; All development should be supported by, and have good access to, infrastructure, open space, public services and utilities, which will be provided wherever possible through the protection and enhancement of existing provision / facilities.

Following a review of the North Norfolk Local Development Framework Core Strategy it is evident that a coastal defence scheme at Mundesley is in accordance with, and supports other development aspirations for the village and will help facilitate the wider regional development plan.

2.3. Environmental and other considerations

2.3.1 Land Use and Landscape

Mundesley is principally a small holiday village, which attracts tourists to its beaches which have been awarded the 'Blue Flag' for the quality of the bathing waters and the high standard of facilities offered. The village contains important tourist accommodation and facilities including a promenade, café and attractions, maritime museum, car parking areas and beach access points. During the summer months the population increases considerably.

The predominant use of cliff top land surrounding Mundesley is agricultural, and it is typically designated as Grade 3 farming land. In addition, the coastal road between Trimingham and Mundesley also runs along the cliff edge.

The Norfolk coastline between Kelling and Mundesley falls within the Norfolk Area of Outstanding Natural Beauty (AONB), the boundary of which skirts around the villages of Sheringham, Overstrand and Mundesley. The landscape in this area is dominated by the Cromer Ridge, a glacial feature constituting the highest ground in Norfolk, and it is recognised as a distinct Landscape Character Area. Although the area beyond Mundesley to Bacton Green also falls within the Cromer Ridge Landscape Character Area the cliffs become sandier, better drained, vegetated and more stable, and their height decreases to almost half of that at Trimingham. All the cliffs in this area are typically fronted by sand/ shingle beaches.

2.3.2 Environmental Designations

There are a number of environmental designations (or potential designations) either on or in close proximity to the Mundesley coastline that any proposed scheme will have the potential to impact upon. A brief summary of these designations is detailed below:

Sites of Special Scientific interest (SSSI), National Nature Reserves (NNRs) and Geological Conservation Review sites (GCR).

Both the Sidestrand to Trimingham Cliffs and the Mundesley Cliffs located to the northwest and southeast of Mundesley, respectively, are both designated as Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs) and Geological Conservation Review sites (GCR).

Sidestrand to Trimingham Cliffs - The Sidestrand to Trimingham Cliffs are soft cliffs and extend for a distance of 6.5km. The cliffs are up to 60m high and are subject to frequent cliff falls and slumping. They are considered to be of national and international geological importance because of the following four features; the chalk, the Pleistocene sediments, fossil invertebrates and mass movement.

The chalk outcrops within these cliffs contain a rich fossil invertebrate fauna and provide the youngest exposure of Upper Cretaceous chalk in the British Isles (the Maastrichtian succession), which is of fundamental importance to British Cretaceous geology and of wider significance to studies of the late Cretaceous period elsewhere in north-west Europe.

The rotational landslips along these cliffs are internationally important coastal geomorphological features. The cliffs also expose one of the best pre-glacial stratigraphic sequences in England including a series of unconsolidated Pleistocene sediment layers in the underlying chalk.

In addition, these cliffs are among the best soft cliff sites for invertebrates in East Anglia. Typically, the soft cliffs and mobility along this coastline create a mosaic of habitats from bare clay and sand to ruderal communities and semi-stabilised grassland with occasional seepage lines developing areas of lush vegetation.

Mundesley Cliffs - The Mundesley Cliffs are designated for their geological interest, as they represent a nationally important site for its extensive Pleistocene sequence. The cliffs along the stretch of coast just south of Mundesley provide some of the very best sections in the Pleistocene Cromer Forest-bed Formation, especially in Cromerian marine and freshwater deposits, and freshwater sediments of the early Anglian Cold Stage. At Mundesley the marine and rare freshwater deposits of Pastonian age are particularly well-developed.

County Wildlife Site (CWS)

The coastal cliffs fronting Mundesley adjacent to the SSSI are also designated as a County Wildlife Site (CWS) (Site Ref. 1228). The Norfolk Wildlife Trust provided the 1985 citation which identifies that the 5.9 hectare site contains dense sward and scattered scrub habitats that need to be conserved; these habitats include various grasses and herbs but are typically dominated by brambles.

Marine Conservation Zone (MCZ)

In January 2016 the Cromer Shoal Chalk Beds located 200 metres off the North Norfolk Coast were designated as an MCZ. This newly designated site begins to the west of Weybourne and ends at Happisborough in the east, extending around 10 km out to sea and covering a total area of approximately 321 km^2.

The site has been designated to protect seaweed-dominated infralittoral rock. These rocks, typically found in shallow water, are an important habitat, providing a home for a variety of small creatures which shelter and feed amongst the seaweeds.

Within a wider area that is predominantly sandy, the chalk beds provide stable surfaces for seaweeds and static animals to settle on and grow. The beds are nursery areas for juvenile species as well as being important in the food chain for animals such as the fish, tompot blenny and the Lesser Spotted Dogfish. The chalk beds are home to lobsters and crabs which settle within the crevices and holes. The area supports the small-scale crab and lobster fishery vital to the character and economy of the area. Other common species include sea squirts, hermit crabs and pipefish, a relative of the seahorse.

Special Area of Conservation – Candidate Site (SACc)

In January 2017, another area located just off-shore to the southeast of Mundesley (as shown in Figure 2.3) was identified as a candidate or possible site for a future SAC under the European Union's Habitats Directive (92/43/EEC). It has been identified for the potential conservation of natural habitats associated with Harbour Porpoise (Phocoena phocoena). Although no final decision on the status of the site is expected until distribution data on the Porpoise is collected and analysed.

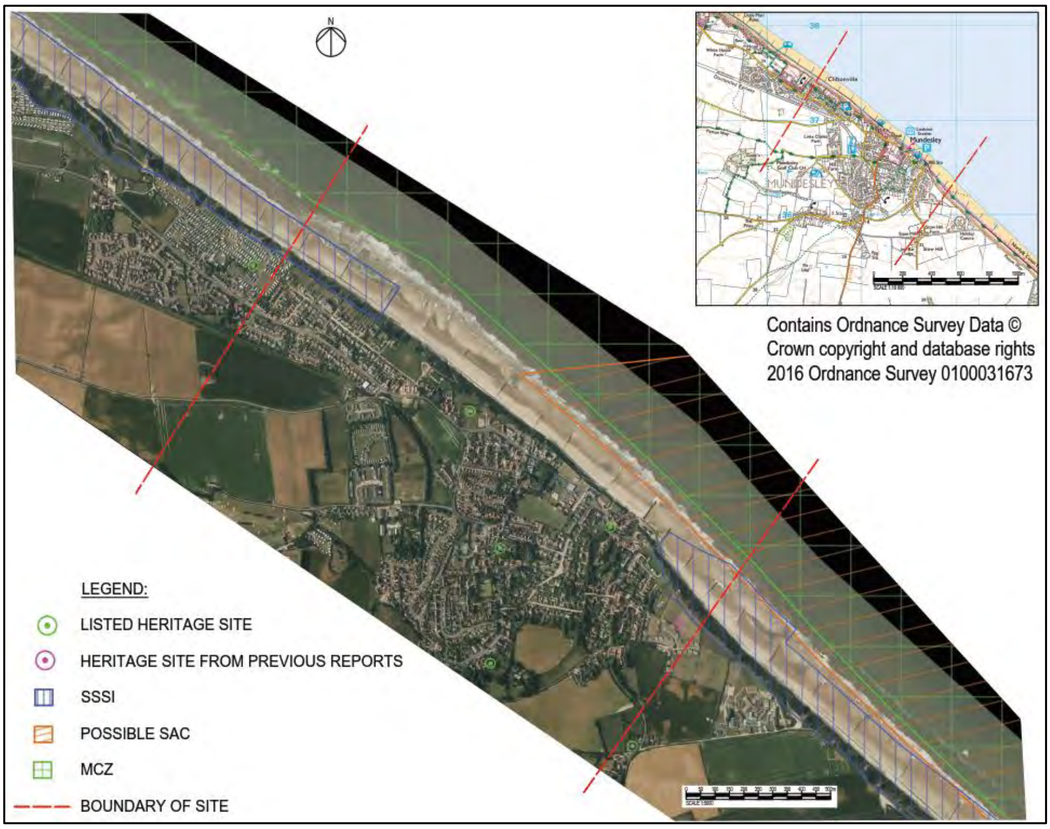

Figure 2.3 Key environmental designations within or close to the site extent

2.3.3 Cultural Heritage

There are number of historic monument and Grade II listed sites located in close proximity to the Mundesley area that have the potential to be impacted if the cliffs continue to recede unabated, these are listed below and are identified on Figure 2.3.

1. A Tank Trap (HER no. 32621),
2. An underground military headquarters with associative gun emplacement (HER no. 14142),
3. An Early Saxon cemetery (HER no. 6872),
4. The grade II listed All Saints Church (HER no. 6884),
5. The grade II listed Brick Kiln (HER no. 14141), believed to be the only surviving 'haystack' kiln in the county, and
6. The grade II listed The Del (HER No. 224670).

2.3.4 Water Framework Directive

There are two separate water bodies located within the frontage at Mundesley: Norfolk East Coastal Water (coastal) and the River Mun (fluvial).

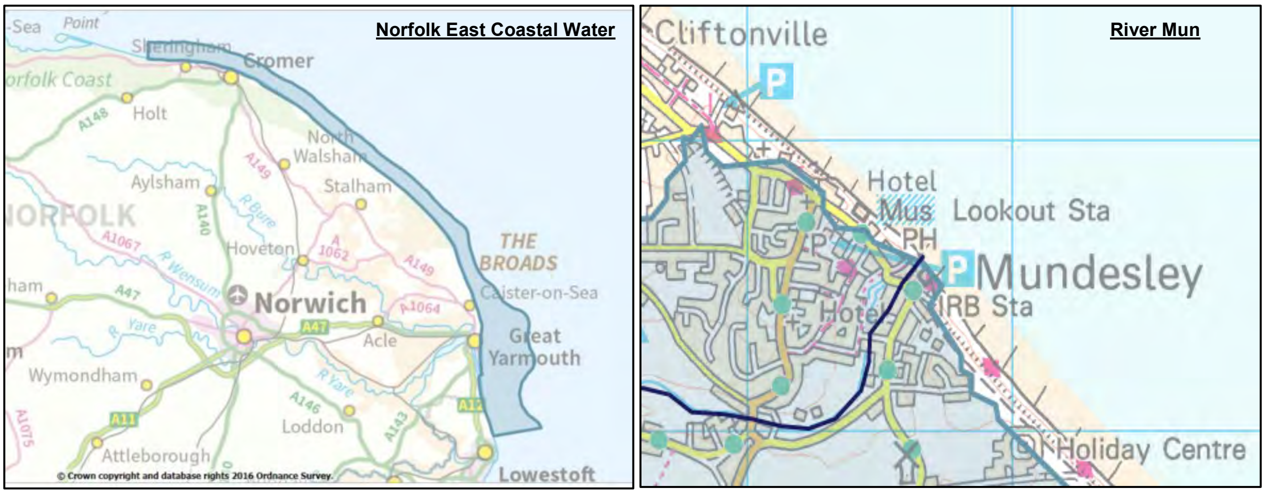

Figure 2.4 – Location of local WFD water bodies

Norfolk East Coastal Water - The coastal water body is referred to as the Norfolk East Coastal Water; a sub group of both the Norfolk East and the Anglian catchments. The existing hydromorphological designation for this water body is heavily modified.

The objective for the Norfolk East Coastal water body was to achieve an overall 'Moderate' Status by 2015, having achieved that objective there are no current specific operational measures in place to improve the catchment status. Any predicted improvements in the status of water bodies by 2021 are based upon having no measures in place.

River Mun - The fluvial water body located in the Mundesley study area is the River Mun, which is a sub group of North Norfolk Rivers. The hydromorphological status of this water body does not consider it to be artificial or heavily modified.

The objective for the River Mun water body is to have a 'Good' status by 2027; although in 2015 the overall water body classification was poor. Currently the only operational measures in place to achieve the desired status are related to changes in the abstraction licence conditions on the River Mun in order to address the potential serious damage that the current licences permit.

2.3.5 Regulatory Requirements

Table 2.5 summarises the various consents and approvals that will be required for implementing a scheme on the coastline at Mundesley, the table also details who the relevant stakeholder or consenting authorities are and what initial engagement has already taken place.

Table 2.5 – Summary of the required consenting and approval regime.

Approving Authority / Stakeholder	Status	Works going forward
Natural England – Various Environmental Consents	Initial email of support received from NE based on the preferred option following the public consultation (Attached in Appendix F). A full letter of support will be sought during detailed design.	To be concluded at the detailed design phase
MMO – Marine Licence	Will only be required for works below the MHWS.	To be concluded at the detailed design phase
Environment Agency – Various Consents	Discussions on-going with regional Environment Agency team, who support the proposed scheme, various consents to be sourced at the detailed design phase.	To be concluded at the detailed design phase
Local Planning Authority	Early discussion indicate that the scheme will need planning permission and consultation with the local planning officer will be ongoing as the scheme develops	To be concluded at the detailed design phase
Crown Estates	Delivery of materials by sea and any works below MHWS will potentially require consent from the Crown Estate.	To be concluded at the detailed design phase
Trinity House	Scheme not expected to impact on local navigation, however, delivery of materials is likely to require further consultation.	To be concluded at the detailed design phase
County Archaeological Officer	Proposed works will not impact on the local historic monuments and grade II listed sites, sites only impacted in a Do Nothing scenario	If a scheme fails to be adopted consultation will commence.
Local landowners	Discussions ongoing through the Stakeholder Liaison Group. Consent for the use of access ramps during the works will be required.	To be concluded at the detailed design phase

2.4. Investment objectives

The investment objectives have been set to reflect the importance of delivering robust and sustainable erosion risk management infrastructure for existing communities, acknowledging the importance of the area for both tourism and future development opportunities as identified in the Council's Core Development Strategy (see Section 2.2.4).

The key investment objectives for the project are:

- To reduce erosion risk to people, property and infrastructure for the duration of the scheme;
- To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable;
- To enhance the frontages resilience to climate change impacts;
- To maintain and where possible enhance natural, historic and built environments;
- To avoid disruption to and where possible enhance local tourism;
- To facilitate sustainable growth in the village of Mundesley by enabling development opportunities for employment and residential purposes along with the associated infrastructure.

These objectives also comprise the critical success factors for the scheme (see Section 3.2).

2.5. Current arrangements

2.5.1 Maintenance

North Norfolk District Council currently spends approximately £310,000 each year maintaining 21 miles of coastline. This annual maintenance budget typically covers the cost of the following:

- Inspection and surveys of coastal defence assets;
- Repairs (maintenance) of assets to account for wear and tear;
- Minor Storm damage clear up and minor repairs (for major repairs additional emergency funding is applied for);
- Repairs to address health and safety hazards, particularly regarding failing structures.

For the purposes of economic appraisal, and in order to estimate the Present Value (PV) whole life costs, the general annual maintenance costs for Mundesley have been calculated based on the Council's current yearly spend (which is based on their annual budget) and the proportion of the 21 miles of coastline that the Mundesley frontage represents. This equates to £19,000 a year for the Mundesley frontage, which NNDC have committed to maintaining throughout the 50 year appraisal period (a PV total of £465,411).

2.5.2 NNDC Contributions

NNDC have committed to contribute **£306,000** (Cash) (or £301,176 PV) from their general revenue budget towards the capital expense of the scheme.

2.5.3 Third Party Funding Commitments

Following various negotiations and applications by NNDC the third party cash contributions that have been secured to date are presented in Table 2.6 below:

Table 2.6 – Secured Third Party Funding

No.	Funding Source	Secured Contribution Amount (Cash)	Secured Contribution Amount (PV) – Year 1	Purpose of Funding
1	RFCC Local Levy	£70,000*	£70,000*	Preparation of business case
2	Mundesley Parish Council	£20,000	£19,324	Maintaining defences
3	Anglian Water	£250,000	£241,546	Maintaining defence (particularly of their assets)

*Already received

2.5.4 Total confirmed financial (PV) contributions

Combining both the NNDC and third party contributions secured for the scheme to date results in a Partnership Funding (PF) contribution PV total of **£632,046.**

Please note that details of funding commitments received to date are contained in Appendices G and H.

2.6. Main benefits

The people and key assets that will benefit from a scheme throughout the appraisal period would include:

- Approximately 600-700 local residents (based on the Norfolk average of 2.3 people per residential property);
- 297 residential properties;

- 96 commercial properties;
- Various historic monuments or listed sites;
- Community facilities (including a library and museum);
- Electricity substations;
- Anglian Water pumping station;
- Various utility infrastructure;
- The beach and foreshore;
- Various roads (including the B1159);
- Several beach access points;
- Local tourism and tourism related properties (holiday cottages, beach huts etc.);
- The Lifeboat station; and
- Environmental habitats;

Additional benefits of the scheme will include:

- Improved safety of residents and users of the sites along the frontage;
- Strategic infrastructure with scheduled future maintenance;
- Reduces the burden on the reactive emergency response to future storm events;
- Reduction in business disruption due to erosion damage with positive impacts for the local economy; and
- Safeguarding existing employment areas and facilitating future growth.

2.7. Main risks

Identification and appraisal of the risks for the scheme has been carried out and a risk register developed (see Appendix J). The key risks and potential mitigation are summarised in Table 2.7 below.

Table 2.7 – Key risks to delivery

No	Key risks	Description	Likelihood	Potential impact	Risk Owner	Mitigation
1	Variation in material prices (particularly rock and timber)	Variability in markets for major component of the material cost for the scheme	High	Medium	NNDC	Optimism bias of 30% has been applied to all estimated costs. NNDC will seek to bulk purchase most materials with beneficial prices and store locally.
2	Fluctuations in currency market (Value of £)	Variability in the value of the pound will impact on the cost of any imported materials for the scheme	High	Medium	NNDC	Optimism bias, seek to bulk purchase with beneficial prices and store locally.
3	Unforeseen technical issues	Unforeseen specific technical issues identified during detailed design leading to redesign of sections of work	Medium	Medium	NNDC	Designer's risk assessment to be undertaken during the detailed design process by suitably experienced personnel. Optimism Bias of 30% has also been applied to all cost estimates to cover all unforeseen risks. Detailed ground investigation following Eurocode standards prior to completion of detailed design.
4	Funding changes in delivery period due to multiple sources of contributions and third party funding either being delayed or not materialising.	Adds inflation to the scheme, risk of additional mob/demob costs	Medium	High	NNDC	Early engagement with potential third party funders has been on-going and written funding commitments have been obtained from NNDC, Mundesley Parish Council and Anglian Water. Continued engagement will ensure that legal agreements are completed and the funding arrives in a timely manner. Possible re-profiling of contributions with updates on the scheme.
5	Funding shortfall due to overspends	Failure to complete the scheme due to lack of money	Medium	High	NNDC	The scheme has been designed to be affordable, if unforeseen costs arise they will either be met by NNDC or the scope of works will be reduced, therefore works will be scheduled in order of priority.
6	Potential for damage to properties during construction	Vibration during works (particularly beach access) cause damage to nearby buildings	Medium	Medium	Contractor	Condition survey of buildings prior to construction, monitoring during construction, avoiding potentially sensitive locations.
7	Accelerated deterioration of existing defences.	Defences fail accelerating the need for works	Medium	Low	NNDC	Condition of the existing defences to be regularly monitored, works to commence early in the programme.

No	Key risks	Description	Likelihood	Potential impact	Risk Owner	Mitigation
8	Delays or objections in obtaining the required consents and approvals	Project delayed due to delays or objections in obtaining consents and approvals from the various approval authorities.	Medium	Medium	NNDC	Early and on-going engagement with the relevant approval authorities will identify any potential issues early in the detailed design process. Adequate time will also be allowed in the programme to obtain all the required consents.
9	Change of landowners/uses along the frontage	Impact on design with additional cost and time requirements	Medium	Med	NNDC	Continued engagement throughout detailed design and construction to work with landowners/operators to identify potential changes as early as possible
10	Unexploded Ordnance	Discovery of UXO during construction works	Medium	High	NNDC	Detailed UXO search will be undertaken during the detailed design process, and if required potential mitigation measures such as watching brief or probing can be adopted during construction. In addition the construction programme will be designed to be flexible to minimise downtime on discovery of a UXO.
11	Changes in guidance or legislation	Changes in legislation could impact on mitigation required during construction	High	Medium	NNDC	Major changes not foreseen, sensitivity analysis undertaken which demonstrates that the scheme is robust against a reasonable range of uncertainty

2.8. Constraints

Identification and consideration of key constraints for the scheme has been carried out and these are summarised in Table 2.8 below.

Table 2.8: Key constraints identified for the scheme

Constraint	Implication	Planned Approach
Potential funding constraints for third party contributions (i.e. need to be spent in a specific year)	The need for timely progression of programme for the scheme to ensure continued expenditure	Prioritise expenditure of time constrained funding contributions.
Time limitation of any consents or approvals required by the scheme	Construction will need to start within 3 years of planning permission being granted	Carefully planned programme in relation to planning application and effective project management to avoid major programme delays.
Conditions of various consents or approvals (i.e. planning permission and Marine Licence etc.)	Could impact duration, techniques, materials etc. which could increase cost and delay to the programme	Liaise with the approval authorities during detailed design and careful planning of construction and the programme accordingly.
Environmental requirements	Construction techniques and timings maybe constrained by environmental mitigation requirements.	Early agreement of required mitigation strategy through the design and consenting process.
Variable construction windows for works will potentially need to be balanced between environmental constraints and busy tourist seasons.	Phasing of construction works and overall programme could be affected	Continue to work closely with landowners / operators/ stakeholders to schedule and optimise construction phasing and activities.

2.9. Dependencies

The successful delivery of a coastal defence scheme at Mundesley is dependent on each of the following:

- With an initial Partnership Funding score of approximately 87%, 13% of the required capital funding is to be achieved through alternative funding sources.
- Timely delivery of funding from third parties (NNDC, Anglian Water and Mundesley Parish Council)
- Timely delivery of funding from Defra (FCERM GiA)
- NNDC commit to the on-going maintenance of the frontage.
- NNDC commit to further capital investment throughout the scheme’s life cycle
- All consent and approvals for the scheme (as identified in Table 2.5) are obtained without delay or any significant constraints.

3. The Economic Case

3.1. Introduction

An economic appraisal was undertaken to determine the relative economic benefits, costs and return on investment of each of the options and this formed an integral part of the wider assessment carried out in selecting the final scheme. It also underpins the business case for the scheme and has been used to determine the Partnership Funding calculation, including estimation of the required financial contributions.

The economic appraisal was carried out in accordance with the framework of the HM Treasury and Environment Agency Flood and Coastal Erosion Risk Management appraisal guidance (FCERM-AG, 2010). The appraisal used a cost benefit analysis (CBA) and provides a rational and systematic framework for assessing the advantages and disadvantages of alternative options against a 'Do Nothing' baseline.

Whole life option benefits, including direct and indirect flood damages, were valued in accordance with Treasury Green Book rules and the latest FCERM Economic Appraisal Handbook (Multi-Coloured Manual). Whole life option costs were built up using standard industry price guides, contractor cost advice and benchmarking of similar schemes.

Options were appraised following FCERM decision rules. Although the economic leading option was identified, the need to deliver the investment objectives and the available contributions were influential in the ultimate decision for the preferred scheme. The appraisal of options at all levels was supported by the appropriate environmental assessments which considered the environmental receptors identified in Section 2.3. Further details of the economic damage assessment can be found in Appendix C.

3.2. Critical success factors

The five critical success factors identified for the scheme (Table 3.1) are underpinned by the investment objectives (see Section 2.4). The importance rating given to each factor (where 1 is high importance) is reflective of the main drivers for delivering the scheme, which are focused around the reduction of erosion risk to existing communities, whilst acknowledging important wider objectives linked to other business strategies outlined in Section 2.2.

Table 3.1- Critical success factors for the scheme

No	Critical Success Factor	Measurement Criteria	Importance (1-5)
1	To reduce erosion risk to people, property and infrastructure for the duration of the scheme	No. of people better protected against erosion over whole life of the scheme. No. of residential properties at reduced risk of erosion over whole life of the scheme. No. of commercial properties at reduced risk of erosion over the whole life of the scheme. No. of key infrastructure assets at reduced risk of erosion over the whole life of the scheme.	1
2	To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable	All consents and approvals obtained Planning permission granted. Efficiency savings realised. Positive Benefit: Cost for investment. Required contributions secured. Scheme implemented on time and to budget.	1
3	To maintain and where possible enhance natural, historic and built environments	No net loss of key habitats (and any enhancements). Compliant with environment regulations and legislation. No. of cultural heritage assets at reduced risk of erosion over the whole life of the scheme.	1
4	To maintain and where possible enhance the tourist industry in Mundesley	No. of commercial properties at reduced risk of erosion over the whole life of the scheme. No. of community facilities at reduced risk of erosion over the whole life of the scheme. Maintain or improve the number of tourists visiting Mundesley on an annual basis over the whole life of the scheme.	3
5	To facilitate NNDC in meeting their Development goals for Mundesley including employment and residential properties and associated infrastructure over the life of the scheme.	No. of m^2 of new employment area generated over the whole life of the scheme No. of new jobs created over the whole life of the scheme No. of new residential dwellings over the whole life of the scheme. No. of new key infrastructure assets facilitated over the whole life of the scheme	5

These factors formed the basis for assessing the effectiveness of the proposed scheme, with measurable attributes that can be used to monitor successful implementation.

3.3. Longlist options

As outlined in Section 2.1.6, there are a number of potential management approaches for the Mundesley frontage. Following an initial investigation and identification of all the outline design constraints a longlist of potential coastal management measures was established in collaboration with NNDC.

The longlist was then subjected to a qualitative multi-criteria feasibility appraisal, supported by the preliminary environmental assessment (outlined in Section 2.2) in order to develop a short-list of options (comprising packages of management measures) to take forward and investigate further. Each of the longlist options were assessed in terms of the following parameters:

- Functionality (technical performance)
- SMP compliance
- Buildability
- Future maintenance
- Environmental impacts/benefits
- Comparative (indicative) costing
- Health and Safety
- Risks
- Public acceptance

A summary of the longlist appraisal results along with the primary reasons for either shortlisting or rejecting each of the options is presented in Table 3.2 below.

Table 3.2 – Longlist Options

Option name	Description	**Short-listed?**	**Reason for shortlist or rejection**
Do Nothing	This option involves no further spending on defences and ceases all existing maintenance.	Yes	**Dismissed** as a potential option, however, **shortlisted** for further analysis as the baseline against which to compare all other options.
Do Minimum	This option allows for routine maintenance only until the defences reach the end of their residual life and fail, then all spending and maintenance will cease.	Yes	This option is also **dismissed** as a potential option as it is effectively a delayed 'Do Nothing' option and provides minimal benefits and does not address the erosion problem. However, it is **shortlisted** in accordance with FCERM guidance for comparison purposes.
Option 1 – Seawall			
Option 1A: Maintain the existing seawall and construct new seawall along the rest of the frontage	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. Also includes the construction of a new seawall along the entire frontage to protect the cliffs from wave attack.	No	Although this option would protect the cliffs from any further erosion, it is both cost prohibitive and would be significantly detrimental to the environment and is therefore **dismissed** as a potential option.
Option 1B: Maintain the existing seawall and apron through concrete encasement	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance.	Yes	Effective and proven way of extending the life of the existing seawall structure and is therefore **shortlisted** for further analysis.
Option 1C - Concrete Sea wall and Apron Encasement with additional rock armour protection	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. But also includes the additional protection of a particularly exposed section with rock armour protection.	Yes	Similar to Option 1B in that it aims to extend the life of the existing structure. However, this option proposes to have additional rock armour protection at a particularly vulnerable section and is therefore also **shortlisted** for further analysis
Option 1 D – Raise the existing seawall in line with climate change	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. But also includes for raising the existing seawall in line with climate change projections to maintain the existing standard of protection.	No	Since the seawall only protects part of the frontage, there are no significant assets at risk of flooding and the objective of the scheme is to reduce the risk of erosion, there is very limited value in raising the existing seawall in line with climate change (when compared to the potential costs involved). In addition, it would be technically challenging and would rely on the integrity of the existing structure and is therefore **dismissed** as a potential option.
Option 2 - Off-shore Rock Armour Breakwater	This option involves constructing off-shore breakwaters made of rock armour to protect the coastline from the worst of the coastal conditions	No	This option would potentially have a detrimental impact on environmental and coastal processes. It would also be technically difficult to implement and very expensive and is therefore **dismissed** as a potential option.
Option 3 - Rock Armour Revetment	This option involves constructing a new rock armour revetment at the toe of the cliff along the length of the frontage (except along the existing seawall) protecting the cliff from wave action.	Yes	The rock armour will effectively dissipate wave energy and can be repositioned if required or if displaced. The revetment would be fairly expensive and impact on both the environment although would provide a more natural aesthetic than the concrete alternative. **Shortlisted** for further analysis.
Option 4 - Concrete Block Revetment	This option involves constructing a new concrete block revetment at the toe of the cliff along the length of the frontage	No	Although this option would protect the cliffs from any further erosion, it would be technically difficult to implement and is both cost prohibitive and would be

	(except along the existing seawall) protecting the cliff from wave action.		significantly detrimental to the environment and is therefore **dismissed** as a potential option.
Option 5 - Rock Armour Protection Sill (placed on beach)	This option involves placing rock armour at the top of the beach along the length of the frontage (except along the existing seawall) protecting the cliff from wave action.	Yes	The rock armour will effectively dissipate wave energy and can be repositioned if required or if displaced. The sill would be cheaper than a rock amour revetment, and significantly more durable than a timber revetment. It would also provide a more natural aesthetic than the concrete alternative. **Shortlisted** for further analysis.
Option 6 – Timber Revetment			
Option 6A - Replace Timber Revetment with Oak	This option involves replacing the existing structure as it approaches the end of its residual life with a new like-for-like oak replacement.	No	The existing timber revetments have effectively defended the cliffs from the worst of the wave energy. The price of a new structure is expensive and durability of an oak structure is questionable resulting in the on–going maintenance costs also being high, it is therefore **dismissed** as a potential option.
Option 6B - Replace Timber Revetment with tropical hardwood	This option involves replacing the existing structure as it approaches the end of its residual life with a like-for-like tropical hardwood replacement	No	The existing timber revetments have effectively defended the cliffs from the worst of the wave energy. The price of a new structure is expensive (more so than oak) and the long-term durability of tropical hardwood structure (although better than oak) is also questionable therefore the on–going maintenance costs will also be high, it is therefore **dismissed** as a potential option.
Option 6C – Refurbish existing revetment with oak	This option involves maintaining the existing structure through significant refurbishment using oak timbers	Yes	Although the replacement of this structure is not been found to be economically viable, the prolonging of the existing structure through refurbishment is being **shortlisted** for further analysis.
Option 6D – Refurbish existing revetment with tropical hardwood	This option involves maintaining the existing structure through significant refurbishment using tropical hardwood timbers	Yes	Although the replacement of this structure is not been found to be economically viable, the prolonging of the existing structure through refurbishment is being **shortlisted** for further analysis.
Option 7 – Steel Framed Structure			
Option 7A – Reinforce existing Steel Framed structure - Concrete Blocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front of the existing structure and filling the void with pre-cast concrete blocks.	Yes	The existing steel framed structure has proved a very effective method of reducing erosion therefore this option is being **shortlisted** for further analysis as will effectively prolong the existing structures life.
Option 7B - Reinforce existing Steel Framed structure - Rock	This option is similar to Option 7A; however, the void is filled with natural rock armour instead of pre-cast concrete blocks.	Yes	The existing steel framed structure has proved a very effective method of reducing erosion therefore this option is being **shortlisted** for further analysis as will effectively prolong the existing structures life.
Option 7C – Reinforce and raise existing structure – concrete blocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front of the existing structure and filling the void and raising the entire structure with pre-cast concrete blocks.	No	The addition of raising the structure to increase the level of protection offered provides very limited additional benefits over the life of the structure (at this time) and it therefore **dismissed** as a potential option. However, this option could be relooked at in the future if Option 7A is implemented.
Option 7D - Reinforce and raise existing structure – Rocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front	No	The addition of raising the structure to increase the level of protection offered provides very limited additional benefits over the life of the structure (at this time)

	of the existing structure and filling the void and raising the entire structure with rock armour.		and it therefore **dismissed** as a potential option. However, this option could be relooked at in the future if Option 7B is implemented.
Option 7E – New steel framed structure – with concrete blocks	This option involves constructing a new steel frame structure filled with pre-cast concrete blocks in place of the existing timber revetment.	No	The steel framed structure has proved a very effective method of reducing erosion in the past. The high costs associated with this option combined with the aesthetic impact on the landscape have resulted in this option being **dismissed**.
Option 7F - New steel framed structure – with rocks	This option involves constructing a new steel frame structure filled with rock armour in place of the existing timber revetment.	No	The steel framed structure has proved a very effective method of reducing erosion in the past. The high costs associated with this option combined with the aesthetic impact on the landscape have resulted in this option being **dismissed**.
Option 8 – Timber Groynes			
8A Maintain through refurbishment	This option involves prolonging the life of the existing timber groynes through refurbishment and continued maintenance.	Yes	Despite their current state of disrepair the existing groynes are still very effective at retaining material on the beach; therefore prolonging the existing structures lives through refurbishment is being **shortlisted** for further analysis.
8B Replace with like for like	This option involves replacing the existing groynes with a new like-for-like timber structure.	No	Due to the effectiveness of the existing structure and the expense of replacing it, this option has been **dismissed** as a potential option
8C Refurbish and enhance to impermeable structure	This option involves enhancing and prolonging the life of the existing timber groynes by refurbishing them whilst also creating impermeable structures, also includes continued maintenance.	No	Whilst enhancing the groynes (making them impermeable) will improve their ability to retain material, this option is unlikely to be acceptable to Natural England and other stakeholders as it will interfere with the existing coastal processes. It is therefore **dismissed** as a potential option.
8DReplace with an impermeable structure	This option involves replacing the existing groynes with a new impermeable timber structure.	No	Whilst enhancing the groynes (making them impermeable) will improve their ability to retain material, this option is both expensive and unlikely to be acceptable to Natural England and other stakeholders as it will interfere with the existing coastal processes. It is therefore **dismissed** as a potential option.
8E Maintain through refurbishment with rock protection	This option involves prolonging the life of the existing timber groynes through refurbishment and continued maintenance. Whilst also further protecting the vulnerable seaward ends with rock armour protection.	Yes	Like option 8A this option aims to prolong the life of the existing structures through refurbishment, in addition this option also aims to make the structure more durable to coastal condition and is therefore **shortlisted** for further analysis.
Option 9 - Rock Armour Groynes	This option involves installing new rock armour groynes along the frontage to trap more sediment to raise the level of the existing beach and therefore offer greater protection to the cliffs by reducing their exposure to wave action.	No	Although this option would potentially enhance the existing protection by raising beach levels, it would be both very expensive and change the aesthetics of the existing landscape. In addition it does not make the best use of the existing timber groynes. It is therefore **dismissed** as a potential option.
Option 10 - Gabion Toe Protection	This option involves installing rock filled gabion baskets along the toe of the cliffs protecting them from wave action.	No	The durability of gabion baskets in a marine and tidal environment is poor and the baskets are not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
Option 11 - Beach Nourishment	This option involves importing beach material to raise the level of the existing beach and therefore offer greater protection to	Yes	Although this option is likely to be very expensive to both implement and maintain, and it would need to be supplemented by improvements to the existing beach

	the cliffs by reducing their exposure to wave action.		management structures, it is being **shortlisted** for further analysis as it would improve the amenity value of the existing beach and is popular with the public.
Option 12 - Cliff Stabilisation	This option involves incorporates various cliff stabilisation techniques (such as anchor bolts and wire netting) to stabilise the face of the cliffs and limit the amount of erosion.	No	Since the cliffs are a SSSI and designated due to their geological interest, any cliff stabilisation works would be environmentally detrimental and unlikely to be supported by the public or other stakeholders, it is therefore **dismissed** as a potential option.
Option 13 - Embankment Scour Protection			
A - Scour protection gabions	This option involves installing rock filled gabion baskets along the toe of the embankment protecting the slope from overtopping waves.	No	The durability of gabion baskets in a marine and tidal environment is poor and the baskets are not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
B - Upstand wall	This option involves replacing the existing dwarf wall on the landward side of the promenade with a small upstand wall to shelter the embankment from overtopping waves.	Yes	This option has been **shortlisted** for further analysis as it will successfully prevent scour, has a straight forward construction method, is low maintenance and will have limited impact on the existing slope.
C - Interlocking porous concrete block/ mattress revetment	This option involves placing a porous concrete mattress and geotextile layer on the face of the embankment to protect the soil from overtopping waves	Yes	This option has been **shortlisted** for further analysis as it will successfully prevent scour, is relatively cheap, easy to install, low maintenance and will allow vegetation to grow through the mattress which will improve the visual impact of the defence.
D - Scour protection concrete canvas	This option involves placing a non-porous concrete canvas on the face of the embankment to protect the soil from overtopping waves.	No	Reject for various reasons: • Will detrimentally impact on the aesthetics of the embankment • Will destroy existing vegetation on the embankment • Will interfere with existing surface water drainage.
E - erosion control mat	This option involves attaching an erosion control mat (hessian or similar) to the face of the embankment to protect the soil from overtopping waves.	No	The durability of erosion control mat in a marine and tidal environment is poor and it is not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
F - Sprayed concrete protection	This option involves spraying the slopes of the embankment with a liquid concrete (shotcrete or similar) to provide the embankment with a protective layer to protect the soil from overtopping waves.	No	Reject for various reasons: • Will detrimentally impact on the aesthetics of the embankment • Construction methodology caries a significant pollution risk • Will destroy existing vegetation on the embankment • Will interfere with existing surface water drainage.

3.4. Shortlist options

3.4.1 Overview

Each of the options shortlisted for more detailed appraisal (Table 3.2), were subjected to further development and assessment including developing outline designs, undertaking both capital and whole life cost estimates, identifying buildability, functionality and health and safety issues and assessing the risks and environmental impacts as well as considering all of their advantages and disadvantages.

The outline designs for each of the shortlisted options are contained in Appendix B. The costing report (Appendix D) details how the estimated costs were calculated along with any associated assumptions that have been made. The Option Appraisal Report (Appendix E) details the technical and environmental appraisal process and discusses the various advantages and disadvantages of each of the options.

3.4.2 Shortlist options

Each of the shortlisted options along with a brief description of the associated works are summarised below in Table 3.3 below:

Table 3.3 – Shortlisted Options

No Active Intervention
The Do Nothing option would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course. The Do Nothing approach is the baseline against which all other options will be compared. This approach is discounted because it is not compliant with the 'Hold the Line' policy and will ultimately lead to large damages, but it will be used as a baseline to judge other options.
Do Minimum
The Do Minimum option involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works. The **Do Minimum** approach is effectively a delayed Do Nothing option, as it will also eventually allow the defences to fail and nature to take its course. This approach is also discounted because it is not compliant with the 'Hold the Line' policy and will also lead to large damages, but it has been considered within this OBC in line with the FCERM guidance.
Active Intervention Options:
Option 1 – Seawall
Option 1B: Maintain the existing seawall and apron through concrete encasement - This option proposes to maintain the existing seawall and apron throughout the desired benefit period by encasing the existing structure in reinforced concrete when necessary.
Option 1C: Concrete Sea wall and apron encasement with additional rock armour protection - Like Option 1B this option proposes to maintain the existing seawall and apron throughout the desired benefit period by encasing the existing structure in reinforced concrete when necessary. However, this option also proposes to provide additional rock armour protection to particularly vulnerable sections of the structure, therefore extending the residual life and reducing the need for future works
Seawall Summary - Option 1C: Maintaining the existing seawall and apron through encasement and rock protection will cost effectively ensure that the seawall is retained throughout the required benefit period and will therefore be carried forward to be considered as part of the final solution, as this option will have to be delivered in combination with other management options (i.e. where there is no seawall) to protect the entire frontage. Although Option 1B is initially the cheaper option, because of its additional maintenance requirements it is less cost effective over the entire appraisal period and will therefore not be considered in combination with other options to potentially form part of the final solution.
Option 3: Rock Armour Revetment
This option is comprised of constructing a rock armour revetment at the toe of the cliff across the entire frontage (except along the existing seawall). A potential rock armour revetment will effectively protect the cliffs from erosion throughout the required benefit period and will limit the need for future maintenance. However, it will be extremely expensive to implement and will significantly impact on both the designated cliffs and sediment supplies to local coastal processes. However, it will be considered in combination with other options to potentially form part of the final solution further assessment.
Option 5: Rock Armour Protection Sill (placed on beach)
This option proposes to place rock armour protection along the frontage (except along the existing seawall) on the beach in front of the cliffs, either supplementing or (in time) replacing the existing defences. For pricing purposes the following three variations of this option have been considered: A. Placed along the entire length (except along the existing seawall). B. Placed to supplement and in time replace the timber revetment only. C. Placed to supplement the steel framed structure only.

Placed rock armour protection will effectively reduce the rate of cliff erosion throughout the required benefit period and will limit the need for future maintenance. When compared to the Rock Revetment option it is relatively cheap to implement and will have only limited impact on the designated cliffs. All three variants (A, B and C) of the placed rock options will be considered in combination with other options to potentially form part of the final solution.
Option 6: Timber Revetment
Option 6C: Refurbish existing revetment with oak - This option proposes to refurbish and maintain the existing timber revetment with locally sourced oak. It is assumed that the existing design of the timber revetment will be maintained and will continue to utilise the existing steel sheet piling.
Option 6D: Refurbish existing revetment with tropical hardwood - Similar to Option 6C this option also proposes to refurbish and maintain the existing timber revetment, however, with imported tropical hardwood rather than oak. Again it is assumed that the existing design of the timber revetment will be maintained and will continue to utilise the existing steel sheet piling.
Timber Revetment Summary - The refurbishing and maintaining of the existing timber revetment will ensure that the cliffs receive continued protection throughout the required benefit period. Although oak is initially cheaper, in the longer term tropical hardwood is more cost effective due to the anticipated reduction in maintenance needs. Therefore Option 6D, the tropical hardwood option will be considered in combination with other options to potentially form part of the final solution further assessment.
Option 7: Steel Framed Structure
Option 7A: Reinforce existing Steel Framed structure (Concrete Blocks) - The reinforcement of the existing steel framed protection option is to add another steel frame approximately 2m in front of the existing structure. This has two purposes: firstly to contain new prefabricated concrete blockwork placed in the new frame in order to improve wave dissipation, and secondly to support/contain the existing concrete cube/rock filled steel structure.
Option 7B: Reinforce existing Steel Framed structure (Rock Armour) - This option is the same option 7A, however rather than fill the proposed steel structure with prefabricated concrete, this option will use imported rock armour.
Steel Framed Structure Summary - Reinforcing the existing steel framed structure will ensure that the cliffs receive continued protection throughout the required benefit period. Option 7B provides both the cheapest and most natural (aesthetically) way of filling the new steel structure and will therefore be considered in combination with other options to potentially form part of a scheme option to be considered further in the assessment. However, there remains significant cost, construction issues and potential clashes with existing structures that will have to be resolved if this option is progressed.
Option 8 – Timber Groynes
Option 8A: Maintain through refurbishment - This option proposes to maintain the existing timber groynes by refurbishment, which will include replacing the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. No significant changes would be made to the design of the groynes and they would remain permeable. Typically, the majority of the timber elements that need replacing are located at the seaward end of the groynes.
Option 8E: Maintain through refurbishment with rock protection - Like Option 8A this options also includes a 'major' refurbishment of the existing timber groynes by replacing 30% of the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. However, this option also includes placing rock armour protection around the more vulnerable seaward end of the existing groynes in order to reduce the future maintenance requirements.
Timber Groynes Summary - By maintaining the existing groynes through refurbishment it will ensure that the existing groynes are retained throughout the required benefit period, which is crucial for maintaining beach levels in front of the other defences. The addition of rock armour protection (8E) around the seaward end of the existing groynes will enhance the groynes ability to withstand increasing pressures resulting from climate change and therefore reduce maintenance requirements. Although the PV cost benefits of reducing future maintenance through rock armour protection are not realised until beyond the 50 year benefit period, the difference is minimal and this option will significantly reduce the need for maintenance and therefore reducing the risk to workers in the inter-tidal zone. Therefore Option 8E will be considered in combination with other options to potentially form part of the final solution further assessment.
Option 11 - Beach Nourishment
The beach nourishment/recharge option involves the addition of new material to the beach to increase its level. The beach recharge would supply material via spraying from a barge onto the beach; the material would match the existing beach material. The increase in the level of the beach will cause waves to break further from the cliff and therefore reduce the amount of wave energy reaching the cliffs. The outline design of the option includes increasing the crest level of the beach to a height greater than the present day 1 in 100 year water level (annual exceedance probability). The scheme will require periodic beach recharge or 'top-ups' to maintain the scheme and account for the removal of the material as the beach returns to its natural levels. Beach nourishment is very expensive and may interfere with local inter-tidal habitats. It will also have to be carried out in conjunction with on-going maintenance of the existing groynes to be effective. However, it will act to reduce the impact of wave action on the cliffs and will enhance the public amenity value of the existing beach. Therefore it will be considered in combination with other options to potentially form part of the final solution further assessment, however, the high costs involved in implementing this option mean it is unlikely to be progressed.

Option 13 - Embankment Scour Protection
Since none of the other shortlisted options allow for the raising or enhancing of the existing seawall it is necessary to protect the existing cliff face and access track behind the seawall from the scour that results from significant overtopping events. The shortlisted scour protection options are detailed below:
Option 13B: Upstand wall - The new scour protection wall option is to install a new reinforced concrete wall at the landward side of the existing promenade (effectively raising the height of the existing seawall). There is already a dwarf wall in this location, but a higher wall would reduce the amount of overtopping. To prevent the amenity use of the walkway being impacted (location of beach huts in the summer) the new wall would be built 'into' the embankment to reduce its footprint on the promenade.
Option 13C: Interlocking porous concrete block/ mattress revetment - This option involves the placing of a cabled concrete solid block mattress over the lower end of the embankment. The crest height of the new protection will be designed to accommodate increasing levels of overtopping due to climate change. The mattress will be laid over a geotextile for drainage/filtration purposes. The use of porous 'Armorflex' blocks (or similar) will allow for vegetation to establish through the blocks improving the aesthetics of the protective slope.
Embankment Scour Protection Summary - Both options 13B and 13C will effectively protect the embankment behind the seawall from overtopping waves and both options will have an impact on the visual landscape, and although the Concrete Mattress has potential access issues to overcome during construction, it is the most cost effective of the two options and will therefore be considered in combination with other options to potentially form part of the final solution further assessment.

3.4.3 Adaptive Option - Rock Armour Placement Alternative

Several of the shortlisted options detailed in table 3.3 above utilise rock armour. In order to capitalise on potential bulk ordering cost efficiencies all of the rock could be combined into one order. If each of the rock options were combined then they would total approximately 30,600 tonnes of rock. However, a typical off-shore rock delivery is limited to approximately a 25,000 tonne barge. Consequently, an Adaptive Option has also been developed which rationalises the initial rock requirements of the shortlisted options to a total of 25,000 tonnes in order to achieve significant efficiencies whilst procuring rock armour protection.

Both of the technical and environmental assessments of this Adaptive Option are the same as those for all the other options containing rock armour. The primary difference is that under this Adaptive Option the quantity of rock will not be sufficient to protect the entire frontage. Therefore under the adaptive option the rock armour used to supplement the timber revetment will be placed on the beach behind the most vulnerable sections of the existing structure (i.e. those in the poorest condition), then when the timber revetment reaches the end of its residual life and fails, the rock armour will already be in place. However, should some sections of the revetment deteriorate or fail earlier than expected then the rock armour can be moved (or adapted) to protect the most vulnerable sections.

It should be noted that since this option has a shortfall of approximately 5,600 tonnes of rock to protect the entire frontage, in time as the timber revetment continues to fail; it will eventually need an additional supply of rock armour, although this is not anticipated within the first 10 years.

This Adaptive Option has also been considered within the option appraisal process and further details can also be found in Appendices B, D and E. However, in summary this Adaptive Option (like the other rock options) will effectively reduce the rate of cliff erosion throughout the required benefit period, will also limit the need for future maintenance and will have only a limited impact on the designated cliffs. Although the rock supply will have to be topped up in the future, this adaptive option will be considered in combination with other options to potentially form part of the final solution further assessment.

3.5. Scheme Options

One thing that is common to all of the shortlisted options is that none of them can be adopted to protect the entire frontage. It is necessary, due to the nature of the coastline, the existing defences and for reasons of affordability that a coastal protection scheme will need to comprise a combination of interventions from the shortlisted options.

Having assessed and costed all of the potential defence options it has been possible to develop a number of different combinations for a scheme to deliver a 'Hold the Line' Policy for the next 50 years. In total 9 different combinations of the various shortlisted options, each compiled to ensure that the entire frontage is protected, have been considered over a 50 appraisal period.

3.5.1 Scheme Options Considered

Tables 3.4 and 3.5 below summarise how the appraised (Section 3.4) shortlisted options are combined together to form complete defence solutions for a scheme for the whole frontage.

Table 3.4 – Scheme options – potential combinations

Shortlist options	Scheme Options								
	1	2	3	4	5	6	7	8	9
Do nothing	✓	×	×	×	×	×	×	×	×
Do Minimum	×	✓	×	×	×	×	×	×	×
Seawall Refurb. with rock	×	×	✓	✓	✓	✓	✓	×	✓
Seawall (Reduced Scope)	×	×	×	×	×	×	×	✓	×
Rock Revetment	×	×	✓	×	×	×	×	×	×
Rock Placement (A)	×	×	×	×	×	×	✓	×	×
Rock Placement (B)	×	×	×	×	✓	×	×	×	×
Rock Placement (C)	×	×	×	×	×	✓	×	×	×
Timber Revetment	×	×	×	✓	×	✓	×	×	×
Steel Structure	×	×	×	✓	✓	×	×	×	×
Timber Groyne with rock	×	×	✓	✓	✓	✓	✓	✓	✓
Beach Re-Nourishment	×	×	×	×	×	×	×	✓	×
Scour Protection	×	×	✓	✓	✓	✓	✓	✓	✓
Adaptive Rock Placement	×	×	×	×	×	×	×	×	✓

Table 3.5 – Scheme Option Descriptions

Scheme Option	Description
1	**Do Nothing**; Stop all funding, no further capital works or maintenance.
2	**Do Minimum**; No capital spend, only routine maintenance until the defences reach the end of their residual life, then stop maintenance
3	**Rock Revetment**; Includes for a rock armour revetment along the toe of the cliff for the entire frontage except along the existing seawall. This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
4	**Maintain Existing**: This option is to maintain all of the existing defences, this will including reinforcing the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
5	**Partial Rock placement A**: Includes for rock armour protection along the length of the existing timber revetment, to reinforce the existing steel structure and to undertake seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
6	**Partial Rock placement B**: Includes for rock armour protection along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
7	**Full Rock Placement:** Includes for the placement of rock armour protection along the length of the frontage except along the existing seawall. This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
8	**Beach Re-Nourishment**; Including a significant quantity of beach re-nourishment to raise the level of the beach. This option also includes for seawall (not apron) and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
9	**Adaptive Option**: Similar to Option 7 as it also includes for the placement of rock armour along the remainder of the frontage, but is limited to 1 initial shipment of rock (i.e. 25,000 tonnes). This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

Further information on each of these scheme options can be found in Appendix D.

3.6. Economic appraisal

3.6.1 Benefits

Direct

To quantify the direct erosion damages to properties and assets under the 'Do Nothing' option and therefore establish the benefits of 'Do Something' options, the erosion extents determined by the SCAPE model (summarised in section 2.1.7) was used in conjunction with the National Receptor Database property dataset to determine potential property damages. Other direct damages included with in the assessment are for potential damages to infrastructure such as roads and utilities.

Indirect

In addition to direct asset damages, wherever possible a range of relevant intangible damages were also quantified following the Multi-Coloured Manual guidelines this included potential damages such as traffic and risk to life.

All direct and indirect damages have been applied using the methodologies outline in the Multi-Coloured Manual. All damage values have been uplifted to January 2018. A summary of the economic benefits provided by each of the options is presented in Table 3.6. This presents the damages and benefits over the 50 year appraisal period (to match that of the scheme). For reference, the damages and benefits for a longer term 100 year appraisal period are also presented. For further information on methodologies and assumptions applied in the valuation of damages and benefits see Appendix C.

Table 3.6 – Present value (PV) damages and benefits

Option	PV Damages (50 yr. appraisal period)	PV Benefits (50 yr. appraisal period)	PV Damages (100 yr. appraisal period)	PV Benefits (100 yr. appraisal period)
Do Nothing	£41,235,000	-	£48,230,000	-
Do Minimum	£33,613,000	£7,622,000	£41,281,000	£6,949,000
HTL	£0	£41,235,000	£319,000	£47,910,000

3.6.2 Costs

The costing of options was carried out using a variety of sources and utilising the best available information. Option lengths, heights and typical cross-section details were used in developing unit costs based on existing design heights. Costs were developed using standard industry price guides, benchmarking of similar schemes and estimates provided by potential suppliers. The costs include a 30% optimism bias as per FCERM-AG for scheme appraisal. Future maintenance and replacement (where appropriate) costs have also been estimated and included in the whole life costs. Cost advice was also obtained from the AECOM pricing team to benchmark and ratify the first principle costing.

In addition to capital construction costs, cost estimates for detailed design, preliminaries (preparation work) and additional costs relating to the scale of the works were included as a percentage of the overall construction costs. A value of 35% was applied to cover these items in line with industry guidance for a feasibility level project.

A summary of the whole life cash costs and present value costs is detailed in Table 3.7 below.

Table 3.7 – Whole life costs of scheme options (50 year life)

Scheme Option (50 year life)	Whole Life Costs (cash)	Whole Life Costs (PV)
1. Do Nothing	£0	£0
2. Do Minimum	£950,000	£465,411
3. Rock Revetment	£12,845,578	£10,339,879
4. Maintain Existing	£10,915,369	£6,723,062
5. Partial Rock placement A	£9,022,240	£6,232,996
6. Partial Rock placement B	£9,274,295	£5,763,265
7. Full Rock Placement	£7,381,166	£5,273,198
8. Beach Re-Nourishment	£14,791,872	£10,196,191
9. Adaptive Option	£7,200,744	£4,994,538

For further information on methodologies and assumptions applied in the cost estimates see Appendix D.

3.6.3 Present Values and Prices Indices

Following the FCERM-AG standard annual discount rates of 3.5% for the years 0 to 30, 3% for the years 31 to 70, and 2.5% for the years 71 to 99 were applied to derive present value option costs and benefits which were then compared (Table 3.9). For a breakdown of the present value option costs for all options see Table 3.8.

Table 3.8 – Whole life costs of scheme options

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Appraisal Duration	Do Nothing	(50 Years)	(50 Years)	(50 Years)	(50 Years)	(50 Years)	(50 Years)	(50 Years)	(50 Years)
Existing staff costs	£0	£0	£0	£0	£0	£0	£0	£0	£0
Further staff costs	£0	£0	£0	£0	£0	£0	£0	£0	£0
Consultants' fees	£0	£0	£275,341	£122,010	£139,811	£103,472	£121,273	£221,723	£103,460
ECI fees	£0	£0	£34,652	£15,355	£17,595	£13,022	£15,262	£27,904	£13,021
Contractors' fees	£0	£0	£410,690	£181,986	£208,537	£154,336	£180,887	£330,715	£154,319
Cost consultants' fees	£0	£0	£51,099	£22,643	£25,947	£19,203	£22,506	£41,148	£19,201
Site investigation and survey	£0	£0	£51,978	£23,033	£26,393	£19,533	£22,894	£41,856	£19,531
Construction	£0	£62,835	£5,356,830	£2,373,736	£2,720,052	£2,013,080	£2,359,396	£4,313,678	£2,012,850
Environmental mitigation	£0	£0	£66,960	£29,672	£34,001	£25,164	£29,492	£53,921	£25,161
Environmental enhancement	£0	£0	£0	£0	£0	£0	£0	£0	£0
Site supervision	£0	£0	£133,921	£59,343	£68,001	£50,327	£58,985	£107,842	£50,321
Land and compensation	£0	£0	£200,881	£89,015	£102,002	£75,491	£88,477	£161,763	£75,482
Subtotal	£0	£68,299	£6,707,345	£2,972,181	£3,405,807	£2,520,600	£3,090,823	£5,401,203	£2,520,312
Risk: Optimism bias (30%)	£0	£20,490	£2,012,204	£891,654	£1,021,742	£756,180	£927,247	£1,620,361	£756,094
Other	£0	£0	£0	£0	£0	£0	£0	£0	£0
Subtotal	£0	£88,789	£8,719,549	£3,863,835	£4,427,549	£3,276,780	£4,018,070	£7,021,564	£3,276,405
Future costs (construction and maintenance)	£0	£289,709	£1,246,408	£2,199,405	£1,388,805	£1,912,681	£965,483	£2,442,021	£1,321,640
Optimism bias	£0	£86,913	£373,922	£659,822	£416,642	£573,804	£289,645	£732,606	£396,492
Project total (PV) costs	£0	£465,411	£10,339,879	£6,723,062	£6,232,996	£5,763,265	£5,273,198	£10,196,191	£4,994,538

Please note the PV costs in this table exclude the PV appraisal costs (£70k).

3.6.3 Scheme Option ranking and Economic appraisal conclusion

Table 3.9 – Economic appraisal summary (50 year appraisal period).

Scheme Options	Present Value costs (£)	Present Value damages(£)	Present Value benefits (£)	Average benefit: cost ratio (BCR)	Incremental benefit: cost ratio (IBCR)	Economic leading option
1. Do Nothing	£ -	£ 41,235,000	£ -			-
2. Do Minimum	£465,411	£ 33,613,000	£7,622,000	16.38	16.38	-
9. Adaptive Option	£4,994,538	£ -	£41,235,000	8.26	7.42	Yes
7. Full Rock Placement	£5,273,198	£ -	£41,235,000	7.82	0.00	-
6. Partial Rock placement B	£5,763,265	£ -	£41,235,000	7.15	0.00	-
5. Partial Rock placement A	£6,232,996	£ -	£41,235,000	6.62	0.00	-
4. Maintain Existing	£6,723,062	£ -	£41,235,000	6.13	0.00	-
8. Beach Re-Nourishment	£10,196,191	£ -	£41,235,000	4.04	0.00	
3. Rock Revetment	£10,339,879	£ -	£41,235,000	3.99	0.00	-

Please note the PV costs in this table exclude the PV appraisal costs (£70k).

The economic appraisal shows that when assessed against the FCERM decision rules the economically preferred option for a scheme for the 50 year period is Option 9 (the Adaptive Option) as it has the best benefit to cost ratio (BCR) of 8.26:1. Although the Do Minimum (Option 2) has a higher BCR of 16.38, when Option 9 is compared incrementally against the Do Minimum option it achieves an incremental benefit cost ratio of 7.42:1, which robustly justifies the additional spend of Option 9 over that of the Do Minimum.

(Please also note that the Do Minimum option is not in line with the SMP policy and would be detrimental to both the natural and built environments of Mundesley if implemented.)

Although the scheme has an appraisal period of 50 years, which delivers the SMP policy, to test the economic case for extending protection of the frontage to year 100, the costs and benefits for such an option were explored (Table 3.10).

Table 3.10 – Economic Appraisal Summary (100 year appraisal period).

Scheme Options	Present Value costs (£'000)	Present Value damages(£'000)	Present Value benefits (£'000)	Average benefit: cost ratio (BCR)	Incremental benefit: cost ratio (IBCR)	Economic leading option
1. Do Nothing	£ -	£48,230,000	£ -			-
2. Do Minimum	£567,364	£41,281,000	£6,949,000	14.93	14.93	-
9. Adaptive Option	£5,470,208	£319,000	£47,911,000	8.76	8.18	Yes
7. Full Rock Placement	£5,754,835	£319,000	£47,911,000	8.33	0.00	-
6. Partial Rock placement B	£6,536,128	£319,000	£47,911,000	7.33	0.00	-
5. Partial Rock placement A	£6,920,107	£319,000	£47,911,000	6.92	0.00	-
4. Maintain Existing	£7,701,400	£319,000	£47,911,000	6.22	0.00	-
3. Rock Revetment	£10,883,802	£319,000	£47,911,000	4.40	0.00	-
8. Beach Re-Nourishment	£11,175,526	£319,000	£47,911,000	4.29	0.00	-

Please note the PV costs in this table exclude the PV appraisal costs (£70k).

The results show that the economically preferred option over 100 year period remains the Adaptive Option (Option 9), with a benefit to cost ratio of 8.76:1. In addition, the appraisal found that when Scheme Option 9 is compared to 'Do Minimum' it achieves an incremental benefit cost ratio of 8.18:1, which clearly demonstrates that if the 'hold the line' policy was to be extended to 100 years then the additional spend would be economically justified and outweighed by the additional benefits. This therefore demonstrates that in future revisions of the SMP or Coastal Strategy, the case to extend a hold the line policy to year 100 should be revisited and reconsidered. The delivery of such a Policy will however still remain subject to securing the required funding.

3.6.4 Critical Success Factor

By utilising the assessment undertaken of all the constituent shortlisted options detailed in Section 3.4 and the economic appraisal of the scheme options summarised in Section 3.6.3 it has been possible to measure each of the scheme options against the critical success factors that have been identified for the scheme (Section 3.2).

Table 3.11 below summarises the critical success assessment, please note that only the scheme options with a 50 year appraisal period have been assessed in line with the SMP policy.

Table 3.11 – Critical Success Assessment

Critical Success Factor	Scheme Options								
	1	2	3	4	5	6	7	8	9
To reduce erosion risk to people, property and infrastructure for the duration of the scheme	☹	☹	☺	☺	☺	☺	☺	😐	☺
To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable	☺	☺	☹	😐	😐	😐	😐	☹	☺
To maintain and where possible enhance natural, historic and built environments	☹	☹	😐	☺	☺	☺	☺	😐	☺
To maintain and where possible enhance the tourist industry in Mundesley	☹	☹	😐	😐	😐	😐	😐	☺	😐
To facilitate NNDC in meeting their Development goals for Mundesley including employment and residential properties and associated infrastructure over the life of the scheme.	☹	☹	☺	☺	☺	☺	☺	☺	☺

The results of this critical success assessment support the results of the economical appraisal, as Scheme Option 9 is again the preferred option. This is because Scheme Option 9:

- Successfully reduces the erosion risk to the people, property and infrastructure of Mundesley.
- Is the most cost effective of the active intervention options.
- Is both technically feasible and sustainable.
- Protects the natural, historic and built environments without any significant impacts on local designations, Landscapes or coastal processes.
- Does not adversely impact and will help to maintain the existing tourism industry.
- Does not adversely impact and will help to facilitate NNDC’s development plans for Mundesley.

3.7. Non-financial benefits appraisal

The scheme benefits outlined in Table 3.9 represent the economic damage avoided (FCERM eligible) and these are assessed from a national economic perspective, and does not permit the inclusion of potential local benefits which are transferable and displaceable. This allows nationally consistent appraisal of scheme benefits and outcomes and provides a ‘level playing field’ for Partnership Funding assessments.

However, the local economic benefits of a scheme will be significantly greater than the FCERM figures and additional local economic benefits can be derived as a result of the intervention. By evaluating the potential contribution to the local economy of investing in an erosion risk protection scheme, it helps build an understanding of other positive impacts on the local economy. For Mundesley the key aspects of this include:

- Facilitation of business continuity and sustainability of business activity in an area;
- Continuation of tourism and recreation usage; and
- Continuation of maritime response/ rescue services.

Although not included in the FCERM appraisal, a high level estimated valuation of these other local economic benefits was undertaken. This further adds to the case for change and demonstrates the local value of delivering the scheme. For the assessment of additional local economic benefits a 30 year appraisal period was adopted (rather than the 50 year period for the partnership funding assessment) because, in line with best practice, the assessment should focus only on the direct impacts of the scheme intervention, not other factors that can influence the longer term behaviours and trends of commerce and tourism.

3.7.1 Qualitative impacts

Without a scheme to mitigate erosion risk there would be significant impacts to the local economy and community in Mundesley. Table 3.12 presents the non-residential assets that would be lost over the next 100 years in a Do Nothing scenario.

Table 3.12 - Summary of commercial / tourism related assets at risk of erosion (Do Nothing)

Years	Assets lost	Impact of loss on local economy / community
0-10	Lifeboat station	Loss of maritime rescue service, potential increased risk to life for seafarers
11-20	60 beach huts, Restaurant / Cafeteria, shop, 2 holiday cottages, village hall, library	Loss of amenity and recreation supporting assets. Local economic impacts due to reduced visitor numbers and reduced spend due to degradation of services and accommodation etc.
21-30	Hotel, Church, Restaurant, Museum, 4 shops, other commercial, 3 holiday cottages, public toilets, amusements, parking, recycling site,	Further loss of community and visitor interest features. Direct impacts to economy through loss of retail outlets.
31-40	3 Holiday cottages	Further loss of visitor accommodation.
41-50	2 holiday cottages	Further loss of visitor accommodation.
51-60	1 holiday cottage	Further loss of visitor accommodation.
61-70	1 holiday cottage	Further loss of visitor accommodation.
71-80	3 holiday cottages / chalets, petrol station	Further loss of visitor accommodation and supporting services
81-90	6 holiday cottages / chalets, playground, other commercial enterprise	Loss of community recreation assets.
91-100	8 holiday cottages / chalets	Further loss of visitor accommodation.

The impacts identifed in Table 3.12 demonstrate the importance of a scheme to prevent significant detrimental impacts to the local economy. Initially impacts would be relatively minor but without intervention from year 10, key assets for the community and visitors would be lost. Firstly the inshore Lifeboat station will be lost to erosion and this would have major health and safety implications from seafarers as there would be no local response and rescue service for maritime users (nearest alternatives at either Cromer or Happisburgh). This would therefore increase the threat to life.

Over time the blue flag beach, beach huts, critical infrastructure and services and coastal access would be adversely affected or eventually lost. Local trade would suffer considerably as many of the shops and businesses rely heavily on day trippers and holiday makers. Eventually Mundesley would become an undesirable place to live and visit and alternative locations would be sought.

3.7.2 Qualitative benefits – Local Tourism

Local tourism benefits provided by the preferred option

Indicative valuations were carried out using methodologies adapted from the MCM manual, Defra GVA toolkit, and applied data from estimated tourism spend figures provided in previous tourism Study for Norfolk (Tourism Benefit & Impacts Analysis – In the Norfolk coastal area of outstanding natural beauty, 2006). Given the studies age and the lack of available detailed data, some simplistic conservative assumptions and estimates have been necessary, therefore the data presented below is likely to represent lowest estimates and the true local economic benefit is likely to be greater.

The Mundesley Tourist Office states that "well over 7000 visitors pass through" their tourism office each year (Mundesley Visitors Centre, 2018). Many of these visitors come to use the beaches for amenity and recreation such as walking or fishing, or to see the museum. Many also use the local cafés and restaurants and many stay in the range of different tourism accommodation. Therefore without intervention to prevent erosion, from year 10, many of the features that attract and serve the visitors will begin to be lost or adversely impacted. A reduction in visitors and tourism spend has been estimated as a result and is assumed by year 30 tourism would effectively cease as alternative locations would serve their needs as Mundesley becomes unattractive and lacking in the required services and features that bring people to the village today.

The estimated cash benefit to the local economy from the preferred option maintaining tourism at current day levels is £8.8m. The discounted (PV) whole life tourism benefit over the 30 years is estimated to be approximately £3.9m.

These valuations are based on an estimate of how quickly tourism would go elsewhere if erosion was unmitigated. They are also based on daily spend rates of day trippers (£40/day) and of people staying on holiday (£200/trip). The high level assessment also assumes an even split of the two types of visitor. It is likely that many more people visit the area than adopted in this valuation so the actual local economic tourism benefit associated with the scheme could be far greater. The estimates also do not account for potential increases in tourism which the preferred option could facilitate.

Table 3.13 - Total economic benefits provided by the scheme.

Category	PV £m
Local economic tourism benefits	3.9
FCERM Benefits for the Preferred option	41.2
Total	**45.1**

The conservative valuation of additional local tourism benefits totals £3.9m (PV) over the next 30 years, which equates to approximately an additional 10% of the total benefits and therefore increases the total financial benefits of the preferred option to £45.1m (Table 3.13). This qualitative assessment of the tourism benefits demonstrates that by implementing an active intervention scheme (through the preferred technical, environmental and economic option) there would be a significant benefit to the local economy.

3.8. Preferred Scheme option

Following the technical and environmental assessment (Section 3.4) and the completion of the economic appraisal (Section 3.6) Option 9 - the Adaptive Option is the preferred option. In order to protect the entire frontage Option 9 – the Adaptive Option is comprised of 4 separate elements of work, a description of each element is summarised below along with an indicative activity schedule of capital works throughout the appraisal period. (Further details of the preferred options can be found in Appendix D and E)

Rock Works: This adaptive option proposes to place rock armour protection along the frontage (except along the existing seawall) on the beach in front of the cliffs, either supplementing or (in time) replacing the existing defences. Initially for procurement efficiency the quantity of rock will be limited to 25,000 tonnes (one seaward delivery), however, as the existing defences (timber revetment and steel framed structures) reach the end of their residual life and fail the rock will be moved into place and eventually an additional supply of rocks will be required although this is not anticipated within the first 10 years.

Scour Protection: This option includes for the placing of a cabled concrete solid block mattress over the lower end of the embankment (behind the seawall). The crest height of the new protection will be designed to accommodate increasing levels of overtopping due to climate change. The mattress will be laid over a geotextile for drainage/filtration purposes. The use of porous 'Armorflex' blocks (or similar) will allow for vegetation to establish through the blocks eventually improving the aesthetics of the protective slope.

Timber Groynes: This option also includes for a major refurbishment of the existing timber groynes by replacing 30% of the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. In addition, this option also includes placing rock armour protection around the more vulnerable seaward end of the existing groynes in order to reduce the future maintenance requirements.

Seawall and apron: This option proposes to maintain the existing seawall and apron throughout the desired policy period by encasing the existing structure in reinforced concrete when necessary; initially this involves encasing only a limited number of sections of the existing wall, ensuring that the residual life of the entire seawall is uniform. In addition, this option also includes additional rock armour protection for particularly vulnerable sections of the structure, therefore reducing the need for future works.

Table 3.14 – Schedule of works over the life of the scheme.

Year	Schedule of Works
Year 1	1. Deliver, placement and storage of 25,000 tonnes of rock armour. 2. Install the concrete mattress scour protection behind the existing seawall. 3. Undertake major (30%) refurbishment of timber groynes 4. Undertake concrete encasement of relevant sections of seawall and apron. 5. Protect vulnerable sections of seawall and timber groynes with rock armour.
Year 11+	1. Supply additional rock armour, as the remaining timber revetment reaches the end of its expected residual life.
Every 10 years: (Years 11,21,31,41)	1. Undertake minor (10%) refurbishment of timber groynes 2. Undertake maintenance of rock armour (re-position rocks etc.) 3. Undertake maintenance of concrete mattress.
Year 31	1. Undertake concrete encasement of seawall. 2. Replace concrete mattress behind the seawall

A summary of the outcome measures resulting from the implementation of the preferred option are summarised below in Table 3.15.

Table 3.15 - Summary of preferred option contribution to outcome measures

Contributions to outcome measures	
Outcome 1 − Ratio of whole-life benefits to costs	
Present value benefits (£k)	£41,235
Present value costs (£k)*	£5,064,538*
Benefit: cost ratio	8.14 to 1
Outcome 2 − Households at reduced risk of flooding	n/a
Outcome 3 – Households with reduced risk of erosion	
3a – Households with reduced risk of erosion (nr)	297
Number of households in: (long term > 20 years, medium term <= 20 years)	
20% most deprived areas	Long – 0 Medium – 0
21-40% most deprived areas	Long – 131 Medium – 27
60% least deprived areas	Long – 127 Medium – 12
Outcome 4 – Water framework directive	n/a

*Please note the PV costs in this table **include** the PV appraisal costs (£70k).

3.9. Sensitivity analysis

A range of sensitivty tests have been undertaken to determine the impact of changing various parameters on the economic damages and benefits of the preferred option (assuming a 50 year appraisal / benefit period). These sensitivity tests include:

- Sensitivity 1: increased residual life of the exising defences
- Sensitivity 2: reduced erosion rate
- Sensitivity 3: reduced property values
- Partnership funding sensitivity 1: increased whole life option costs
- Partnership funding sensitivity 4: increased duration of benefits

3.9.1 – Sensitivity 1 Increased Residual Life

Increasing the residual life of the existing defences delays the onset of property erosion. This results in a greater discount factor being applied to the property damages and additional damages and therefore reduced whole life economic damages/benefits. For the purpose of the sensitivity test it has been assumed that the residual life of the existing defences is increased by 5 years. The results are presented in Table 3.16 below.

Table 3.16 - Economic damages and benefits of sensitivity test 1

Option	Original economics		Sensitivity test 1	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	33,580	0
Do Minimum	33,613	7,621	27,541	6,039
SMP6 HTL 50yrs	0	41,235	0	33,580

Table 3.17 presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 1, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 6.63, which remains above 1 demonstrating that the scheme is still viable even if the defence residual life is increased by 5 years. The Partnership Funding score is 78%, increasing to 97% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £99k would be required (total contributions of £731k).

Table 3.17 - Summary of sensitivity test 1 benefit cost ratio and partnership funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required for PF score of 100%
SMP6 HTL 50yrs – Base Case	£5,065k	£41,235k	8.14	87%	105%	-
Sensitivity Test 1	£5,065k	£33,580k	6.63	78%	97%	£99k

adjusted PF score assuming £632k contributions

3.9.2 – Sensitivity 2 reduced erosion rate

Reducing the erosion rate of the shoreline causes a delay to the onset of erosion to the properties and also a slower pace of loss of properties and associated additional damages. This also results in a greater discount factor being applied and therefore reduces the whole life economic damages / benefits. In addition, with this reduced erosion rate some properties which eroded later on in the original economic appraisal do not erode under this test scenario. For the purpose of the sensitivity test it was assumed that the erosion rates would be reduced by 50%. The results are presented in Table 3.18 below.

Table 3.18 - Economic damages and benefits of sensitivity test 2

Option	Original economics		Sensitivity test 2	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	14,125	0
Do Minimum	33,613	7,621	9,938	4,187
SMP6 HTL 50yrs	0	41,235	0	14,125

Table 3.19 below presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 2, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 2.79, which remains above 1 demonstrating that the scheme is still viable even if the erosion rate is reduced by 50%. The Partnership Funding score is 29%, increasing to 48% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £1,756k would be required (total contributions of £2,388k).

Table 3.19 - Summary of sensitivity test 2 benefit cost ratio and partnership funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required for PF score of 100%
SMP6 HTL 50yrs – Base Case	£5,065k	£41,235k	8.14	87%	105%	-
Sensitivity Test 2	£5,065k	£14,125k	2.79	29%	48%	£1,756k

adjusted PF score assuming £632k contributions

3.9.3 – Sensitivity 3 reduced residential property values

Reducing the value of residential properties in the economic assessment leads to reduced economic damages associated with the write off of the properties due to erosion. The reduction in property values has no impact on the value of the additional damages in the assessment. For the purpose of sensitivity test 3 the residential property values have been reduced by 20%. The results are presented in Table 3.20 below.

Table 3.20 - Economic damages and benefits of sensitivity test 3

Option	Original economics		Sensitivity test 3	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	34,361	0
Do Minimum	33,613	7,621	28,012	6,348
SMP6 HTL 50yrs	0	41,235	0	34,361

Table 3.21 below presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 3, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 6.78, which remains above 1 demonstrating that the scheme is still viable even if the residential property values are reduced by 20%. The Partnership Funding score is 79%, increasing to 98% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £70k would be required (total contributions of £702k).

Table 3.21 - Summary of sensitivity test 3 benefit cost ratio and partnership funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required for PF score of 100%
SMP6 HTL 50yrs – Base Case	£5,065k	£41,235k	8.14	87%	105%	-
Sensitivity Test 3	£5,065k	£34,361k	6.78	79%	98%	£70k

adjusted PF score assuming £632k contributions

3.9.4 – Partnership Funding Calculator Sensitivity 1 – 25% increase whole life costs

The in-built partnership funding calculator sensitivity test 1 increases whole life option costs by 25%. This sensitivity test also assumes that a strategic approach was not taken which reduces the maximum grant rate to 45%. Table 3.22 below presents the partnership funding score of the preferred option under sensitivity test 1 in the partnership funding calculator.

As shown, with the Partnership Funding calculator sensitivity test 1 the benefit cost ratio of the option remains above 1. However, the Partnership Funding score reduces signficantly to 31%. In order to achieve an adjusted Partnership funding score of 100% an additonal £2,248k in contributions would be required (total contributions of £2,880k).

Table 3.22 - Summary of partnership funding calculator sensitivity test 1 (25% increase in whole life costs)

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required for PF score of 100%
SMP6 HTL 50yrs – Base Case	£5,065k	£41,235k	8.14	87%	105%	-
PF Calculator Sensitivity Test 1	£6,331k	£41,235k	6.51	31%	NA	£2,248k

**adjusted PF score assuming £632k contributions*

3.9.5 – Partnership Funding Calculator Sensitivity 4 – Increased duration of benefits

The in-built partnership funding calculator sensitivity test 4 increases the benefits duration by 25% (from 50 to 62 years). This essentially means that it is taking longer to achieve the same benefit outcomes from the scheme which in turn reduces the partnership funding score (as the cost stays the same). Table 3.23 below presents the partnership funding score of the preferred option under sensitivity test 4 in the partnership funding calculator.

As shown, with the Partnership Funding calculator sensitivity test 4 the benefit cost ratio of the option remains above 1. However, the Partnership Funding score reduces to 57%. In order to achieve an adjusted Partnership Funding score of 100% an adidtional £808k in contributions would be required (total contributions of £1,440k).

Table 3.23 - Summary of partnership funding calculator sensitivity test 4 (increased duration of benefits by 25%)

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required for PF score of 100%
SMP6 HTL 50yrs – Base Case	£5,065k	£41,235k	8.14	87%	105%	-
PF Calculator Sensitivity Test 4 - SMP6 HTL 62yrs	£5,065k	£41,235k	8.14	57%	76%	£808k

**adjusted PF score assuming £632k contributions*

3.9.6 – Sensitivity Analysis Summary

The sensitivity analysis found that the preferred option (Scheme Option 9) remains economically viable, with a benefit cost ratio robustly above 1 in all of the stress test scenarios, demonstrating that the scheme is financially justified. However, the sensitivity analysis also shows that when the economic variables are stressed, the amount of third party contributions required to ensure that the scheme is fundable also increases.

4. The Commercial case

4.1. Introduction and Procurement Strategy

Procurement for the scheme will involve the detailed design, associated surveys and investigations, construction and supporting specialist advice and expertise required to successfully manage and deliver a major capital project.

The key criteria for any project, which link to the procurement strategy, tend to be interdependent and often in tension, these include:

- time (speed or certainty of completion date)
- cost (price level or cost certainty)
- quality (functionality and performance)

The most suitable procurement strategy is largely dependent on the priority assigned to each of these and could include a traditional design-bid-build or a specialist design and build (D&B) contract. An alternative strategy is for the works to be separated into smaller pieces of work and delivered through NNDC's existing supply chains. The merits of each have been summarised in Table 4.1.

Table 4.1: Overview of the different procurement approaches.

Approach	Good for:	Not suited for:
Traditional (design-bid-build)	• Quality – full design pre tender • Design flexibility – variations and instructions • Specialist subcontractors • Design control • Cost – there may be lump sum cost benefit unless multiple changes made • Risk – Client led risk management	• Time – require full detailed pack pre tender • Cost – may not a benefit if many changes made
Design and build	• Time – Fast track, overlap of design and construction • Cost – lump sum / guaranteed maximum price • Single point of responsibility – Contractor design and build responsibility • Innovation – can lead to efficiencies • Low risk for the client • Named subcontractors – in employers requirements	• Quality – cheapest route to meet contract specification can lead to low quality products/ build quality. • Design flexibility – request for changes will have cost/time implications
Deliver piecemeal through existing supply chains	• Design flexibility – variations and instructions • Programme flexibility – Can be delivered over several years • Reliability and quality of known Contractors • Prioritising works – Client can determine what needs to be prioritised • Cost assurance through existing supply chains	• Specialist works (i.e. tidal working, rock armour etc.) • Quality – variable standards provided by different contractors • Cost – Multiple contracts will result in additional fees • Innovation – limited opportunity for efficiencies • Risk – Client will hold a greater share of risks • Time – Unlikely to be delivered quickly

The NNDC priorities for this scheme are cost certainty and quality of the final outputs. Given the merits detailed in Table 4.1, the preferred procurement strategy for the scheme is leaning towards delivery through a traditional design-bid-build approach. This would allow for greater control over design and quality by procuring appropriate designers and contractors and allowing the opportunity to work as an integrated team. It would also provide the potential to maximise efficiency savings throughout the design process and still provide greater cost certainty through client led risk management.

Procurement of any services and works associated with delivery of the scheme will follow NNDC Contract Procedure Rules to ensure compliance with relevant EU Directives and UK legislation. The use of existing frameworks, where they exist and are applicable to the scheme, are favourable given the reduced time and costs associated with procuring services and works through these vehicles whilst ensuring compliance with procurement rules.

4.2. Key contractual terms and risk allocation

Appropriate contractual terms are important to minimise (or allocate) risk during the term of the contract. The current risks identified fall into three categories. Firstly they may be retained by the Council in instances where the cost of risk transfer is prohibitive, there is no market appetite for the risk and/or the risk is best managed by the Council. Secondly a decision may be taken to seek to transfer the risk to the works Contractor; this will be done after considering standard industry practice, whether the counter party has sufficient information to realistically price and manage the risk and/or if transferring the risk will provide optimal value to the Council. The third category is where it is considered prudent to share risks between the Council and the Contractor and there are provisions within construction contracts to regulate the governance of risk sharing.

Any services and works to be provided by a contractor shall be based on the terms of the relevant NEC contract, in accordance with the requirements set out in the relevant framework agreement (if appropriate). The proposed contract choice for any services to be procured will be the NEC Professional Services Contract and for any works will be the NEC Engineering and Construction Contract or NEC Engineering and Construction Short Contract (where applicable).

The proposed contract choice for any services/works to be delivered as part of the scheme will be either Option A priced contract with activity schedule or Option C target contract with activity schedule. The key contractual terms of each will be dependent on the services/works to be delivered, any identified amendments within the framework agreement (if appropriate) and recommendations from the NNDC legal team in relation to secondary options and additional conditions. Contractual terms have not been developed as part of the outline business case but this will be undertaken at the next stage of the scheme.

4.3. Procurement route and timescales

A number of different routes to market have been explored and those considered capable of delivering the needs of the scheme were identified. These include:

- Water and Environment Management Framework (WEM Framework)
- Scape Procurement – Civil Engineering and Infrastructure Framework (Scape Framework)
- Bespoke NNDC Tender
- Targeted procurement through existing NNDC supply chains or the Coastal Partnership East’s Dynamic Purchasing System.

An overview of each of these routes is summarised in the Table 4.2.

Table 4.2: Overview of the available routes to market for the scheme.

Route	Summary	Pros	Cons
WEM Framework	Framework for the Environment Agency and Risk Management Authorities that need to use consultants and contractors for engineering and environmental work, especially flood and coastal risk management. Formalised in 2013 with an initial four year contract and extended to 2020. Uses NEC ECC Option A, C or E	• Competitive rates and costs embedded into the framework • Numerous contractors awarded onto the framework • Potential to realise efficiency savings compared to a bespoke tender • Supports an integrated delivery team • No fee to utilise the framework	• In order to drive down the target cost of the scheme NNDC may need to own more of the potential construction risks. • Unlikely to utilise local contractors.
Scape Framework (Through the Coastal Partnership East)	Framework enables civil engineering and infrastructure works in sectors such as environmental, engineering, transportation, leisure, recycling and waste, defence, ports, harbours and marine, flood defence and coastal engineering, energy, education, industrial, commercial and other public sector assets. Formalised in January 2015 with a four year contract. Uses NEC PSC or ECC Option A or C	• Competitive rates and costs embedded into the framework (core costs) • Hybrid D&B option which enables designer and contractor suppliers to be appointed separately through open book competitive tendering enabling the effective use of market knowledge • Four stage process with entry to the first three by initiation from the client • Future work is reliant on present performance • Pre-construction cost certainty and risk reduction prior to target cost setting • Supports an integrated delivery team • 22 standard performance indicators with flexibility for client to add additional • First stage (feasibility) can be commenced prior to gaining funding	• Fee to utilise the framework (0.25%) • Single supplier on the framework • Selection and management of the supply chain is the responsibility of Balfour Beatty • Unlikely to utilise local contractors.

Route	Summary	Pros	Cons
		approvals • Potential to realise efficiency savings compared to a bespoke tender	
Bespoke NNDC Tender	One off tender which would need to be compliant with OJEU procurement rules should thresholds be met.	• Competitively priced on the open market • Specialist contractors can be sought • Various contract options available through this route. • Will attract large international/ national contractors with relevant experience to tender	• Significant time and resources would be required if OJEU is required which would not maximise potential efficiency savings • Quality of a potentially unknown contractor is unknown. • Unlikely to be awarded to a local contractor.
Targeted Procurement through existing NNDC supply chain or Coastal Partnership East's Dynamic Purchasing System	Separating the scheme into smaller pieces of work and procuring through NNDC's existing supply chains or Coastal Partnership East's Dynamic Purchasing System Potential opportunities for shared procurement with other local schemes.	• Some potential cost savings during the procurement process • Known quality and performance of existing contractors • Cost certainty of existing supply chain • Potential efficiencies through existing local supply chains • Likely to be awarded to local contractors wherever possible.	• Multiple contracts and multiple mobilisations may be more expensive and time consuming • Existing supply chain may not have the specialist skills required. • Potentially mobilising multiple contractors is unlikely to be delivered quickly.

An appraisal of these options in relation to the scheme is provided in the Table 4.3.

Table 4.3: Options appraisal of the available routes to market for the scheme

Option	Appraisal	Outcome
WEM Framework	*Fit with Business Need* High – would allow for a timely procurement process with suppliers that have the relevant expertise and experience to deliver the scheme *Complexity* Medium – one approved supplier with responsibility for the selection and management of the supply chain *Risk* Low – WEM framework Contractors are all pre-approved with relevant expertise and all work to pre-determined terms and conditions. However, potentially higher costs on some activities.	Preferred route to market, utilising EA approved contractors with relevant expertise and pre-determined terms and conditions. Will also benefit from EA support.
Scape Framework	*Fit with Business Need* High – would allow for a timely procurement process with a supplier that has the relevant expertise and experience to support delivery of the scheme *Complexity* Medium – one approved supplier with responsibility for the selection and management of the supply chain *Risk* Low - four stage process with entry to the first three by initiation from the client; pre-construction cost certainty and risk reduction prior to target cost setting. However, potentially higher costs on some activities.	Unlikely to be utilised as this procurement method as it is designed to support design and build contracts.
Bespoke Tender	*Fit with Business Need* Low – would not allow for a timely procurement process *Complexity* Medium – could be one supplier with responsibility for the selection and management of the supply chain, or it could be multiple suppliers. *Risk* High – NNDC responsible for checking the potential suppliers have the relevant expertise and resources.	Unlikely to be utilised due to the extensive time and resources which would be required to complete the procurement process
Targeted procurement through existing supply chain.	*Fit with Business Need* High – could be delivered through contractors known to NNDC on already agreed terms and conditions. *Complexity* Med – Potentially multiple contractors delivering various elements. Relies on NNDC for management and coordination. But potential for large efficiencies if existing supply chains are used. *Risk* Med - Potentially multiple contractors delivering various elements. Relies on NNDC for	Unlikely to be utilised exclusively due to the specialist requirements of the work and the additional responsibility and management requirements for NNDC. However, could result in some

Option	Appraisal	Outcome
	management and coordination.	efficiencies if adopted for some elements of the work.

As identified in Table 4.3, the WEM Framework has been identified as the preferred route to market for the scheme, although it is also considered that additional value for money can be achieved through targeted local procurement for some aspects of the scheme.

The WEM Framework offers a low risk timely route to market which will optimise the potential for design control, cost certainty, risk management and efficiencies through and established framework with pre-determined terms and conditions. In addition, this Framework enables the user to appoint each supplier separately whilst still enabling early contractor involvement. This route will also benefit from potential support from working with partner organisations, such as, NCPMS and NEAS within the Environment Agency.

Local procurement processes are well established with high quality efficient outputs delivered as demonstrated in the recently completed Sheringham West Coastal Management Scheme. Depending on the timescales of other local projects there may be some potential for various synergies resulting in opportunities for joint procurement and management of some aspects of the scheme.

4.4. Efficiencies and commercial issues

A Combined Efficiency Reporting Tool (CERT) form has been developed alongside this OBC (see Appendix I). This has identified approximately £836k of potential efficiency savings for the scheme, equating to approximately 24% of the total PV capital cost which can be delivered or reinvested into the scheme. These efficiencies will be generated by:

- The addition of rock protection around the most vulnerable section of the timber groynes and seawall, the maintenance requirements are reduced (est. £59k).
- The placement design of rock armour protection allowing the existing steel framed structures to be left in situ without posing an increased risk to the public when they fail. (est. £116k).
- Bulk purchasing a large quantity of rock and stock piling it for the future (est. £392k).
- Through the use of tropical timbers (instead of oak) the maintenance of groynes is further reduced (est. £24k).
- Option selection avoids any complex structures therefore reducing design costs (est. 1% or £35k).
- Negotiating the free use of privately owned access roads to the beach to reduce programme delays of using the NNDC owned access point (est. 1% or £35k).
- Negotiating the free use of privately owned land for a site compound and material storage throughout construction (est. 1% or £35k).
- Competitive tendering (est. 1% or £35k).
- Utilising existing framework agreements reduces procurement costs (est. 1% or £35k).
- Utilising existing framework agreements the scheme will benefit from cheaper rates and agreed terms and conditions previously negotiated (est. 2% or £70k).

Identifying and realising efficiencies will be an integral part of the delivery of the scheme, with an aim to deliver 15% efficiency savings on the overall scheme cost. NNDC will work closely alongside the Designer and Contractor(s) to ensure regular monitoring and forecasting of efficiency savings. These will be reported on a quarterly basis to NNDC and the Environment Agency via the CERT and on a more frequent basis as part of Project Management reporting.

5. The Financial case

5.1. Financial summary

The total project cost for approval is **£3,385,362** (Cash). A financial summary showing the projected cash and present value cost breakdown for the scheme is provided in Table 5.1.

Table 5.1: Financial summary of projected costs for the scheme.

Costs	*Cost for economic appraisal (PV)*	*Whole-life cash cost*	*Total project cost (approval)*
Costs to OBC:	*N/a -sunk costs*		*Excl. previous app*
Existing staff costs		*£0*	*£0*
Further staff costs		*£0*	*£0*
Site investigation and survey		*£0*	*£0*
Consultants' fees		*£70,000*	*£0*
Subtotal		*£70,000*	*£0*
OBC to construction (Year 0):			
Existing staff costs	*£0*	*£0*	*£0*
Further staff costs	*£0*	*£0*	*£0*
Site investigation and survey	*£19,531*	*£19,531*	*£19,531*
Consultants' fees	*£83,332*	*£83,332*	*£83,332*
Contractors' fees (ECI)	*£13,021*	*£13,021*	*£13,021*
Cost consultants' fees	*£9,765*	*£9,765*	*£9,765*
Other costs	*£0*	*£0*	*£0*
Subtotal	*£125,649*	*£125,649*	*£125,649*
Construction (Year 1) :			
Construction costs	*£2,214,135*	*£2,291,630*	*£2,235,737*
Inflation allowance at 2.5% APR			*£78,586*
Environmental enhancement	*£0*	*£0*	*£0*
Environmental mitigation	*£25,161*	*£26,041*	*£25,406*
Existing staff costs	*£0*	*£0*	*£0*
Further staff costs	*£0*	*£0*	*£0*
Consultants' fees	*£20,129*	*£20,833*	*£20,325*
Site supervision	*£50,321*	*£52,082*	*£50,812*
Cost consultants' fees	*£9,435*	*£9,765*	*£9,527*
Land purchase and compensation	*£75,482*	*£78,124*	*£76,218*
Other costs	*£0*	*£0*	*£0*
Subtotal	*£2,394,663*	*£2,478,476*	*£2,496,611*
Risk contingency:			
Optimism Bias - 30%			*£763,102*
Optimism Bias - 30%	*£756,094*	*£781,237*	
Future costs:			
Maintenance	*£358,008*	*£730,769*	
Future construction	*£963,632*	*£2,204,140*	
Optimism Bias (on future costs)	*£396,492*	*£880,473*	
Project total costs	***£4,994,538***	***£7,270,744***	***£3,385,362***

5.2. Funding sources

Based on the scheme costs provided in Table 5.1 and the potential benefits and outcomes (see Section 3) the scheme has a raw Partnership Funding (PF) score of 87%, however, with non-Grant in Aid contributions totalling £632,035 (PV) it results in an adjusted PF score of 105%. A copy of the PF calculator is provided in Appendix A.

One of the critical tasks that has been undertaken has been to explore all known potential sources of external funding available. A summary of the main funding opportunities available is provided in Table 5.2. Other potential sources explored, but discounted at this stage, include Section 106 Agreements, Business Improvement Districts and Coastal Protection Charges.

Table 5.2: Summary of main potential contribution sources.

Source	Potential funding ask		Likelihood	Notes
	PV	Cash		
Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA)	£2,714,359	£2,809,362	High	Requires commitment from Council to underwrite funding shortfall
Mundesley Parish Council	£19,324	£20,000	Confirmed	Confirmation in Appendix G
Anglian Water investment	£241,546	£250,000	Confirmed	Confirmation in Appendix G
NNDC - Capital Contribution	£225,248	£227,414	Secured	Confirmation in Appendix H
NNDC – Inflation	£75,928	£78,586	Secured	Confirmation in Appendix H
RFCC Local Levy	£70,000	£70,000	Received	Funding for business case
Direct private contributions	Will need to be gained through individual agreements		Low	Some potential direct contributions identified

It is recognised that some of the funding contribution opportunities will not be realised until the scheme progresses further, however, the NNDC Board agreed in May 2018 to commit to the delivery of the preferred option, through underwriting any potential contribution shortfall (subject to an affordability assessment) following procurement (refer to Appendix H).

Mundesley Parish Council has confirmed their commitment to contribute £20k. An email confirming their contribution can be found in Appendix G.

Anglian Water has committed to investing £250k towards the delivery of the preferred option as it directly benefits their assets in Mundesley. An email confirming their contribution can also be found in Appendix G.

The annualised funding profile for the scheme, considering available contributions is provided in Table 5.3.

Table 5.3: Annualised funding profile and breakdown of contributions (Cash)

Annualised funding needs (£)	-	Yr. 0	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Total
	Pre 2018	2018/19	2019/20	2020/21	2021/22	2022/23+	
Grant in Aid	-	-	£2,809,362	-	-	-	£2,809,362
RFCC Local Levy	£70,000*	-	-	-	-	-	£70,000*
Contributions (Utilities)	-	-	£250,000	-	-	-	£250,000
Contributions (Parish Council)	-	-	£20,000	-	-	-	£20,000
NNDC Contributions - Capital	-	£163,344	£64,070	-	-	-	£227,414
NNDC - Inflation (@ 2.5% APR)	-	-	£78,586	-	-	-	£78,586
Project total costs	£70,000	£163,344	£3,222,018	£0	£0	£0	£3,385,362*

*£70,000 has already been received from Local Levy and therefore excluded from the total

5.3. Impact on revenue and balance sheet

NNDC is accountable under Section 151 of the 1972 Local Government Act ‘Financial Administration’ to administer the financial affairs of the authority by one designated financial officer. The Section 151 Officer (or Chief Finance Officer) has the duties and powers to alert councillors and the auditor in the case of unlawful expenditure, and therefore sets the standards that the Council must meet and provides an internal check that they have been met.

NNDC, as a local authority, is required to have an annual external audit under Section 2 of the Audit Commission Act 1998. The general duties of the external auditor under Section 5 of the Act include ensuring the compliance with requirements of all statutory provisions applicable to the accounts, i.e. financial requirements. In addition, NNDC will ensure that a robust governance framework is in place through which accountability for the regularity and propriety of GiA, and other funding, can be clearly defined.

NNDC will act as the Accountable Body for the project and will be responsible for performance and compliance to ensure the activities supported fit within the programme objectives, are value for money and are an efficient use of public resources. NNDC has a long and proven track record of delivering large, complex Government funded programmes.

NNDC has considerable experience of managing projects which have been contracted out, monitoring performance and financial spend in order to ensure outputs are delivered. The project will be managed through a system of robust appraisal and monitoring throughout the life of the programme as well as being responsible for its delivery. Auditing systems are already in place and these will be adapted to suit the specific requirements of the programme.

Alongside the Project Manager, NNDC will source the appropriate specialists to assist with contract delivery/management/ performance and due diligence. The Project Team will also draw upon the support of specialist colleagues from other relevant in house service areas such as the legal, finance, risk and procurement, as required.

Any contractors will be required to submit regular updates to the Project Team and will be required to provide details on spend, outputs and milestones and give explanations for any variances from their actual performance against their anticipated profile and consequent risks to delivery outputs.

The Project Manager will check the completion of each work stage and identification of eligible expenditure prior to signing off payment of any invoices. The Project Manager will maintain copies of key files and documents relating to all project activity including expenditure.

On completion of construction anticipated to be in 2019/20, an erosion management asset register will be created. There will be minimal initial maintenance in the first 10 years and no further anticipated capital spend. The revenue costs associated with the maintenance required over the whole life of the scheme have been estimated and these will subsequently be covered by NNDC.

5.4. Overall affordability

The annualised PV spend profile showing the overall affordability for the scheme going forward is provided in Table 5.4. The scheme eligibility for FCERM Grant in Aid has been considered separately (see Section 5.2).

Table 5.4: Annualised spend profile

Annualised spend profile (£k) (PV)	Pre 2018	Yr. 0 2018/19	Yr. 1 2019/20	Yr. 2 2020/21	Yr. 3 2021/22	Yr. 4+	Total
Staff costs	-	-	-	-	-	-	-
External fees	70.00	125.65	77.94	-	-	-	273.59
Construction costs	-	-	2160.13	-	-	-	2160.13
Environmental	-	-	24.55	-	-	-	24.55
Land and compensation	-	-	73.64	-	-	-	73.64
Other: (list)	-	-	-	-	-	-	0.00
Risk - Optimism Bias	-	37.69	700.88	-	-	-	738.57
Inflation (@2.5% APR)	-	-	75.93	-	-	-	75.93
Project total costs	**70.00**	**163.34**	**3113.06**	**-**	**-**	**-**	**3346.41**
Less: Contributions		163.34	398.70	-	-	-	562.05
Less: Local Levy being claimed	70.00	-	-	-	-	-	70.00
Capital grant claim	-	-	2714.36	-	-	-	2714.36
Grant rate (%)	-	-	81%	-	-	-	-

6. The Management case

6.1. Project management

The scheme will be delivered in accordance with NNDC's existing project management system. The project will be overseen by a multi-agency Project Board comprising senior management representation from NNDC, Coastal Partnership East, the Environment Agency and the appointed supplier(s) and will be supported by a project team lead by a dedicated Project Manager.

6.1.1 Project structure and governance

The Project Board will provide direction and management for the project. The Project Board will be the overall authority for the project and is accountable for its success or failure. The board members have the sufficient authority to carry out their responsibilities effectively. The collective responsibilities of the Project Board members will include:

- Accepting and demonstrating ownership for the project;
- Working as a team to provide collective and unified direction;
- Effective delegation with appropriate project tolerances and exception management processes;
- Facilitating cross functional working ensuring that the project structure is recognised and respected by line management;
- Committing all of the resources required to successfully complete the project;
- Effective decision making including risk, issue and change management;
- Project assurance and quality control;
- Ensuring timely and effective communication within the project and with external stakeholders; and
- Ensuring that the project deliverables are reliable, sustainable and can be maintained efficiently.

The proposed governance arrangements and interface between each element is indicatively displayed in Figure 6.1

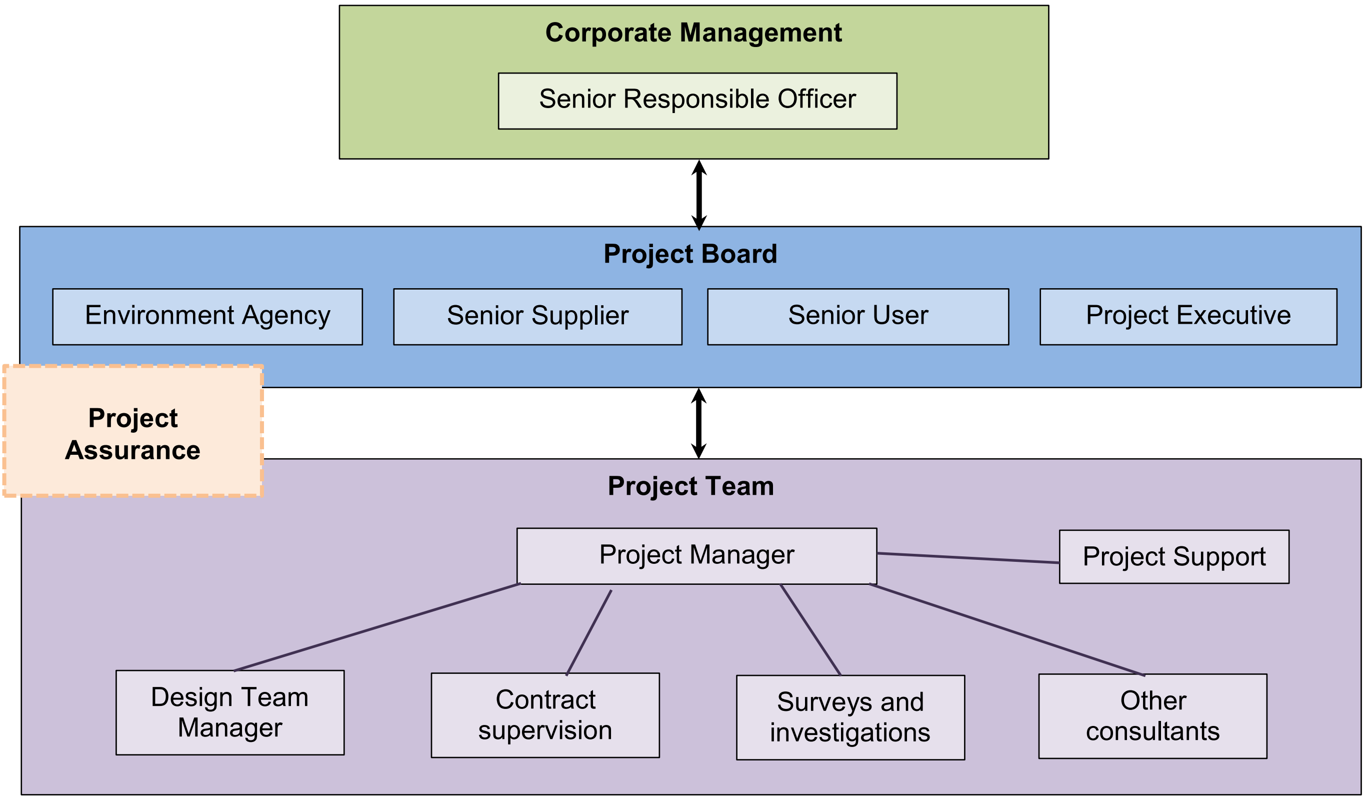

Figure 6.1: Indicative Project Governance Structure

6.1.2 Project roles and responsibilities

The main roles and responsibilities for the scheme are detailed in Table 6.1 below.

Table 6.1: Key roles and responsibilities.

Role	Person	Responsibility
Senior Responsible Officer	NNDC Director **Steve Blatch**	Enable linkage between the top level strategic direction of the organisation and the management activities required to achieve strategic objectives. • Ensures the goals of the scheme remain valid in response to external changes. • Supports senior managers who have to plan and control activities, set priorities and allocate resources for implementation of groups and related projects. • Ensures the impact of changes on the organisations and stakeholders involved is managed and that the intended change is achieved in the optimum way. • Enables the effective delegation and management. • Ensures all issues are recognised and managed to maximise success. • Ensures risks to the scheme's successful completion are identified, monitored, managed and controlled in a way acceptable to management. • Ensures all stakeholders are informed and involved and that their interests are appropriately considered. • Helps to focus management attention clearly on the realisation of benefits that are defined and understood at the outset and achieved throughout the lifetime of the scheme and beyond.
Project Executive	Coastal Partnership East Director **Bill Parker**	The Project Executive represents NNDC/Coastal Partnership East and is ultimately responsible for the project, supported by the Senior User and Senior Supplier. The Project Executive's role is to ensure that the scheme is focused throughout its life cycle on achieving its objectives and delivering a product that will achieve the projected benefits. The Project Executive has to ensure that the scheme delivers value for money, ensuring a cost-conscious approach to the project, balancing the demands of business, user and supplier. •Oversee the development of the Project Brief and Business Need. • Ensure that there is a coherent project organisation structure and logical set of plans for the delivery of the scheme. • Authorise stage expenditure and set stage tolerances. • Monitor and control the progress of the project at a strategic level, in particular reviewing the Business Need continually (e.g. at each end stage review). • Ensure that any proposed changes of scope, cost or timescale are checked against their possible effects on the Business Need. • Ensure that risks are being tracked and mitigated as effectively as possible. • Chair Project Board meetings. • Recommend future action on the scheme to the SRO if the project tolerance is exceeded. • Approve the End Project Report and Post Project Review Report and ensure that any outstanding issues are documented and passed on to the appropriate body for action. • Approve the sending of the project closure notification to the SRO. • Ensure that the benefits have been realised by holding a Post Project Review and forward the results of the review to the appropriate stakeholders. The Project Executive is responsible for overall business assurance of the scheme. Business assurance covers: • Validation and monitoring of the Business Need against external events and against project progress. • Keeping the project in line with NNDC strategies. • Monitoring project finance on behalf of NNDC. • Monitoring the business risks to ensure that these are kept under control. • Monitoring internal fee expenditure. • Monitoring changes to the Project Plan to see whether there is any impact on the needs of the business or the project Business Case. • Assessing the impact of potential changes on the Business Case and Project Plan. • Monitoring stage and project progress against the agreed tolerances.
Senior User(s)	NNDC Coastal Manager **Rob Goodliffe**	The Senior User is responsible for the specification of the needs of all those who will use the final product, for user liaison with the project team and for monitoring that the solution will meet those needs within the constraints of the Business Case in terms of quality, functionality and ease of use. • Ensure the desired outcome of the scheme is specified. • Make sure that progress towards the outcome required remains consistent. • Promote and maintain focus on the desired outcomes. • Ensure that any resources required for the project are made available. • Ensure that the deliverables are signed off once completed. • Resolve user requirements and priority conflicts. • Provide the user view on Post Project Review outcomes. • Brief and advise management on all matters concerning the project.
Senior Supplier	To Be Appointed	The Senior Supplier is responsible for the technical integrity of the elements of the project under their commissions.

Role	Person	Responsibility
		• Agree objectives for Design Support and construction activities. • Select and appoint the Construction Project Team members. • Provide design support and construction capability. • Make sure that progress towards the outcome remains consistent and in accordance with specifications, standards, and tolerances. • Promote and maintain focus on the desired project outcome from the point of view of the Contractor. • Ensure that the resources required for the Design Support and Construction activities are made available. • Contribute Contractor opinions on Project Board decisions on whether to implement recommendations on proposed changes. • Monitor compliance with relevant legislation and Standing Orders. • Resolve construction team requirements and priority conflicts. • Arbitrate on, and ensure resolution of, any construction team priority or resource conflicts. The Senior Supplier assurance role responsibilities are defined as follows: • Advise on the buildability and economics of emerging designs. • Advise on the selection of construction supply chain procurement strategy. • Monitor the completeness and quality of Project Management deliverables, to ensure that the project is being run effectively. • Monitor project risks and ensure that due planning takes place for their mitigation. • Monitor project programmes and financial progress and advise on required action where required. • Assure the technical competence of constructed solutions through an appropriate level of compliance testing / review. • Monitor potential changes and their impact on the correctness, completeness and integrity of deliverables. • Assure that adequate co-ordination between suppliers is taking place and to arbitrate on any conflict of opinion that may arise between disciplines.
Project Assurance	Project Board	Project Assurance provides an independent view of how the project is progressing. There are three views of assurance; business, user and supplier. Assurance is about checking that the project remains viable in terms of costs and benefits (business assurance), checking the user requirements are being met (user assurance) and that the project is delivering a suitable solution (supplier assurance). Given that each of the three views of assurance reflects the interest of the principal Project Board Members, Project Assurance will be undertaken by the Project Board member with specific responsibilities identified with each role.
Project Manager	Coastal Partnership East Coastal Engineering Manager **Tamzen Pope**	The Project Manager has the authority to run the project on a day-to-day basis on behalf of the Project Board within the constraints and tolerances laid down. The Project Manager's prime responsibility is to ensure that the project produces the required product, to the required standard of quality and within the specified constraints of time and cost. The Project Manager is also responsible for the project producing a result that is capable of achieving the benefits defined in the Business Case. • Ensure project objectives are clearly defined and articulated. • Define deliverables necessary to achieve project outcomes. • Manage the production of the required deliverables. • Direct and motivate the project team. • Plan and monitor the project. • Prepare Project, Stage and, if necessary, Exception Plans and agree them with the Project Board. • Manage the risks, including the development of contingency plans. • Take responsibility for overall progress and use of resources and initiate corrective action where necessary. • Be responsible for change control. • Prepare and report to the Project Board through Highlight Reports and End Stage Reports and Exception Reports. • Liaise with the Project Board or its appointed Project Assurance roles to assure the overall direction and integrity of the project. • Agree technical and quality strategies with appropriate members of the Project Board. • Ensure compliance with relevant legislation and Local Authorities Standing Orders. • Prepare the End Project Report. • Identify and obtain any support and advice required for the management, planning and control of the project. • Be responsible for project administration. • Be responsible for the overall control of internal and external fee expenditure. • Commission specialist consultants, surveys and investigations.
Project Support	Assistant PM, Admin (tbc)	The provision of any Project Support on a formal basis is optional at the discretion of the Project Manager. Tasks need to be done by the Project Manager or delegated to a separate project support entity, and this will be driven by the needs of the project and the Project Manager. Project Support may be in the form of advice on project management tools, guidance, administrative services such as filing, and the collection of actuals. Responsibilities include: • Ensure relevant Purchase Orders are in place.

Role	Person	Responsibility
		• Administer change control. • Set up and maintain project files. • Set up fees within costing system. • Reporting on actual cost vs fee. • Assist with fee recovery. • Collect actuals data and forecasts for Performance Management. • Update plans. • Assist with the compilation of reports. • Specialist tool expertise (for example, planning and control tools, risk analysis).
Design Team Manager	To Be Appointed	The Design Team Manager's prime responsibility is to ensure production of those products defined by the Project Manager to an appropriate quality, in a timescale and at a cost acceptable to the Project Board. The Design Team Manager reports to, and takes direction from, the Project Manager. • Prepare plans for the team's work and agree these with the Project Manager. • Manage and co-ordinate the duties and deliverables of the design team. • Direct, motivate, plan and monitor the team's work. • Take responsibility for the progress of the team's work and use of team resources and initiate corrective action where necessary within the constraints laid down by the Project Manager. • Advise the Project Manager of any deviations from plan, recommend corrective action and help prepare any appropriate Exception Plans. • Return to the Project Manager deliverables that have been completed. • Ensure all Project Issues are properly reported to the Project Manager. • Ensure evaluation of Project Issues that arise within the team's work and recommend action to the Project Manager. • Arrange and lead design team meetings and produce Design Reports as agreed with the Project Manager. • Ensure that quality controls of the team's work are planned and performed correctly. • Identify and advise the Project Manager of any risks associated with a deliverable. • Ensure that all identified risks are entered on the Risk Log. • Manage specific risks as directed by the Project Manager. • Carry out the role of Contract Administrator as defined within the contract. • Ensure compliance of the design with all relevant legislation and Local Authority Standing Orders.
Other Project Team Roles Contract Supervision, Surveys and Investigations, Other Consultants	To Be Appointed	Other Project Team roles will provide the support and advice required for the management, planning and control of the project as defined in their scope of works.
Other support roles	Legal Advisor, Procurement Manager, Communication, Property, Finance	NNDC internal resources will provide professional advice and guidance to the project as required.

6.1.3 Project Plan

The key dates and milestones for the delivery of the scheme are provided in Table 6.2.

Table 6.2: Key dates and milestones.

Activity	Target Completion Date	Comment
Anglian Water Funding Approval	April 2018	Confirmation Received
NNDC Approval	Spring 2018	-
Project Business Case Approval	Spring 2018	Includes Environment Agency (FCERM GiA)
Detailed Design (including surveys etc.)	Summer/Autumn 2018	Assumes a 4 month programme (including any investigations) following business case approval,
Obtain all necessary consents	Winter 2018	Assumes a 4 month programme following the detailed design to obtain all the various required consents.
Complete delivery agreement for the Construction Stage	Spring 2019	Allows 2-3 months for procurement activities following the receipt of all required consents.
Construction work to be started on site	Summer 2019	Allows for at least a 6 weeks mobilisation period following contract award.
Construction work completed	Winter 2019	Assumes a 6 month construction programme

6.2. Communications and Stakeholder engagement

The development of this OBC and associated studies was overseen by a project team that included NNDC, who provided management and assurance. Regular project progress meetings were used by the project team to provide regular communications between the core organisations involved (NNDC, St La Haye Ltd and AECOM).

Extensive external engagement was carried out throughout development and appraisal of the potential options for the scheme. This has resulted in overwhelming 'in principle' support for the scheme and has informed decision making process and optimisation of the preferred option.

The communications undertaken during development of the scheme included:

- Frequent landowner and stakeholder engagement throughout the development of the options and appraisal process;
- Establishment of Scheme Local Liaison Group;
- Two public exhibition events associated with the consultation on the feasible scheme options;
- Frequent landowner and stakeholder engagement throughout the development of the outline design of the proposed scheme; and
- Engagement with statutory consultees inviting inputs and reviews of the proposed scheme.

Key future communications include:

- Continued landowner and stakeholder engagement and negotiations. Where possible maintaining continuity with established points of contact.
- Continued engagement with the Scheme Local Liaison Group.
- Additional external communications with wider public through existing channels, as required.
- Regular dialogue between Contractor and Stakeholders via a dedicated communications representative.
- Statutory consultee input and liaison as and when required e.g. Marine Management Organisation, Planning, and Natural England etc.
- Additional consultation associated with a potential Planning Application for the scheme.

6.3. Change management

Change management control procedures will be used for the project. This will be through the use of an Issues and Change report managed by the Project Manager. This will be discussed with the Project Board to ensure consistency in reviewing all project changes and also whether there is a need to implement the change. Dependent on the issue, the Project Board will allow discretion of the Project Manager to address certain issues. However, where tolerance boundaries have been set, then should any proposed implementation deviate beyond these tolerances, the Project Board must be involved in the decision whether to implement or not.

During implementation, the Project Manager should ensure that its status is reported to the Project Board up to the point when the issue or change has been fully implemented.

6.4. Benefits realisation

The realisation of benefits will be managed by NNDC in their capacity as the lead organisation for delivering the scheme. All benefits will be realised when construction works have been completed. The works are currently expected to be completed in 2019 and therefore NNDC will report the realisation of benefits at that time in accordance with the measurement criteria set out for each critical success factor (Table 3.1). Potential efficiency savings have been identified for the scheme (see Section 4.4) and these will be tracked and monitored by the Project Manager via quarterly CERT reporting throughout the scheme delivery.

The Outcome Measures to be delivered by the scheme, and the year of anticipated realisation are detailed in Table 6.3. It might be possible to phase the realisation of Outcome Measures following completion of significant sections of the scheme. However, it is not possible to provide a forecast with any confidence at present as the phasing of construction works will have to be sensitively scheduled by the contractor having regard to site constraints and environmental mitigation.

Table 6.3: Outcome Measures resulting from the scheme

Outcome Measure (OM)	Yr. 0 2018/19	Yr. 1 2019/20	Yr. 2 2020/21	Yr. 3 2021/22	Yr. 4+ 2022/23+	Total
OM3a Households with reduced risk of erosion (nr)	-	297	-	-	-	297
OM3b Proportion of those in 3a protected from loss within 20 years (nr)	-	39	-	-	-	39
OM3c Proportion of households in 3b that are in the 20% most deprived areas (nr)	-	-	-	-	-	-

6.5. Risk management

The key project risks, risk owners and the proposed mitigation measures for each are summarised in Table 2.7. The scheme risks are assessed in further detail in the risk register which is available in Appendix J.

6.6. Contract management

Contract management will be delivered in accordance with the NNDC procurement policy which includes the Financial Procedure Rules and Contracts Procedure Rules ensuring compliance with all relevant EU Directives and UK legislation. All contracts relating to the procurement of services and/or works to assist with delivery of the scheme will utilise the established NEC Professional Services Contract (PSC) or Engineering and Construction Contract (ECC) (as applicable).

Part of the function of the project team (under the direction of the Project Manager) will be to deliver the contract management role for the scheme. An appropriate team to support this function will be employed to deliver this role, such as an ECC Project Manager, Cost Consultant and Site Supervisors.

6.7. Assurance

Project Assurance will be undertaken by the Project Board, which comprises members with specific responsibilities as per those detailed in Table 6.1.

6.8. Post project evaluation

As part of the closedown of the project a post project evaluation will be completed. This is to verify that all objectives have been met, the intended benefits are realised and lessons learnt during the life of the project are captured and shared with the Project Board. The evaluation process will include:

- Confirmation of the achieved outcomes to assess successful delivery of the investment objectives.
- Review and report on the lessons learned so they can be shared with colleagues to replicate successes and avoid pitfalls.
- Ensure receipt of the Health and Safety File (Construction and Design Management Regulations, 2015).
- Ensure that ongoing support arrangements are identified, provided for and formally handed over.
- Complete the end of project report.
- Secure formal sign-off.

It is also proposed that NNDC undertake a post-project implementation review after the first significant storm event following the completion of the works to determine whether the benefits of the scheme have been fully realised.

6.9. Contingency plans

The proposed project management approach will help minimise the need for contingency but in the event that something were to occur that would require it to be considered, the following allowances have been identified:

- Funding contingency; some funding contingency has been included to cover the identified risks. In addition NNDC have also underwritten any potential funding shortfall (see section 5.2)
- Resource issues; key roles will have assistant support that could provide temporary cover if absences were to occur; replacements will be considered for longer term absences through the most appropriate avenue.
- Programme delays; flexibility and contingency have been built into the future programme to cover identified risks.

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name Mundesley OBC - HTL 50 years
Unique Project Number

Key: Input cells / Calculated cells

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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SUMMARY: prospect of FCRM GiA funding

Scheme Benefit to Cost Ratio:	**8.14**	to 1
Effective return to taxpayer:	**15.19**	to 1
Effective return on contributions:	**65.24**	to 1

Raw Partnership Funding Score	**87%**	(1)
External Contribution or saving required to achieve an Adjusted Score of 100%	**450,124**	(2)
Adjusted Partnership Funding Score (PF)	**105%**	(3)
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**2,714,359**	(4)

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA**	(5)
Duration of Benefits (years)	**50**	(7)
PV Whole-Life Benefits:	**41,235,000**	(8)
PV Costs		
PV Appraisal Costs	70,000	(9)
PV design & Construction Costs	3,276,405	(10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**3,346,405**	(11)
PV Post-Construction Costs	1,718,133	(12)
PV Whole-Life Costs:	**5,064,538**	(13)
PV Contributions secured to date		
PV Local Levy secured to date	70,000	(14)
PV Public Contributions secured to date	301,176	(15)
PV Private Contributions secured to date	260,870	(16)
PV Funding form other Environment Agency functions/sources secured to date		(17)
PV Total Contributions secured to date	632,046	(18)

Yes (6)
Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.
NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before: Moderate risk	Before: Significant risk	Before: Very significant risk	After: Moderate risk	After: Significant risk	After: Very significant risk	Change due to scheme: Moderate risk	Change: Significant risk	Change: Very significant risk
20% most deprived areas	-	-	-	-	-		0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	-	-	-	-	-	-	0	0	0
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	Qual. benefits (discounted)	
20% most deprived areas	£ -	£ -	OM2 (20%)	£ -
21-40% most deprived areas	£ -	£ -	OM2 (21-40%)	£ -
60% least deprived areas	£ -	£ -	OM2 (60%)	£ -

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before: Long-term loss	Before: Medium-term loss
20% most deprived areas	-	-
21-40% most deprived areas	131	27
60% least deprived areas	127	12

Damages per household avoided:	Long-term loss	Medium-term loss	
Annual damages avoided	£ 6,000	£ 6,000	
Loss expected in	50	20	years
Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015	

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	Qual. benefits (discounted):	
20% most deprived areas	£ -	£ -	OM3 (20%)	£ -
21-40% most deprived areas	-£ 236,464	-£ 11,823,208	OM3 (21-40%)	£ 5,838,908
60% least deprived areas	-£ 186,499	-£ 9,324,947	OM3 (60%)	£ 4,605,138

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:			Assumed benefits per unit:	Qual. benefits (discounted):	
OM4a		Hectares of net water-dependent habitat created	£ 15,000	OM4a	£ -
OM4b		Hectares of net intertidal habitat created	£ 50,000	OM4b	£ -
OM4c		Kilometres of protected river improved	£ 80,000	OM4c	£ -
				OM4	**£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

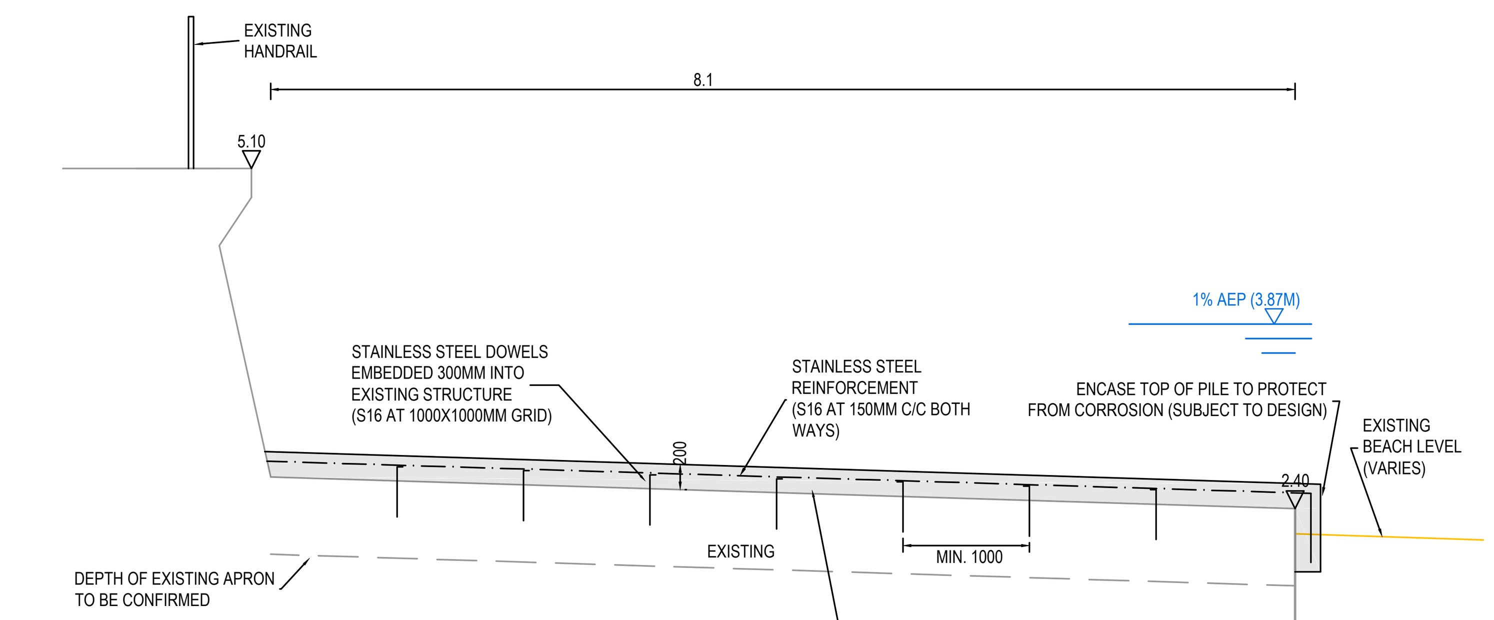
OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 30,790,955	5.56 p in the £1	£ 1,710,609
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM3	20% most	£ -	45.0	£ -
	21-40%	£ 5,838,908	30.0	£ 1,751,672
	Least 60%	£ 4,605,138	20.0	£ 921,028
OM4		£ -	100.0	£ -
Total		£ 41,235,000		**£ 4,383,308**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

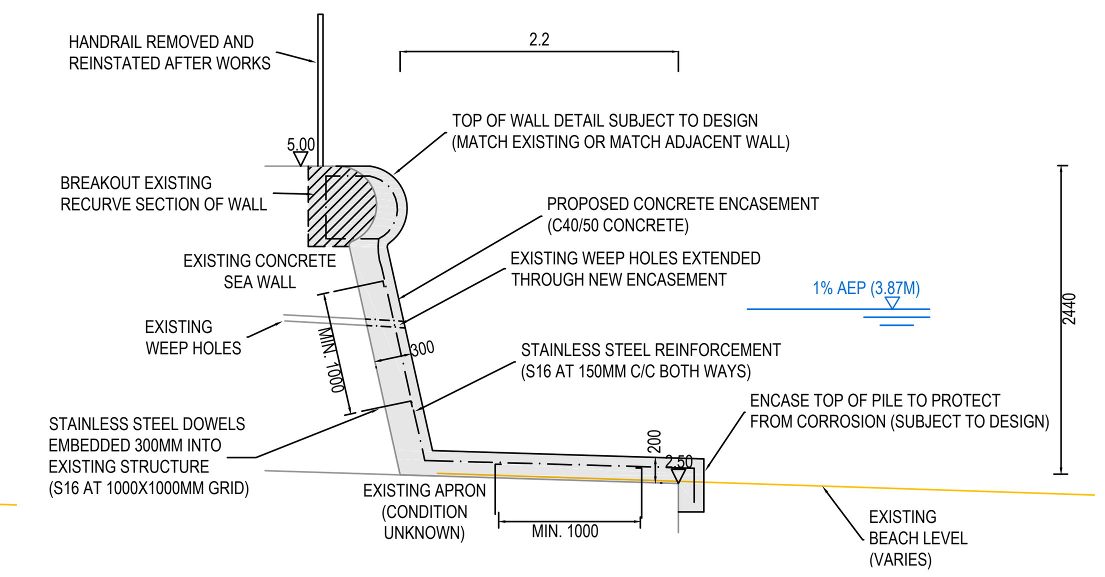
Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	87%	450,124
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	31%	2,879,680
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	87%	450,124
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	83%	574,655
Sensitivity 4 - Increase Duration of Benefits by 25%	57%	1,439,981
Sensitivity 5 - Reduce Duration of Benefits by 25%	81%	622,627

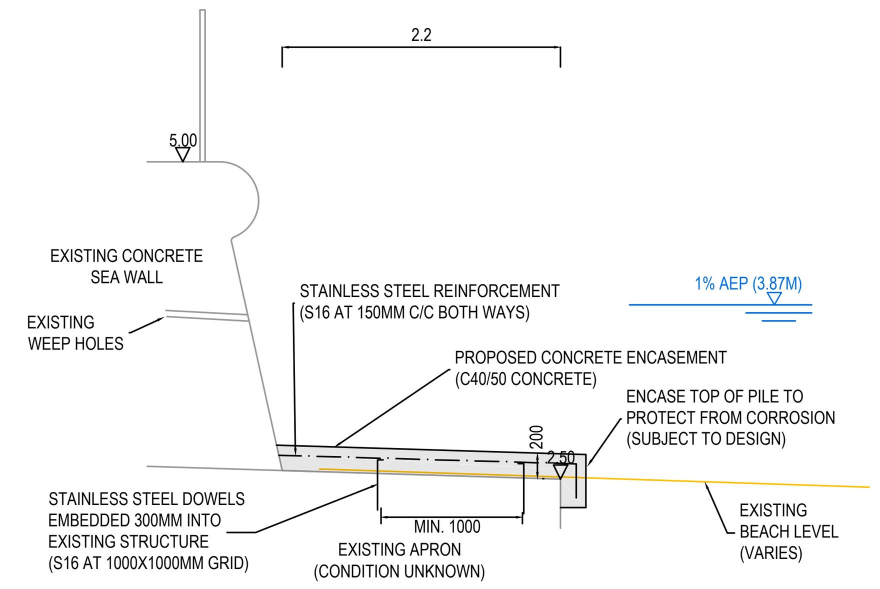
END OF WORKSHEET



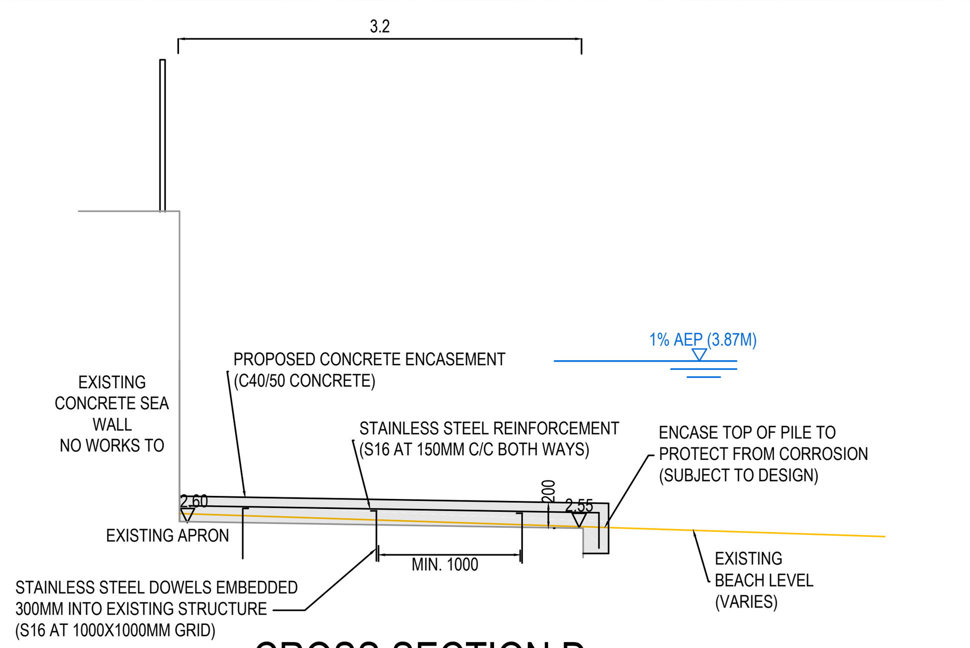
CROSS SECTION A.
SEAWALL FRONTAGE 1 WITH APRON ENCASEMENT



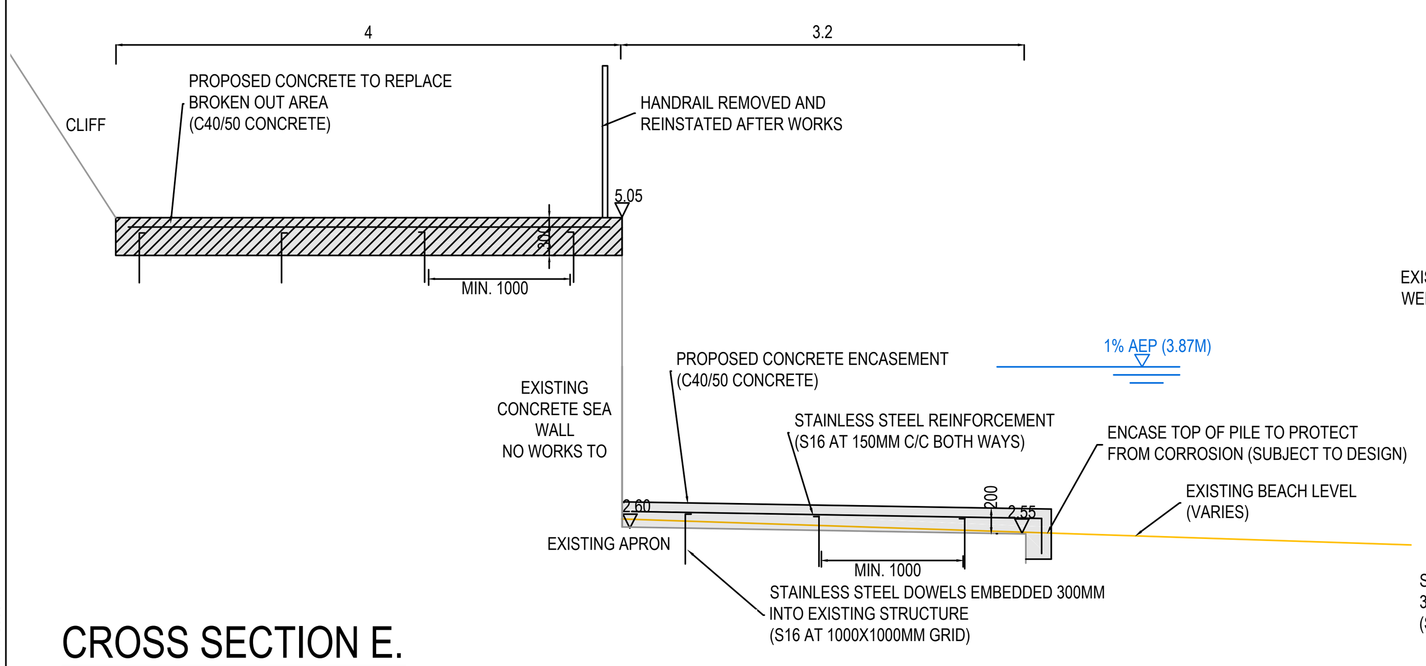
CROSS SECTION B.
SEAWALL FRONTAGE 2A WITH SEAWALL AND APRON ENCASEMENT



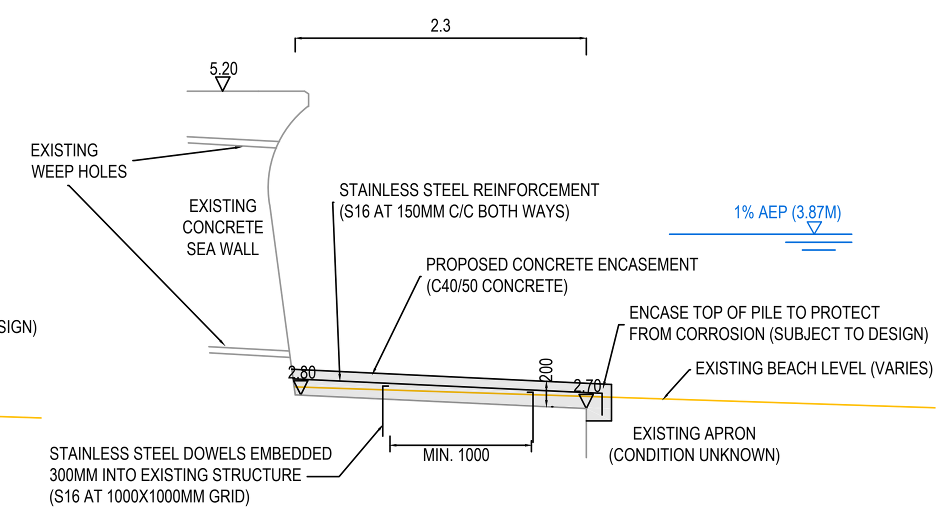
CROSS SECTION C.
SEAWALL FRONTAGE 2B WITH APRON ENCASEMENT



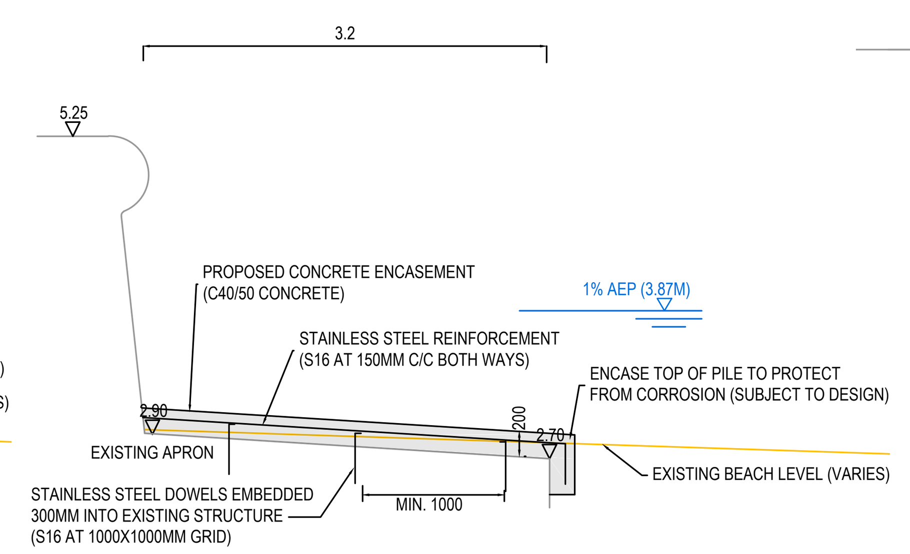
CROSS SECTION D.
SEAWALL FRONTAGE 3A WITH APRON ENCASEMENT



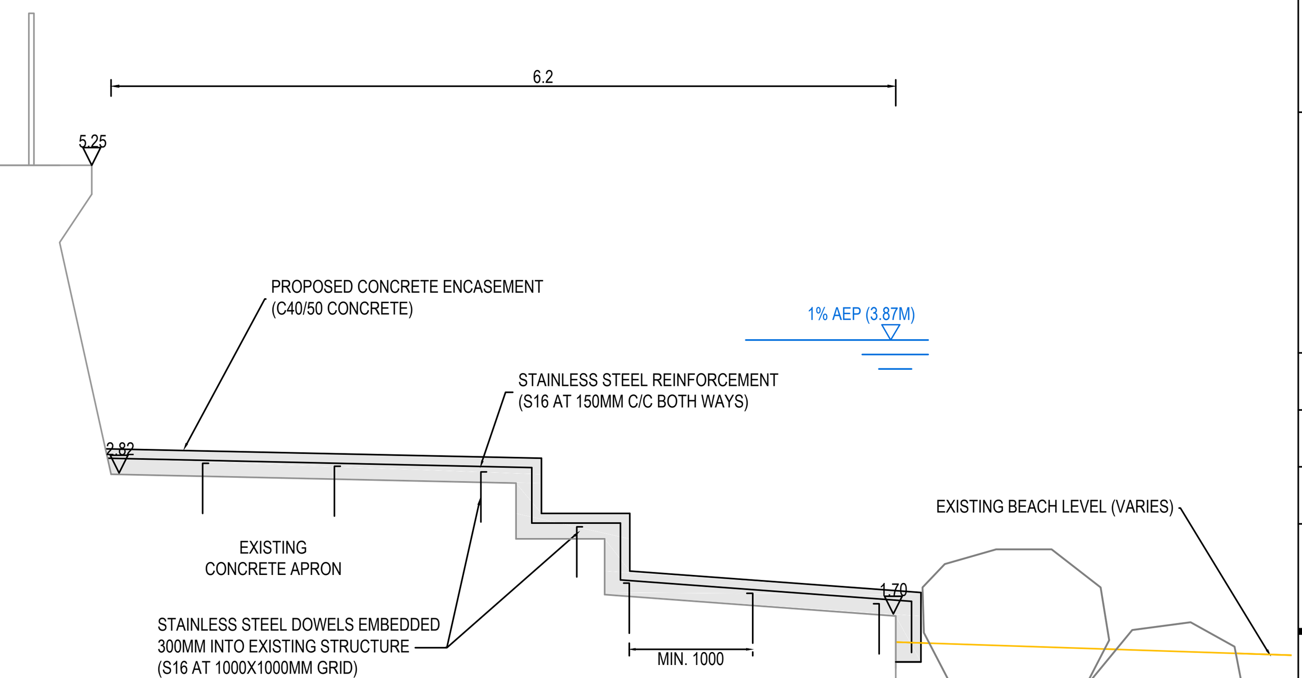
CROSS SECTION E.
SEAWALL FRONTAGE 3B WITH NEW CONCRETE DECK AND APRON ENCASEMENT



CROSS SECTION F.
SEAWALL FRONTAGE 4 WITH APRON ENCASEMENT



CROSS SECTION G.
SEAWALL FRONTAGE 5 WITH APRON ENCASEMENT



CROSS SECTION H.
SEAWALL FRONTAGE 6 WITH APRON ENCASEMENT AND ROCK ARMOUR PROTECTION

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

NOTES

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2. DO NOT SCALE FROM THIS DRAWING, USE ONLY PRINTED DIMENSIONS.
3. ALL DIMENSIONS IN MILLIMETRES, ALL LEVELS IN METRES UNLESS DEFINED OTHERWISE.
4. DIMENSIONS OF EXISTING STRUCTURES HAVE BEEN INTERPRETED FROM AVAILABLE INFORMATION FOR THE PURPOSE OF OUTLINE DESIGN. DIMENSIONS SHOULD BE REVIEWED PRIOR TO DETAILED DESIGN.
5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 1 RELATES TO THE AREA S7T FROM THE CONDITION ASSESSMENT
7. SEAWALL FRONTAGE 2A RELATES TO THE AREA S6 FROM THE CONDITION ASSESSMENT
8. SEAWALL FRONTAGE 2A RELATES TO THE AREA S6 FROM THE CONDITION ASSESSMENT
9. SEAWALL FRONTAGE 3A RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
10. SEAWALL FRONTAGE 3B RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
11. SEAWALL FRONTAGE 4 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
SEAWALL FRONTAGE 5 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
SEAWALL FRONTAGE 6 RELATES TO THE AREA S4 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- NEW STEEL METAL STEPS (DESIGN TO BE CONFIRMED)
- CROSS SECTION LOCATIONS
- ROCK ARMOUR
- EXISTING BEACH LEVEL (VARIES)
- BREAKOUT OF EXISTING CONCRETE
- RAMP WIDENED (DETAILS TO BE CONFIRMED AT DETAIL DESIGN)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE

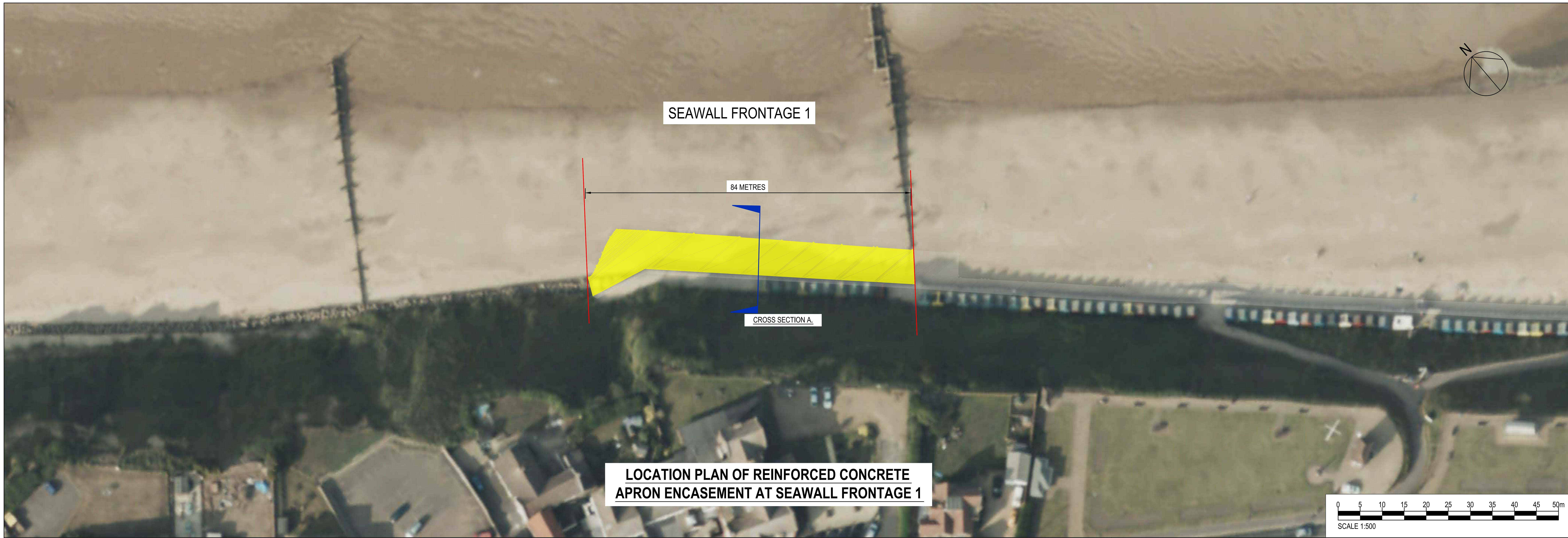
OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

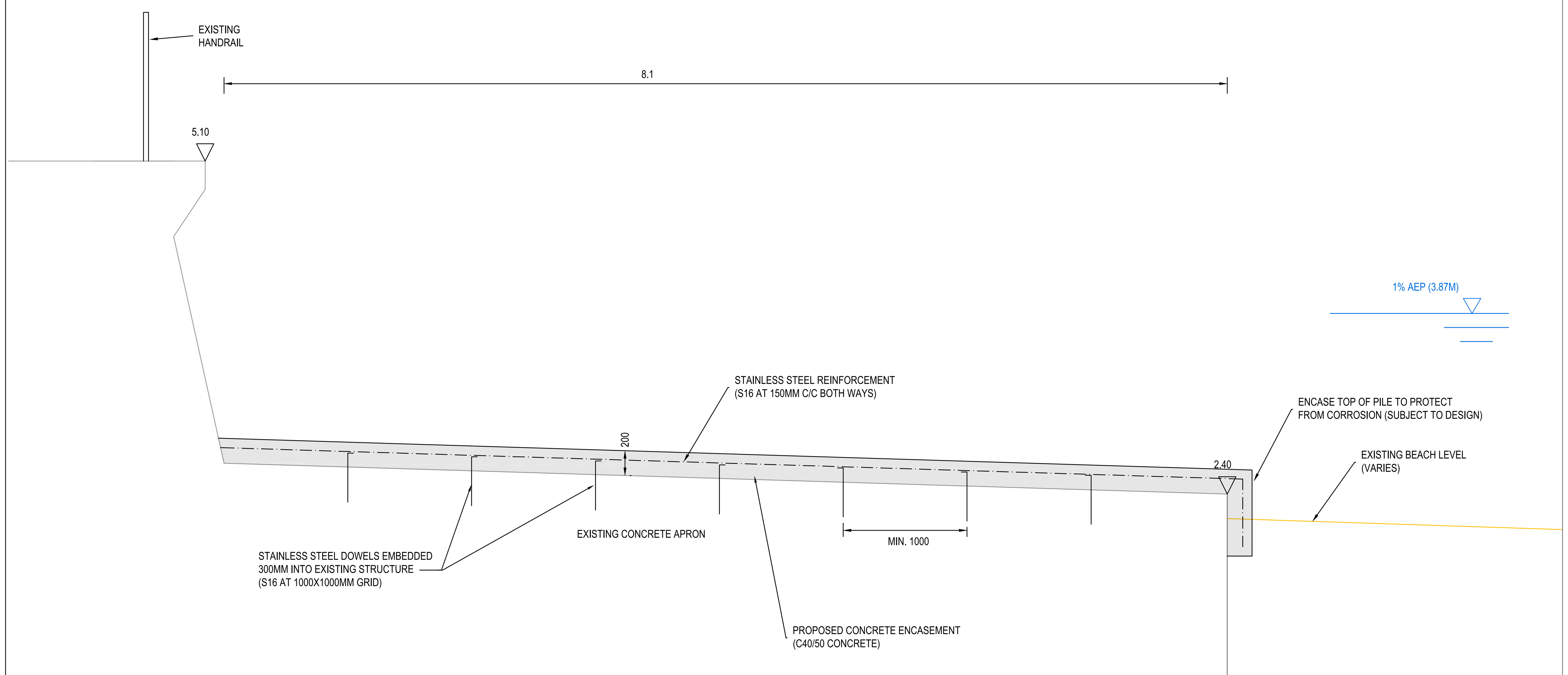
AECOM Internal Project No.: 60519091
Suitability: S2
Scale @ A1: 1:50 / 1:1000
Zone: -

AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number: MOBC-ACM-XX-00-DR-CE-02011
Rev: P2

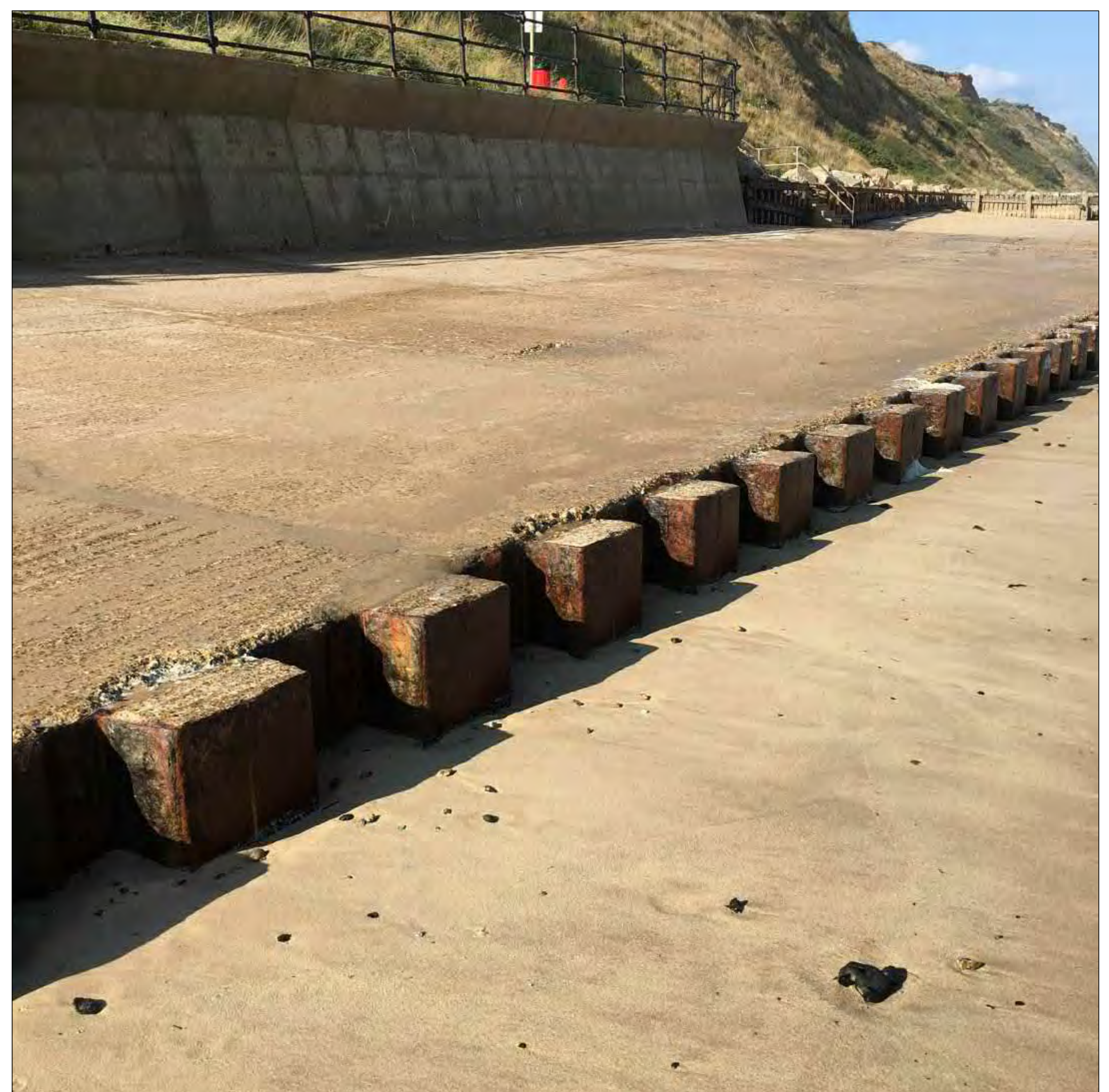


LOCATION PLAN OF REINFORCED CONCRETE APRON ENCASEMENT AT SEAWALL FRONTAGE 1



CROSS SECTION A. APRON ENCASEMENT AT SEAWALL FRONTAGE 1

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25



PHOTOGRAPH OF CURRENT APRON AT SEAWALL FRONTAGE 1

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 1 RELATES TO THE AREA S7T FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 1

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

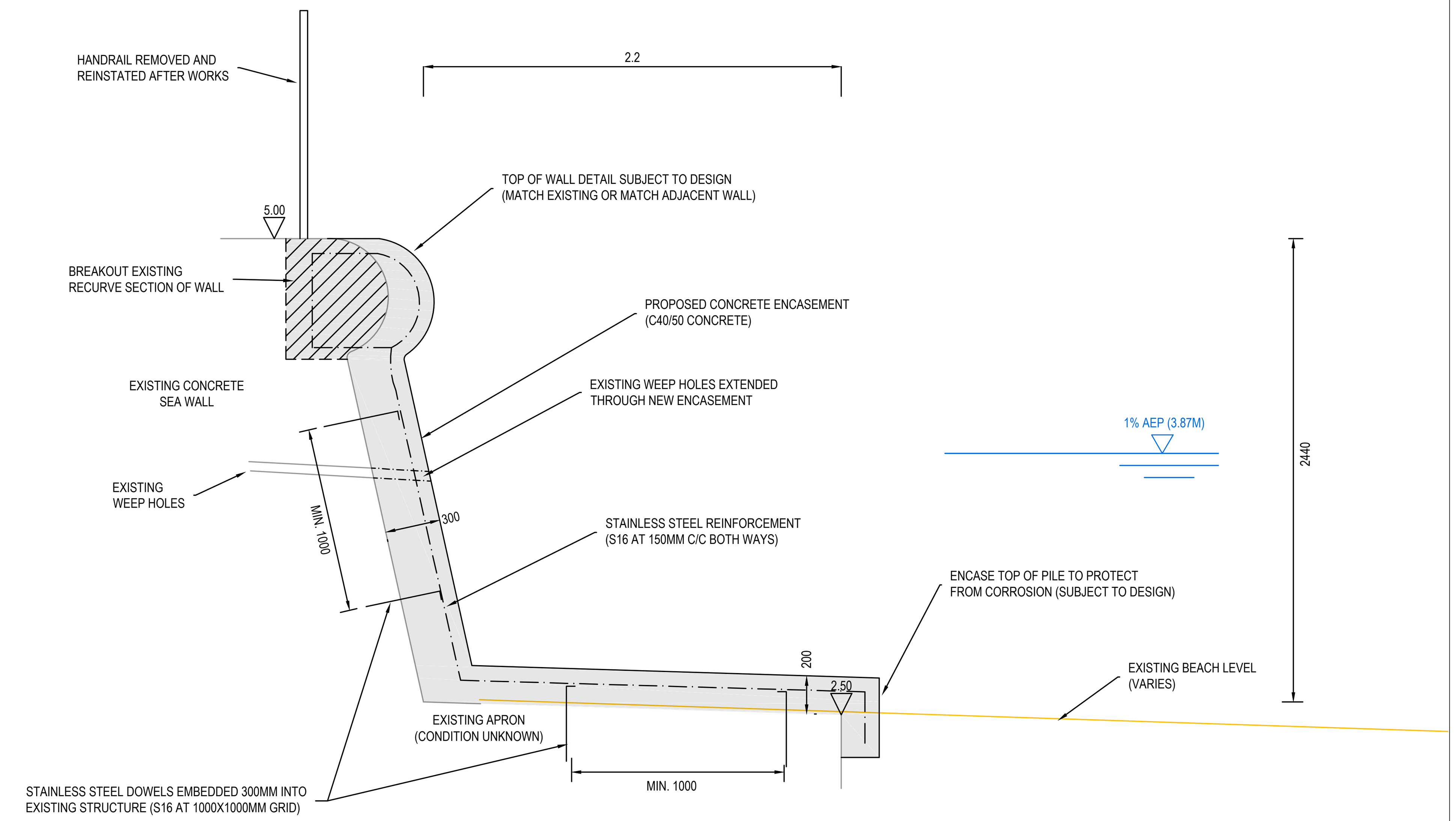
AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:25 / 1:500	-

AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-02012	P2

Plot Date : 5/11/2018 12:32 PM
File Name : SEAWALL & APRON UPDATED 090617

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 2A



CROSS SECTION B.
SEAWALL AND APRON ENCASEMENT AT
SEAWALL FRONTAGE 2A

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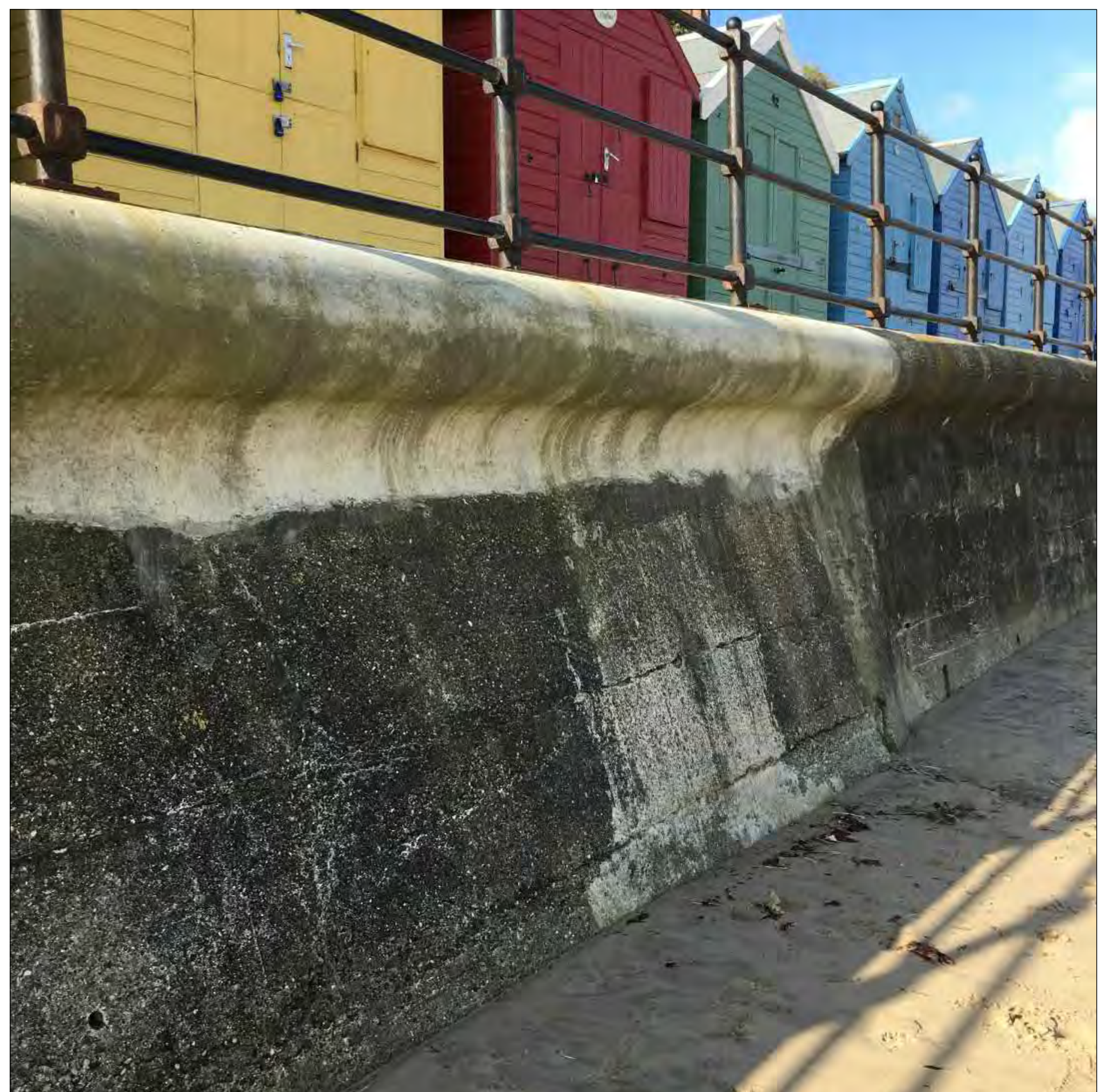
SCALE 1:25



PHOTOGRAPH OF EMERGENCY REPAIR TO
SEAWALL AT SEAWALL FRONTAGE 2A

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 2A RELATES TO THE AREA S6 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)
- BREAKOUT OF EXISTING CONCRETE
- RAMP WIDENED (DETAILS TO BE CONFIRMED AT DETAIL DESIGN)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 2A

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1: 1:25 / 1:500	Zone: -

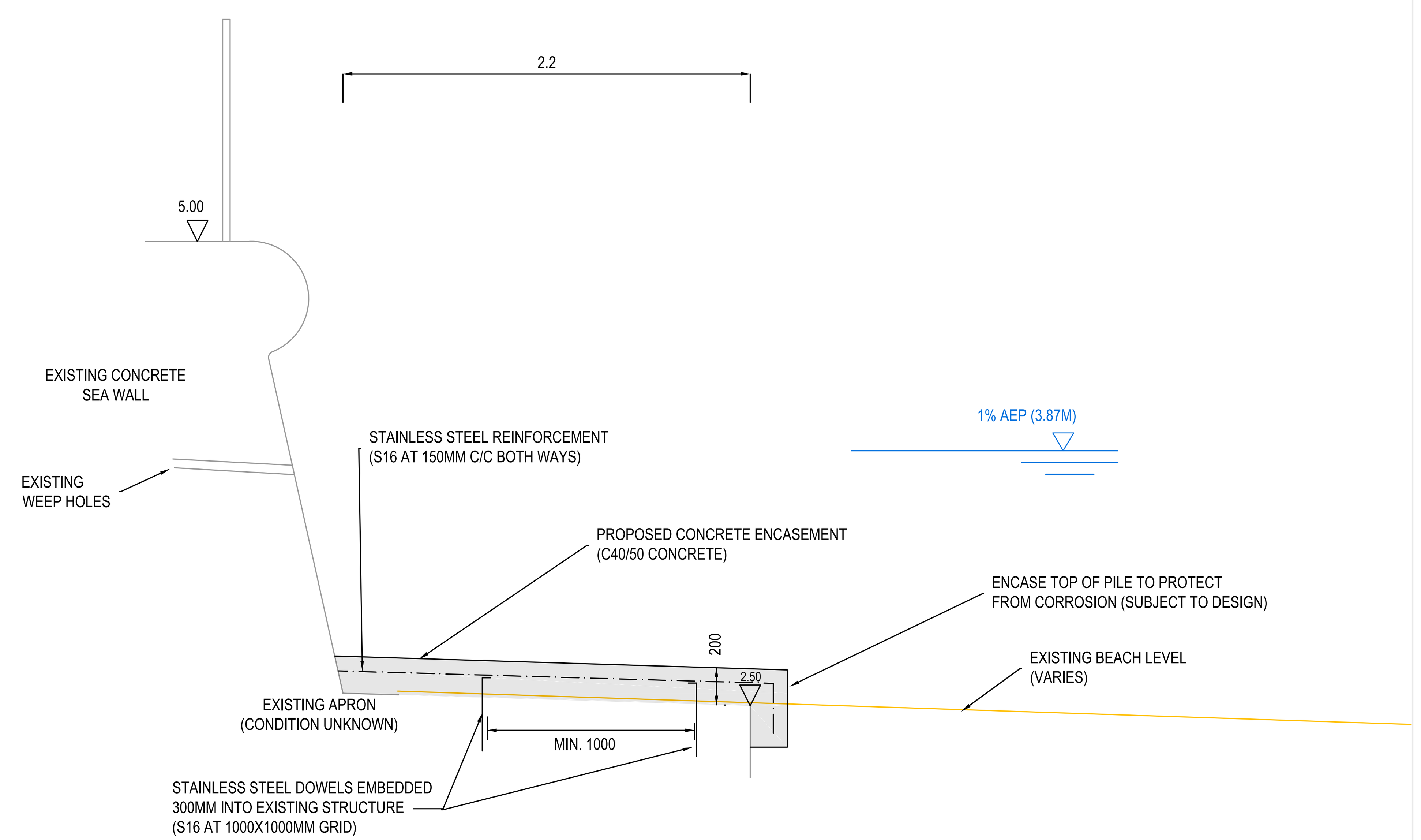
AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number
MOBC-ACM-XX-00-DR-CE-02013

Rev
P2

Plot Date : 5/11/2018 12:39 PM
File Name : SEAWALL & APRON UPDATED 090617

LOCATION PLAN OF REINFORCED CONCRETE APRON ENCASEMENT AT SEAWALL FRONTAGE 2B



CROSS SECTION C. APRON ENCASEMENT AT SEAWALL FRONTAGE 2B

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CONCRETE SEA WALL AT SEAWALL FRONTAGE 2B

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 2B RELATES TO THE AREA S6 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)
- RAMP WIDENED (DETAILS TO BE CONFIRMED AT DETAIL DESIGN)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 2B

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:500	-

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Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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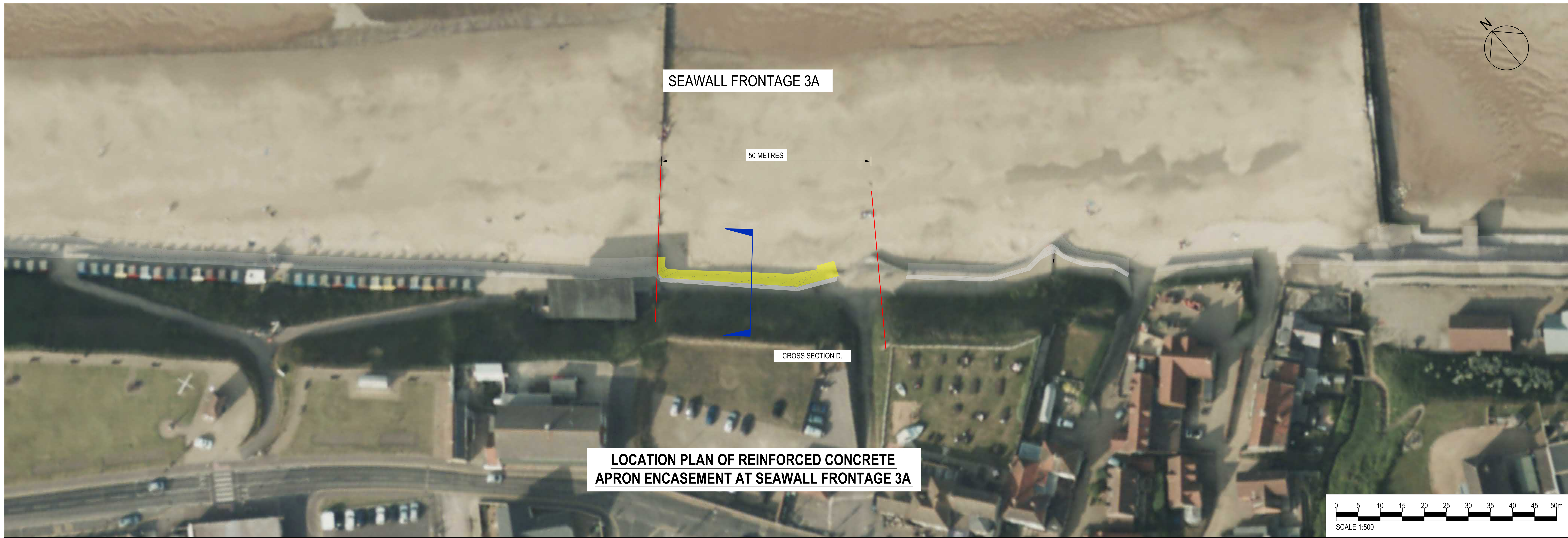
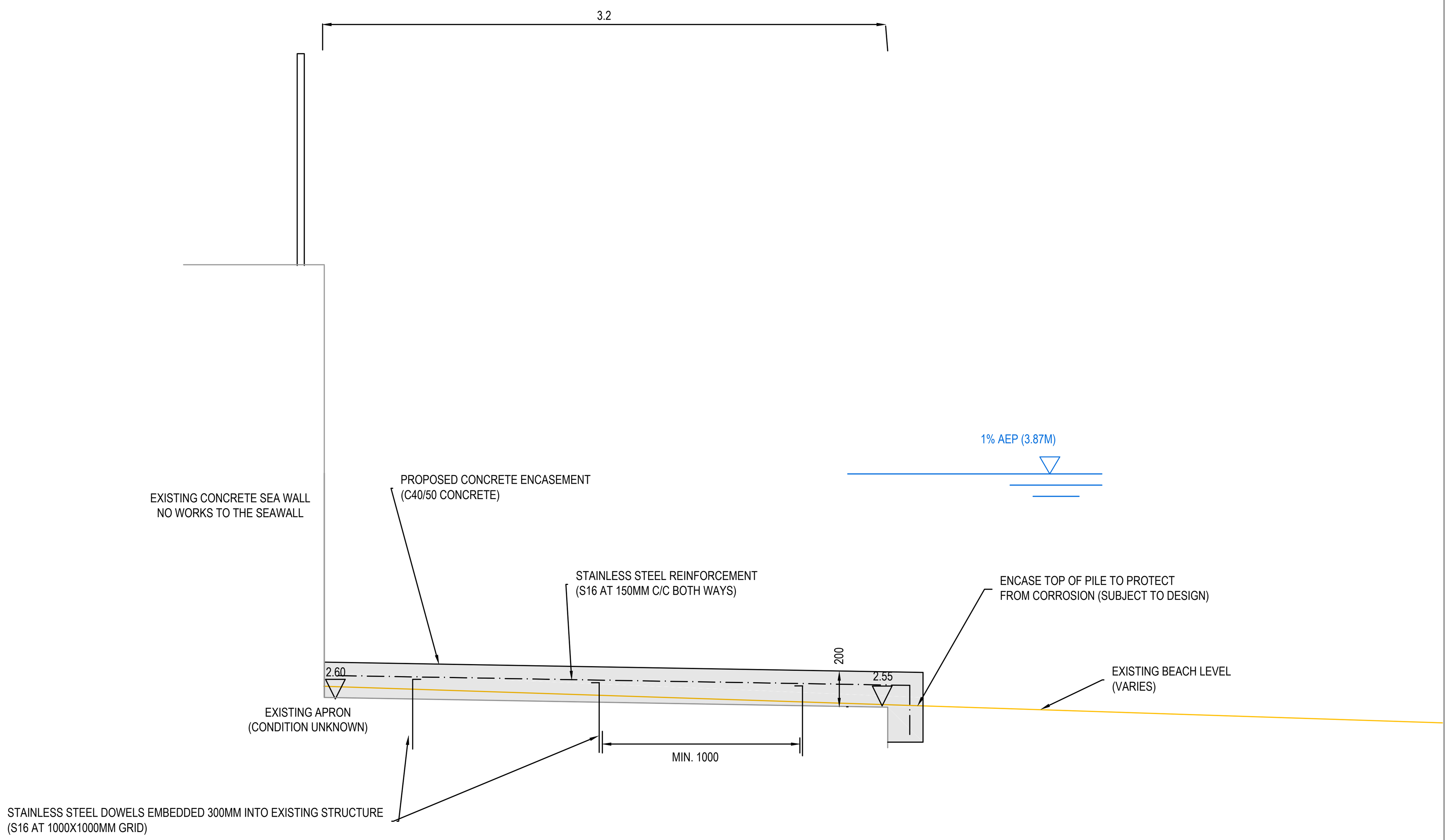
Drawing Number: MOBC-ACM-XX-00-DR-CE-02014
Rev: P2

Plot Date: 5/11/2018 12:39 PM
File Name: SEAWALL & APRON UPDATED 290817



LOCATION PLAN OF REINFORCED CONCRETE
APRON ENCASEMENT AT SEAWALL FRONTAGE 3A



CROSS SECTION D.
APRON ENCASEMENT AT SEAWALL FRONTAGE 3A

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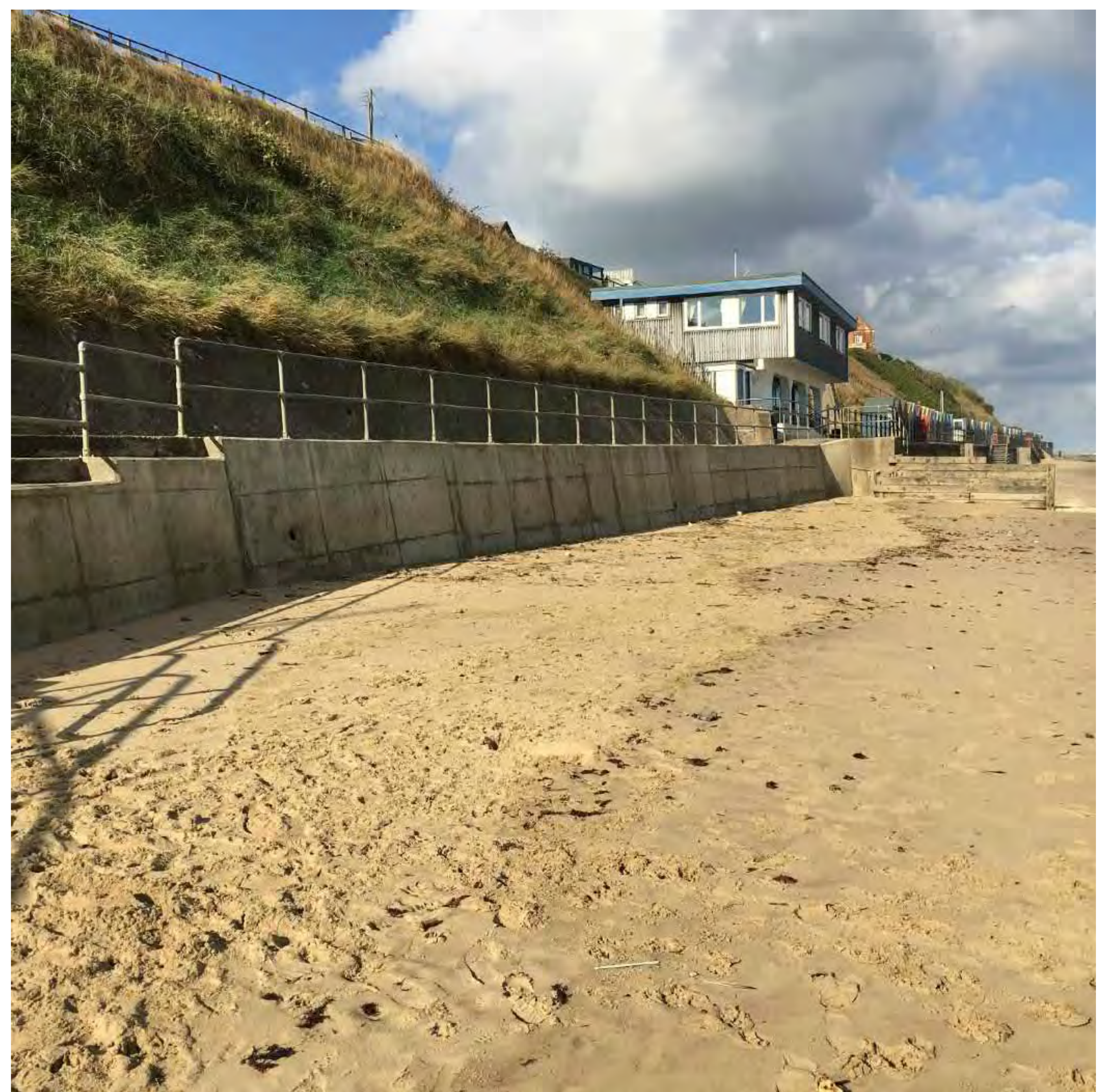
SCALE 1:25



PHOTOGRAPH OF RECENT ENCASED SEA WALL
AT SEAWALL FRONTAGE 3A

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6. SEAWALL FRONTAGE 3A RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 3A

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:500	-

AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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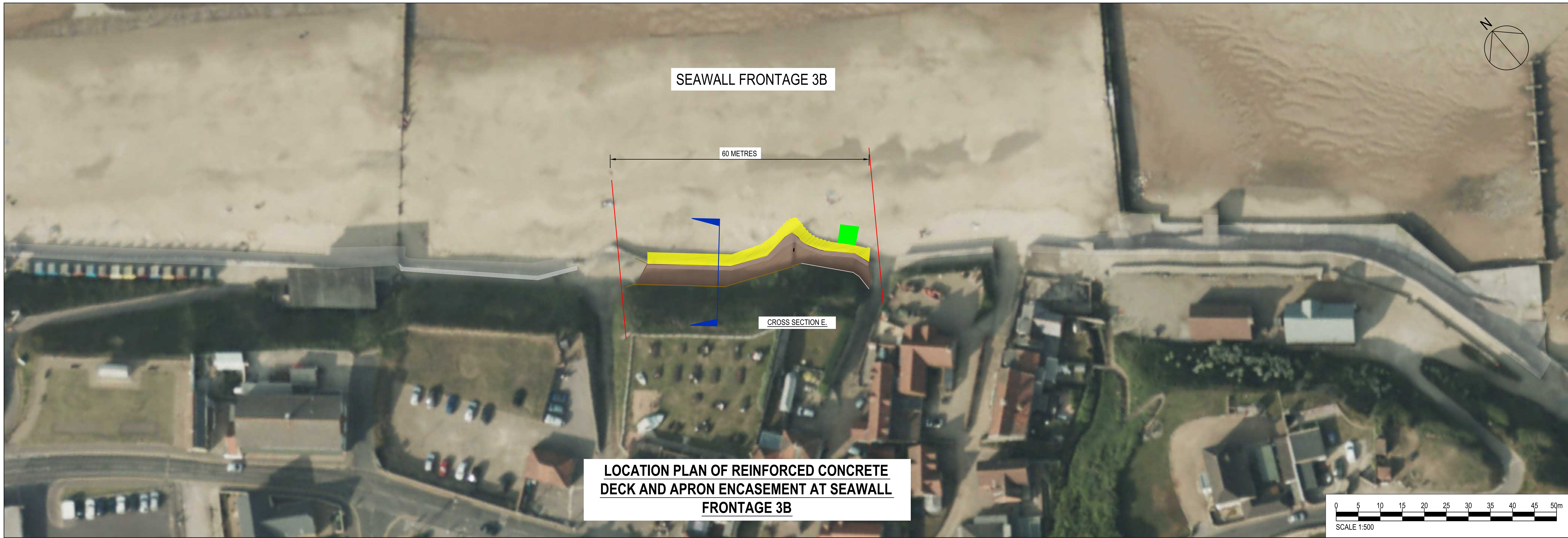
Drawing Number
MOBC-ACM-XX-00-DR-CE-02015

Rev
P2

Plot Date : 5/11/2018 12:40 PM
File Name : SEAWALL & APRON UPDATED 050617



LOCATION PLAN OF REINFORCED CONCRETE DECK AND APRON ENCASEMENT AT SEAWALL FRONTAGE 3B

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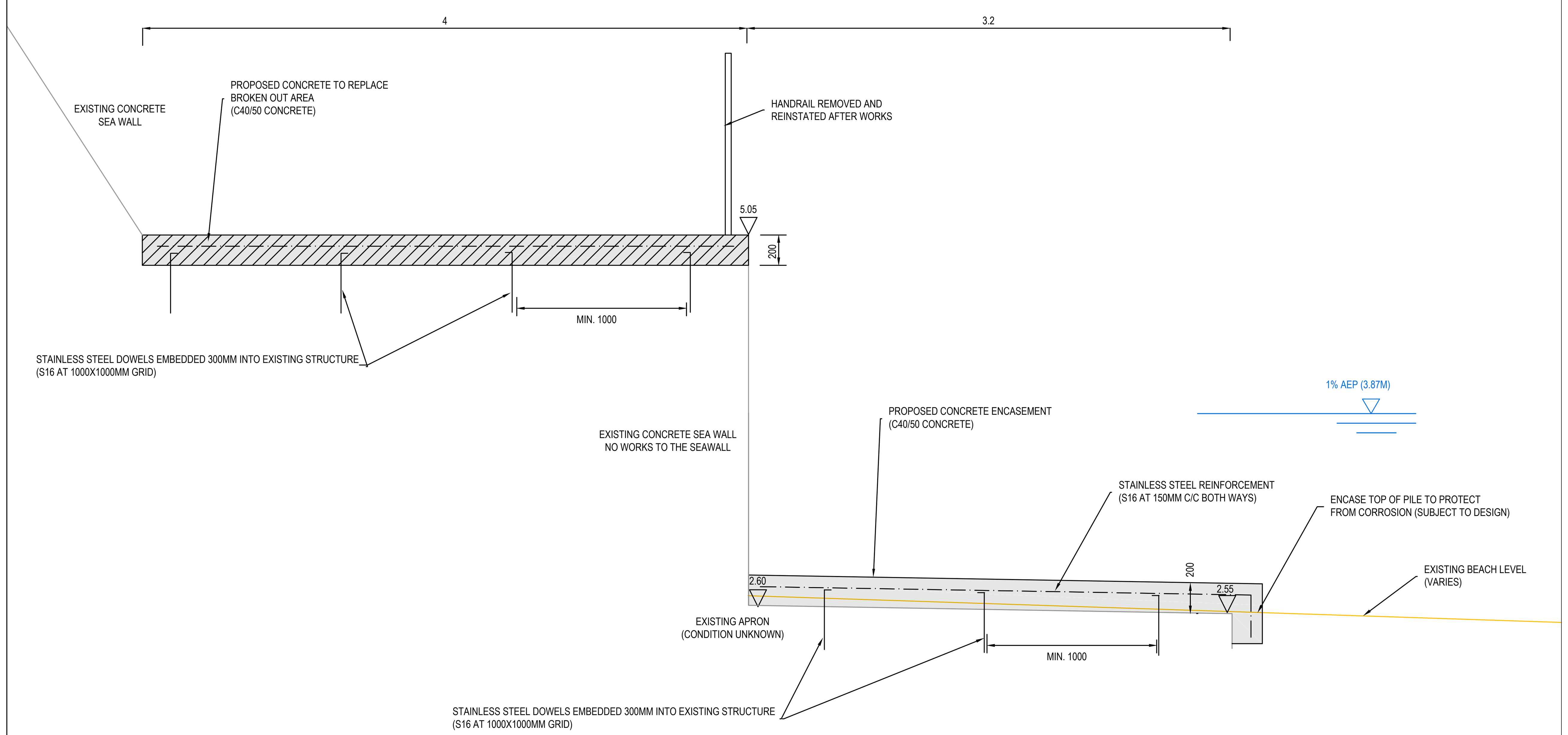
5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 3B RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)
- BREAKOUT OF EXISTING CONCRETE
- NEW STEEL METAL STEPS (DESIGN TO BE CONFIRMED)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION E.
DECK AND APRON ENCASEMENT AT SEAWALL FRONTAGE 3B

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CURRENT SEAWALL AT SEAWALL FRONTAGE 3B

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 3B

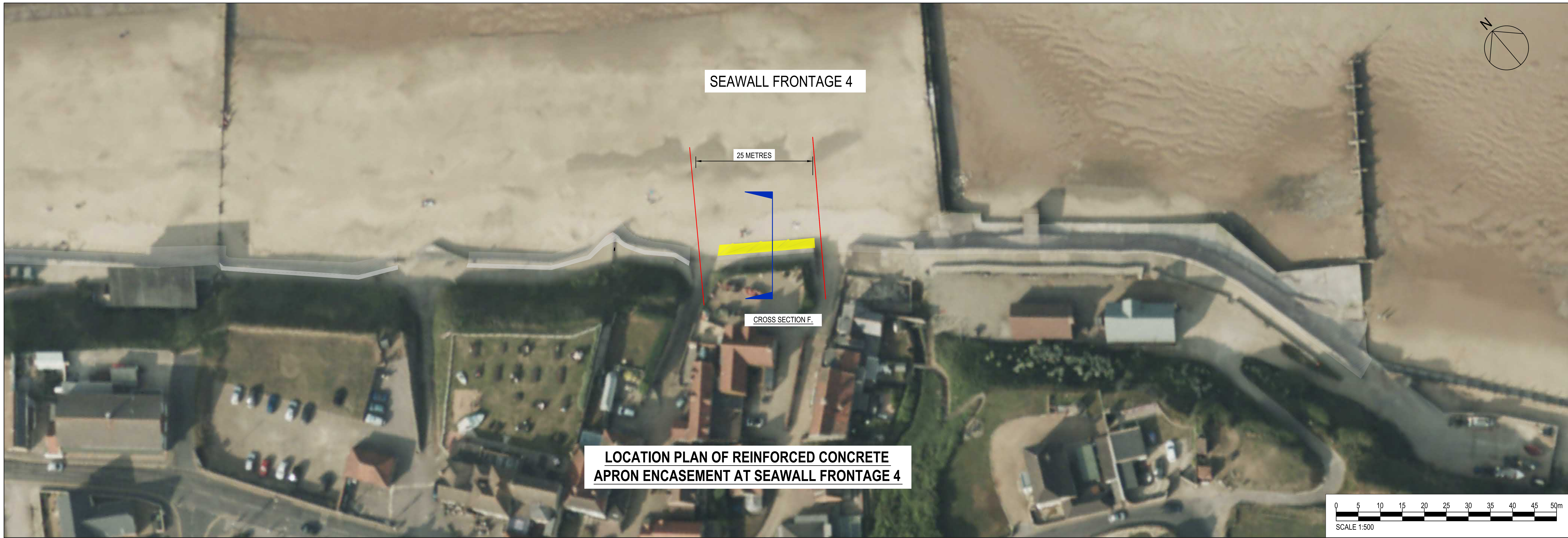
Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.: 60519091
Suitability: S2
Scale @ A1: 1:25 / 1:500
Zone: -

AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

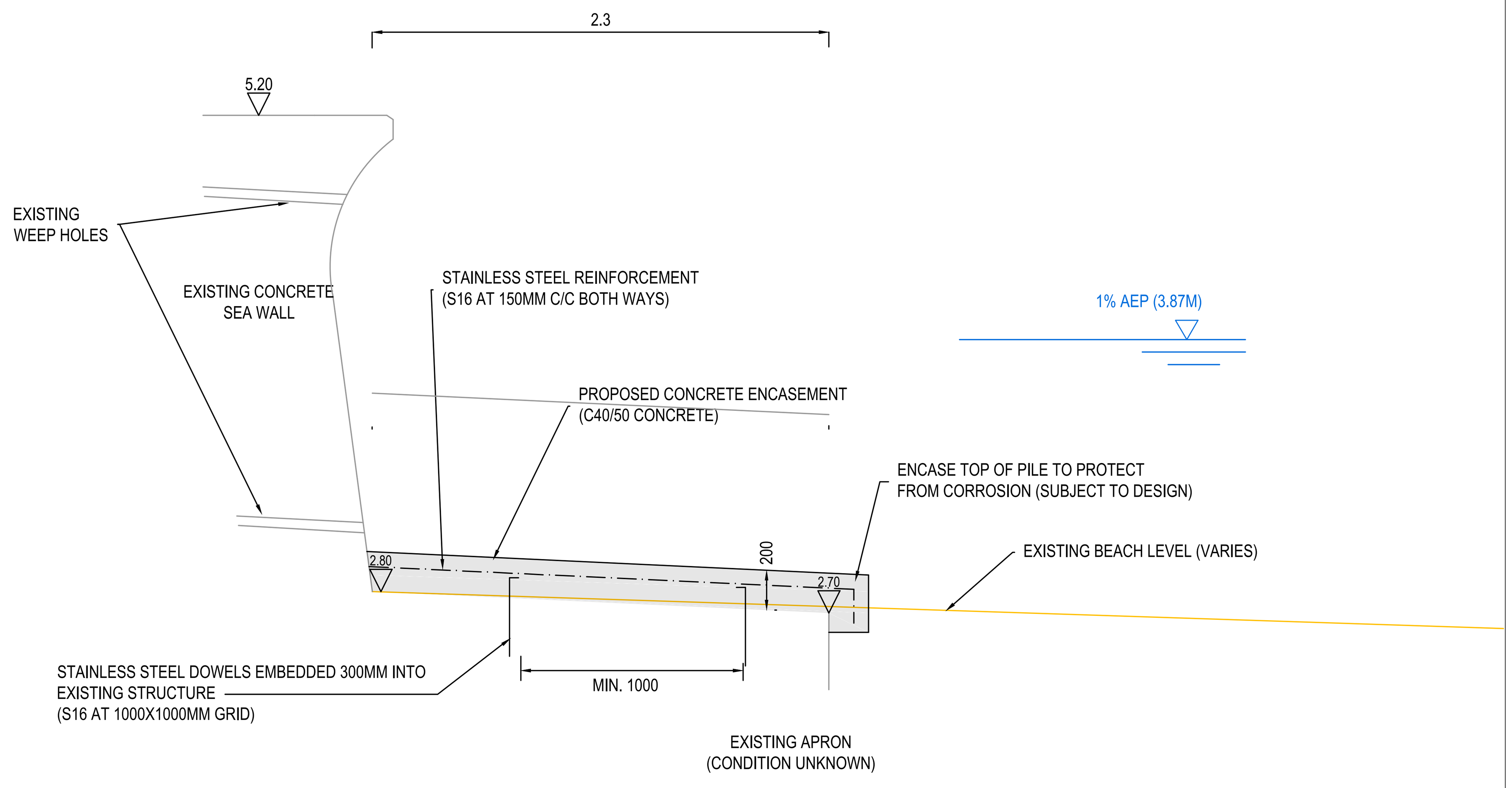
Drawing Number: MOBC-ACM-XX-00-DR-CE-02016
Rev: P2

Plot Date : 5/11/2018 12:41 PM
File Name : SEAWALL & APRON UPDATED 090817



LOCATION PLAN OF REINFORCED CONCRETE
APRON ENCASEMENT AT SEAWALL FRONTAGE 4

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION F.
APRON ENCASEMENT AT SEAWALL FRONTAGE 4

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CURRENT SEAWALL AT SEAWALL FRONTAGE 4

NOTES

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6. SEAWALL FRONTAGE 4 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 4

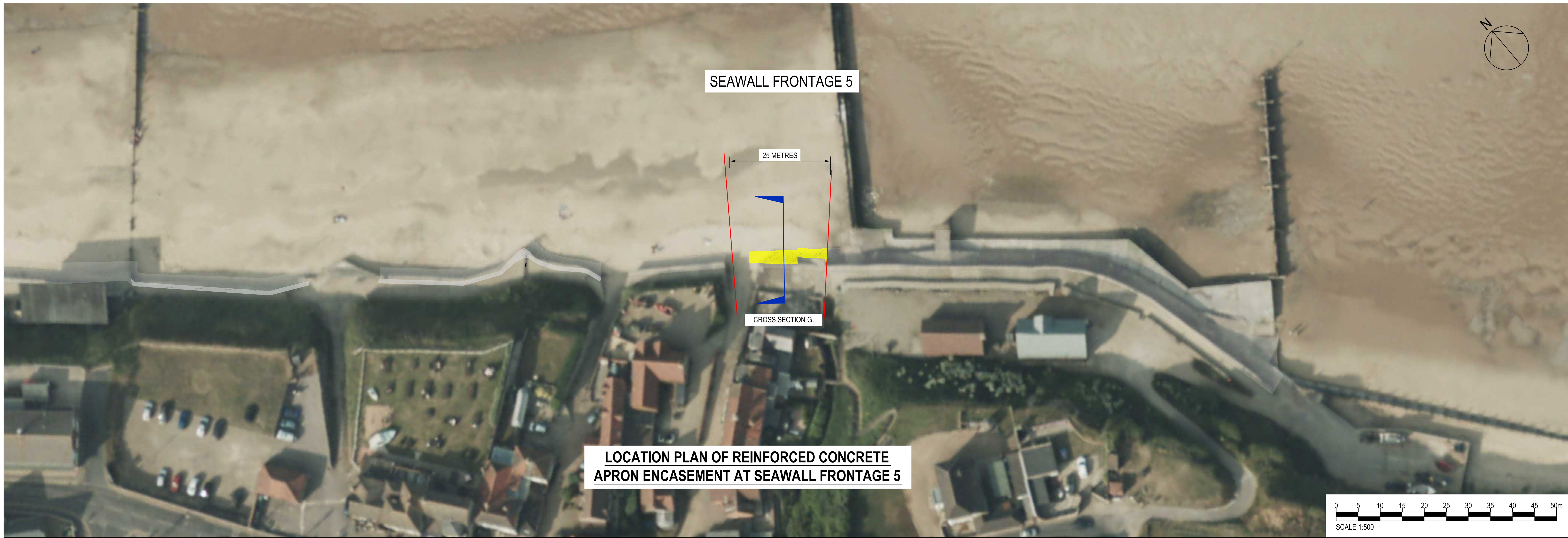
Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:25 / 1:500	-

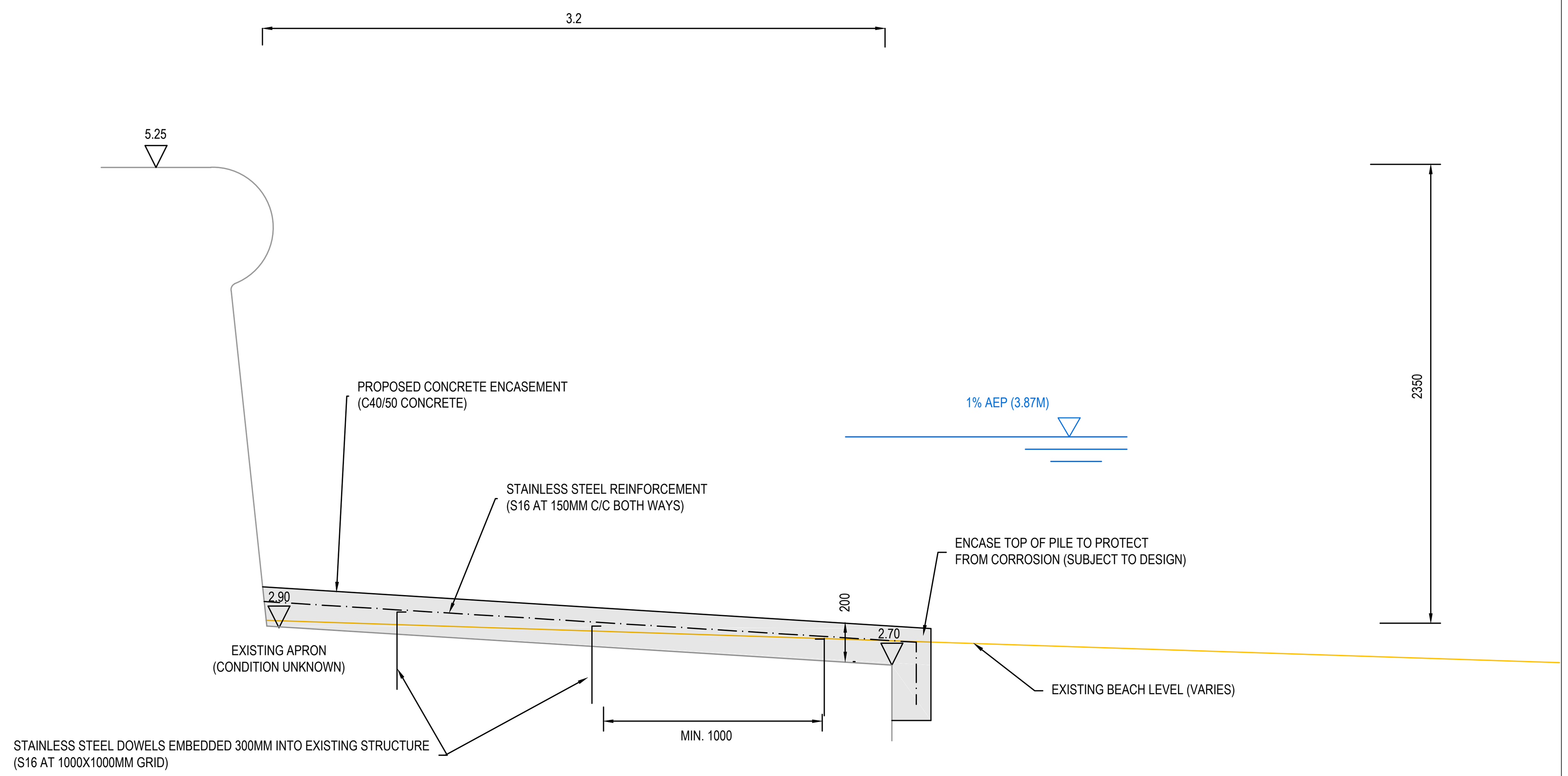
AECOM Infrastructure & Environment UK Limited
Midpoint
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number: MOBC-ACM-XX-00-DR-CE-02017

Rev: P2



LOCATION PLAN OF REINFORCED CONCRETE APRON ENCASEMENT AT SEAWALL FRONTAGE 5



CROSS SECTION G.
APRON ENCASEMENT AT SEAWALL FRONTAGE 5

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CURRENT SEAWALL AT SEAWALL FRONTAGE 5

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 5 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- EXISTING BEACH LEVEL (VARIES)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By	Check	Date	Suffix
FINAL ISSUE FOR OBC	GB	DG	10/05/18	P2
SHORTLIST ISSUE	GB	DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 5

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:500	-

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Tel:+44 (0)1256 310 200
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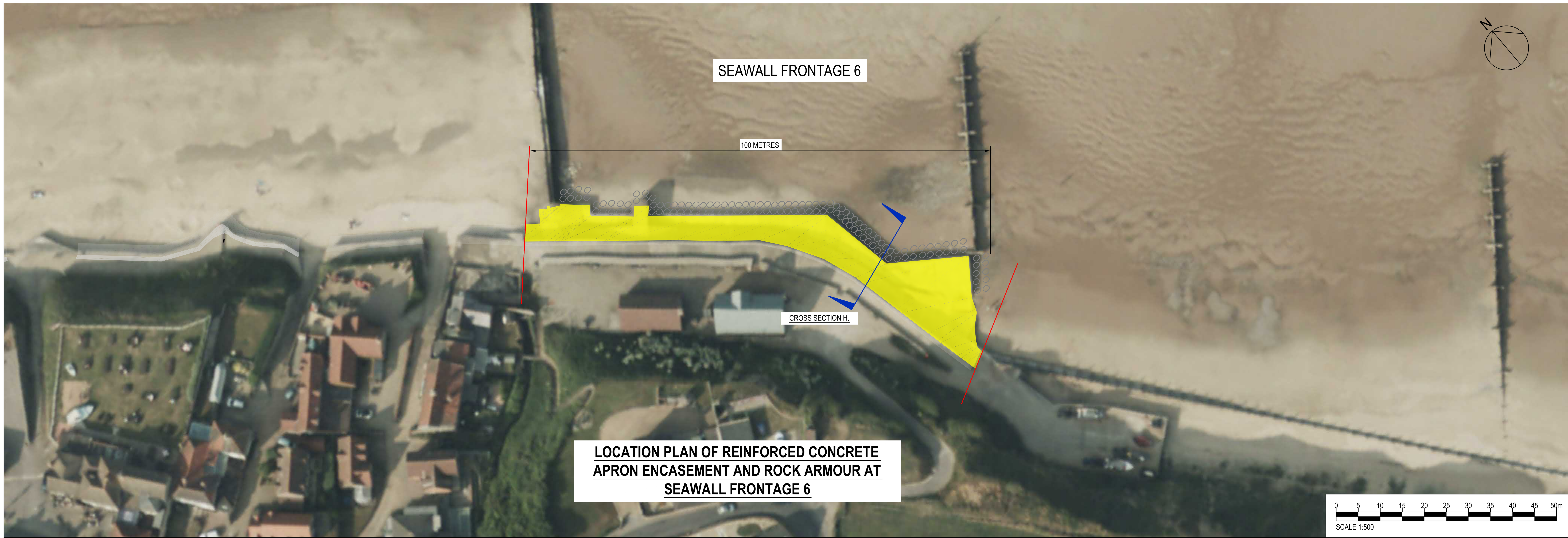
Drawing Number: MOBC-ACM-XX-00-DR-CE-02018
Rev: P2

Plot Date: 5/11/2018 12:42 PM
File Name: SEAWALL & APRON UPDATED 050817



LOCATION PLAN OF REINFORCED CONCRETE APRON ENCASEMENT AND ROCK ARMOUR AT SEAWALL FRONTAGE 6

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

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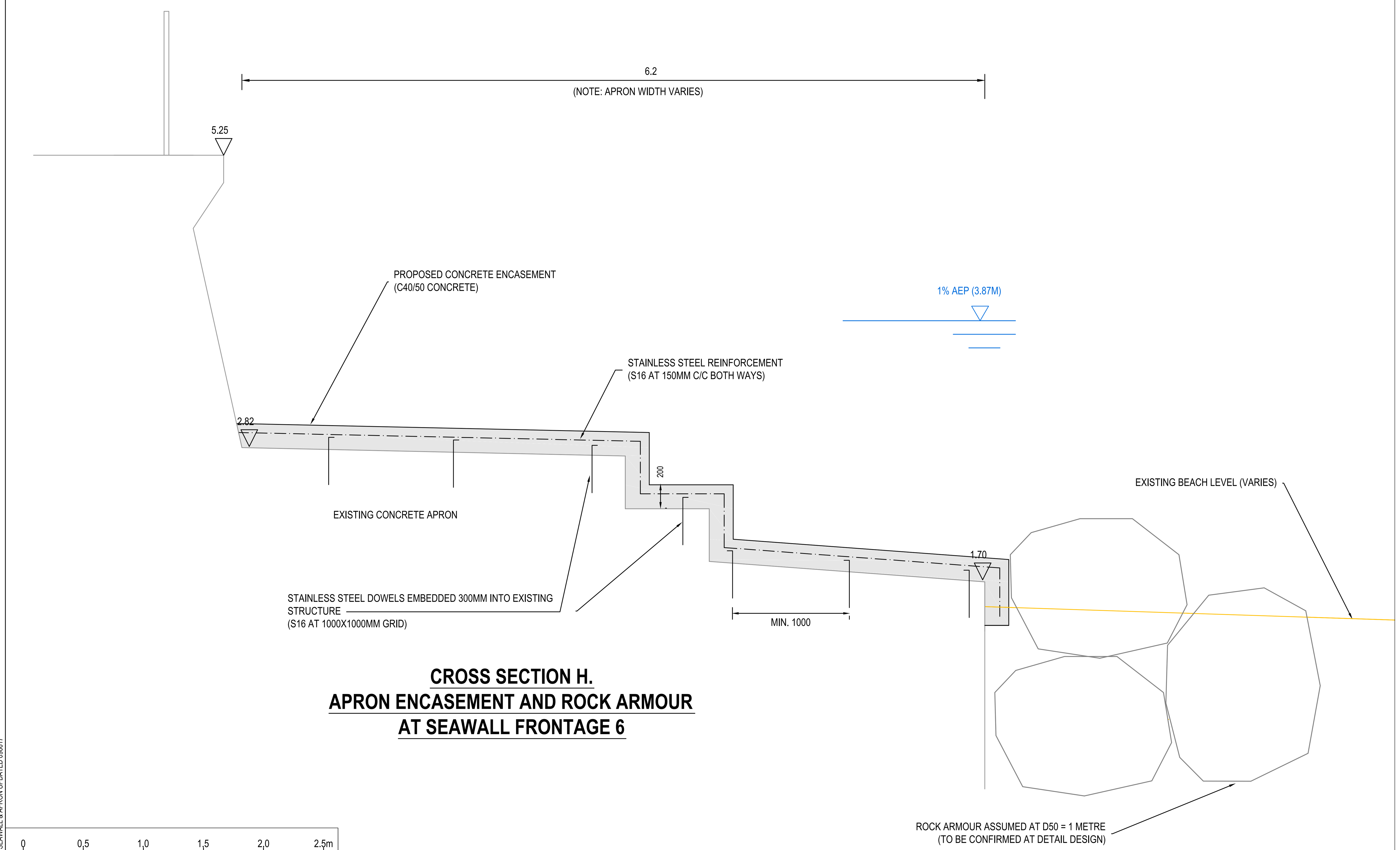
5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 6 RELATES TO THE AREA S4 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- CROSS SECTION LOCATIONS
- ROCK ARMOUR
- EXISTING BEACH LEVEL (VARIES)



CROSS SECTION H.
APRON ENCASEMENT AND ROCK ARMOUR AT SEAWALL FRONTAGE 6

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CURRENT SEAWALL AND APRON AT SEAWALL FRONTAGE 6

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 6

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:500	-

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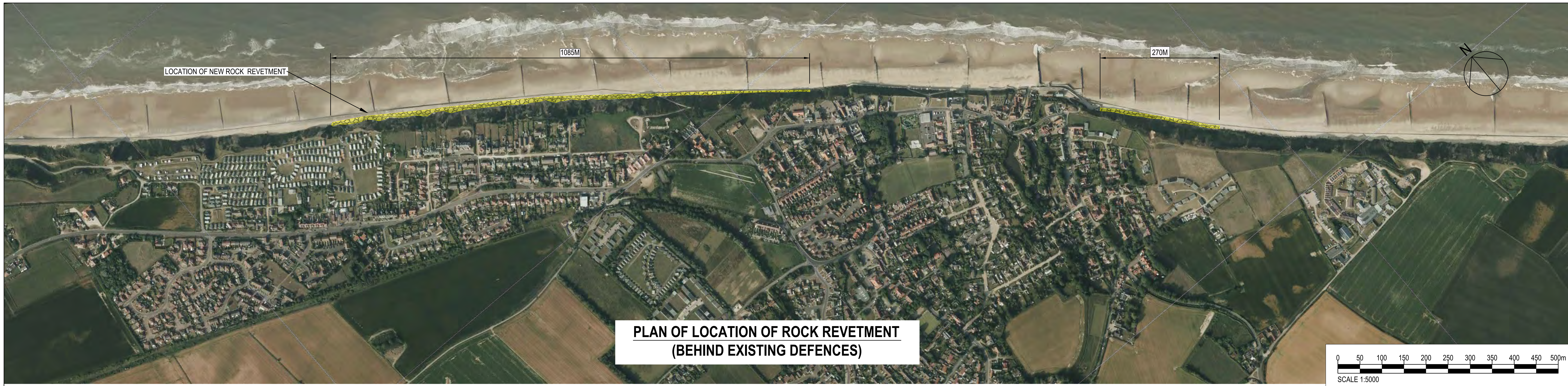
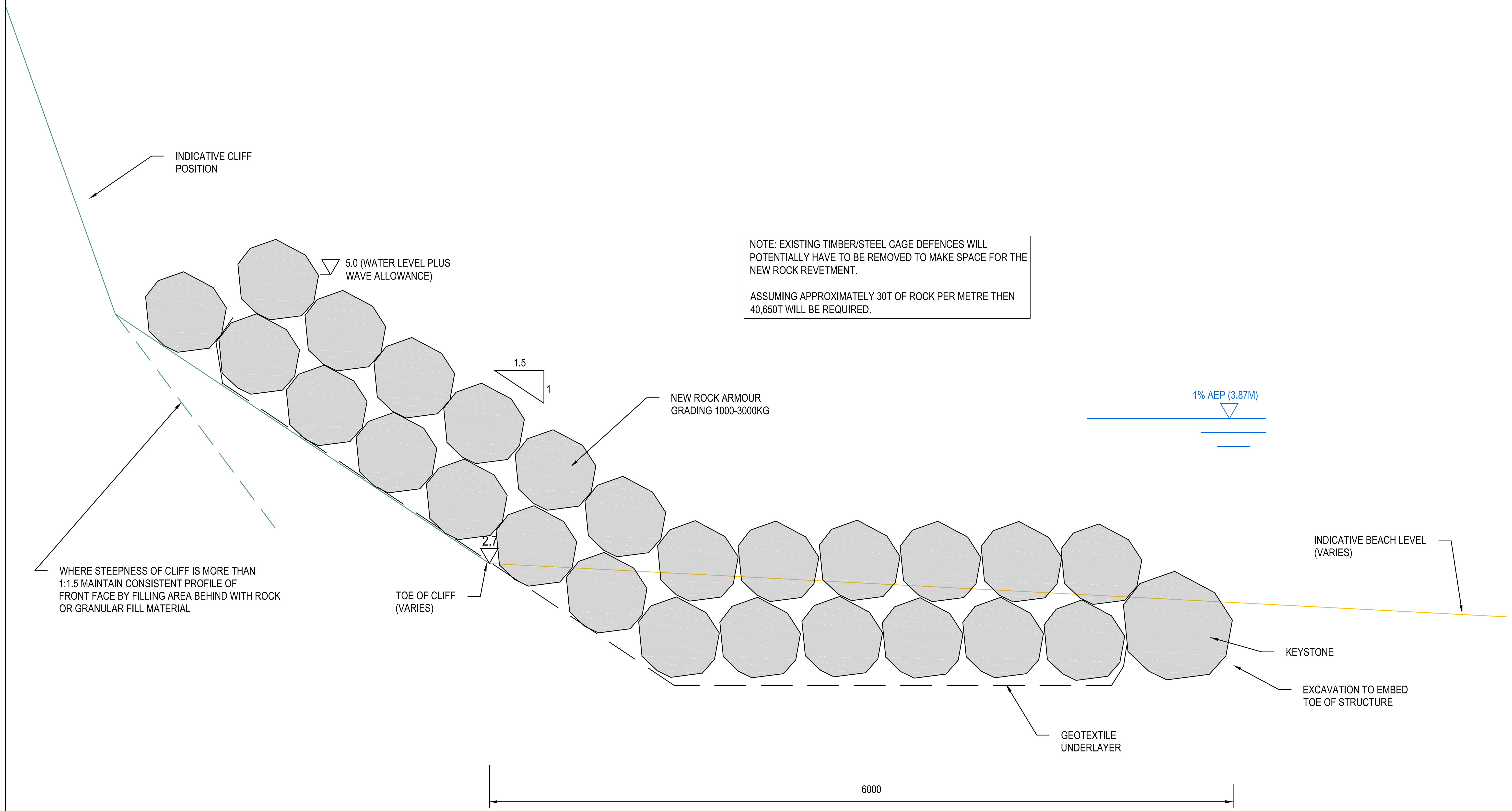
Plot Date : 5/11/2018 12:42 PM
File Name : SEAWALL & APRON UPDATED 090617



PLAN OF LOCATION OF ROCK REVETMENT (BEHIND EXISTING DEFENCES)

0 50 100 150 200 250 300 350 400 450 500m
SCALE 1:5000



CROSS SECTION OF ROCK REVETMENT (BEHIND EXISTING DEFENCES)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CLIFF TOE SETBACK FROM EXISTING DEFENCES SHOWING PROPOSED LOCATION

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LEGEND

NEW ROCK REVETMENT LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P4
SHORTLIST ISSUE	GB / DG	04/09/17	P3
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 3
ROCK REVETMENT

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:5000	-

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Tel:+44 (0)1256 310 200
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Drawing Number: MOBC-ACM-XX-00-DR-CE-01031
Rev: P4

Plot Date : 5/11/2018 12:50 PM
File Name : ROCK REVETMENT

PLAN OF PROPOSED ROCK PROTECTION

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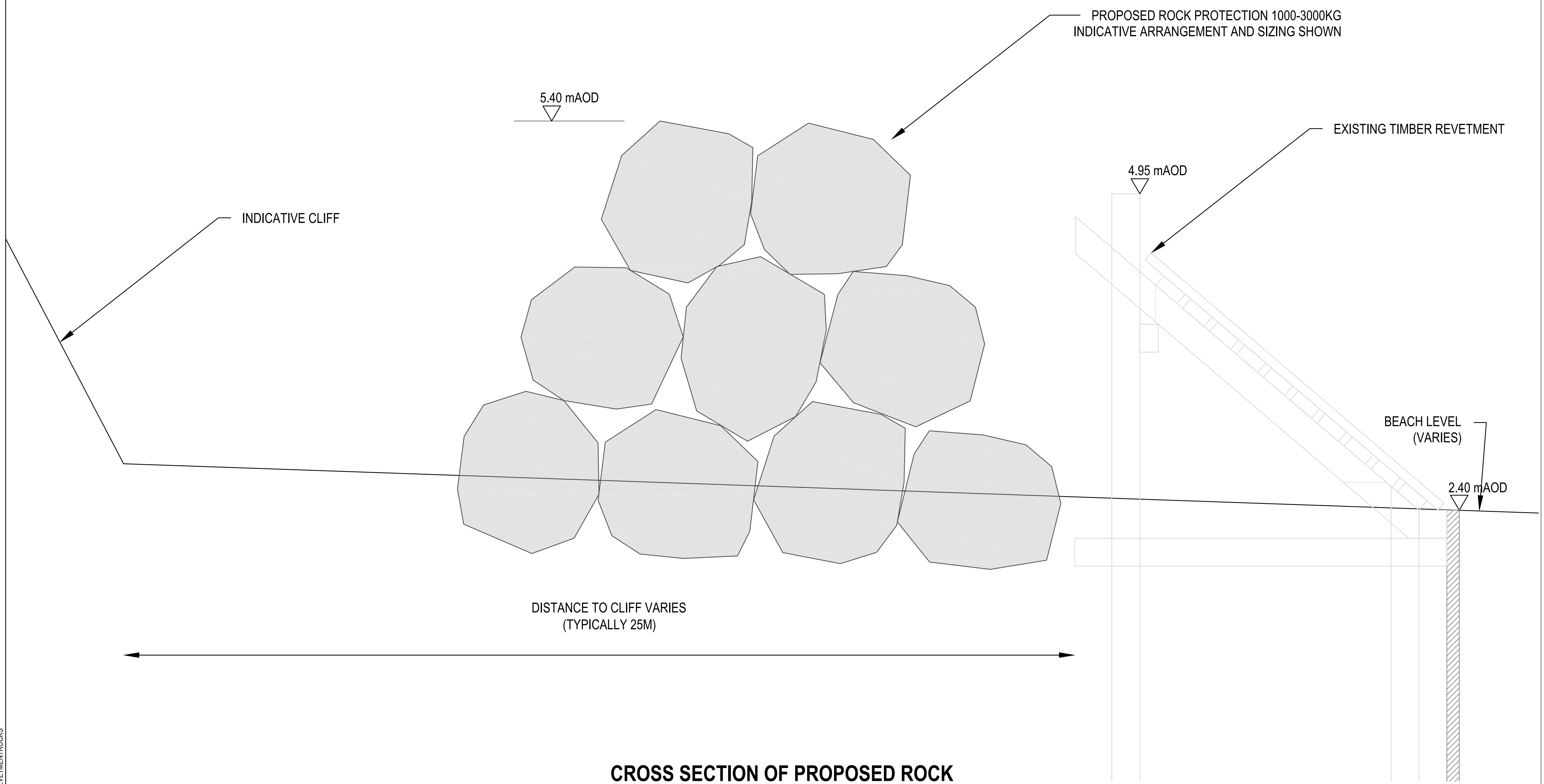
6. ALL LEVELS ARE QUOTED TO ORDNANCE DATUM NEWLYN.

LEGEND

LOCATION OF PROPOSED ROCK PROTECTION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION OF PROPOSED ROCK PROTECTION AND EXISTING TIMBER REVETMENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PROPOSED LOCATION OF ROCK PROTECTION

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P4
SHORTLIST ISSUE	GB / DG	04/09/17	P3
LONGLIST OPTION ISSUE	DM / DG	21/04/2017	P2
DRAFT ISSUE	DM / DG	23/03/2017	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 5
ROCK ARMOUR PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
DM	DM	DG	PN	28/04/2017

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:25 / 1:5000	-

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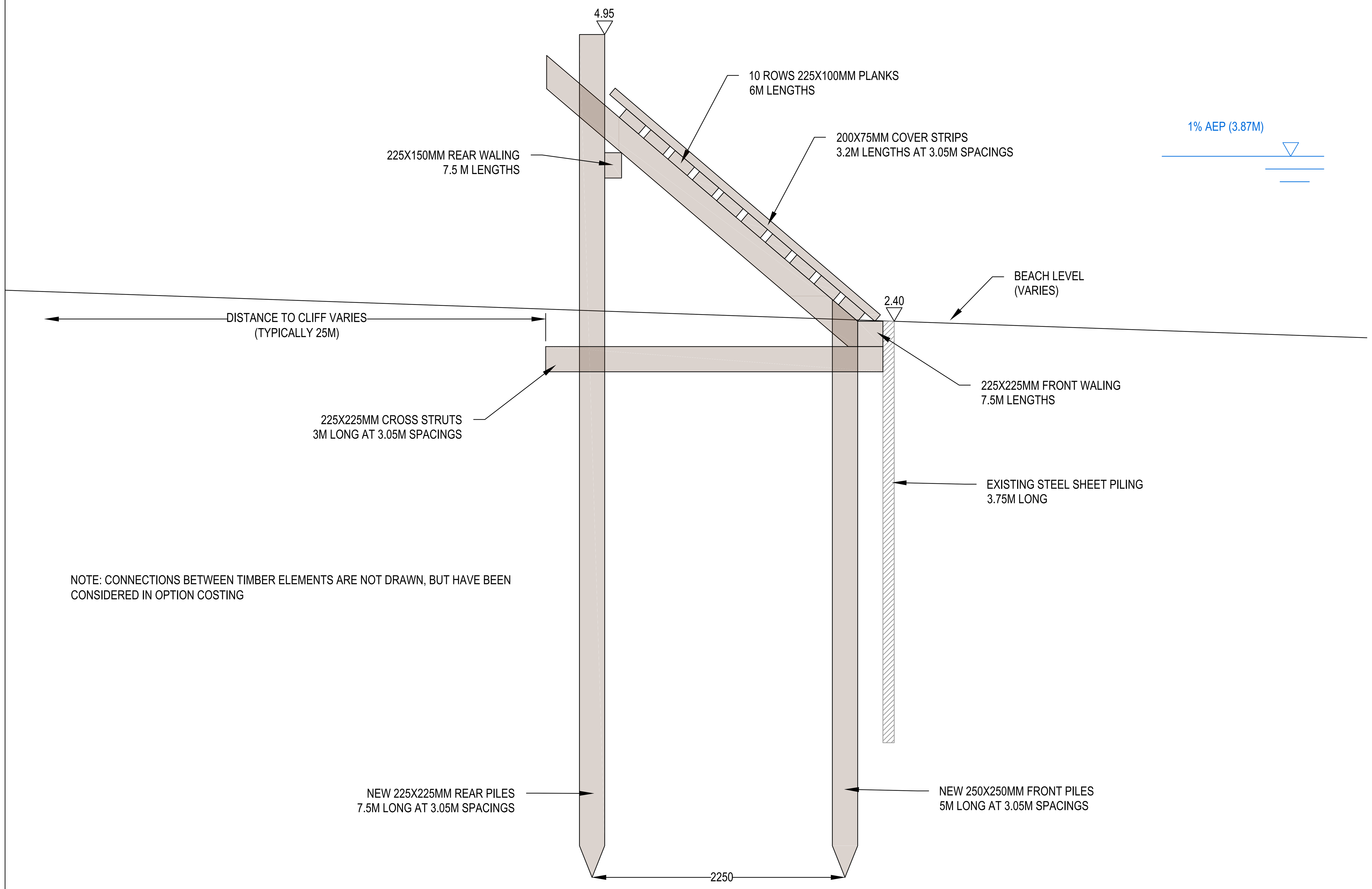
Drawing Number
MOBC-ACM-XX-00-DR-CE-01051

Rev
P4

Plot Date : 5/11/2018 12:56 PM
File Name : TIMBER REVETMENTROCKS

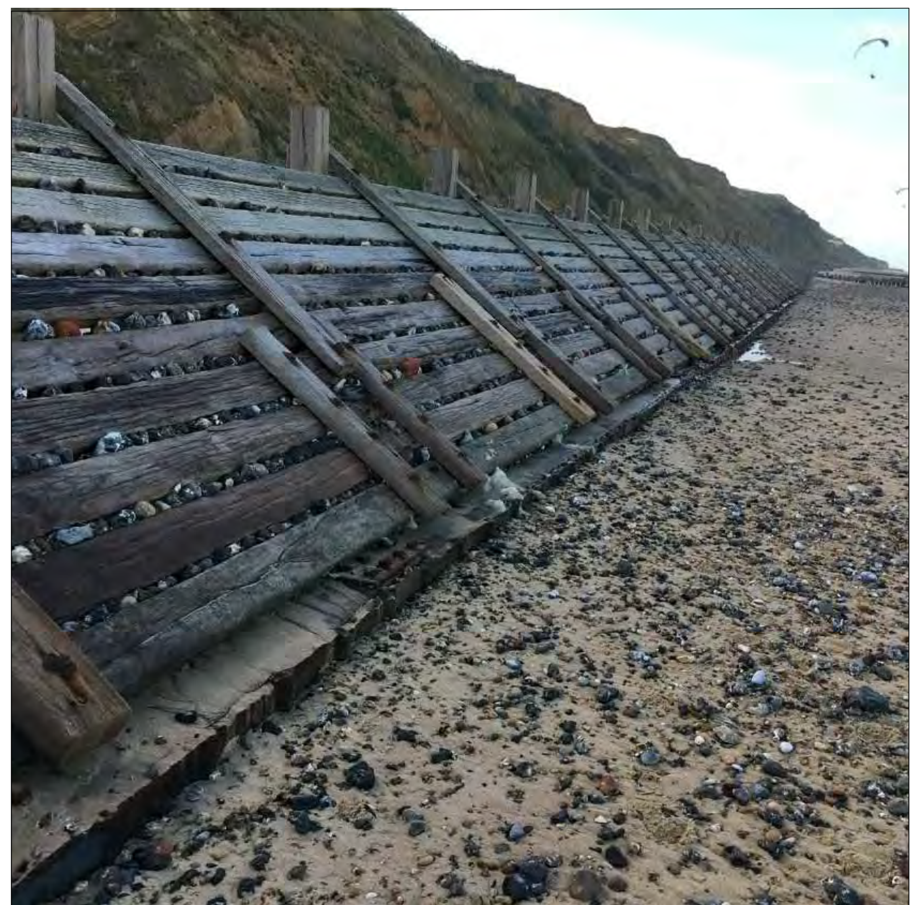
PLAN OF LOCATION OF TIMBER REVETMENT (REFURBISHMENT OF EXISTING)



NOTE: CONNECTIONS BETWEEN TIMBER ELEMENTS ARE NOT DRAWN, BUT HAVE BEEN CONSIDERED IN OPTION COSTING

CROSS SECTION OF EXISTING TIMBER REVETMENT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW TIMBER REVETMENT LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By	Check	Date	Suffix
FINAL ISSUE FOR OBC	GB	DG	10/05/18	P2
SHORTLIST ISSUE	GB	DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY OUTLINE BUSINESS CASE

Drawing Title
OPTION 6
REFURB TIMBER REVETMENT

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:5000	-

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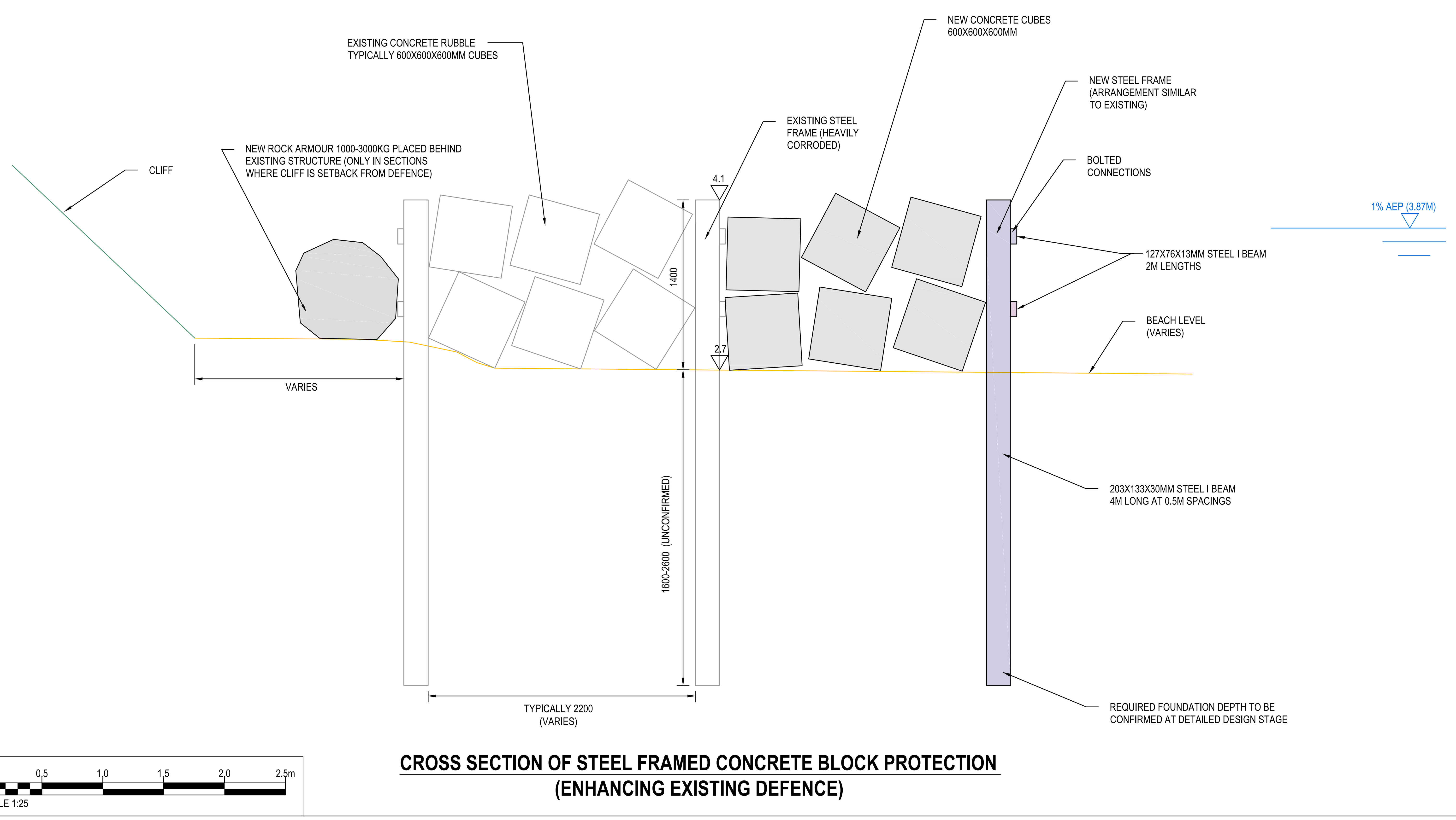
Drawing Number: MOBC-ACM-XX-00-DR-CE-02061 | Rev: P2

Plot Date : 5/11/2018 2:40 PM
File Name : TIMBER REVETMENT

LOCATION OF PLAN OF STEEL FRAMED CONCRETE BLOCK PROTECTION
(ENHANCING EXISTING DEFENCE)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION OF STEEL FRAMED CONCRETE BLOCK PROTECTION
(ENHANCING EXISTING DEFENCE)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. ALL LEVELS ARE QUOTED TO ORDNANCE DATUM NEWLYN

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P4
SHORTLIST ISSUE	GB / DG	04/09/17	P3
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH CONCRETE BLOCKS

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:50 / 1:1000	-

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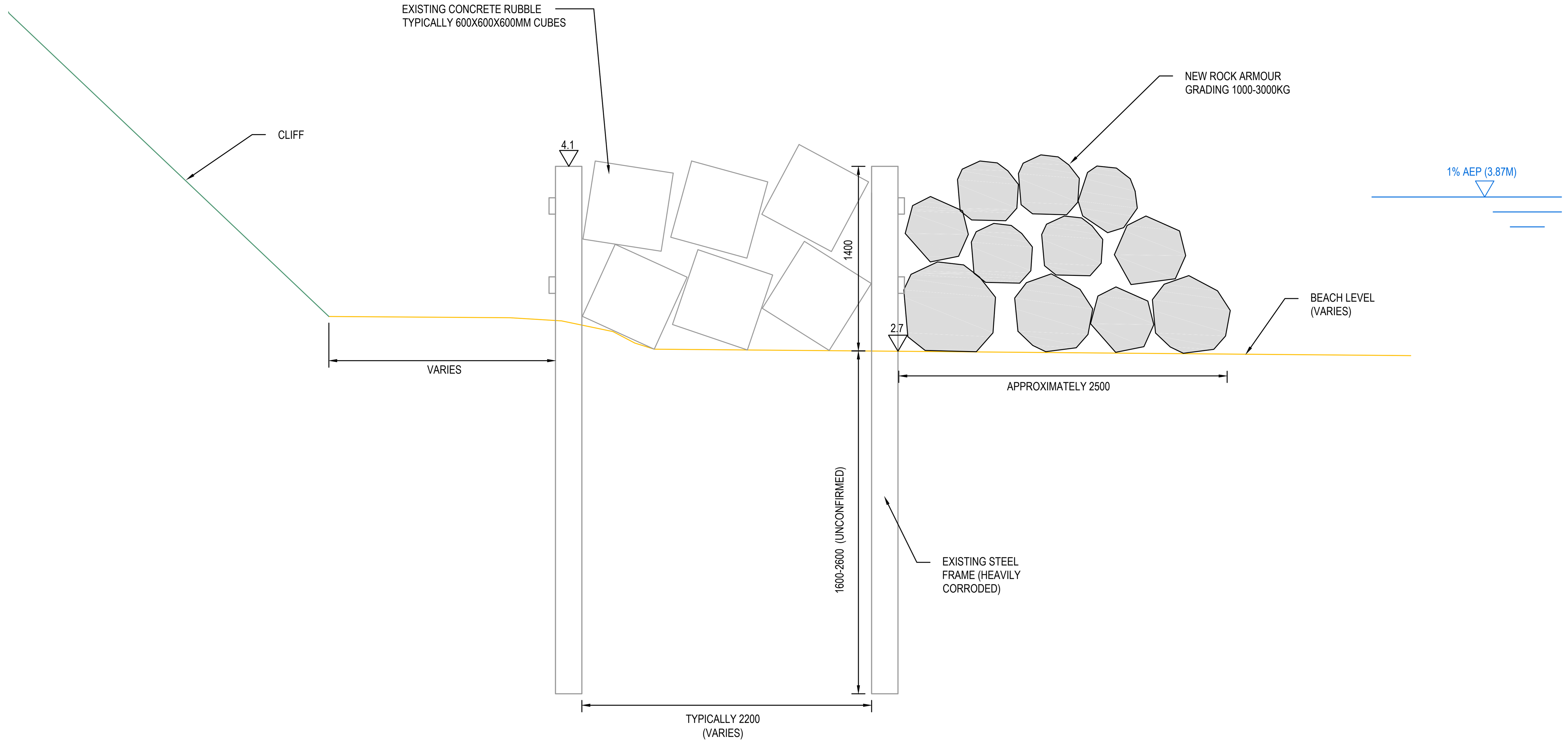
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01071	P4

Plot Date : 5/11/2018 1:06 PM
File Name : STEEL FRAME

LOCATION OF PLAN OF ADDITIONAL ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE - NO ADDITIONAL FRAME)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION OF ADDITIONAL ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE - NO ADDITIONAL FRAME)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

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6. ALL LEVELS ARE QUOTED TO ORDNANCE DATUM NEWLYN

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P4
SHORTLIST ISSUE	GB / DG	04/09/17	P3
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH ROCK (NO ADDITIONAL FRAME)

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:1000	-

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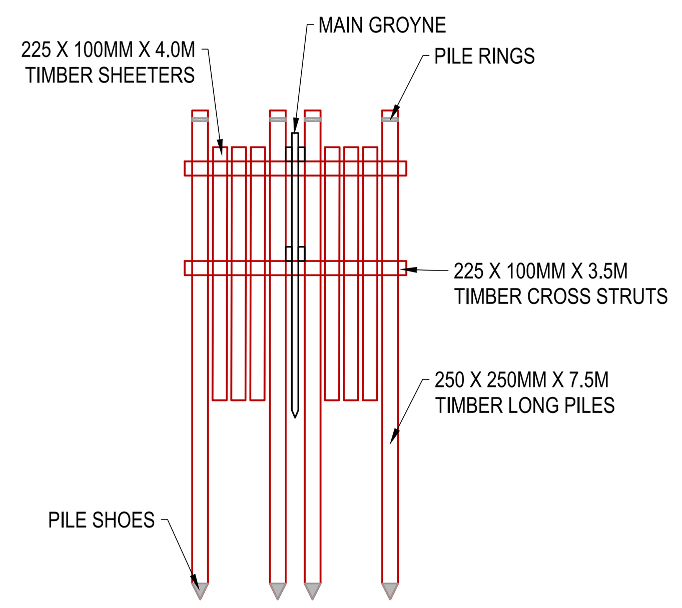
Drawing Number: MOBC-ACM-XX-00-DR-CE-01079
Rev: P4

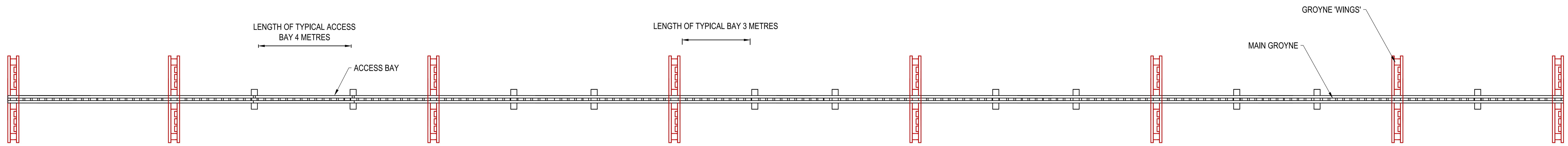
Plot Date : 5/11/2018 1:11 PM
File Name : STEEL FRAME

LONG SECTION OF EXISTING GROYNE



CROSS SECTION A

NOTE - DRAWING SHOWS INDICATIVE REPRESENTATION OF THE EXISTING GROYNES TO BE REFURBISHED WITH TROPICAL TIMBERS. IT HAS BEEN ASSUMED THAT 30% OF THE EXISTING TIMBERS WILL BE REPLACED.



PLAN OF EXISTING GROYNE

0 1 2 3 4 5 6 7 8 9 10m
SCALE 1:100

Plot Date : 5/11/2018 1:37 PM
File Name : GROYNESLEVELS

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LEGEND

MAIN GROYNE STRUCTURE
'WINGS' (SUPPORTS) OF GROYNE
INDICATIVE BEACH LEVEL

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 8
REUFRB GROYNES

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	24/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:100	-

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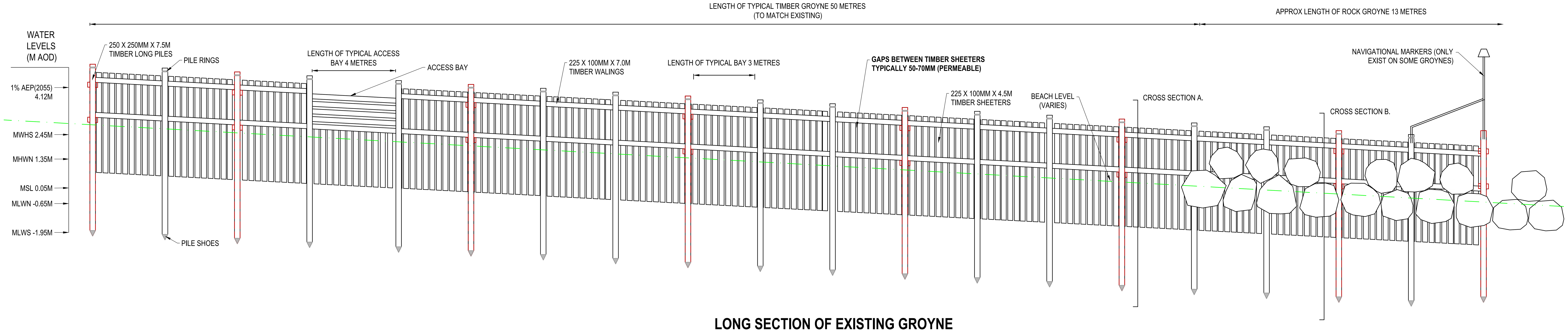
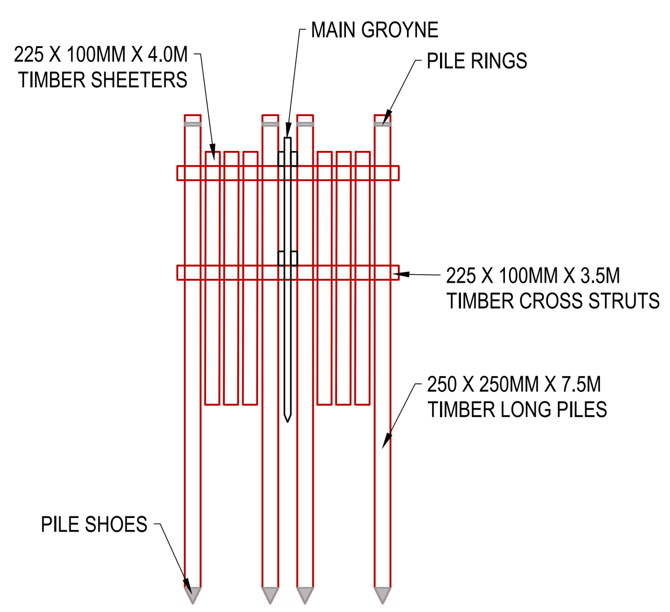
MOBC-ACM-XX-00-DR-CE-02081

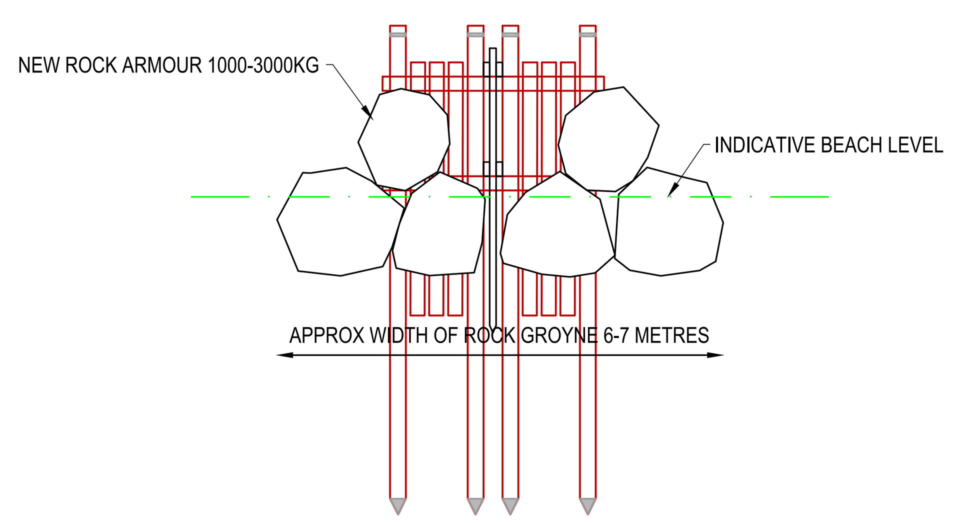
Rev
P2



LONG SECTION OF EXISTING GROYNE WITH ADDITIONAL ROCK

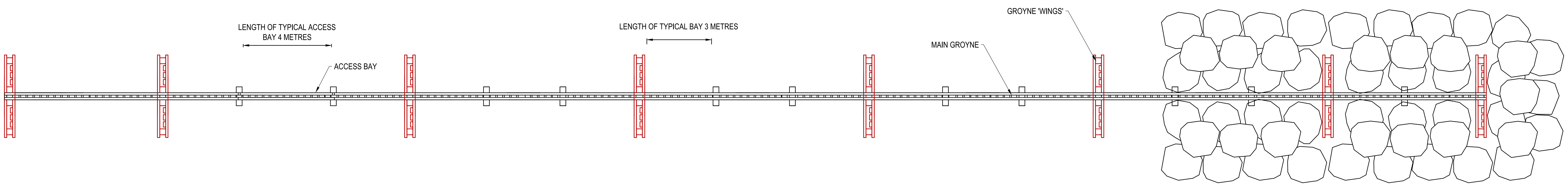


CROSS SECTION A



CROSS SECTION B

NOTE - DRAWING SHOWS INDICATIVE REPRESENTATION OF THE EXISTING GROYNES TO BE REFURBISHED WITH TROPICAL TIMBERS. IT HAS BEEN ASSUMED THAT 30% OF THE EXISTING TIMBERS WILL BE REPLACED. ROCK TO BE ADDED AT THE SEAWARD ENDS OF THE GROYNES.



PLAN OF EXISTING GROYNE WITH ADDITIONAL ROCK

0 1 2 3 4 5 6 7 8 9 10m
SCALE 1:100

Plot Date : 6/25/2018 9:16 AM
File Name : GROYNESLEVELS

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LEGEND

MAIN GROYNE STRUCTURE
'WINGS' (SUPPORTS) OF GROYNE
INDICATIVE BEACH LEVEL

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P2
SHORTLIST ISSUE	GB / DG	04/09/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 8
REFURB GROYNES AND
ADD ROCK
OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	04/09/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:100	-

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Scott House
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Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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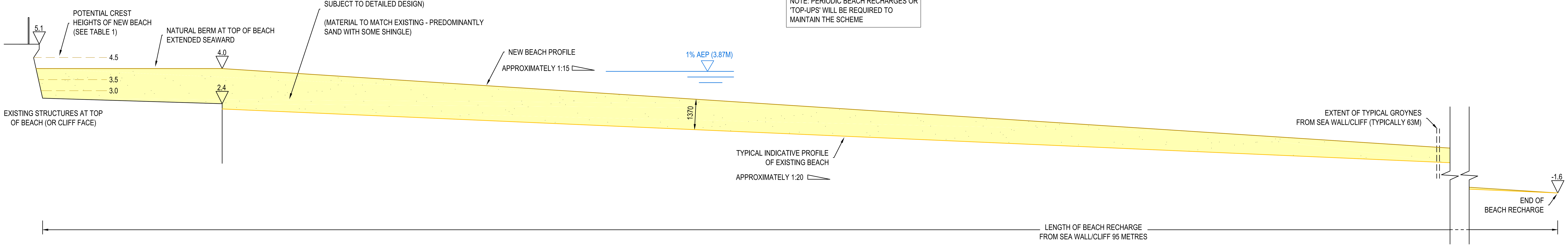
Drawing Number: MOBC-ACM-XX-00-DR-CE-02082
Rev: P2

PLAN OF LOCATION OF BEACH RECHARGE

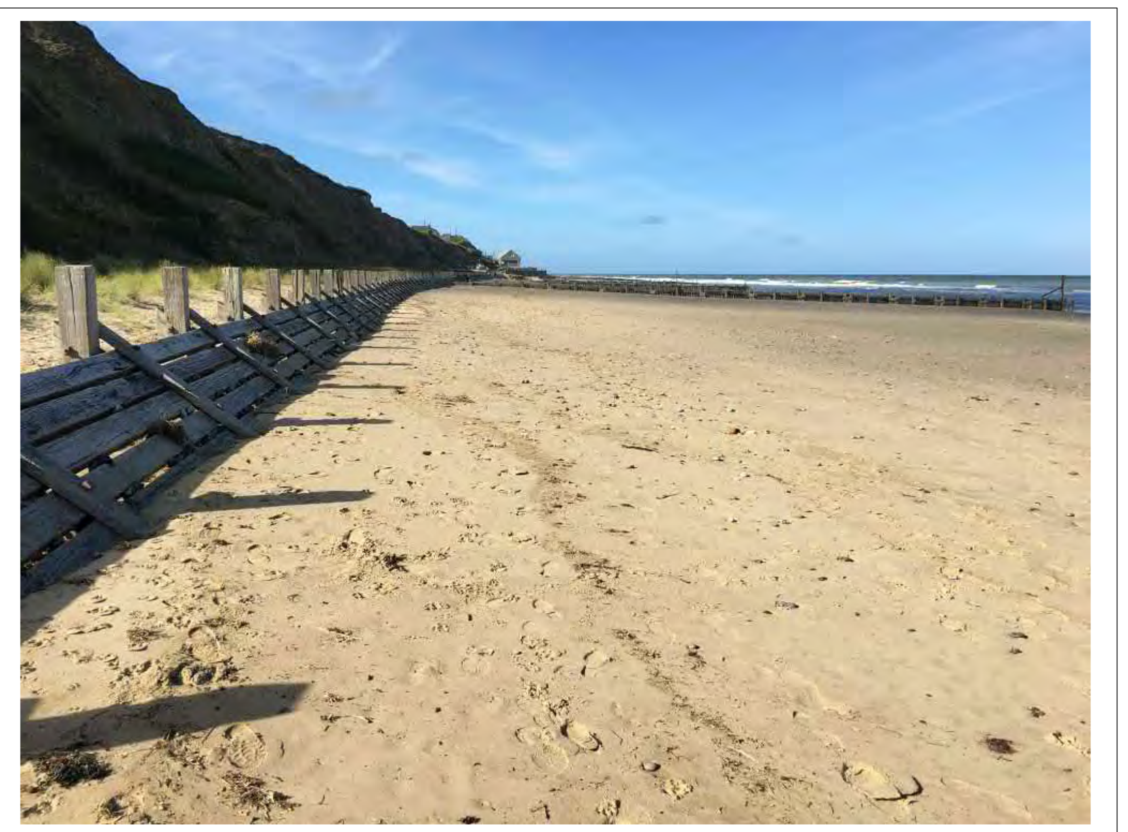
TABLE 1 - VOLUME OF MATERIAL REQUIRED TO CREATE CREST LEVELS BASED ON INDICATIVE PROFILE OF EXISTING BEACH LEVELS.	
CREST HEIGHT OF NEW BEACH PROFILE (M AOD)	VOLUME OF MATERIAL REQUIRED PER METRE (M^3/M)
4.5	145
4.0	91
3.5	50
3.0	20

NOTE: PERIODIC BEACH RECHARGES OR 'TOP-UPS' WILL BE REQUIRED TO MAINTAIN THE SCHEME



0 1 2 3 4 5 6 7 8 9 10m
SCALE 1:100

CROSS SECTION OF BEACH RECHARGE



PHOTOGRAPHS OF EXISTING BEACH

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LEGEND

BEACH RECHARGE AREAS

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
FINAL ISSUE FOR OBC	GB / DG	10/05/18	P4
SHORTLIST ISSUE	GB / DG	04/09/17	P3
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 11
BEACH RECHARGE

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
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AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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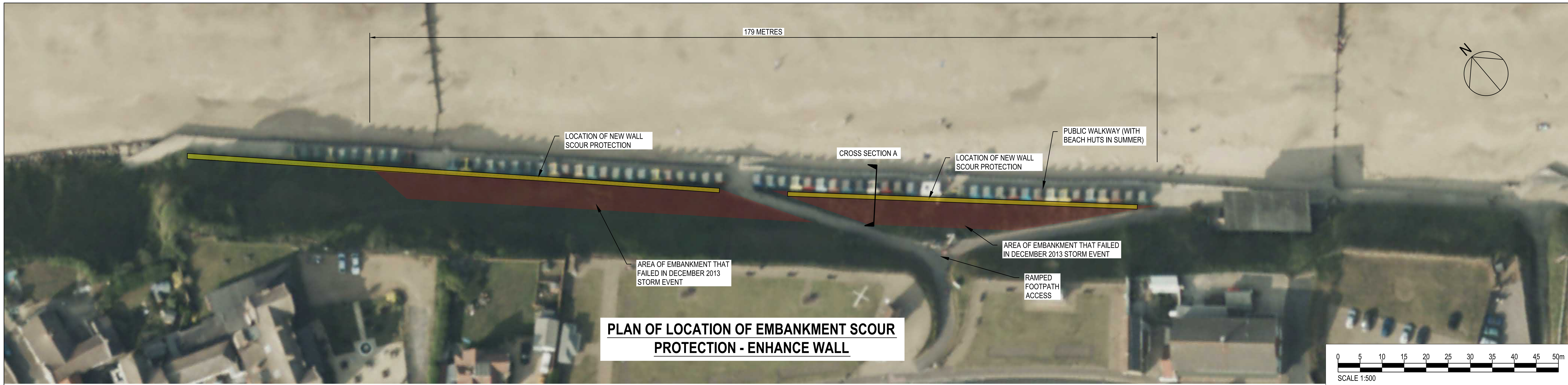
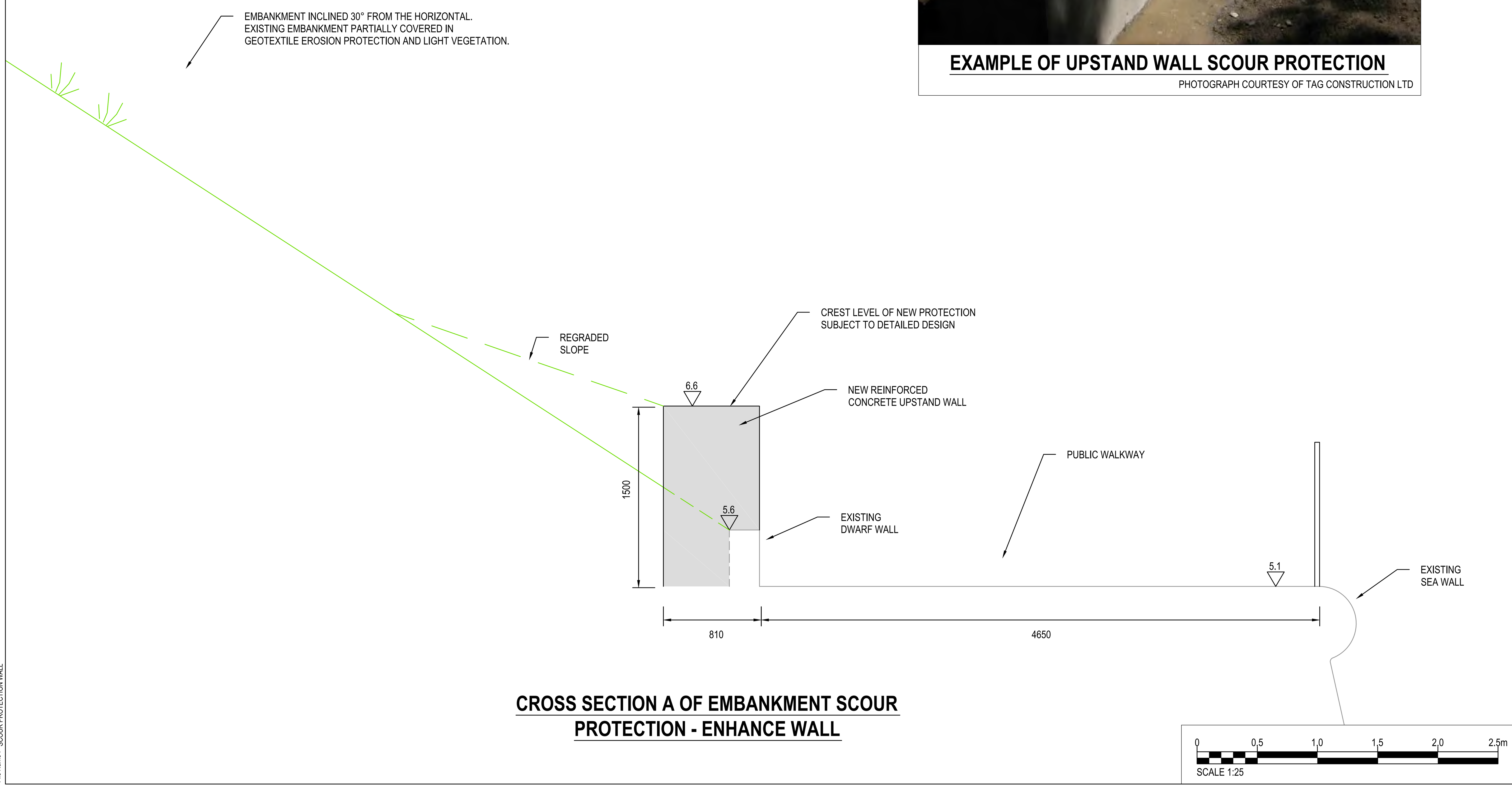


PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

EXAMPLE OF UPSTAND WALL SCOUR PROTECTION

PHOTOGRAPH COURTESY OF TAG CONSTRUCTION LTD



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

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LEGEND

- AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2013 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.
- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

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Purpose of issue

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Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

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OPTION 12
EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

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AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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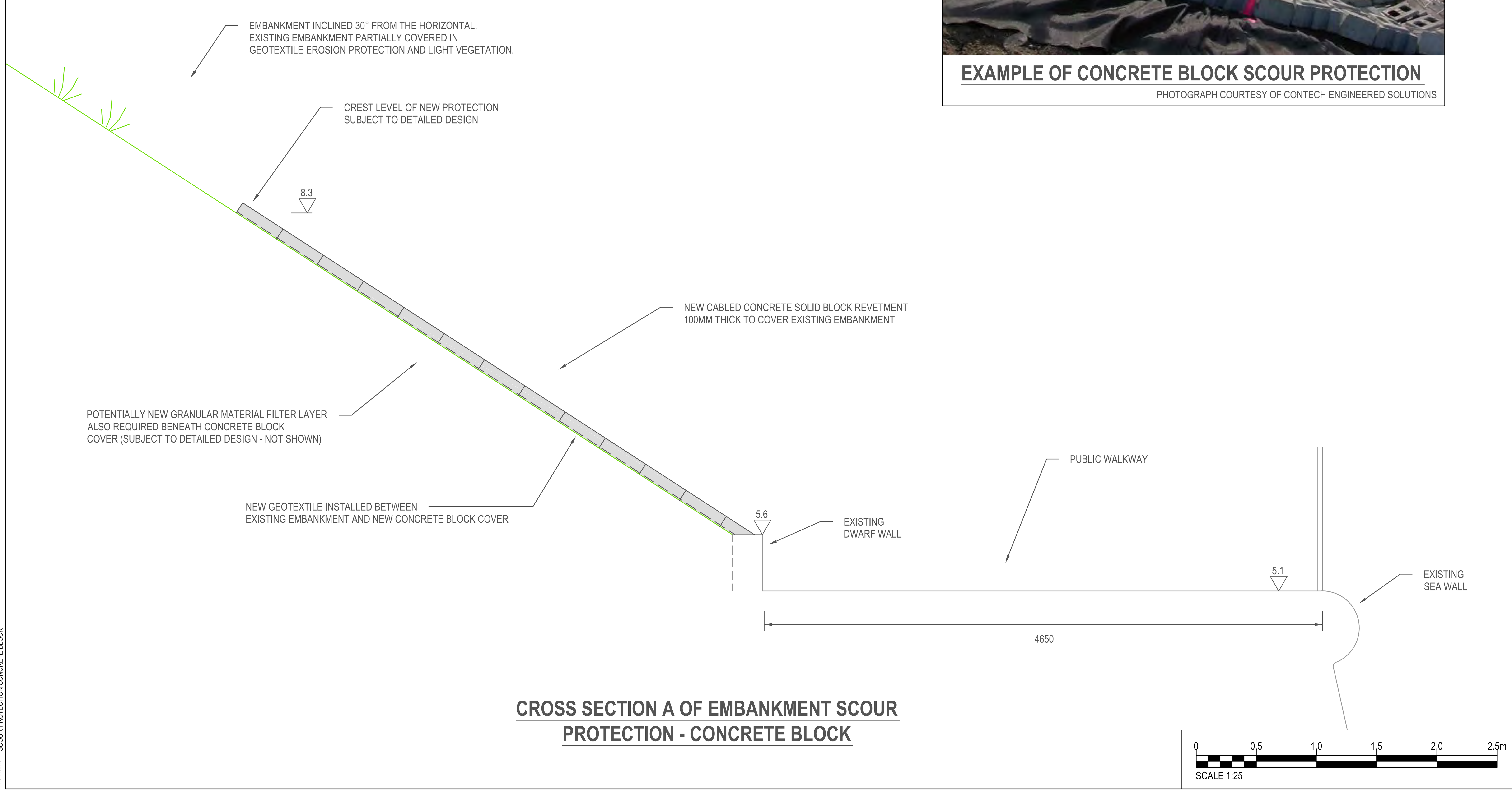
Plot Date: 5/11/2018 1:45 PM
File Name: SCOUR PROTECTION WALL

PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - CONCRETE BLOCK

EXAMPLE OF CONCRETE BLOCK SCOUR PROTECTION

PHOTOGRAPH COURTESY OF CONTECH ENGINEERED SOLUTIONS



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - CONCRETE BLOCK

PHOTOGRAPH OF EXISTING EMBANKMENT

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- AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2013 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.
- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

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Purpose of issue

FOR OPTION APPRAISAL

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OPTION 12
EMBANKMENT SCOUR PROTECTION - CONCRETE BLOCK

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AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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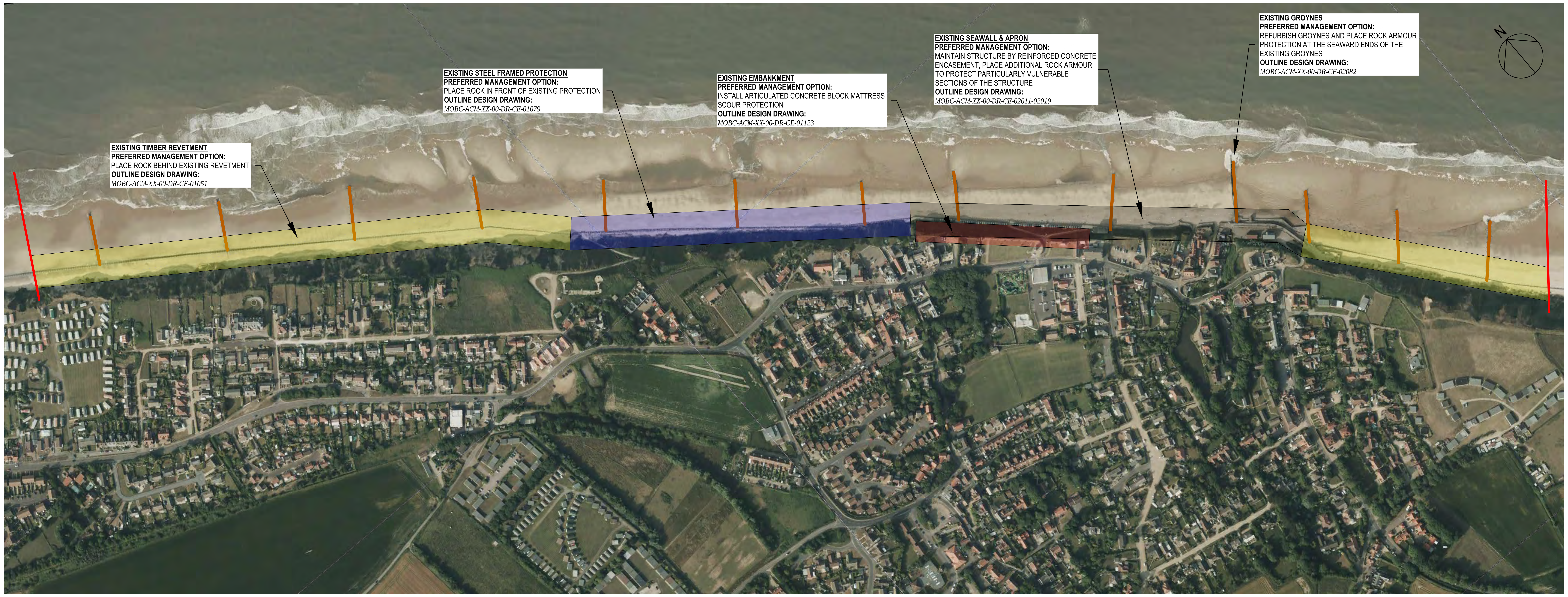

PLAN SHOWING PREFERRED MANAGEMENT OPTIONS ALONG THE FRONTAGE
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LEGEND

- EXTENT OF SITE
- INDICATIVE LOCATION OF EXISTING TIMBER GROYNES
- INDICATIVE LOCATION OF EXISTING TIMBER REVETMENT
- INDICATIVE LOCATION OF EXISTING STEEL FRAMED PROTECTION
- INDICATIVE LOCATION OF EXISTING CONCRETE SEAWALL
- INDICATIVE LOCATION OF EXISTING EMBANKMENT AT RISK OF SCOUR

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

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OUTLINE BUSINESS CASE

Drawing Title
PREFERRED SCHEME OPTION
OPTION 9 - ADAPTATION
OVERVIEW PLAN

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AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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Economic Assessment Report

Mundesley Outline Business Case

North Norfolk District Council

60519091

June 2018

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

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Issue	Association / Company Name
PDF Copy	North Norfolk District Council

Prepared for:

North Norfolk District Council 01263 513811 (Out of hours: 01223 849782)

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

Prepared by:

AECOM Infrastructure & Environment UK Limited
Midpoint
Alençon Link
Basingstoke
Hampshire RG21 7PP
UK

T: +44(0)1256 310200

Table of Contents

1. Introduction 5
1.1 Overview and purpose of this report 5
1.2 Economic appraisal 5
1.3 Previous Studies 5
1.4 Scenarios Evaluated 6
1.5 Property Data 6
2. Estimating 'Do Nothing' Damages 8
2.1 Estimating erosion extents – SCAPE modelling 8
2.2 Properties at risk 9
2.3 Other Damages/Benefits 9
3. Strategic Option Benefits 12
3.1 'Do Nothing' option benefits and damages 12
3.2 'Do Minimum' option benefits and damages 12
3.3 'SMP6' (HTL 50 years) option benefits and damages 13
3.4 'Modified SMP6' (HTL 100 years) option benefits and damages 14
4. Partnership Funding Assessment of Strategic Options 15
4.1 Context and approach 15
4.2 Contributions and Partnership Funding results 16
5. Sensitivity tests 17
5.1 Sensitivity 1 – increased residual life 17
5.2 Sensitivity 2 – reduced erosion rate 18
5.3 Sensitivity 3 – reduced residential property values 19
5.4 Partnership funding calculator sensitivity 1 – 25% increase in whole life costs 19
5.5 Partnership funding calculator sensitivity 4 – increased duration of benefits 20
6. Additional Local Economic Benefits 21
6.1 Qualitative impacts 21
6.2 Quantification of impacts 21
7. References 24
Appendix A – FCERM-AG Calculation Summary Sheet 25
Appendix B – Partnership Funding calculator 26

1. Introduction

1.1 Overview and purpose of this report

As part of the development of the Mundesley Outline Business Case (OBC), AECOM has undertaken an economic appraisal. The appraisal includes valuation of the potential damage that could result from coastal erosion as a result of a 'Do Nothing' scenario and the benefits that could be obtained by a number of potential erosion defence measures.

'Do Nothing' is a hypothetical 'walk away' scenario and represents the worst case in terms of potential erosion risk and therefore damage. Determining the 'Do Nothing' damages helps to demonstrate the scale of the potential issue being faced and provides a baseline against which potential mitigation options can be compared and evaluated.

This report presents the methodology and results of the economic assessment. It compares the benefits of potential measures which will be used in the development of a business case for the final preferred option.

1.2 Economic appraisal

The aim of an economic appraisal is to determine whether the implementation of erosion risk management options is financially worthwhile and to also ensure the most efficient allocation of resources is achieved.

In order to achieve this, the economic appraisal undertaken in this study compared the potential erosion damages associated with undertaking no remedial works along the frontage (a 'Do Nothing' scenario) and implementing coastal erosion defences to slow down / stop the process (a 'Hold the Line' scenario).

By expressing all of the potential erosion damages in a directly comparable unit of measurement; in monetary terms, a rational and systematic framework is provided for assessing the advantages and disadvantages of alternative options.

The appraisal was undertaken in line with the framework of the HM Treasury and Environment Agency Flood and Coastal Erosion Risk Management appraisal guidance (FCERM-AG, 2010). FCERM-AG represents the latest standard of assessment for all flood and coastal risk projects in England. As part of this economic appraisal only pre-2012 properties have been considered in order to comply with the FCERM Grant in Aid rules which state that 'For all outcome measures, benefits in relation to any new properties (residential or non-residential) or existing buildings converted into housing after 1 January 2012 will not be counted' ('Flood and Coastal Resilience Partnership Funding' Defra, 2011).

The appraisal period adopted in this study is 100 years. Options were appraised over 3 time periods (also known as epochs):

- Short term (0– 20 years)
- Medium Term (20 – 50 years)
- Longer term (50 – 100 years)

1.3 Previous Studies

This economic work is part of an update to a previous study undertaken along the frontage. AECOM undertook a review of the economic assessment work undertaken by Mott MacDonald as part of the 'Cromer to Winterton Ness Coastal Management Study' (2013). The purpose of this review was to evaluate the approach used, including any assumptions, in order to verify that the economic analysis undertaken was robust and realistic.

The interim report produced previously (AECOM, 2016) contains a review of the approach used as part of this previous assessment and examines the validity of the assumptions used. In summary the 'Cromer to Winterton Ness Coastal Management Study' was found to be compliant with the FCERM guidance, however, it identified a number of areas where more detailed analysis was required in order to provide a more robust economic appraisal. The following elements have been examined further as part of this updated economics phase of work:

Tangible Damages/Benefits

- Rate of erosion; when does each individual property get written off due to erosion.

- Beach huts; commercial damages for lost beach hut pitches should be considered.

- Boundaries; confirm the boundaries of the erosion area.

- Access; consider the impact of erosion on access roads.

- Review and update the cost of replacement infrastructure.

- Services; further investigation into the potential impact on local services.

Intangible Damages/Benefits

- Risk to life; consider the risk to life posed by erosion.

- Environment; creation of habitat.

It should be noted that the local impact of coastal erosion on tourism has not been examined within this study due to the lack of visitor data for the area meaning a robust assessment of this aspect could not be carried out.

1.4 Scenarios Evaluated

The following scenarios were assessed:

- No Active Intervention (also known as 'Do Nothing') – This is the baseline for comparison. No action is undertaken to maintain the current erosion defences and they are allowed to fail.

- 'Do Minimum' – Structures are maintained to maximise their residual lives. But, no major capital refurbishment works will take place to replace / improve structures at the end of their lives.

- 'SMP6' – 'Hold the Line' for an initial 50 years. After 50 years defences are allowed to fail and a 'Do Nothing' policy is reverted to.

- 'Modified SMP6' – A 'Hold the Line' policy is maintained across the entire frontage for the duration of the 100 year appraisal period.

1.5 Property Data

To identify individual properties at risk, North Norfolk District Council provided an address point dataset (National Receptor Database, 2011) which included the property address, post code, property type (e.g. residential – flat, residential – detached, commercial - warehouse) and property coordinates for all residential assets within the strategy area. Initially the database was checked to remove any post 2012 properties however following a review of the resulting data it was found that in filtering the data, a large number of eligible properties were removed. A manual check using Google StreetView was undertaken to confirm that none of the buildings removed from the data set were constructed before 2012 and therefore should actually be included in the property dataset. An example of this is Coronation Hall which was constructed in 1910 however is removed from the filtered dataset (circled in red in Figure 1 below). Figure 1 shows the filtered property points (with post 2012 properties removed) and the unfiltered data. The 'Do Nothing' 100 year erosion boundary extent is shown in blue.

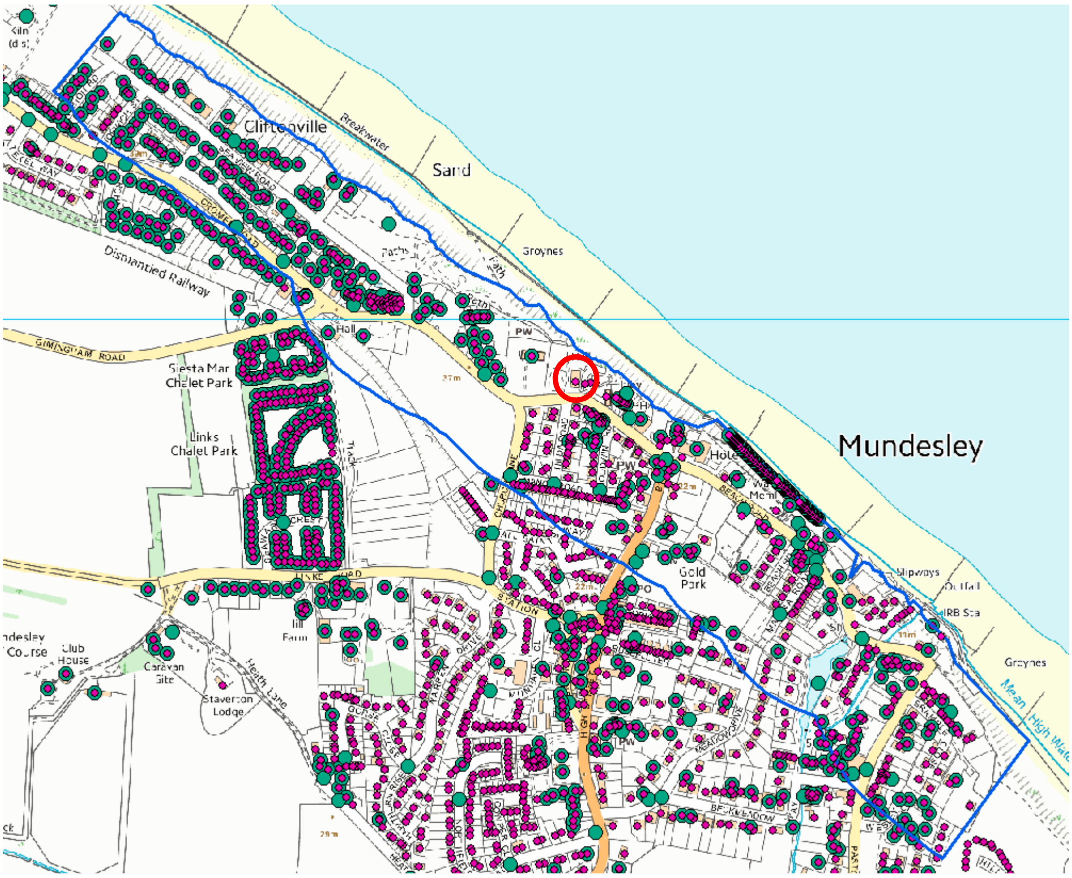

Figure 1: Post 2012 filtered NRD data (green points) and unfiltered NRD data (purple points). 'Do Nothing' erosion boundary is shown in blue. Coronation Hall, which was constructed in 1910, is circled in red.

Once the property data set was finalised, it was then subdivided into residential and commercial properties depending on the buildings associated MCM code. The value of each residential property was required in order to consider potential write-off damage values within the economic analysis. Average house sale prices were obtained for the last 12 months (up to January 2018) based on data provided by Zoopla (www.zoopla.co.uk) for the Mundesley area (NR11). The data was averaged by property type (detached, semi-detached, terrace, bungalow and flat). These were then applied to each property in the appraisal, for the purpose of assessing write-off damages.

Table 1-1: Average sold price per postcode January 2017 – January 2018 (source: zoopla.co.uk)

Property Type	Average sold price (January 2018)
Detached	£325,358
Semi-detached	£233,140
Terrace	£223,812
Flat	£195,900
Dwelling	£274,767

Values for commercial properties were applied in line with the MCM method which provides a market value (£/m²) from the Valuation Office Agency depending on the MCM code applied in the NRD (2011) dataset. A manual check was undertaken using Google Maps (2016) in order to ensure that the properties listed as being commercial were classified correctly.

2. Estimating 'Do Nothing' Damages

2.1 Estimating erosion extents – SCAPE modelling

SCAPE (Soft Cliff And Platform Erosion) modelling was undertaken as part of the Cromer to Winterton Ness Coastal Study (CWNCS). The base year for this study was 2012. AECOM completed a detailed review of this modelling work which can be found in the Interim Report (AECOM, 2016). This assessment concluded that the SCAPE erosion model results are reasonable in predicting the future coastline for this soft cliff area and the approach utilised fits the FCERM analysis.

The SCAPE erosion extents for the 'Do Nothing' and SMP6 scenarios are shown below.

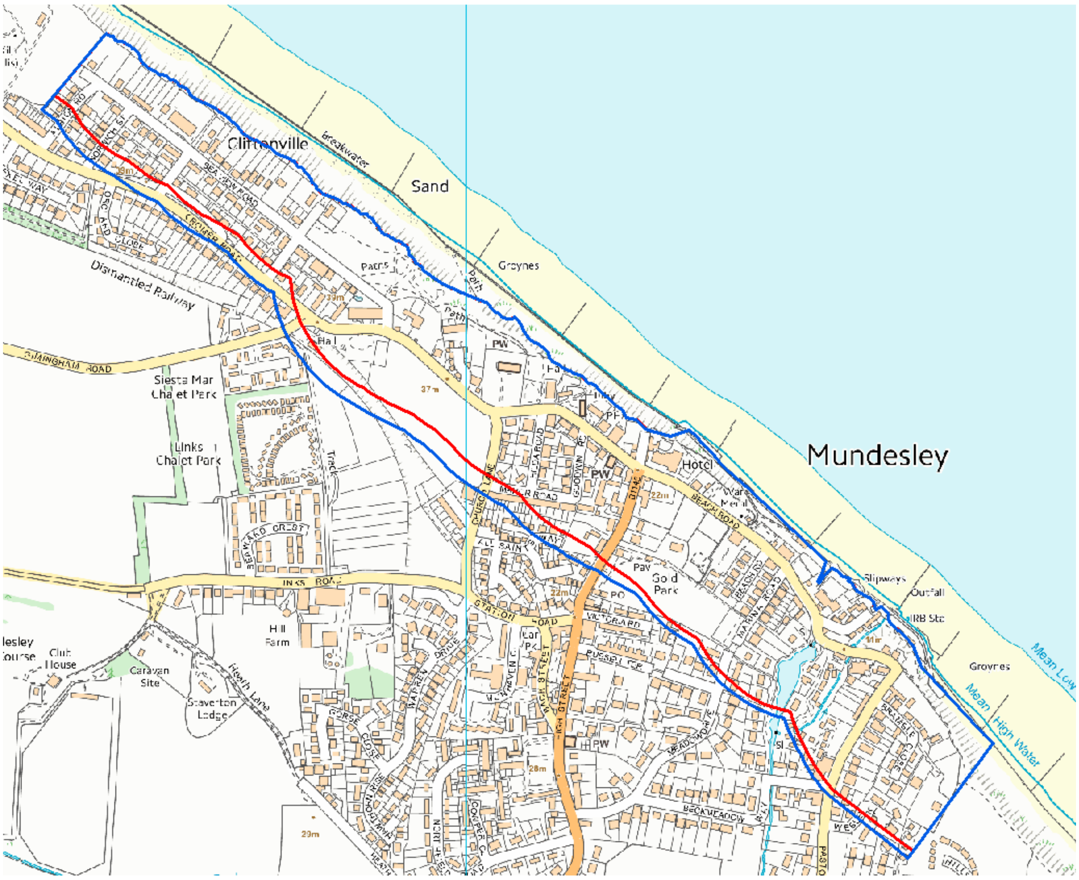

Figure 2: SCAPE model erosion extents. Do Nothing outline is shown in blue and the SMP6 scenario outline is shown in red.

Whilst the SCAPE modelling provided erosion rates for the situation after the defences have failed, it does not address the fact that some of the frontage currently is eroding whilst being protected by erosion defences. This is because there are defences existing on the frontage, such as a timber revetment and steel framed structure which heavily reduce wave energy impacting the cliffs, but do not completely eliminate it as a seawall structure would. The policy along these sections of the frontage can still be considered to be 'Hold the Line', even though cliff erosion is not eliminated, because of the presence of erosion defences which substantially reduce the rate of erosion.

To reflect this in the calculations of option benefits, all the scenarios included an erosion rate to the west and east of the seawall even when the policy of 'Hold the Line' is in place – to reflect the fact that a seawall does not exist in these locations and will not in the future. Properties were identified which will be eroded from the recession of the coast in these areas. This rate was based on historical monitoring data of the cliff recession over the last 20 years (Coastal Trends Report – North East Norfolk and North Suffolk (Kelling Hard to Lowestoft Ness, Environment Agency, 2013). Note that whilst these erosion rates with the current defences would increase over time due to climate change, it is assumed protection would be improved in the future to maintain the current standard of erosion protection and therefore the erosion rate will not vary.

Table 2-1: Erosion rates east and west of sea wall where timber revetment and steel framed defences exist (based on historic rates from monitoring)

Location	Erosion rate
West of sea wall	0.2 m/yr
East of sea wall	0.5 m/yr

2.2 Properties at risk

Inspection of the coastal modelling results in GIS allowed the baseline 'Do Nothing' erosion risk to be established for the study area. The erosion extents were viewed in conjunction with the address point dataset (NRD, 2011) in order to identify the properties at risk.

As recommended by the FCERM appraisal guidance, a buffer of 5m was applied around each of the properties. This accounts for the fact that once a property is within 5m of the eroded edge, it will be too dangerous to occupy therefore will no longer be habitable and can therefore be written off.

The number of commercial and residential properties (cumulative) expected to be at risk over the next 100 years from coastal erosion under the baseline 'Do Nothing' scenario is presented in Table 2-2 below.

Table 2-2: Cumulative number of residential and commercial properties at risk from coastal erosion over the next 100 years under 'Do Nothing' scenario

Epoch	Residential properties at risk	Commercial properties at risk	Total properties at risk
Short (0-20 years)	39	65	104
Medium (20-50 years)	297	96	393
Long (50-100 years)	510	119	629

This breakdown highlights that there are considerably more residential properties at risk across this frontage than commercial.

2.3 Other Damages/Benefits

Road Erosion

Following a review of the erosion contours, the B1159 at Mundesley was identified as being at risk from erosion. Given the size and capacity of the surrounding roads, it was determined that a permanent road diversion would not be possible and that a new roadway would have to be constructed to replace this route.

The Mott MacDonald study estimated that constructing a new 7.3m wide road would cost £1,268,421. It should be noted that this cost originated from a 2003 study and therefore for this updated economics assessment it was necessary to uplift the costs to the present day. This resulted in a cost of £1,837,050 for the replacement of this roadway due to coastal erosion (equivalent 2018 cost).

With the Do Nothing scenario the road is expected to erode in year 13 so therefore the road replacement cost was discounted by a factor of 0.639 to give a present value cost / economic damage for this scenario. For the alternative scenarios the year of erosion is different so therefore different discount factors were applied to capture this variation.

Anglian Wastewater Treatment Erosion

The Mott MacDonald study identified that the cliff top pumping station at Mundesley is at risk from coastal erosion. The estimated cost for relocating/replacing this along with its associated infrastructure was estimated to be £1,501,000, uplifted to 2018 prices.

With the Do Nothing scenario the pumping station is expected to erode in year 10 so therefore the relocation / replacement cost was discounted by a factor of 0.709 to give a present value cost / economic damage for this scenario. For the alternative scenarios the year of erosion is different so therefore different discount factors were applied to capture this variation.

Property Access Erosion

The effect of coastal erosion on property access was also considered. Certain properties may not be eroded; however, the access route to the property may be affected therefore making the property itself inaccessible and consequently uninhabitable. A manual assessment was done by overlaying the erosion lines with the local road network and identifying when each of the access routes would be affected. The access route to each of the properties was determined using Google StreetView images.

The year of write-off for the relevant properties was then amended to reflect when the access road to the property would be eroded and the property would therefore be considered to be uninhabitable.

Services Erosion

A utility search for the area was obtained as part of this updated phase of works to identify the services at risk due to coastal erosion. The loss of these services would cut off essential supply to individual properties causing them to become uninhabitable and therefore written off in the economic assessment.

A buffer of 5m was applied around all services as per the FCERM guidance. Following an examination of the services pathways, it was found that these line up with the roadway across the majority of the site (see Figure 3).

Figure 3: Map showing the location of all services (in blue) in relation to the roadways

As a result the erosion of access roads and services would take place simultaneously thus rendering properties uninhabitable at the same time. This was already accounted for in the economic assessment in order to avoid the double counting of property and services losses; therefore no additional damage was assumed.

The loss of hydrants was assessed separately as some of these do not correspond with road access and therefore may be lost earlier in the epoch causing properties to become uninhabitable.

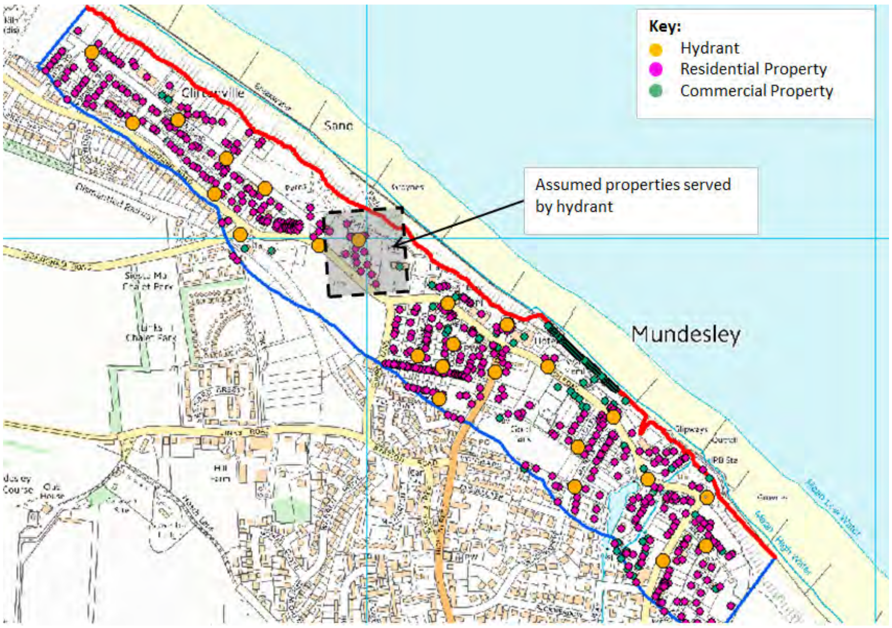

Figure 4: Location of hydrants in relation to commercial and residential (hydrant which will erode earlier than properties it serves is highlighted)

Figure 4 shows the location of all hydrants within the study area and identifies which ones will erode before the properties it serves are affected. As a result, the erosion years for these properties (17 residential and 1 commercial) were brought forward to account for this.

Risk to Life

There is no official guidance associated with potential loss of life from cliff erosion events. The value of a loss of a life has been estimated as £1,785,638 based on Department of Transport guidance – 'Valuation of The Benefits of Prevention of Road Accidents and Casualties', Department for Transport, 2000 (value has been updated to 2018 to account for inflation).

An assumption that one life will be lost in the 'Do Nothing' and 'Do Minimum' scenarios has been made. It is estimated that with the 'SMP6' option the probability of this occurring will reduce to 50% because the frontage will be unprotected for approximately half the time. An average discount factor has been applied to the cash value for loss of a life for the relevant period under each scenario.

Risk to Life associated with erosion loss of Lifeboat Station

Under the Do Nothing scenario the Lifeboat Station will be lost to erosion in year 11 which will have major health and safety implications from seafarers as there would be no local response and rescue service for maritime users. Without a local lifeboat response times in an emergency would be much longer and there would be an increased risk of putting people lives in jeopardy and therefore an increased threat to life.

On this basis a high level conservative valuation of this benefit has been made using an indexed Defra Reference Valuation for loss of life (£1.8m per person), combined with the estimated annual probability of increased risk to life from year 11 (the point at which the Lifeboat station is likely to be lost without a scheme to protect it from erosion). It has been assumed that loss of the Lifeboat station would lead to an average of one loss of life every 10 years.

The estimated cash (undiscounted) damage associated with erosion loss of the Lifeboat Station (through an increased risk to life) is approximately £7.2m. The discounted loss of life damage/benefit is approximately £2.8m.

Environmental Habitat Creation

The Partnership Funding calculator (see Section 4) considers whether potential schemes meet any environmental obligations that will increase the benefit of the scheme. For options which facilitate an increase in habitat for certain species there is potential to claim an environmental benefit. Along the frontage, the cliff eroding will increase the size of the existing Site of Special Scientific Interest (water habitat) that currently is bounded by the cliff line. An increase in size of this SSSI is potentially considered in Outcome Measure 4a, 'hectares of net water-dependent habitat created'. However, the erosion of the cliffs would also occur in the 'Do Nothing' scenario and because of this it cannot be claimed as an additional benefit in the other scenarios.

3. Strategic Option Benefits

3.1 'Do Nothing' option benefits and damages

The number of properties expected to be at risk from coastal erosion over the next 100 years under the above scenario is set out in the table below.

Table 3-1: Number of residential properties at risk from coastal erosion for the 'Do Nothing' scenario (non-cumulative)

Epoch	Residential properties at risk of erosion	Commercial properties at risk of erosion
Short (0-20 years)	39	65
Medium (20-50 years)	258	31
Long (50-100 years)	213	23

Table 3-2 and Table 3-3 below set out the PV damages associated with the above scenario for a 50 year and 100 year appraisal period respectively. The tables provide a breakdown of the damages associated with property along with local infrastructure and the potential risk to life value for the duration of the appraisal period.

Table 3-2: Present value damages expected over the next 50 years under the baseline 'Do Nothing' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
31,363	4,027	1,174	1,064	3,579	28	41,235

Table 3-3: Present value damages expected over the next 100 years under the baseline 'Do Nothing' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
38,406	4,290	1,174	1,064	3,259	35	48,230

note – compared to 50yr appraisal period, the risk to life is considered to be lower because the discount factor for the life lost is less for the 100yr appraisal period

3.2 'Do Minimum' option benefits and damages

The number of properties expected to be at risk from coastal erosion over the next 100 years under the above scenario is set out in the table below.

Table 3-4: Number of residential properties at risk from coastal erosion for the 'Do Minimum' scenario (non-cumulative)

Epoch	Residential properties at risk of erosion	Commercial properties at risk of erosion
Short (0-20 years)	21	1
Medium (20-50 years)	252	95
Long (50-100 years)	237	23

Table 3-5 and Table 3-6 below set out the PV damages associated with the above scenario for a 50 year and 100 year appraisal period respectively. The tables provide a breakdown of the damages associated with property along with local infrastructure and the potential risk to life value for the duration of the appraisal period.

Table 3-5: Present value damages expected over the next 50 years under the baseline 'Do Minimum' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
25,608	3,178	1,023	754	3,029	20	33,613

Table 3-6: Present value damages expected over the next 100 years under the baseline 'Do Minimum' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
33,306	3,428	1,023	754	2,737	32	41,281

note – compared to 50yr appraisal period, the risk to life is considered to be lower because the discount factor for the life lost is less for the 100yr appraisal period

As a result of the damages listed above, the introduction of the 'Do Minimum' defence measures will result in a PV benefit of **£7,622,000** over a 50 year appraisal period and a benefit of **£6,949,000** over the 100 year appraisal period. The reason why the benefits are less over the 100 year appraisal period is because the property damages after year 50 are included (whereas for the 50 year appraisal period, all property damages after year 50 are not considered).

3.3 'SMP6' (HTL 50 years) option benefits and damages

The number of properties expected to be at risk from coastal erosion over the next 100 years under the above scenario is set out in the table below.

Table 3-7: Number of residential properties at risk from coastal erosion for the 'SMP6' scenario (non-cumulative)

Epoch	Residential properties at risk of erosion	Commercial properties at risk of erosion
Short (0-20 years)	0	0
Medium (20-50 years)	0	0
Long (50-100 years)	508	118

Table 3-8 and Table 3-9 below set out the PV damages associated with the above scenario for a 50 year and 100 year appraisal period respectively. The tables provide a breakdown of the damages associated with property along with local infrastructure and the potential risk to life value for the duration of the appraisal period.

Table 3-8: Present value damages expected over the next 50 years under the baseline 'SMP6' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
0	0	0	0	0	0	0

Table 3-9: Present value damages expected over the next 100 years under the baseline 'SMP6' approach

PV Erosion Damages (£k)		PV Other (£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
15,326	1,554	332	296	188	15	17,711

As a result of the damage listed above, the introduction of the SMP6 defence measures over the next 50 years will result in a PV benefit of **£41,235,000** over a 50 year appraisal period and a benefit of **£30,591,000** over the 100 year appraisal period. The reason why the benefits are less over the 100 year appraisal period is because the property damages after year 50 are included when the management approach transitions to Do Nothing (whereas for the 50 year appraisal period, all property damages after year 50 are not considered).

3.4 'Modified SMP6' (HTL 100 years) option benefits and damages

The number of properties expected to be at risk from coastal erosion over the next 100 years under the above scenario are set out in the table below.

Table 3-10: Number of residential properties at risk from coastal erosion for the 'Modified SMP6' scenario (non-cumulative)

Epoch	Residential properties at risk of erosion	Commercial properties at risk of erosion
Short (0-20 years)	0	0
Medium (20-50 years)	0	0
Long (50-100 years)	10	0

Table 3-11 below sets out the PV damages associated with the above scenario for a 100 year appraisal period. This provides a breakdown of the damages associated with property along with local infrastructure and the potential risk to life value for the duration of the appraisal period.

A 50 year appraisal period has not been considered for this option because the option is for the full 100 years.

Table 3-11: Present value damages expected over the next 100 years under the baseline 'Modified SMP6' approach

PV Erosion Damages –(£k)		PV Other(£k)				PV Total (£k)
Residential	Commercial	Road Erosion (£k)	Anglian WWT Plant (£k)	Risk to Life (£k)	Services (£k)	
319	0	0	0	0	0	319

As a result of the damage listed above, the introduction of the SMP6 defence measures over the next 100 years will result in a PV benefit of **£47,910,000** over the 100 year appraisal period.

4. Partnership Funding Assessment of Strategic Options

4.1 Context and approach

In the past, flood and coastal defence projects were largely funded from a national budget. Funding for coastal management schemes was allocated on an 'all or nothing' basis. In May 2011 the Government announced changes to the system to encourage more local contributions to flood defence schemes. This was a recommendation of the Pitt Review and it generally has widespread support.

In the current 'Partnership Funding' system, public money (Grant in Aid or 'GiA') is made available to part fund justifiable schemes, while any shortfall in funding is made up by other parties with a vested interest in seeing the project go ahead. The levels of funding made available by the government through GiA are based on the economic, social and environmental benefits that the project will bring.

Partnership Funding is therefore an effective way of making the FCERM GiA go further. With the Partnership Funding system, if sufficient contributions can be attracted, any project could proceed so long as it is economically, socially and environmentally viable.

The previous 'Cromer to Winterton Ness Coastal Management Study' found that potential schemes for the Mundesley frontage achieved a benefit to cost ratio (BCR) of approximately 5:1 and partnership funding (PF) scores in excess of 190%, suggesting that the potential schemes are both economically viable and fundable through Grant in Aid (GiA) funding.

As part of this updated economic appraisal these PF calculation scores have been reviewed and updated to reflect the revised property counts and benefits associated with each of the options.

The partnership funding assessment was carried out in accordance with the Environment Agency funding guidance for flood and coastal protection schemes. The Defra Flood and Coastal Resilience Partnership Funding arrangement defines the level of Grant in Aid (GiA) a project could achieve based on a series of Defra Outcome Measure (OM) targets.

There are four outcome measures under which projects can attract GiA. These are:

1. All benefits arising as a result of the investment, less than those valued under the other outcome measures (outcome measure 1).

2. Households moved from one category of flood risk to a lower category (outcome measure 2).

3. Households better protected against coastal erosion (outcome measure 3).

4. Statutory environmental obligations met through flood and erosion risk management (outcome measure 4).

Outcome measures 3 and 4 are the most relevant to this study. This analysis used the National Receptor Database (NRD) data provided by the Environment Agency in order to determine how many properties (both residential and commercial) would be at risk over the assessment period. The NRD contained items such as street furniture, postal boxes and property shells which were excluded from the final property count as the benefits associated with retaining these would be negligible.

As part of the Partnership Funding calculator the Index of Multiple Deprivation (2015) was used to divide the affected properties into categories of deprivation. It was found that the properties fell into two categories; households were in either one of the 21-40% most deprived areas or an area in the 60% least deprived areas.

The Partnership Funding calculator assesses the level of funding available based on the number of households removed from risk for the following periods: Medium-term loss (≤20 years) and Long-term loss (20-50 years).

4.2 Contributions and Partnership Funding results

NNDC's preferred option is 'SMP6' to 'Hold the Line' for 50 years. The benefits of this option have been determined following the methodology in this report. The OM1 benefits in the funding assessment are based on a **50 year benefit period** of the scheme which are approximately £41.24m. Note that this is a larger benefit than when a full 100 year appraisal period is considered (see chapter 3) because a 50 year appraisal period does not consider the loss of properties from year 50 onwards.

The numbers of households protected from erosion by the option (OM3 benefits) are presented in Table 4-1 below.

Table 4-1. OM3 benefits of the preferred option

Number of households in:	Long-term loss (>20 years)	Medium-term loss (<=20 years)
20% most deprived areas	-	-
21-40% most deprived areas	131	27
60% least deprived areas	127	12

The whole life present value option costs are approximately £5,064k. An appraisal cost of £70k has been included in the Partnership Funding calculator. The contributions towards the option total £632k.

Based on the above, the Partnership Funding score for the option is 105%, with total PV FCERM GiA towards the upfront costs of the scheme, estimated to be approximately £2,714k. The Partnership Funding score is summarised in Table 4-2 below.

Table 4-2. Partnership Funding score of the preferred option (50 year benefit period)

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*
SMP6 HTL 50yrs	£5,064k	£41,235k	8.14	87%	105%

adjusted PF score assuming PV £632k contributions

5. Sensitivity tests

A range of sensitivty tests have been undertaken to determine the impact of changing various parameters on the economic damages and benefits of the options. The sensitivity tests have been completed for a **50 year appraisal period** so that the impact on funding of the scheme can be assessed. These sensitivity tests include:

- Sensitivity 1: increased residual life of the exising defences
- Sensitivity 2: reduced erosion rate
- Sensitivity 3: reduced property values
- Partnership Funding sensitivity 1: increased whole life option costs
- Partnership Funding sensitivity 4: increased duration of benefits

5.1 Sensitivity 1 – increased residual life

Increasing the residual life of the existing defences delays the onset of property erosion. This results in a greater discount factor being applied to the property damages and additional damages and therefore reduced whole life economic damages/benefits. For the purpose of the sensitivity test it has been assumed that the residual life of the existing defences will be increased by 5 years, as summarised in the table below.

Table 5-1. Assumed residual life for original economics and sensitivity test 1

Defence	Residual life assumed for original economics	Residual life assumed for sensitivity test 1
West of Seawall	3 years	8 years
East of Seawall	3 years	8 years
Seawall	10 years	15 years

The economic damages of sensitivity test 1, assuming a 5 year extension of the residual life of the existing defences, are presented in Table 5-2 below.

Table 5-2. Economic damages and benefits of sensitivity test 1

Option	Original economics		Sensitivity test 1	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	33,580	0
Do Minimum	33,613	7,622	27,541	6,039
SMP6 HTL 50yrs	0	41,235	0	33,580

Table 5-3 presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 1, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 6.63, which remains above 1 demonstrating that the scheme is still viable even if the defence residual life is increased by 5 years. The Partnership Funding score is 78%, increasing to 97% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £99k would be required (total contributions of £731k).

Table 5-3. Summary of sensitivity 1 benefit cost ratio and Partnership Funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required to achieve PF score of 100%
SMP6 HTL 50yrs	£5,065k	£33,580k	6.63	78%	97%	£99k

adjusted PF score assuming £632k contributions

5.2 Sensitivity 2 – reduced erosion rate

Reducing the erosion rate of the shoreline causes a delay to the onset of erosion to the properties and also a slower pace of loss of properties and associated additional damages. This also results in a greater discount factor being applied and therefore reduces the whole life economic damages / benefits. In addition, with this reduced erosion rate some properties which eroded later on in the original economic appraisal do not erode under this test scenario. For the purpose of the sensitivity test it was assumed that the erosion rates would be reduced by 50%, as summarised in the table below.

Table 5-4. Assumed erosion rates for original economics and sensitivity test 2

Area	Erosion rate assumed for original economics (m/yr)		Erosion rate assumed for sensitivity test 1	
	Before failure	After failure	Before failure	After failure
West of Seawall	0.2	2.5	0.1	1.25
East of Seawall	0.5	2.5	0.25	1.25
Seawall	0	2.7	0	1.35

The economic damages of sensitivity test 2, assuming a 50% reduction in erosion rates, are presented in Table 5-5 below.

Table 5-5. Economic damages and benefits of sensitivity test 2

Option	Original economics		Sensitivity test 2	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	14,125	0
Do Minimum	33,613	7,622	9,938	4,187
SMP6 HTL 50yrs	0	41,235	0	14,125

Table 5-6 below presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 2, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 2.79, which remains above 1 demonstrating that the scheme is still viable even if the erosion rate is reduced by 50%. The Partnership Funding score is 29%, increasing to 48% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £1,756k would be required (total contributions of £2,388k).

Table 5-6. Summary of sensitivity 2 benefit cost ratio and Partnership Funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required to achieve PF score of 100%
SMP6 HTL 50yrs	£5,065k	£14,125k	2.79	29%	48%	£1,756k

adjusted PF score assuming £632k contributions

5.3 Sensitivity 3 – reduced residential property values

Reducing the value of residential properties in the economic assessment leads to reduced economic damages associated with the write off of the properties due to erosion. The reduction in property values has no impact on the value of the additional damages in the assessment. For the purpose of sensitivity test 3 the residential property values have been reduced by 20%, as summarised in the table below.

Table 5-7. Property values adopted in the original economics and sensitivity test 3

Residential property type	Property value in original economics (for January 2018)	Assumed property value in sensitivity test 3 (-20%)
Detached	£325,328	£260,286
Semi detached	£233,140	£186,512
Terrace	£223,812	£179,050
Flat	£195,900	£156,720
Dwelling	£274,767	£219,814

The economic damages of sensitivity test 3, assuming a 20% reduction in residential property values, are presented in Table 5-8 below.

Table 5-8. Economic damages and benefits of sensitivity test 3

Option	Original economics		Sensitivity test 3	
	Damages (£k)	Benefits (£k)	Damages (£k)	Benefits (£k)
Do Nothing	41,235	0	34,361	0
Do Minimum	33,613	7,622	28,012	6,348
SMP6 HTL 50yrs	0	41,235	0	34,361

Table 5-9 below presents the preferred option cost benefit ratio and Partnership Funding score for sensitivity test 3, assuming a whole life option cost of £5,065k. As can be seen, the benefit cost ratio of the option is 6.78, which remains above 1 demonstrating that the scheme is still viable even if the residential property values are reduced by 20%. The Partnership Funding score is 79%, increasing to 98% with contributions of £632k. In order to achieve a Partnership Funding score of 100%, an additional contribution of £70k would be required (total contributions of £702k).

Table 5-9. Summary of sensitivity 3 benefit cost ratio and Partnership Funding

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required to achieve PF score of 100%
SMP6 HTL 50yrs	£5,065k	£34,361k	6.78	79%	98%	£70k

adjusted PF score assuming £632k contributions

5.4 Partnership Funding calculator sensitivity test 1 – 25% increase in whole life costs

The in-built Partnership Funding calculator sensitivity test 1 increases whole life option costs by 25%. This sensitivity test also assumes that a strategic approach was not taken which reduces the maximum grant rate to 45%. Table 5-10 below presents the Partnership Funding score of the preferred option under sensitivity test 1 in the Partnership Funding calculator.

As shown, with the Partnership Funding calculator sensitivity test 1 the benefit cost ratio of the option remains above 1. However, the Partnership Funding score reduces signficantly to 31%. In order to achieve an adjusted

Partnership funding score of 100% an additonal £2,248k in contributions would be required (total contributions of £2,880k).

Table 5-10. Summary of Partnership Funding calculator sensitivity test 1 (25% increase in whole life costs)

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required to achieve PF score of 100%
SMP6 HTL 50yrs	£6,331k	£41,235k	6.51	31%	NA	£2,248k

adjusted PF score assuming £632k contributions

5.5 Partnership Funding calculator sensitivity test 4 – increased duration of benefits

The in-built Partnership Funding calculator sensitivity test 4 increases the benefits duration by 25% (from 50 to 62 years). This essentially means that it is taking longer to achieve the same benefit outcomes of the scheme which in turn reduces the Partnership Funding score (as the cost stays the same). Table 5-11 below presents the partnershiup funding score of the preferred option under sensitivity test 4 in the Partnership Funding calculator.

As shown, with the Partnership Funding calculator sensitivity test 4 the benefit cost ratio of the option remains above 1. However, the Partnership Funding score reduces to 57%. In order to achieve an adjusted Partnership Funding score of 100% an additional £808k in contributions would be required (total contributions of £1,440k).

Table 5-11. Summary of Partnership Funding calculator sensitivity test 4 (increased duration of benefits by 25%, from 50 to 62 years)

Option	Cost (PV)	Benefits (PV)	Benefit : Cost ratio	Raw PF score	Adjusted PF score*	Additional contribution required to achieve PF score of 100%
SMP6 HTL 50yrs	£5,065k	£41,235k	8.14	57%	76%	£808k

adjusted PF score assuming £632k contributions

6. Additional Local Economic Benefits

6.1 Qualitative impacts

Without a scheme to mitigate erosion risk there would be significant impacts to the local economy and community at Mundesley. Table 6-1 presents the non-residential assets that would be lost over the next 100 years.

Table 6-1. Summary of commercial / tourism related assets at risk of erosion (Do Nothing)

Years	Assets lost	Impact of loss on local economy / community
0-10	Lifeboat station	Loss of maritime rescue service, potential increased risk to life for seafarers
11-20	60 beach huts, Restaurant / Cafeteria, shop, 2 holiday cottages, village hall, library	Loss of amenity and recreation supporting assets. Local economic impacts due to reduced visitor numbers and reduced spend due to degradation of services and accommodation etc.
21-30	Hotel, Church, Restaurant, Museum, 4 shops, other commercial, 3 holiday cottages, public toilets, amusements, parking, recycling site,	Further loss of community and visitor interest features. Direct impacts to economy through loss of retail outlets.
31-40	3 Holiday cottages	Further loss of visitor accommodation.
41-50	2 holiday cottages	Further loss of visitor accommodation.
51-60	1 holiday cottage	Further loss of visitor accommodation.
61-70	1 holiday cottage	Further loss of visitor accommodation.
71-80	3 holiday cottages / chalets, petrol station	Further loss of visitor accommodation and supporting services
81-90	6 holiday cottages / chalets, playground, other commercial enterprise	Loss of community recreation assets.
91-100	8 holiday cottages / chalets	Further loss of visitor accommodation.

The impacts in Table 6-1 demonstrate the importance of a scheme to prevent significant detrimental impacts to the local economy. Initially impacts would be relatively minor but without intervention from year 10, key assets for the community and visitors would be lost. Over time the blue flag beach, beach huts, critical infrastructure and services and coastal access would be adversely affected or lost over time. Local trade would suffer considerably as a result as many of the shops and businesses rely heavily on day trippers and holiday makers. Eventually Mundesley would become an undesirable place to live and visit and alternative locations would be sought.

6.2 Quantification of impacts

The scheme benefits shown in Chapter 3 represent the economic cost avoided (FCERM eligible) and these are assessed from a national economic perspective which does not permit the inclusion of potential local benefits which are transferable and displaceable. This allows nationally consistent appraisal of scheme benefits and outcomes and a 'level playing field' for Partnership Funding assessments.

However, the local economic benefits of a scheme will be significantly greater than the FCERM figures and additional local economic benefits can be derived as a result of the intervention. By evaluating the potential contribution to the local economy of investing in an erosion risk protection scheme, it helps build an understanding of other positive impacts on the local economy. For Mundesley the key aspects of this include:

- Facilitation of business continuity and sustainability of business activity in an area;
- Continuation of tourism and recreation usage; and
- Continuation of maritime response/ rescue services.

Although not included in the FCERM appraisal, a high level valuation estimate of these other local economic benefits was carried out. This further adds to the case for change and demonstrates the local value of delivering the scheme. For the assessment of additional local economic benefits a 30 year appraisal period was adopted (rather than the 50 year period for the Partnership Funding assessment) because, in line with best practice, the assessment should focus only on the direct impacts of the scheme intervention, not other factors that can influence the longer term behaviours and trends of commerce and tourism.

High level valuation of local tourism benefits provided by the preferred option

Indicative valuations were carried out using methodologies adapted from the MCM manual, Defra GVA toolkit, and applies data from estimated tourism spend figures provided in previous tourism Study for Norfolk (http://www.norfolkcoastaonb.org.uk/mediaps/pdfuploads/pd004157.pdf). Given the lack of available detailed data, some simplistic conservative assumptions and estimates were necessarily applied so figures presented below are likely to represent lowest estimates and the true local economic benefit is likely to be much greater.

The Mundesley Tourist Office states that "well over 7000 visitors pass through" their tourism office each year (http://www.mundesley.org/viscen.html). Many of these visitors come to use the beaches for amenity and recreation such as walking or fishing, or to see the museum. Many also use the local café's and restaurants and many stay in the range of different tourism accommodation. Therefore without intervention to prevent erosion, from year 10, many of the features that attract and serve the visitors will begin to be lost or adversely impacted. A reduction in visitors and tourism spend has been estimated as a result and is assumed by year 30 tourism would effectively cease as alternative locations would serve their needs as Mundesley becomes unattractive and lacking in the required services and features that bring people to the town today.

The estimated cash benefit to the local economy from the preferred option maintaining tourism at current day levels is £8.8m. The discounted whole life tourism benefit is £4m.

These valuations are based on an estimate of how quickly tourism would go elsewhere if erosion was unmitigated. They are also based on daily spend rates of day trippers (£40/ day) and of people staying on holiday (£200/trip). The high level assessment also assumes an even split of the two types of visitor. It is likely that many more people visit the area than adopted in this valuation so the actual local economic tourism benefit associated with the scheme could be far greater. The estimates also do no account for potential increases in tourism which the preferred option could facilitate.

The profile of Cash and Present Value local tourism benefits provided by the preferred option is provided in Table 6-2 below.

Table 6-2. High level estimates of local economic damages associated with tourism avoided by the preferred option

Year (from present)	Numbers of visitors / tourists lost under Do Nothing (benefiting from the preferred option)	Value (£ cash)	Value (£ PV)
0-10	0	0	0
11	350	42,000	28,768
12	700	84,000	55,590
13	1050	126,000	80,565
14	1400	168,000	103,787
15	1750	210,000	125,347
16	2100	252,000	145,330
17	2450	294,000	163,818
18	2800	336,000	180,889
19	3150	378,000	196,619
20	3500	420,000	211,078
21	3850	462,000	224,334
22	4200	504,000	236,452
23	4550	546,000	247,494
24	4900	588,000	257,519
25	5250	630,000	266,583

Year (from present)	Numbers of visitors / tourists lost under Do Nothing (benefiting from the preferred option)	Value (£ cash)	Value (£ PV)
26	5600	672,000	274,739
27	5950	714,000	282,039
28	6300	756,000	288,531
29	6650	798,000	294,261
30	7000	840,000	299,274
Total	**73500**	**8,820,000**	**3,963,015**

7. References

AECOM (2016) Interim Report. Mundesley Outline Business Case.

Defra (2011) Flood and Coastal Resilience Partnership Funding: Defra policy statement on an outcome-focussed partnership approach to funding flood and coastal erosion risk management

Department for Transport (2000) Valuation of the Benefits of Prevention of Road Accidents and Casualties

EFTEC (2010) Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects.

Environment Agency (2010) Flood and Coastal Erosion Risk Management appraisal guidance

Environment Agency (2013) Coastal Trends Report – North East Norfolk and North Suffolk (Kelling Hard to Lowestoft)

HM Treasury (2003) The Green Book: Appraisal and Evaluation in Central Government

Mott MacDonald (2013) Cromer to Winterton Ness Coastal Management Study

Office of National Statistics (2016) Neighbourhood Statistics. Deprivation. http://neighbourhood.statistics.gov.uk/dissemination/NeighbourhoodProfile.do?a=5&b=6275185&c=NR11+8DB&g=6449643&i=1001x1012&j=6308613&m=1&p=1&q=1&r=0&s=1478536917374&enc=1&tab=9

Penning-Rowsell, Edmund Penning-Rowsell, Christophe Viavettene, Joana Pardoe, John Chatterton, Dennis Parker and Joe Morris (2015) The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques. Flood Hazard Research Centre, Middlesex UK.

Appendix A – FCERM-AG Calculation Summary Sheet

Note the below project summary sheet shows damages and benefits only (costs not included) for the 100 year appraisal period.

Project Summary Sheet

Client/Authority			Prepared (date)	02/03/2017
North Norfolk District Council			Printed	09/05/2018
Project name			Prepared by	NC / GB
Mundesley OBC			Checked by	JS
Project reference	60519091		Checked date	03/03/2017
Base date for estimates (year 0)	Jan-2018			
Scaling factor (e.g. £m, £k, £)	£k	(used for all costs, losses and benefits)		
Year	0	30	75	
Discount Rate	3.5%	3.00%	2.50%	
Optimism bias adjustment factor	30%			

Costs and benefits of options

	Costs and benefits £k					
Option number	Option 1	Option 2	Option 3			
Option name	No Active Intervention (NAI)	Do Minimum	SMP6 (50 year HTL)	Modified SMP6 (100 year HTL)		
AEP or SoP (where relevant)						
COSTS:						
PV capital costs						
PV operation and maintenance costs						
PV other						
Optimism bias adjustment	0	0	0	0		
PV negative costs (e.g. sales)	0	0	0	0		
PV contributions						
Total PV Costs £k excluding contributions	0	0	0	0		
Total PV Costs £k taking contributions into account	0	0	0	0		
BENEFITS:						
PV monetised flood damages						
PV monetised flood damages avoided						
PV monetised erosion damages	48,230	41,281	17,711	319		
PV monetised erosion damages avoided (protected)		6,948	30,519	40,962		
Total monetised PV damages £k	48,230	41,281	17,711	319		
Total monetised PV benefits £k		6,948	30,519	47,910		
PV damages (from scoring and weighting)						
PV damages avoided/benefits (from scoring and weighting)						
PV benefits from ecosystem services						
Total PV damages £k	48,230	41,281	17,711	319		
Total PV benefits £k		6,948	30,519	47,910		
DECISION-MAKING CRITERIA:						
excluding contributions						
***Based on total PV benefits** (includes benefits from scoring and weighting and ecosystem services)*						
Net Present Value **NPV**		6,948	30,519	47,910		
Average benefit/cost ratio **BCR**						
Incremental benefit/cost ratio **IBCR**						
***Based on monetised PV benefits** (excludes benefits from scoring and weighting and ecosystem services)*						
Net Present Value **NPV**		6,948	30,519	47,910		
Average benefit/cost ratio **BCR**						
Incremental benefit/cost ratio **IBCR**						
including contributions						
***Taking account of contributions** (includes benefits from scoring and weighting and ecosystem services)*						
Net Present Value **NPV**		6,948	30,519	47,910		
Average benefit/cost ratio **BCR**						
Incremental benefit/cost ratio **IBCR**						
***Based on monetised PV benefits** (excludes benefits from scoring and weighting and ecosystem services)*						
Net Present Value **NPV**		6,948	30,519	47,910		
Average benefit/cost ratio **BCR**						
Incremental benefit/cost ratio **IBCR**						

Appendix B – Partnership Funding calculator

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name	Mundesley OBC - HTL 50 years
Unique Project Number	

Key: Input cells / Calculated cells

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

SUMMARY: prospect of FCRM GiA funding

Scheme Benefit to Cost Ratio:	8.14	to 1
Effective return to taxpayer:	15.19	to 1
Effective return on contributions:	65.24	to 1

Raw Partnership Funding Score	87%	(1)
External Contribution or saving required to achieve an Adjusted Score of 100%	450,124	(2)
Adjusted Partnership Funding Score (PF)	105%	(3)
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	2,714,359	(4)

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	LA	(5)
Duration of Benefits (years)	50	(7)
PV Whole-Life Benefits:	41,235,000	(8)
PV Costs		
PV Appraisal Costs	70,000	(9)
PV design & Construction Costs	3,276,405	(10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	3,346,405	(11)
PV Post-Construction Costs	1,718,133	(12)
PV Whole-Life Costs:	5,064,538	(13)
PV Contributions secured to date		
PV Local Levy secured to date	70,000	(14)
PV Public Contributions secured to date	301,176	(15)
PV Private Contributions secured to date	260,870	(16)
PV Funding form other Environment Agency functions/sources secured to date		(17)
PV Total Contributions secured to date	632,046	(18)

Yes (6) Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:

At:	Before: Moderate risk	Before: Significant risk	Before: Very significant risk	After: Moderate risk	After: Significant risk	After: Very significant risk	Change due to scheme: Moderate risk	Change due to scheme: Significant risk	Change due to scheme: Very significant risk
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	-	-	-	-	-	-	0	0	0
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme		Qual. benefits (discounted)
20% most deprived areas	£ -	£ -	OM2 (20%)	£ -
21-40% most deprived areas	£ -	£ -	OM2 (21-40%)	£ -
60% least deprived areas	£ -	£ -	OM2 (60%)	£ -

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before: Long-term loss	Before: Medium-term loss
20% most deprived areas	-	-
21-40% most deprived areas	131	27
60% least deprived areas	127	12

Damages per household avoided:	Long-term loss	Medium-term loss	
Annual damages avoided	£ 6,000	£ 6,000	
Loss expected in	50	20	years
Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015	

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:		Qual. benefits (discounted):
20% most deprived areas	£ -	£ -	OM3 (20%)	£ -
21-40% most deprived areas	-£ 236,464	-£ 11,823,208	OM3 (21-40%)	£ 5,838,908
60% least deprived areas	-£ 186,499	-£ 9,324,947	OM3 (60%)	£ 4,605,138

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:			Assumed benefits per unit:		Qual. benefits (discounted):
OM4a		Hectares of net water-dependent habitat created	£ 15,000	OM4a	£ -
OM4b		Hectares of net intertidal habitat created	£ 50,000	OM4b	£ -
OM4c		Kilometres of protected river improved	£ 80,000	OM4c	£ -
				OM4	£ -

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 30,790,955	5.56 p in the £1	£ 1,710,609
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM3	20% most	£ -	45.0	£ -
	21-40%	£ 5,838,908	30.0	£ 1,751,672
	Least 60%	£ 4,605,138	20.0	£ 921,028
OM4		£ -	100.0	£ -
Total		£ 41,235,000		£ 4,383,308

Maximum for Outcomes delivered. The actual value any scheme is eligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	87%	450,124
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	31%	2,879,680
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	87%	450,124
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	83%	574,655
Sensitivity 4 - Increase Duration of Benefits by 25%	57%	1,439,981
Sensitivity 5 - Reduce Duration of Benefits by 25%	81%	622,627

END OF WORKSHEET

Option Costing Report

Mundesley Outline Business Case

North Norfolk District Council

60519091

June 2018

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

Quality information

Prepared by	Checked by	Approved by
George Batt Engineer	Dan Glasson Associate	Paul Norton Technical Director

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Prepared for:

North Norfolk District Council 01263 513811 (Out of hours: 01223 849782)

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

Prepared by:

AECOM Infrastructure & Environment UK Limited
Midpoint
Alençon Link
Basingstoke
Hampshire RG21 7PP
UK

T: +44(0)1256 310200

Table of Contents

1. Introduction ... 1
   1.1 Introduction ... 1
   1.2 Purpose of this report ... 1
2. Approach to Costing the Options ... 2
   2.1 Approach to capital construction activities ... 2
   2.2 Preliminary costs and optimism bias ... 2
   2.3 Existing defences at the site ... 3
3. Capital Costs ... 6
   3.1 Option 1: Seawall Maintenance/Refurbishment ... 6
   3.2 Option 3: Rock Revetment ... 27
   3.3 Option 5: Placed Rock Protection ... 29
   3.4 Option 6: Timber Revetment ... 30
   3.5 Option 7: Steel Frame ... 33
   3.6 Option 8: Groynes ... 49
   3.7 Option 11: Scour protection ... 55
   3.8 Option 12: Beach Recharge ... 62
   3.9 Capital cost summary ... 63
4. Costs for Maintenance / Ongoing Works ... 64
   4.1 Option 1: Seawall / apron re-facing ... 64
   4.2 Option 3: Rock revetment ... 64
   4.3 Option 6: Timber revetment ... 64
   4.4 Option 7: Steel framed protection ... 65
   4.5 Option 8: Groyne refurbishment ... 65
   4.6 Option 11: Scour protection ... 65
   4.7 Option 12: Beach recharge ... 65
   4.8 General maintenance along the frontage ... 66
5. Whole Life Costing ... 67
   5.1 Overview ... 67
   5.2 Scheme Option 1 – Do Nothing ... 68
   5.3 Scheme Option 2 – Do Minimum ... 68
   5.4 Scheme Option 3 – Rock Revetment ... 68
   5.5 Scheme Option 4 – Maintain Existing ... 69
   5.6 Scheme Option 5 – Partial Rock Placement A ... 70
   5.7 Scheme Option 6 – Partial Rock Placement B ... 70
   5.8 Scheme Option 7 – Full Rock Placement ... 71
   5.9 Scheme Option 8 – Beach Re-nourishment ... 72
   5.10 Scheme Option 9 – Adaptive Option ... 72
   5.11 Summary of whole life costs ... 73

1. Introduction

1.1 Introduction

AECOM Infrastructure and Environment UK Limited have been appointed by North Norfolk District Council (NNDC) to develop an Outline Business Case (OBC) and seek funding to implement the preferred management policy for the Mundesley frontage within the adopted Shoreline Management Plan.

1.2 Purpose of this report

This report presents how the capital costs of the options have been developed, the assumptions taken and the methodology used. The options in this report have been short listed from a previous report, 'Options – Development and Appraisal'[1]. The costs developed will be used to produce benefit cost ratios for different options in order to compare options and choose a preferred option for which a business case will be developed.

[1] Option Development and Appraisal Report, AECOM, June 2018

2. Approach to Costing the Options

In order to compare the relative economic merits of the options and to generate the benefit cost ratios against the 'Do Nothing' baseline scenario, capital costs for the different options have been estimated.

2.1 Approach to capital construction activities

The cost estimations for capital works were undertaken using the best available information from a variety of sources. In the first instance where costing information was available from previous projects, published data or supplier quotations, these costs were used as a basis to cost the options.

In the absence of this information, values have been estimated from rates provided in civil engineering price books (e.g. SPONS 2016) and Environmental Agency guidance, coupled with experience of costs from similar projects.

For a number of the options considered the cost is dependent on the dimensions of the existing structures. This information was obtained using a combination of methods: LiDAR data (1m grid), historic drawings and topographic survey (sea wall/apron only).

2.1.1 Assumptions

The costs have been produced assuming:

- No services will require diverting;
- The land is not contaminated;
- VAT and any other taxes or duties are excluded;
- Site surveys and investigations are excluded;
- Statutory authority charges such as planning approval, services etc. are excluded;
- An allowance for unknown site or ground conditions is excluded;
- Where required (if past projects are used) inflation in cost has been based on Bank of England calculations;
- Cost of detailed design and developing a full business case is excluded.

2.2 Preliminary costs and optimism bias

2.2.1 Preliminary costs

To cost for items which are not typically accounted for in build-up of costs by tasks using price books, for example: create formwork, supply concrete, place concrete, surface finishing; a preliminary cost of 35% should be applied. The following items are considered to be included in this cost:

- Establishment and running costs of contractors site offices, toilets, mess facilities act;
- Mobilisation and demobilisation of construction equipment;
- Provision of site vehicles;
- Contractors site management team;
- Provision of stores and warehousing including labour and plant;
- Surveys, permits and insurances;
- Contractors profit;

- Contractual requirements i.e. insurance.

2.2.2 Optimism bias

In line with FCERM-AG policy, an optimism bias of 30% was applied to the present value whole life costs for each option. According to Environmental Agency guidance, optimism bias;

"***is the tendency for appraisers to be overly optimistic in early assessment of project costs, time scales and benefits in comparison to the final values. To counter this HM Treasury issues guidance in the form of a percentage to increase the costs depending on the uncertainty surrounding the estimates. At the more detailed project stage, a figure of 30% is more commonly used. This percentage is added to the original estimate and used in the cost-benefit calculations.***"[2]

2.3 Existing defences at the site

Figure 2-1 shows a plan of the site and the locations of the existing defences along the frontage. There are a number of different existing defences along the Mundesley coastline, the main types of defences existing on the frontage are:

- **Timber groynes**
  Timber groynes existing along the frontage acting to trap sediment and increase beach levels. Typically they are 60-70 m long and permeable.

- **Sea wall**
  A concrete sea wall protects approximately 580 m of the frontage. The area landward of this protection is the most heavily built-up part of Mundesley. The sea wall varies in design with different types of recurve detail and widths of apron.

- **Timber revetment**

[2] Flood and Coastal Erosion Risk Management appraisal guidance, Environment Agency, 2010

Two sections of hardwood timber revetment protect the frontage. The section southeast of the sea wall measures approximately 230 m and the section northwest of the sea wall measures approximately 675 m.

- **Steel framed structure**
  A steel framed structure filled with concrete blocks and rubble exists along approximately 465 m of the frontage.

Figure 2-1: Plan showing locations of existing structures

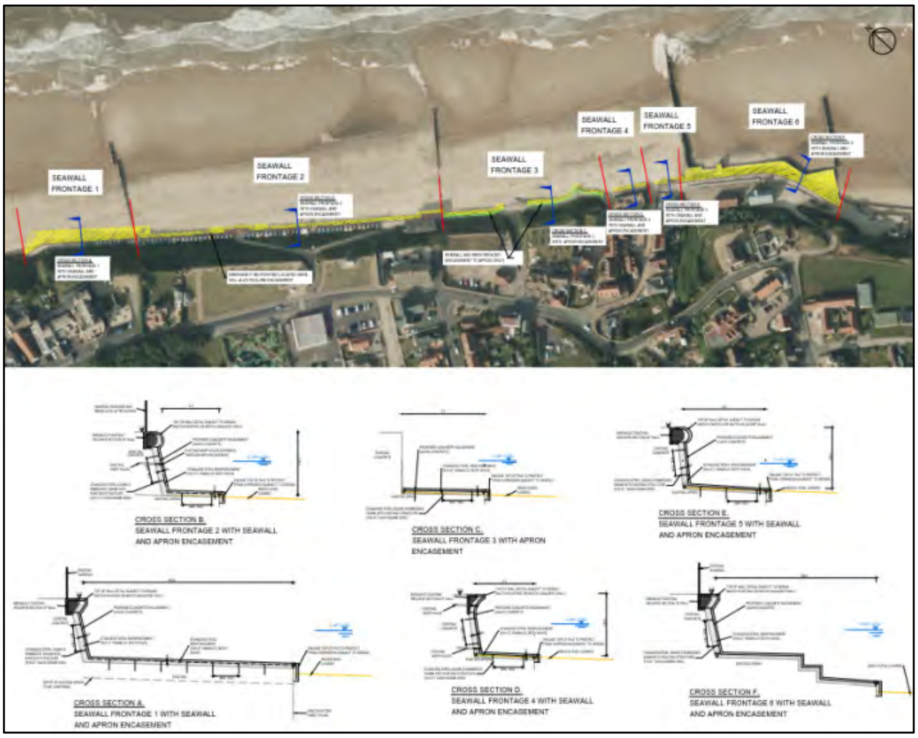
3. Capital Costs

This section presents how the capital costs of the different potential erosion management options have been developed. The options have been briefly described and illustrated, full drawings (extracts are below) and descriptions of the options can be found in 'Short Listed Options – Development and Appraisal'.

The section below comprises tables showing a detailed cost breakdown of the option, showing: the items of work involved, how these items are measured, the measured quantity, the £/unit rate and finally a total cost with and without preliminaries and optimism bias. Also shown are tables of the assumptions behind these costs: how the measured quantity has been derived and where the £/unit rate has been provided from.

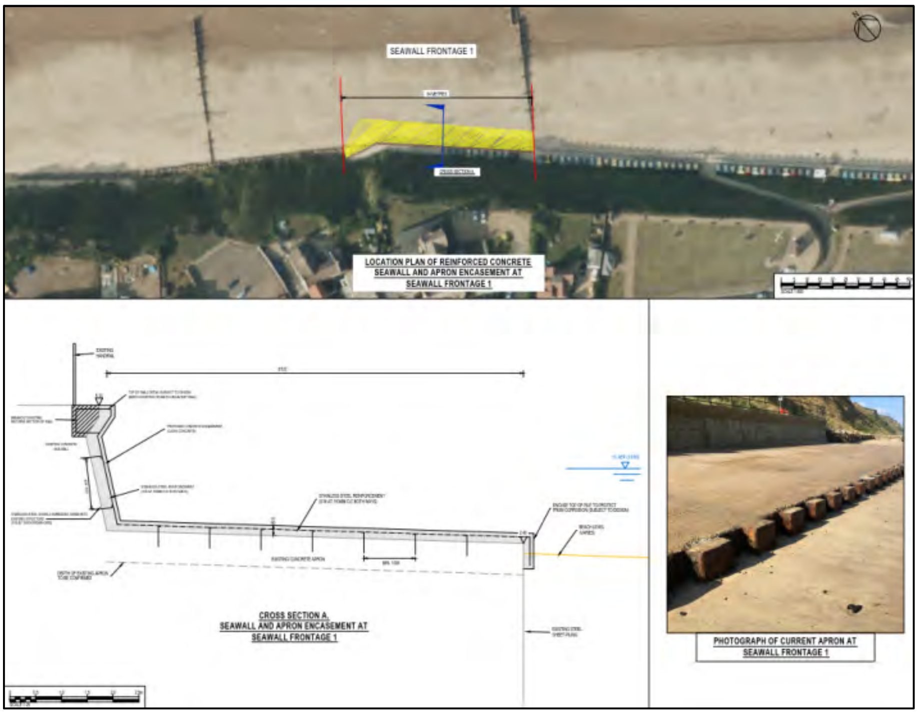
All cost estimates provided in this initial costing section of the report are valid to <u>January 2016.</u> All costs have been updated to January 2018 later in the report.

3.1 Option 1: Seawall Maintenance/Refurbishment



Option 1 is maintenance/refurbishment to the seawall and the apron; it has been split up into sections as there are variations in apron length and seawall height and profile. This option in Section 6 can also include having rock armour fronting the seawall apron as this area is more prone to scouring (both with and without rock armour have been costed).

3.1.1 Seawall Section 1



The cost breakdown for the maintenance/refurbishment of the seawall in Section 1 is presented below, split into wall and apron, as well as assumptions.

Table 3-1: Costing of seawall in Section 1

	unit	measure	rate	total
200mm thick reinforced concrete apron, 8.0m width - cost for 84m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m^3	142.8	£104.32	£14,897
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	m^3	142.8	£8.67	£1,238
Total				***£16,135***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m^3	142.8	£37.29	£5,325
Total				***£5,325***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m^2	42.0	£70.88	£2,977
Total				***£2,977***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size	tn	14.5	£4,184.92	£60,681
Dowels	nr	672.0	£2.81	£1,888
Total				***£62,570***
Surface finishing	-	-	-	-
Steel trowel	m^2	672.0	£1.66	£1,116
Total				***£1,116***
Total	-	-	-	***£88,122***
Preliminary cost at 35%				**£118,965**
+30% optimism bias				**£154,654**
300mm thick reinforced concrete wall - cost for 84m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m^3	80.6	£104.32	£8,412
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	m^3	80.6	£8.67	£699
Total				***£9,112***
Placing of reinforced concrete	-	-	-	-
Walls, thickness 150 - 300mm	m^3	80.6	£45.58	£3,676
Total				***£3,676***
Formwork	-	-	-	-
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	m^2	57.7	£92.51	£5,338
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	m^2	140.3	£60.12	£8,434
Total				***£13,772***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	7.2	£4,395.04	£31,644
Dowels	nr	168.0	£2.81	£472
Total				***£32,116***
Surface finishing	-	-	-	-
Steel trowel	m^2	198.2	£1.66	£329
Total				***£329***
Total	-	-	-	***£59,005***
Preliminary cost at 35%				**£79,657**
+30% optimism bias				**£103,554**

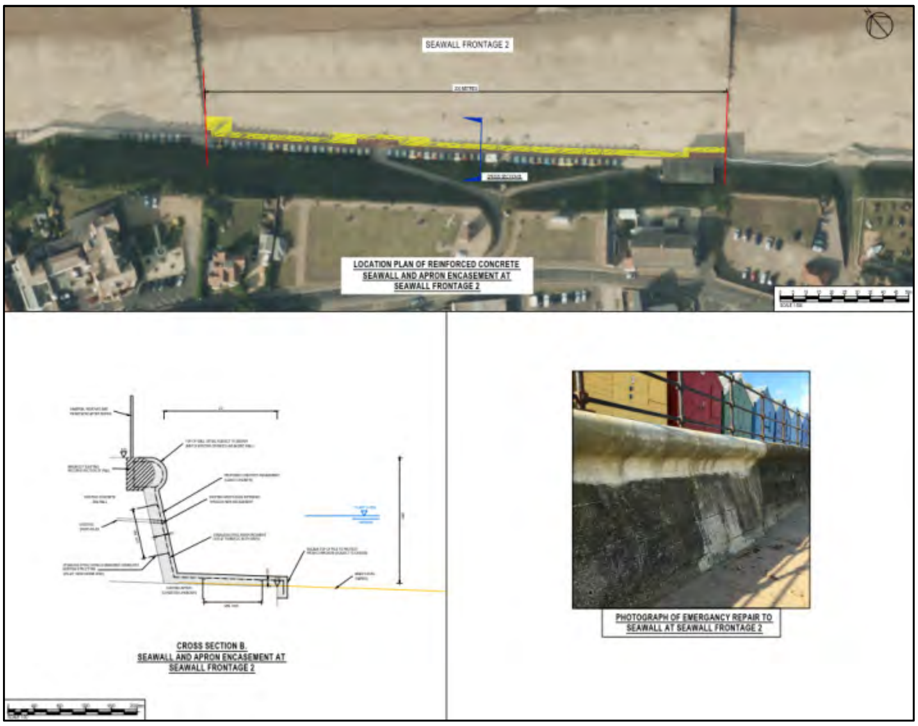
Table 3-2: Total cost of seawall (apron and wall) in Section 1

Total	£147,127	£1,752 per metre
Preliminary cost at 35%	£198,622	£2,365 per metre
+30% optimism bias	£258,208	£3,074 per metre

Table 3-3: Assumptions for the costing of seawall in Section 1

	Assumptions
200mm thick reinforced concrete apron, 8.0m width - cost for 84m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - (8x0.2)+(0.2x0.5) = 1.7m^2 area of concrete (x 84m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - 0.5m is the height of formwork on edge of apron (x 84m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size	Measure - One way, length of apron 84m, 0.15m spacing = 560 bars of 8m length = 4480m. Other way, width of apron 8m, 0.15m spacing = 53.3 bars of 84m length = 4480m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (4480x2) = 1.8m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (8m width x 84m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 8m width x 84m length Rate - SPONS16 p.219
300mm thick reinforced concrete wall - cost for 84m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - area (0.96m^2) from AutoCAD x length of study (84m) from AutoCAD Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Walls, thickness 150 - 300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	Measure - 0.69m length taken from AutoCAD x 84m length Rate - SPONS16 p.212
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	Measure - 1.67m length taken from AutoCAD x 84m length Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of wall 84m, 0.15m spacing = 560 bars of 3.94m length = 2206m. Other way, length of wall reinf. 3.94m, 0.15m spacing = 26.3 bars of 84m length = 2206m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (2206x2) = 0.9m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 horizontally placed dowel will be used for every 1x1m of wall (approx. 2m x 84m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.36m length of wall from AutoCAD x 84m length Rate - SPONS16 p.219

3.1.2 Seawall Section 2



The cost breakdown for the maintenance/refurbishment of the seawall in Section 2 is presented below, split into wall and apron, as well as assumptions.

Table 3-4: Costing of seawall in Section 2

	unit	measure	rate	total
200mm thick reinforced concrete apron, 2.2m width - cost for 200m length				
Provision of concrete				
Cost of concrete (C50@20mm aggregate)	m³	108.0	£104.32	£11,267
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	108.0	£8.67	£936
Total				***£12,203***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m³	108.0	£37.29	£4,027
Total				***£4,027***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m²	100.0	£70.88	£7,088
Total				***£7,088***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size	tn	9.7	£4,184.92	£40,594
Dowels	nr	400.0	£2.81	£1,124
Total				***£41,718***
Surface finishing	-	-	-	-
Steel trowel	m²	440.0	£1.66	£730
Total				***£730***
Total	-	-	-	***£65,766***
Preliminary cost at 35%				**£88,785**
+30% optimism bias				**£115,420**
300mm thick reinforced concrete wall - cost for 200m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	188.0	£104.32	£19,612
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	188.0	£8.67	£1,630
Total				***£21,242***
Placing of reinforced concrete	-	-	-	-
Walls, thickness 150 - 300mm	m³	188.0	£45.58	£8,569
Total				***£8,569***
Formwork	-	-	-	-
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	m²	160.0	£92.51	£14,802
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	m²	334.0	£60.12	£20,080
Total				***£34,882***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	15.1	£4,395.04	£66,365
Dowels	nr	400.0	£2.81	£1,124
Total				***£67,489***
Surface finishing	-	-	-	-
Steel trowel	m²	488.0	£1.66	£810
Total				***£810***
Total	-	-	-	***£132,992***
Preliminary cost at 35%				**£179,539**
+30% optimism bias				**£233,401**

Table 3-5: Total cost of seawall (apron and wall) in Section 2

Total	£198,758	£994 per metre
Preliminary cost at 35%	£268,324	£1,342 per metre
+30% optimism bias	£348,821	£1,744 per metre

Table 3-6: Assumptions for the costing of seawall in Section 2

	Assumptions
200mm thick reinforced concrete apron, width 2.2m - cost for 200m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - (2.2x0.2)+(0.2x0.5) = 0.54m^2 area of concrete (x 200m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - 0.5m is the height of formwork on edge of apron (x 200m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size	Measure - One way, length of apron 200m, 0.15m spacing = 1333 bars of 2.2m length = 2933m. Other way, width of apron 2.2m, 0.15m spacing = 14.7 bars of 200m length = 2933m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (2933x2) = 1.2m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (2.2m width x 84m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.2m width x 200m length Rate - SPONS16 p.219
300mm thick reinforced concrete wall - cost for 200m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - area (0.94m^2) from AutoCAD x length of study (84m) from AutoCAD Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Walls, thickness 150 - 300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	Measure - 0.8m length taken from AutoCAD x 84m length Rate - SPONS16 p.212
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	Measure - 1.67m length taken from AutoCAD x 84m length Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of wall 200m, 0.15m spacing = 1333 bars of 3.5m length = 4667m. Other way, length of wall reinf. 3.5m, 0.15m spacing = 23.3 bars of 200m length = 4667m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (4667x2)= 1.9m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 horizontally placed dowel will be used for every 1x1m of wall (approx. 2m x 200m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.44m length of wall from AutoCAD x 84m length Rate - SPONS16 p.219

3.1.3 Seawall Section 3

The cost breakdown for the maintenance/refurbishment of the seawall in Section 3 is presented below, for the apron only, as well as assumptions.

Table 3-7: Costing of seawall in Section 3

	unit	measure	rate	total
200mm thick reinforced concrete apron, 3.2m width - cost for 95m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m^3	70.3	£104.32	£7,334
Pumping from ready mix truck to point of placing at the rate of $25m^3$/hour	m^3	70.3	£8.67	£610
Total				***£7,943***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m^3	70.3	£37.29	£2,621
Total				***£2,621***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m^2	47.5	£70.88	£3,367
Total				***£3,367***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size	tn	6.6	£4,184.92	£27,620
Dowels	nr	285.0	£2.81	£801
Total				***£28,421***
Surface finishing	-	-	-	-
Steel trowel	m^2	304.0	£1.66	£505
Total				***£505***
Total	-	-	-	***£42,857***
Preliminary cost at 35%				**£57,858**
+30% optimism bias				**£75,215**

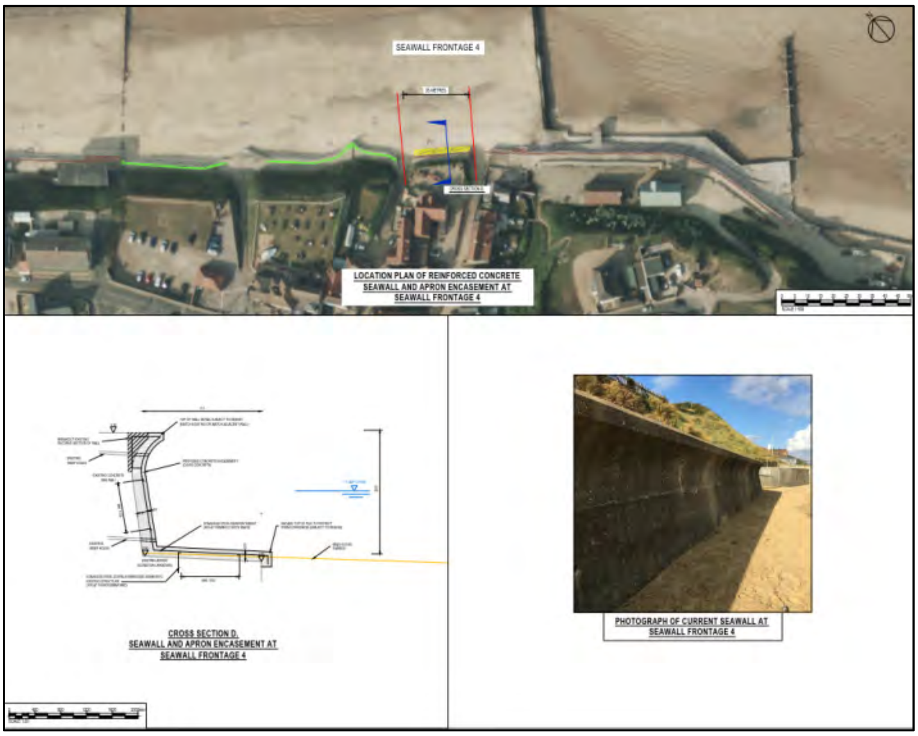
Table 3-8: Total cost of seawall (apron only) in Section 3

Total	£42,857	£451 per metre
Preliminary cost at 35%	£57,858	£609 per metre
+30% optimism bias	£75,215	£792 per metre

Table 3-9: Assumptions for the costing of seawall in Section 3

	Assumptions
200mm thick reinforced concrete apron, 3.2m width - cost for 95m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - (3.2x0.2)+(0.2x0.5) = 0.74m^2 area of concrete (x 95m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - 0.5m is the height of formwork on edge of apron (x 95m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size	Measure - One way, length of apron 95m, 0.15m spacing = 633 bars of 3.2m length = 2027m. Other way, width of apron 3.2m, 0.15m spacing = 21 bars of 95m length = 2027m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (2027x2) = 0.8m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (3.2m width x 84m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 3.2m width x 200m length Rate - SPONS16 p.219

3.1.4 Seawall Section 4



The cost breakdown for the maintenance/refurbishment of the seawall in Section 4 is presented below, split into wall and apron, as well as assumptions.

Table 3-10: Costing of seawall in Section 4

	unit	measure	rate	total
200mm thick reinforced concrete apron, 2.3m width - cost for 25m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	14.0	£104.32	£1,460
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	14.0	£8.67	£121
Total				***£1,582***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m³	14.0	£37.29	£522
Total				***£522***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m²	12.5	£70.88	£886
Total				***£886***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size	tn	1.2	£4,184.92	£5,022
Dowels	nr	50.0	£2.81	£141
Total				***£5,162***
Surface finishing	-	-	-	-
Steel trowel	m²	57.5	£1.66	£95
Total				***£95***
Total	-	-	-	***£8,248***
Preliminary cost at 35%				**£11,134**
+30% optimism bias				**£14,475**
300mm thick reinforced concrete wall - cost for 25m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	19.3	£104.32	£2,008
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	19.3	£8.67	£167
Total				***£2,175***
Placing of reinforced concrete	-	-	-	-
Walls, thickness 150 - 300mm	m³	19.3	£45.58	£877
Total				***£877***
Formwork	-	-	-	-
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	m²	21.0	£92.51	£1,943
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	m²	37.5	£60.12	£2,255
Total				***£4,197***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	2.0	£4,395.04	£8,790
Dowels	nr	50.0	£2.81	£141
Total				£8,931
Surface finishing	-	-	-	-
Steel trowel	m²	58.5	£1.66	£97
Total				***£97***
Total	-	-	-	***£16,277***
Preliminary cost at 35%				**£21,974**
+30% optimism bias				**£28,567**

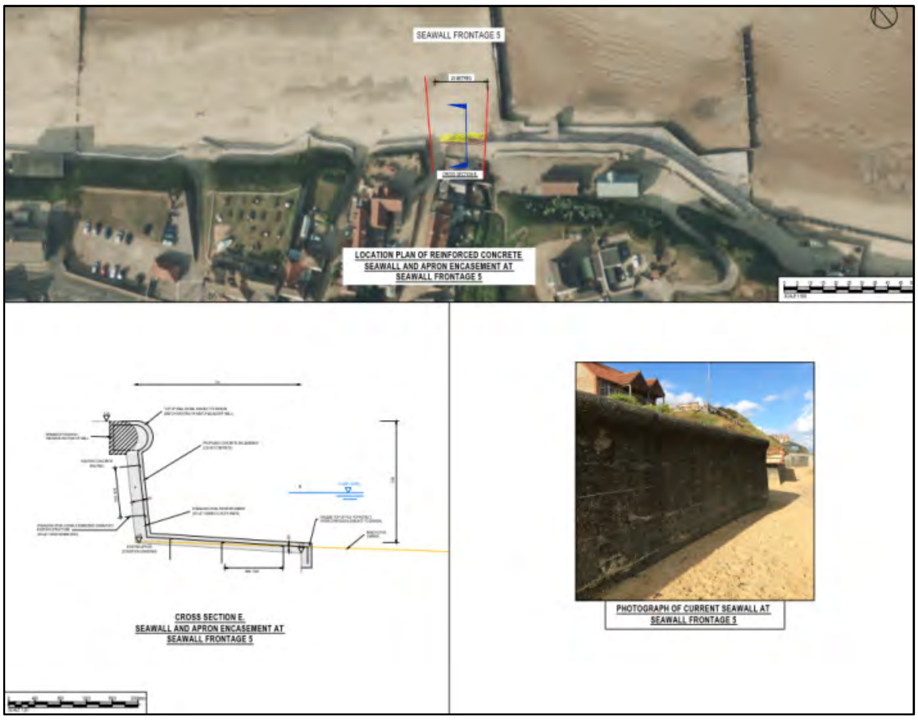
Table 3-11: Total cost of seawall (apron and wall) in Section 4

Total	£24,525	£981 per metre
Preliminary cost at 35%	£33,109	£1,324 per metre
+30% optimism bias	£43,042	£1,722 per metre

Table 3-12: Assumptions for the costing of seawall in Section 4

	Assumptions
200mm thick reinforced concrete apron, 2.3m width - cost for 25m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - (2.3x0.2)+(0.2x0.5) = 0.56m^2 area of concrete (x 95m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - 0.5m is the height of formwork on edge of apron (x 25m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size	Measure - One way, length of apron 25m, 0.15m spacing = 167 bars of 2.3m length = 383m. Other way, width of apron 2.3m, 0.15m spacing = 15 bars of 25m length = 383m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (383x2) = 0.15m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (2.3m width x 25m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.3m width x 25m length Rate - SPONS16 p.219
300mm thick reinforced concrete wall - cost for 25m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - area (0.77m^2) from AutoCAD x length of study (25m) from AutoCAD Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m^3/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Walls, thickness 150 - 300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	Measure - 0.84m length taken from AutoCAD x 25m length Rate - SPONS16 p.212
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	Measure - 1.5m length taken from AutoCAD x 25m length Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of wall 25m, 0.15m spacing = 167 bars of 3.7m length = 618m. Other way, length of wall reinf. 3.7m, 0.15m spacing = 25 bars of 25m length = 618m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (618x2)= 0.25m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 horizontally placed dowel will be used for every 1x1m of wall (approx. 2m x 25m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.34m length of wall from AutoCAD x 25m length Rate - SPONS16 p.219

3.1.5 Seawall Section 5



The cost breakdown for the maintenance/refurbishment of the seawall in Section 5 is presented below, split into wall and apron, as well as assumptions.

Table 3-13: Costing of seawall in Section 5

	unit	measure	rate	total
200mm thick reinforced concrete apron, 3.2m width - cost for 20m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	14.8	£104.32	£1,544
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	14.8	£8.67	£128
Total				***£1,672***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m³	14.8	£37.29	£552
Total				***£552***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m²	10.0	£70.88	£709
Total				***£709***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size	tn	1.4	£4,184.92	£5,859
Dowels	nr	60.0	£2.81	£169
Total				***£6,027***
Surface finishing	-	-	-	-
Steel trowel	m²	64.0	£1.66	£106
Total				***£106***
Total	-	-	-	***£9,067***
Preliminary cost at 35%				**£12,240**
+30% optimism bias				**£15,912**
300mm thick reinforced concrete wall - cost for 20m length				
Provision of concrete				
Cost of concrete (C50@20mm aggregate)	m³	19.0	£104.32	£1,982
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	19.0	£8.67	£165
Total				***£2,147***
Placing of reinforced concrete	-	-	-	-
Walls, thickness 150 - 300mm	m³	19.0	£45.58	£866
Total				***£866***
Formwork	-	-	-	-
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	m²	17.4	£92.51	£1,610
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	m²	32.0	£60.12	£1,924
Total				***£3,534***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	1.6	£4,395.04	£7,032
Dowels	nr	40.0	£2.81	£112
Total				£7,144
Surface finishing	-	-	-	-
Steel trowel	m²	49.4	£1.66	£82
Total				***£82***
Total	-	-	-	***£13,773***
Preliminary cost at 35%				**£18,593**
+30% optimism bias				**£24,171**

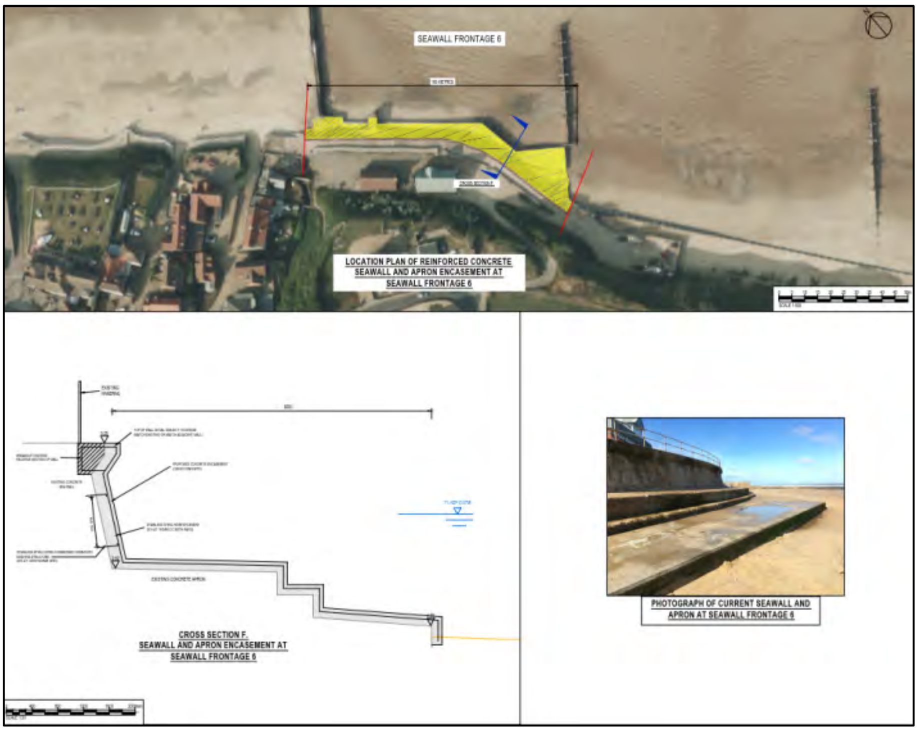
Table 3-14: Total cost of seawall (apron and wall) in Section 5

Total	£22,839	£1,042 per metre
Preliminary cost at 35%	£30,833	£1,542 per metre
+30% optimism bias	£40,083	£2,004 per metre

Table 3-15: Assumptions for the costing of seawall in Section 5

	Assumptions
200mm thick reinforced concrete apron, 3.2m width - cost for 20m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - (3.2x0.2)+(0.2x0.5) = 0.74m^2 area of concrete (x 20m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - 0.5m is the height of formwork on edge of apron (x 20m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size	Measure - One way, length of apron 20m, 0.15m spacing = 133 bars of 3.2m length = 427m. Other way, width of apron 3.2m, 0.15m spacing = 21 bars of 20m length = 427m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (427x2) = 0.17m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (3.2m width x 20m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 3.2m width x 20m length Rate - SPONS16 p.219
300mm thick reinforced concrete wall - cost for 20m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - area (0.95m^2) from AutoCAD x length of study (20m) from AutoCAD Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Walls, thickness 150 - 300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	Measure - 0.87m length taken from AutoCAD x 20m length Rate - SPONS16 p.212
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	Measure - 1.6m length taken from AutoCAD x 20m length Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of wall 20m, 0.15m spacing = 133 bars of 3.7m length = 500m. Other way, length of wall reinf. 3.7m, 0.15m spacing = 25 bars of 20m length = 500m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (500x2) = 0.2m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 horizontally placed dowel will be used for every 1x1m of wall (approx. 2m x 20m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.47m length of wall from AutoCAD x 20m length Rate - SPONS16 p.219

3.1.6 Seawall Section 6



The cost breakdown for the maintenance/refurbishment of the seawall in Section 6 is presented below, split into wall and apron, as well as assumptions.

Table 3-16: Costing of seawall in Section 6

	unit	measure	rate	total
200mm thick reinforced concrete apron, 6.6m width - cost for 100m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	144.0	£104.32	£15,022
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	144.0	£8.67	£1,248
Total				***£16,271***
Placing of reinforced concrete	-	-	-	-
Base, thickness 150-300mm	m³	144.0	£37.29	£5,370
Total				***£5,370***
Formwork	-	-	-	-
Fair finish, plane vertical, exceeding 1.22m	m²	160.0	£70.88	£11,341
Total				***£11,341***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	14.2	£4,395.04	£62,410
Dowels	nr	600.0	£2.81	£1,686
Total				***£64,096***
Surface finishing	-	-	-	-
Steel trowel	m²	660.0	£1.66	£1,096
Total				***£1,096***
Total	-	-	-	***£98,172***
Preliminary cost at 35%				**£132,533**
+30% optimism bias				**£172,292**
300mm thick reinforced concrete wall - cost for 100m length				
Provision of concrete	-	-	-	-
Cost of concrete (C50@20mm aggregate)	m³	96.0	£104.32	£10,015
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m³	96.0	£8.67	£832
Total				***£10,847***
Placing of reinforced concrete	-	-	-	-
Walls, thickness 150 - 300mm	m³	96.0	£45.58	£4,376
Total				***£4,376***
Formwork	-	-	-	-
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	m²	68.7	£92.51	£6,355
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	m²	167.0	£60.12	£10,040
Total				***£16,395***
Reinforcement	-	-	-	-
Stainless steel bars, 16mm nominal size, bent and cut	tn	8.6	£4,395.04	£37,797
Dowels	nr	200.0	£2.81	£562
Total				£38,359
Surface finishing	-	-	-	-
Steel trowel	m²	236.0	£1.66	£392
Total				***£392***
Total	-	-	-	***£70,369***
Preliminary cost at 35%				**£94,998**
+30% optimism bias				**£123,498**

Table 3-17: Total cost of seawall (apron and wall) in Section 6

Total	£168,541	£1,685 per metre
Preliminary cost at 35%	£227,531	£2,275 per metre
+30% optimism bias	£295,790	£2,957 per metre

Table 3-18: Assumptions for the costing of seawall in Section 6

	Assumptions
200mm thick reinforced concrete apron, 6.6m width - cost for 100m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - 1.44m^2 area of concrete from AutoCAD (x 100m length) Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Base, thickness 150-300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane vertical, exceeding 1.22m	Measure - as the apron is stepped the build-up of the frame consists of 0.55m, 0.4m and 0.65m (x 100m length) Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of apron 100m, 0.15m spacing = 667 bars of 6.6m length = 4400m. Other way, width of apron 6.6m, 0.15m spacing = 44 bars of 100m length = 4400m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (4400x2) = 1.8m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 vertically placed dowel will be used for every 1x1m of apron (6.6m width x 100m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 6.6m width x 100m length Rate - SPONS16 p.219
300mm thick reinforced concrete wall - cost for 100m length	
Provision of concrete	
Cost of concrete (C50@20mm aggregate)	Measure - area (0.96m^2) from AutoCAD x length of study (100m) from AutoCAD Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete	
Walls, thickness 150 - 300mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Formwork	
Fair finish, plane sloping, panel exceeding 1.22m, wave return.	Measure - 0.69m length taken from AutoCAD x 100m length Rate - SPONS16 p.212
Fair finish, plane sloping, panel exceeding 1.22m, vertical face	Measure - 1.67m length taken from AutoCAD x 100m length Rate - SPONS16 p.212
Reinforcement	
Stainless steel bars, 16mm nominal size, bent and cut	Measure - One way, length of wall 100m, 0.15m spacing = 667 bars of 4.0m length = 2667m. Other way, length of wall reinf. 4.0m, 0.15m spacing = 27 bars of 100m length = 2667m. Area of rebar = pi x 64 = 0.000201m^2. Volume = area (0.000201m^2 x length of rebar (2667x2) = 1.1m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - 1 horizontally placed dowel will be used for every 1x1m of wall (approx. 2m x 20m length) Rate - SPONS16 p.218
Surface finishing	
Steel trowel	Measure - 2.36m length of wall from AutoCAD x 100m length Rate - SPONS16 p.219

3.1.7 Seawall Section 6 with Rock armour

The cost breakdown for the maintenance/refurbishment of the seawall in Section 6 with rock armour is presented below, split into wall and apron, as well as assumptions.

Table 3-19: Costing of seawall with rock armour in Section 6

	unit	measure	rate	total
200mm thick reinforced concrete apron, 6.6m width - cost for 100m length				
Total (from above)	-	-	-	***£98,172***
Preliminary cost at 35%				**£132,533**
+30% optimism bias				**£172,292**
300mm thick reinforced concrete wall - cost for 100m length				
Total (from above)	-	-	-	***£70,369***
Preliminary cost at 35%				**£94,998**
+30% optimism bias				**£123,498**
Rock Armour (up to 3t) that would be placed in front of the seawall in Section 6				
Rock armour				
Imported armour stones up to 3t each using backacter	m^3	540.0	£60.95	£32,913
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	m^2	240.0	£58.35	£14,004
Total	-	-	-	***£46,917***
Preliminary cost at 35%				**£63,338**
+30% optimism bias				**£82,339**

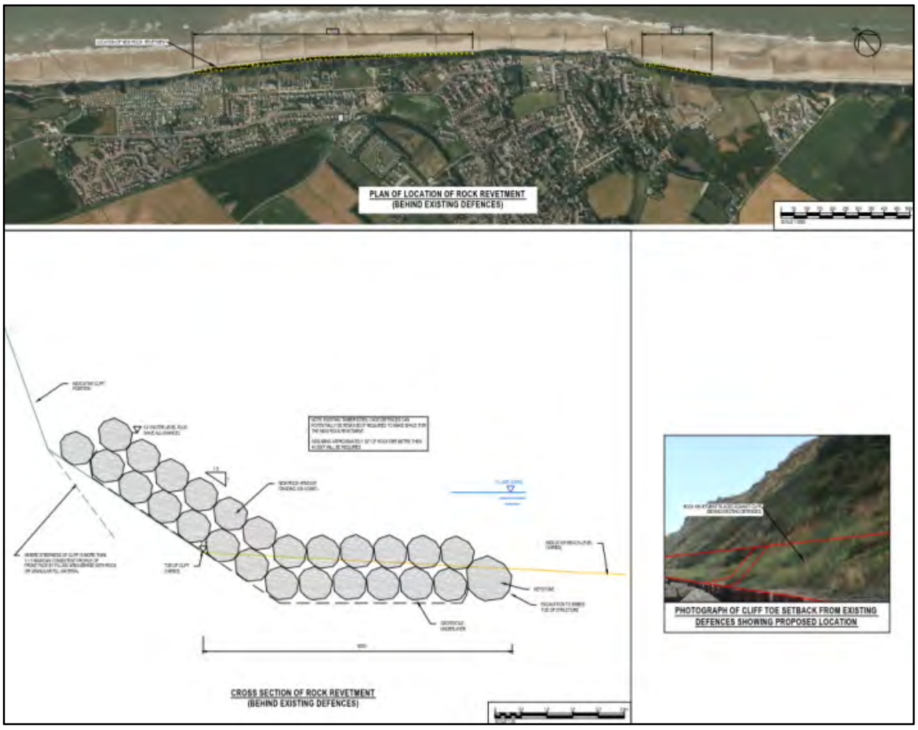
Table 3-20: Total cost of seawall (apron and wall) with rock armour in Section 6

Total	£215,459	£2,154 per metre
Preliminary cost at 35%	£290,869	£2,908 per metre
+30% optimism bias	£378,129	£3,781 per metre

Table 3-21: Assumptions for the costing of seawall with rock armour in Section 6

	Assumptions
Rock Armour (up to 3t) that would be placed in front of the seawall in Section 6	
Rock placed inside steel frame	
Imported armour stones up to 3t each using backacter	Measure - 5.4m^2 from AutoCAD (x 100m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	Measure - 2.4m length of rock face (x 100m length) Rate - SPONS16 p.190

3.2 Option 3: Rock Revetment



The cost breakdown for the installation of a rock revetment against the unprotected cliff is presented below, as well as assumptions.

Table 3-22: Costing of rock revetment

	unit	measure	rate	total
Rock revetment – cost for 1355m length (everywhere but sea wall)				
Excavation of beach material	-	-	-	-
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 0.5-1.0m	m^3	5691.0	£4.21	£23,959
Total				***£23,959***
Installation of geotextile	-	-	-	-
Geotextile for scour and erosion protection, where hydraulic action exists such as coastline protection, inclined at 10-45°	m^2	9078.5	£9.07	£82,342
Total				***£82,342***
Installation of rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	14742.4	£60.95	£898,549
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	m^2	13279.0	£58.35	£774,830
Total				***£1,673,379***
Total	-	-	-	***£1,779,680***
Preliminary cost at 35%				**£2,402,568**
+30% optimism bias				**£3,123,338**

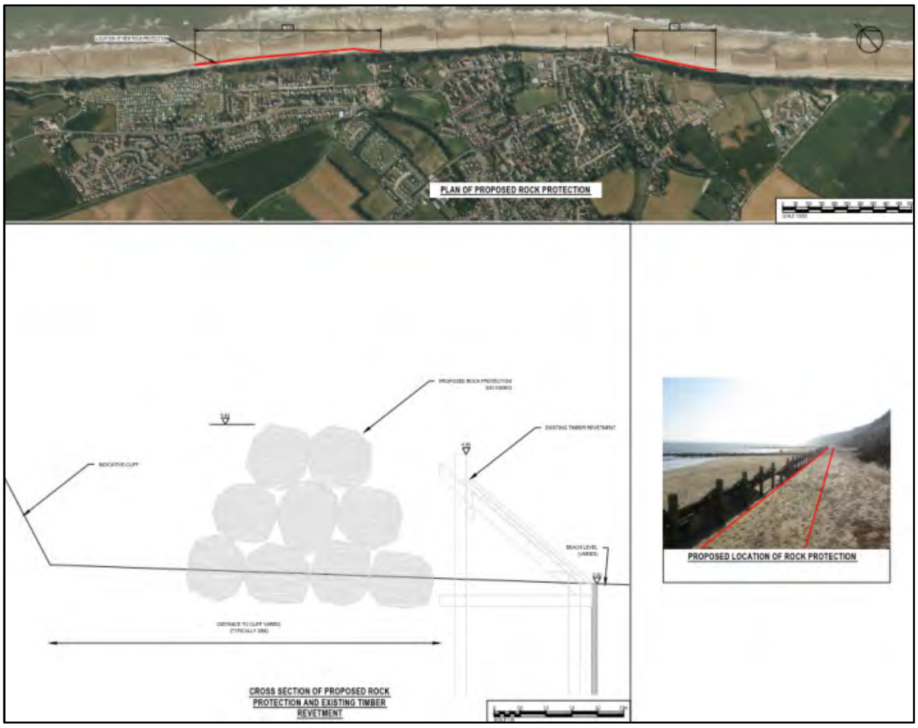
Table 3-23: Total cost of rock revetment

Total	£1,779,680	£1,313 per metre
Preliminary cost at 35%	£2,402,568	£1,773 per metre
+30% optimism bias	£3,123,338	£2,305 per metre

Table 3-24: Assumptions for the costing of rock revetment

	Assumptions
Rock revetment – cost for 1355m length (everywhere but sea wall)	
Excavation of beach material	
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 0.5-1.0m	Measure - 4.2m^2 from AutoCAD (x 1355m length) Rate - SPONS16 p.185
Installation of geotextile	
Geotextile for scour and erosion protection, where hydraulic action exists such as coastline protection, inclined at 10-45°	Measure - 6.7m from AutoCAD (x 1355m length) Rate - SPONS16 p.192
Installation of rock	
Imported armour stones up to 3t each using backacter	Measure - 10.88m^2 from AutoCAD (x 1355m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	Measure - 9.8m length of rock face (x 1355m length) Rate - SPONS16 p.190

3.3 Option 5: Placed Rock Protection



The cost breakdown for the installation of rock armour behind the existing timber revetment is presented below, as well as assumptions.

Table 3-25: Costing of placed rock protection

	unit	measure	rate	total
Placed rock protection – cost for 1035m length (where timber revetment exists)				
Excavation of beach material	-	-	-	-
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 0.5-1.0m	m^3	3622.5	£4.21	£15,251
Total				***£15,251***
Installation of rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	10453.5	£60.95	£637,141
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	m^2	8280.0	£58.35	£483,138
Total				***£1,120,279***
Total	-	-	-	***£1,135,530***
Preliminary cost at 35%				**£1,532,965**
+30% optimism bias				**£1,992,854**

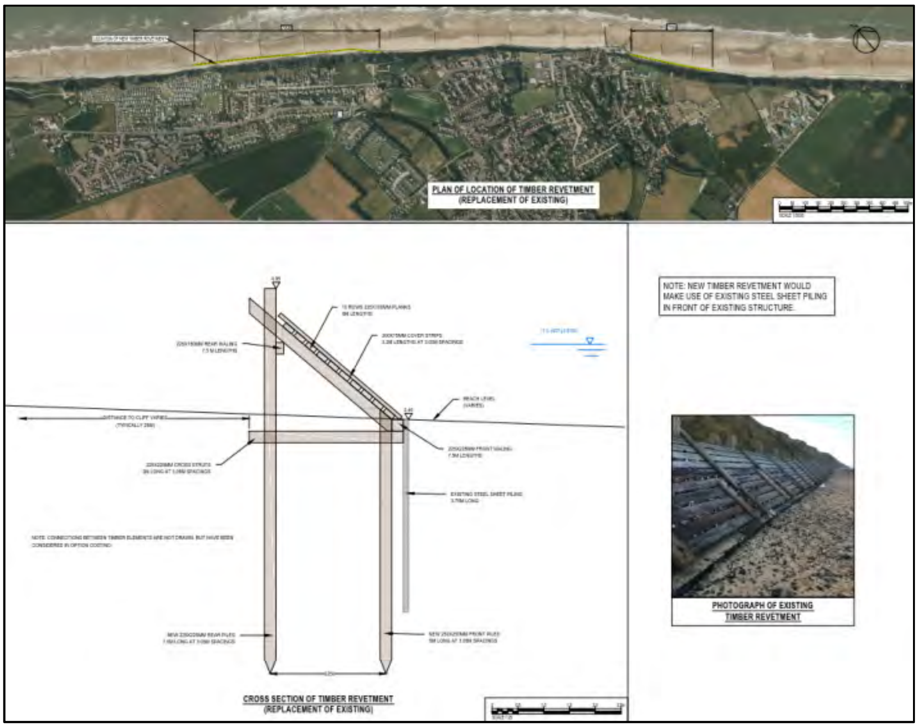
Table 3-26: Total cost of placed rock protection

Total	£1,135,530	£1,097 per metre
Preliminary cost at 35%	£1,532,965	£1,481 per metre
+30% optimism bias	£1,992,854	£1,925 per metre

Table 3-27: Assumptions for the costing of placed rock protection

	Assumptions
Placed rock protection – cost for 1035m length (where timber revetment exists)	
Excavation of beach material	
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 0.5-1.0m	Measure - 3.5m^2 from AutoCAD (x 1035m length) Rate - SPONS16 p.185
Installation of rock	
Imported armour stones up to 3t each using backacter	Measure - 10.1m^2 from AutoCAD (x 1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	Measure - 8m length of rock face (x 1035m length) Rate - SPONS16 p.190

3.4 Option 6: Timber Revetment



The cost breakdown for the installation of a new timber revetment to replace the existing is presented below, using both oak and tropical hardwood, as well as assumptions.

Table 3-28: Costing of oak timber revetment

	unit	measure	rate	total
Timber revetment constructed of Oak - cost for 1035m length (where timber revetment exists)				
Main revetment installation	-	-	-	-
Front piles - 250mm x 250mm x 5m	nr	339	£250.00	£84,836
Rear piles - 225mm x 225mm x 7.5m	nr	339	£320.00	£108,590
Cross struts - 225mm x 225mm x 3m	nr	339	£112.00	£38,007
Cover strips - 200mm x 75mm x 3.2m	nr	339	£38.40	£13,031
Diagonal struts - 200mm x 100mm x 3.5m	nr	339	£56.00	£19,003
Rear waling - 225mm x 150mm (continuous)	m	1035	£27.00	£27,945
Planks - 225mm x 100mm x 10 rows (continuous)	m	10350	£18.00	£186,300
Front waling - 225mm x 225mm (continuous)	m	1035	£40.50	£41,918
Supply and fit pile rings and shoes	nr	679	£175.00	£118,770
Driving piles through sand to 4.5m	nr	679	£18.45	£12,522
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	6787	£15.92	£108,047
Total	-	-	-	***£758,969***
Preliminary cost at 35%				**£1,024,608**
+30% optimism bias				**£1,331,990**

Table 3-29: Total cost of oak timber revetment

Total	£758,969	£733 per metre
Preliminary cost at 35%	£1,024,608	£990 per metre
+30% optimism bias	£1,331,990	£1,287 per metre

Table 3-30: Costing of tropical hardwood timber revetment

	unit	measure	rate	total
Timber revetment constructed of Tropical hardwood - cost for 1035m length (where timber revetment exists)				
Main revetment installation	-	-	-	-
Front piles - 250mm x 250mm x 5m	nr	339	£390.00	£132,344
Rear piles - 225mm x 225mm x 7.5m	nr	339	£520.00	£176,459
Cross struts - 225mm x 225mm x 3m	nr	339	£190.00	£64,475
Cover strips - 200mm x 75mm x 3.2m	nr	339	£60.00	£20,361
Diagonal struts - 200mm x 100mm x 3.5m	nr	339	£87.50	£29,693
Rear waling - 225mm x 150mm (continuous)	m	1035	£42.19	£43,664
Planks - 225mm x 100mm x 10 rows (continuous)	m	10350	£28.13	£291,094
Front waling - 225mm x 225mm (continuous)	m	1035	£63.28	£65,496
Supply and fit pile rings and shoes	nr	679	£175.00	£118,770
Driving piles through sand to 4.5m	nr	679	£18.45	£12,522
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	6787	£15.92	£108,047
Total	-	-	-	**£1,062,925**
Preliminary cost at 35%				**£1,434,949**
+30% optimism bias				**£1,865,434**

Table 3-31: Total cost of tropical hardwood timber revetment

Total	£1,062,925	£1,027 per metre
Preliminary cost at 35%	£1,434,949	£1,386 per metre
+30% optimism bias	£1,865,434	£1,802 per metre

Table 3-32: Assumptions for the costing of oak and tropical hardwood timber revetment

	Assumptions
Timber revetment constructed of Oak - cost for 1035m length (where timber revetment exists)	
Main revetment installation	
Front piles - 250mm x 250mm x 5m	Measure - 3.05m spacing of piles at the front of the revetment, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Rear piles - 225mm x 225mm x 7.5m	Measure - same as front pile Rate - quote from Gilmour & Aitken, 2016
Cross struts - 225mm x 225mm x 3m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Cover strips - 200mm x 75mm x 3.2m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Diagonal struts - 200mm x 100mm x 3.5m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Rear waling - 225mm x 150mm (continuous)	Measure - length of extent 1035m Rate - quote from Gilmour & Aitken, 2016 (£800/m^3)
Planks - 225mm x 100mm x 10 rows (continuous)	Measure - length of extent 1035m x 10 rows of planks Rate - quote from Gilmour & Aitken, 2016 (£800/m^3)
Front waling - 225mm x 225mm (continuous)	Measure - length of extent 1035m Rate - quote from Gilmour & Aitken, 2016 (£800/m^3)
Supply and fit pile rings and shoes	Measure - same of number of front and rear piles Rate - quote from Gilmour & Aitken, 2014
Driving piles through sand to 4.5m	Measure - same of number of front and rear piles Rate - SPONS16 p.286
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Rate - assume 20 bolts every 3.05m Rate - quote from Gilmour & Aitken for material (£11.25) + labour rate from SPONS16 p.277 (£4.67)
Timber revetment constructed of Tropical hardwood - cost for 1035m length (where timber revetment exists)	
Main revetment installation	
Front piles - 250mm x 250mm x 5m	Measure - 3.05m spacing of piles at the front of the revetment, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Rear piles - 225mm x 225mm x 7.5m	Measure - same as front pile Rate - quote from Gilmour & Aitken, 2016
Cross struts - 225mm x 225mm x 3m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Cover strips - 200mm x 75mm x 3.2m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Diagonal struts - 200mm x 100mm x 3.5m	Measure - 3.05 spacing, length of extent 1035m Rate - quote from Gilmour & Aitken, 2016
Rear waling - 225mm x 150mm (continuous)	Measure - length of extent 1035m Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Planks - 225mm x 100mm x 10 rows (continuous)	Measure - length of extent 1035m x 10 rows of planks Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Front waling - 225mm x 225mm (continuous)	Measure - length of extent 1035m Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Supply and fit pile rings and shoes	Measure - same of number of front and rear piles Rate - quote from Gilmour & Aitken, 2014
Driving piles through sand to 4.5m	Measure - same of number of front and rear piles Rate - SPONS16 p.286
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Rate - assume 20 bolts every 3.05m Rate - quote from Gilmour & Aitken for material (£11.25) + labour rate from SPONS16 p.277 (£4.67)

3.5 Option 7: Steel Frame

Option 7 is to either enhance the existing or install a new steel frame protection structure. There are multiple options presented below regarding the steel frame option.

3.5.1 Enhance existing steel frame protection with rock

The cost breakdown for enhancing the existing steel frame protection with rock is presented below, as well as assumptions.

Table 3-33: Costing of enhancement of steel frame protection with rock

	unit	measure	rate	total
Enhancement of existing steel framed protection - new steel frame and rock armour inside – cost for 465m length (where steel frame exists)				
Rock placed behind existing structure	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	325.5	£60.95	£19,839
Total				***£19,839***
Steel frame	-	-	-	-
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	nr	1162.5	£285.60	£332,010
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	m	3022.5	£4.17	£12,604
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	m	930.0	£32.10	£29,853
Bolts, nuts and washers for connections. M10x50.	nr	9300.0	£2.78	£25,854
Total				***£400,321***
Rock placed inside steel frame - using up to 1t rock	-	-	-	-
Imported armour stones up to 1t each using backacter	m^3	976.5	£56.59	£55,260
Total				***£55,260***
Rock placed inside steel frame - using up to 3t rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	976.5	£60.95	£59,518
Total				***£59,518***
Total Cost Using up to 1 Tonne Rock				
Total	-	-	-	***£475,420***
Preliminary cost at 35%				**£641,817**
+30% optimism bias				**£834,362**
Total Cost Using up to 3 Tonne Rock				
Total	-	-	-	***£479,678***
Preliminary cost at 35%				**£647,565**
+30% optimism bias				**£841,834**

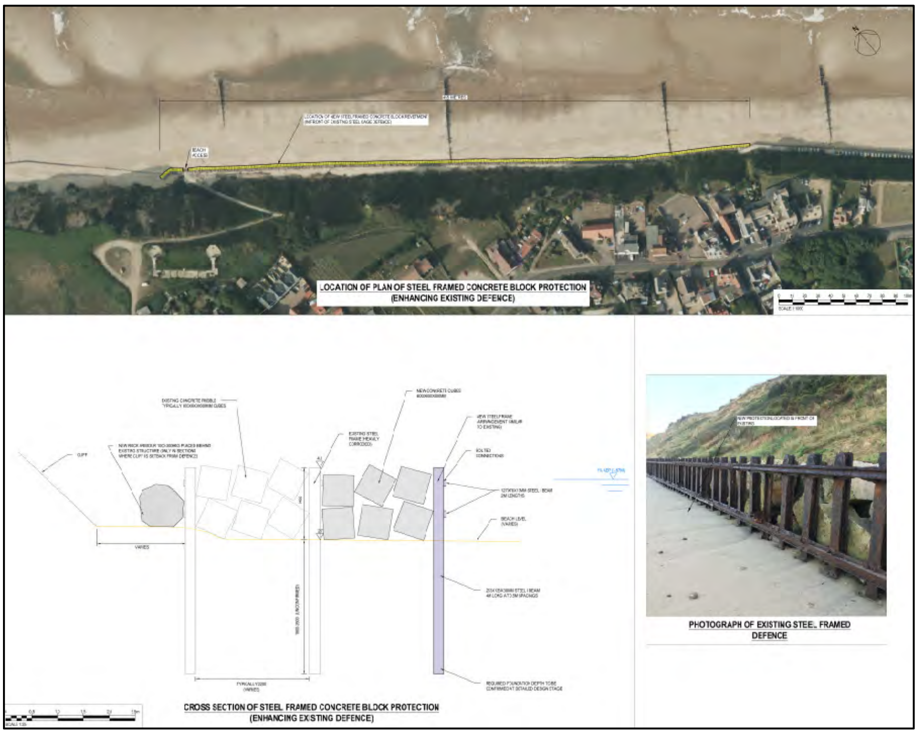
Table 3-34: Total cost of enhancement of steel frame protection with rock

Total Cost Using up to 1 Tonne Rock	£475,420	£1,022 per metre
Preliminary cost at 35%	£641,817	£1,380 per metre
+30% optimism bias	£834,362	£1,794 per metre
Total Cost Using up to 3 Tonne Rock	£479,678	£1,032 per metre
Preliminary cost at 35%	£647,565	£1,393 per metre
+30% optimism bias	£841,834	£1,810 per metre

Table 3-35: Assumptions for the costing of enhancement of steel frame protection with rock

	Assumptions
Rock placed behind existing structure	
Imported armour stones up to 3t each using backacter	Measure - 0.7m^2 from AutoCAD (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Steel frame	
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	Measure - 1 row, spaced at 0.4m intervals, 465m length Rate - quote from 'metals4u'
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.287
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	Measure - 2 rows across 465m length Rate - quote from 'metals4u'
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Rock placed inside steel frame - using up to 1 tonne	
Imported armour stones up to 1t each using backacter	Measure - 2.1m^2 from AutoCAD (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Rock placed inside steel frame - using up to 3 tonne	
Imported armour stones up to 3t each using backacter	Measure - 2.1m^2 from AutoCAD (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)

3.5.2 Enhance existing steel frame protection with concrete



The cost breakdown for enhancing the existing steel frame protection with concrete is presented below, as well as assumptions.

Table 3-36: Costing of enhancement of steel frame protection with concrete

	unit	measure	rate	total
Enhancement of existing steel framed protection - new steel frame and concrete inside – cost for 465m length (where steel frame exists)				
Rock placed behind existing structure	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	325.5	£60.95	£19,839
Total				***£19,839***
Steel frame	-	-	-	-
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	nr	930.0	£285.60	£265,608
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	m	2418.0	£4.17	£10,083
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	m	930.0	£32.10	£29,853
Bolts, nuts and washers for connections. M10x50.	nr	7440.0	£2.78	£20,683
Total				***£326,227***
Concrete blocks	-	-	-	-
Concrete blocks 600x600mm - 'ConectaBloc'.	m^3	859.3	£242.59	£208,459
Installation cost	m^3	859.3	£4.55	£3,910
Total				***£212,368***
Total	-	-	-	***£558,435***
Preliminary cost at 35%				**£753,887**
+30% optimism bias				**£980,053**

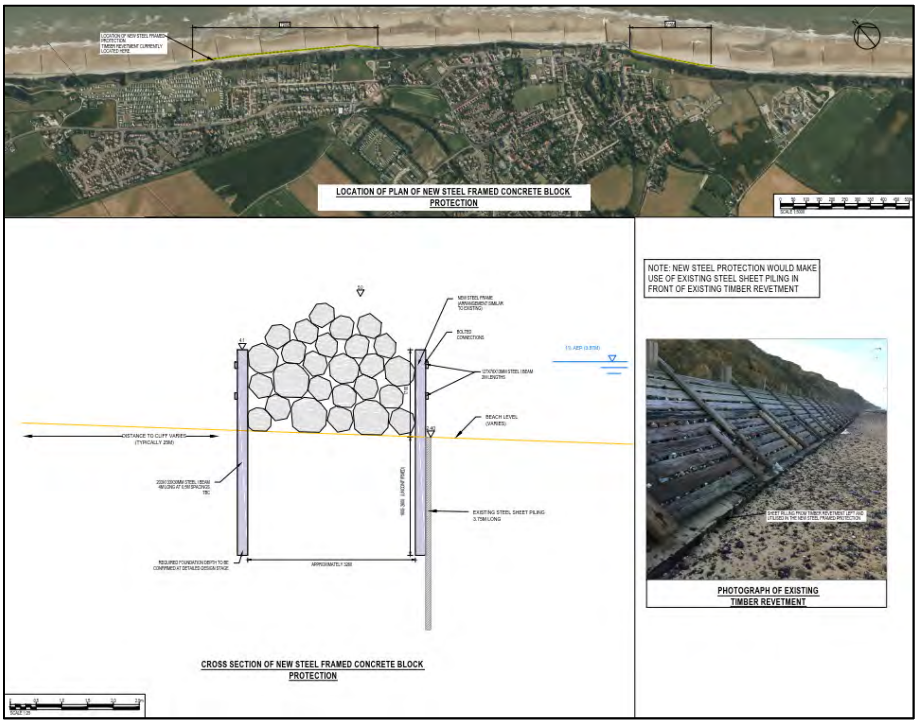
Table 3-37: Total cost of enhancement of steel frame protection with concrete

Total	£558,435	£1,201 per metre
Preliminary cost at 35%	£753,887	£1,621 per metre
+30% optimism bias	£980,053	£2,108 per metre

Table 3-38: Assumptions for the costing of enhancement of steel frame protection with concrete

	Assumptions
Rock placed behind existing structure	
Imported armour stones up to 3t each using backacter	Measure - 0.7m^2 from AutoCAD (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Steel frame	
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	Measure - 1 row, spaced at 0.5m intervals, 465m length Rate - quote from 'metals4u'
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.287
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	Measure - 2 rows across 465m length Rate - quote from 'metals4u'
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Concrete blocks	
Concrete blocks 600x600mm - 'ConectaBloc'.	Measure - 2.2x1.4 = 3.08m^2, with a void ratio of 40% (x 0.6) Rate - quote from Carter-Concrete (material and delivery)
Installation cost	Measure - same as concrete blocks Rate - same rate as for installation of rock armour up to 1t from SPONS16 p.417

3.5.3 New steel frame protection with rock



The cost breakdown for installing a new steel frame protection with rock is presented below, as well as assumptions.

Table 3-39: Costing of new steel frame protection with rock

	unit	measure	rate	total
New steel framed protection - new steel frame and rock armour inside – cost for 1035m length (where timber revetment exists)				
Steel frame	-	-	-	-
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	nr	5175.0	£285.60	£1,477,980
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	m	13455.0	£4.17	£56,107
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	m	4140.0	£32.10	£132,894
Bolts, nuts and washers for connections. M10x50.	nr	41400.0	£2.78	£115,092
Total				***£1,782,073***
Rock placed inside steel frame - using up to 1t rock	-	-	-	-
Imported armour stones up to 1t each using backacter	m^3	5806.4	£56.59	£328,581
Total				***£328,581***
Rock placed inside steel frame - using up to 3t rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	5806.4	£60.95	£353,897
Total				***£353,897***
Total Cost Using up to 1 Tonne Rock				
Total	-	-	-	***£2,110,655***
Preliminary cost at 35%				**£2,849,384**
+30% optimism bias				**£3,704,199**
Total Cost Using up to 3 Tonne Rock				
Total	-	-	-	***£2,135,970***
Preliminary cost at 35%				**£2,883,560**
+30% optimism bias				**£3,748,628**

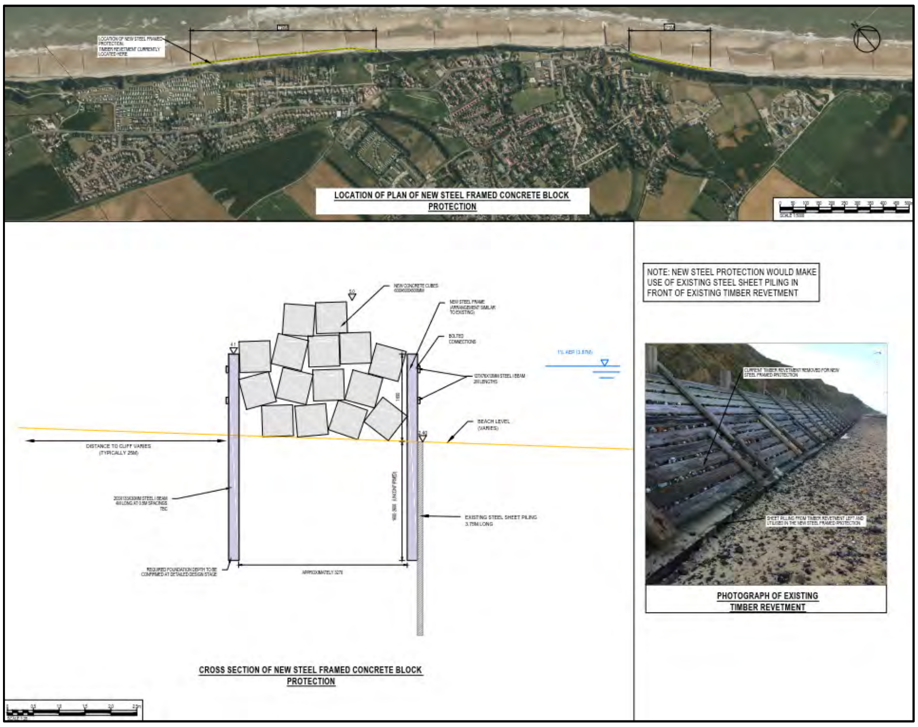
Table 3-40: Total cost of new steel frame protection with rock

Total Cost Using up to 1 Tonne Rock	£2,110,655	£2,039 per metre
Preliminary cost at 35%	£2,849,384	£2,753 per metre
+30% optimism bias	£3,704,199	£3,579 per metre
Total Cost Using up to 3 Tonne Rock	£2,135,970	£2,064 per metre
Preliminary cost at 35%	£2,883,560	£2,786 per metre
+30% optimism bias	£3,748,628	£3,622 per metre

Table 3-41: Assumptions for the costing of new steel frame protection with rock

	Assumptions
Steel frame	
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	Measure - 2 rows, spaced at 0.4m intervals, 1035m length Rate - quote from 'metals4u'
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.287
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	Measure - 2 rows on front and 2 rows on back across 1035m length Rate - quote from 'metals4u'
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Rock placed inside steel frame - using up to 1 tonne	
Imported armour stones up to 1t each using backacter	Measure - 5.6m^2 from AutoCAD (x 1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Rock placed inside steel frame - using up to 3 tonne	
Imported armour stones up to 3t each using backacter	Measure - 5.6m^2 from AutoCAD (x 1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)

3.5.4 New steel frame protection with concrete blocks



The cost breakdown for installing a new steel frame protection with concrete blocks is presented below, as well as assumptions.

Table 3-42: Costing of new steel frame protection with concrete blocks

	unit	measure	rate	total
New steel framed protection - new steel frame and concrete blocks inside – cost for 1035m length (where timber revetment exists)				
Steel frame	-	-	-	-
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	nr	4140.0	£285.60	£1,182,384
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	m	10764.0	£4.17	£44,886
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	m	4140.0	£32.10	£132,894
Bolts, nuts and washers for connections. M10x50.	nr	33120.0	£2.78	£92,074
Total				***£1,452,237***
Concrete blocks placed inside steel frame	-	-	-	-
Concrete blocks 600x600mm - 'ConectaBloc'	m^3	3483.8	£242.59	£845,122
Installation cost	m^3	3483.8	£4.55	£15,851
Total				***£860,973***
Total	-	-	-	***£2,313,211***
Preliminary cost at 35%				**£3,122,834**
+30% optimism bias				**£4,059,685**

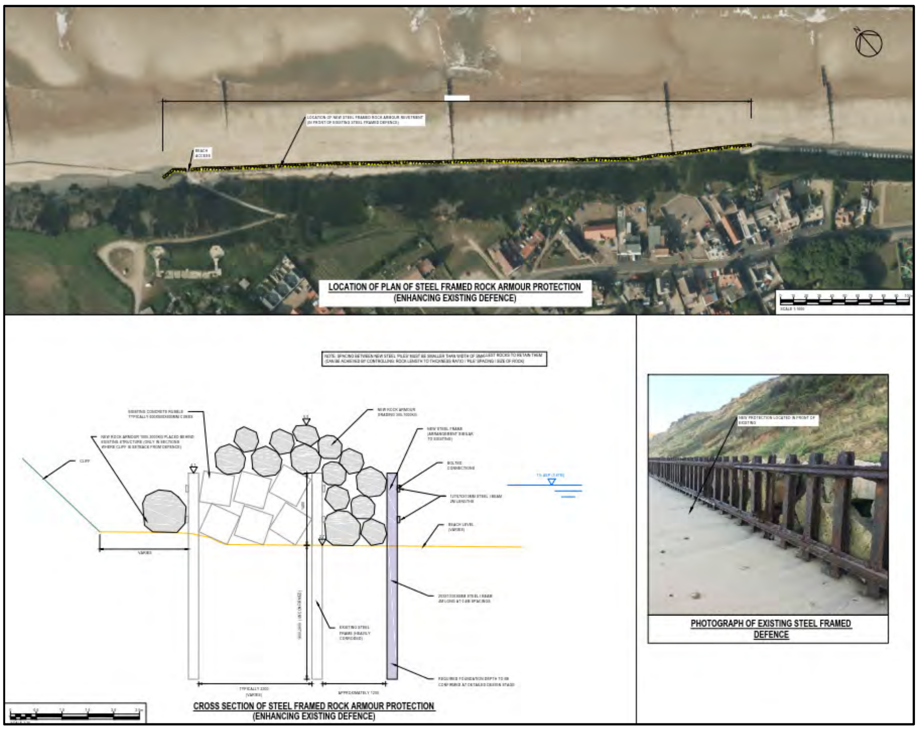
Table 3-43: Total cost of new steel frame protection with concrete blocks

Total	£2,313,211	£2,235 per metre
Preliminary cost at 35%	£3,122,834	£3,017 per metre
+30% optimism bias	£4,059,685	£3,922 per metre

Table 3-44: Assumptions for the costing of new steel frame protection with concrete blocks

	Assumptions
Steel frame	
Universal beam 203x133x30 for vertical elements, 4m length. Mild steel, no surface coating.	Measure - 2 rows, spaced at 0.5m intervals, 465m length Rate - quote from 'metals4u'
Cost of driving vertical beams. Mass isolated steel piles. Mass 45kg/m 203x203, depth, driven, vertical.	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.287
Universal beam 127x76x13 for horizontal elements, 2m length. Mild steel, no surface coating.	Measure - 2 rows on front and 2 rows on back across 465m length Rate - quote from 'metals4u'
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Concrete blocks placed inside steel frame	
Concrete blocks 600x600mm - 'ConectaBloc'.	Measure - 3.3x1.7 = 5.61m^2, with a void ratio of 40% (x 0.6) Rate - quote from Carter-Concrete (material and delivery)
Installation cost	Measure – same as above Rate - used same labour/plant rate as for rock armour up to 1t from SPONS16 p.417

3.5.5 Enhance existing steel frame protection with rock with increased height



The cost breakdown for enhancing the existing steel frame protection with rock is presented below, as well as assumptions.

Table 3-45: Costing of enhancement of steel frame protection with rock with increased height

	unit	measure	rate	total
Enhancement of existing steel framed protection and increase in height - new steel frame and rock armour inside – cost for 465m length (where steel frame exists)				
Enhancement with no increase in height (see above)	-	-	-	-
Using up to 1t rock				£475,420
Using up to 3t rock				£479,678
Extra rock placed inside steel frame - using up to 1t rock	-	-	-	-
Imported armour stones up to 1t each using backacter	m^3	1162.5	£56.59	£65,786
Total				***£65,786***
Extra rock placed inside steel frame - using up to 3t rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	1162.5	£60.95	£70,854
Total				***£70,854***
Total Cost Using up to 1 Tonne Rock				
Total	-	-	-	***£541,206***
Preliminary cost at 35%				**£730,628**
+30% optimism bias				**£949,817**
Total Cost Using up to 3 Tonne Rock				
Total	-	-	-	***£550,532***
Preliminary cost at 35%				**£743,218**
+30% optimism bias				**£966,184**

Table 3-46: Total cost of enhancement of steel frame protection with rock with increased height

Total Cost Using up to 1 Tonne Rock	£541,206	£1,164 per metre
Preliminary cost at 35%	£730,628	£1,571 per metre
+30% optimism bias	£949,817	£2,043 per metre
Total Cost Using up to 3 Tonne Rock	£550,532	£1,184 per metre
Preliminary cost at 35%	£743,218	£1,598 per metre
+30% optimism bias	£966,184	£2,078 per metre

Table 3-47: Assumptions for the costing of enhancement of steel frame protection with rock with increased height

	Assumptions
Extra rock placed inside steel frame - using up to 1t rock	
Imported armour stones up to 1t each using backacter	Measure - 2.5m^2 of extra rock armour (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Extra rock placed inside steel frame - using up to 3t rock	
Imported armour stones up to 3t each using backacter	Measure - 2.5m^2 of extra rock armour (x 465m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)

3.5.6 Enhance existing steel frame protection with concrete and increase height

The cost breakdown for enhancing the existing steel frame protection with concrete is presented below, as well as assumptions.

Table 3-48: Costing of enhancement of steel frame protection with concrete with increased height

	unit	measure	rate	total
Enhancement of existing steel framed protection - new steel frame and concrete inside with increased height – cost for 465m length (where steel frame exists)				
Enhancement with no increase in height (see above)	-	-	-	-
Enhancement using concrete, no height increase				£558,435
Extra concrete blocks placed inside frame to increase height	-	-	-	-
Concrete blocks 600x600x600mm - 'ConectaBloc'.	m^3	697.5	£242.59	£169,203
Total	-	-	-	£727,638
Preliminary cost at 35%				£982,312
+30% optimism bias				£1,277,005

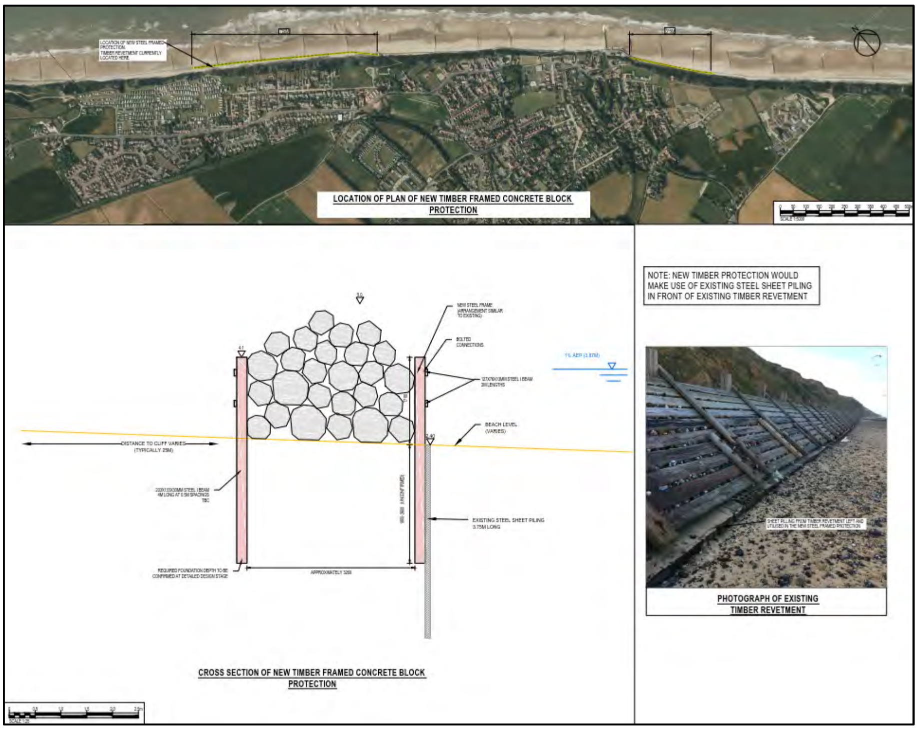
Table 3-49: Total cost of enhancement of steel frame protection with concrete with increased height

Total	£727,638	£1,565 per metre
Preliminary cost at 35%	£982,312	£2,112 per metre
+30% optimism bias	£1,277,005	£2,746 per metre

Table 3-50: Assumptions for the costing of enhancement of steel frame protection with concrete with increased height

	Assumptions
Extra concrete blocks placed inside frame to increase height	
Concrete blocks 600x600x600mm - 'ConectaBloc'.	Measure - 2.5m^2 of extra concrete, with a void ratio of 40% (x 0.6) Rate - quote from Carter-Concrete (material and delivery)

3.5.7 New Oak timber frame protection with rock



The cost breakdown for installing a new Oak timber frame protection with rock is presented below, as well as assumptions.

Table 3-51: Costing of new Oak timber frame protection with rock

	unit	measure	rate	total
New Oak timber framed protection - new timber frame and rock armour inside – cost for 1035m length (where timber revetment exists)				
Timber frame	-	-	-	-
Pile (for vertical elements): 250mm x 250mm x 4m	nr	5175.0	£200.00	£1,035,000
Driving piles	m	13455.0	£5.91	£79,519
Planks (for horizontal elements): 225mm x 100mm x 4m length	m	4140.0	£18.00	£74,520
Bolts, nuts and washers for connections. M10x50.	nr	41400.0	£2.78	£115,092
Total				***£1,304,131***
Rock placed inside timber frame - using up to 1t rock	-	-	-	-
Imported armour stones up to 1t each using backacter	m^3	5806.4	£56.59	£328,581
Total				***£328,581***
Rock placed inside timber frame - using up to 3t rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	5806.4	£60.95	£353,897
Total				***£353,897***
Total Cost Using up to 1 Tonne Rock				
Total	-	-	-	***£1,632,712***
Preliminary cost at 35%				**£2,204,162**
+30% optimism bias				**£2,865,410**
Total Cost Using up to 3 Tonne Rock				
Total	-	-	-	***£1,658,028***
Preliminary cost at 35%				**£2,238,338**
+30% optimism bias				**£2,909,839**

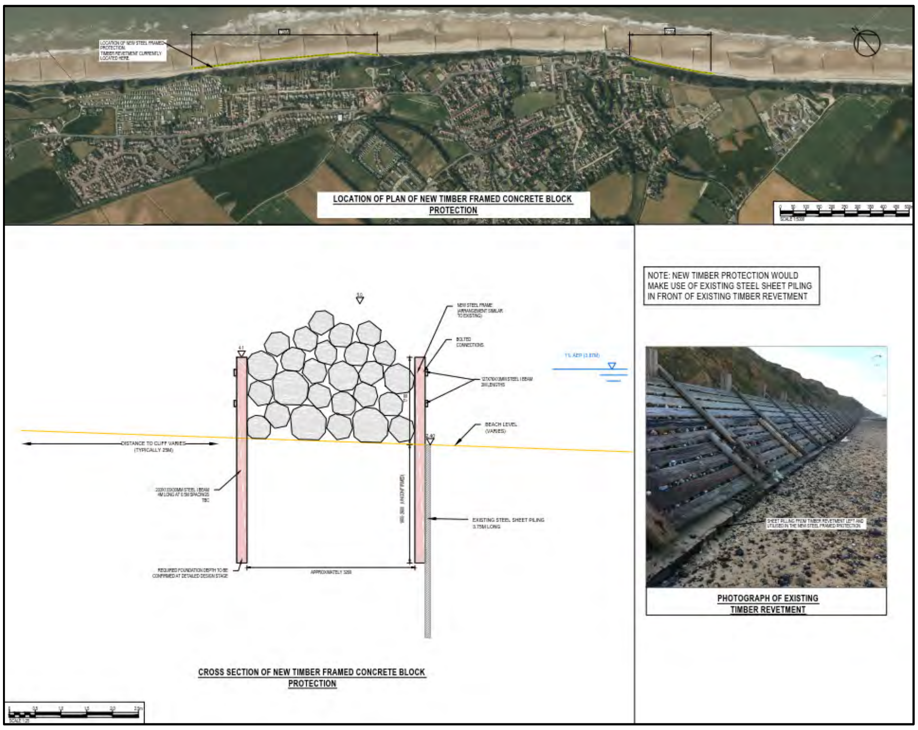
Table 3-52: Total cost of new oak timber frame protection with rock

Total Cost Using up to 1 Tonne Rock	£1,632,712	£1,577 per metre
Preliminary cost at 35%	£2,204,162	£2,130 per metre
+30% optimism bias	£2,865,410	£2,769 per metre
Total Cost Using up to 3 Tonne Rock	£1,658,028	£1,602 per metre
Preliminary cost at 35%	£2,238,338	£2,163 per metre
+30% optimism bias	£2,909,839	£2,811 per metre

Table 3-53: Assumptions for the costing of new Oak timber frame protection with rock

	Assumptions
Timber frame	
Pile (for vertical elements): 250mm x 250mm x 4m	Measure - 2 rows, spaced at 0.4m intervals, 465m length Rate - from quote Gilmour & Aitken, 2016
Driving piles	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.286
Planks (for horizontal elements): 225mm x 100mm x 4m length	Measure - 2 rows on front and 2 rows on back across 1035m length Rate - from quote Gilmour & Aitken 2016
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Rock placed inside timber frame - using up to 1 tonne	
Imported armour stones up to 1t each using backacter	Measure - 5.6m^2 from AutoCAD (x1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Rock placed inside timber frame - using up to 3 tonne	
Imported armour stones up to 3t each using backacter	Measure - 5.6m^2 from AutoCAD (x1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)

3.5.8 New tropical hardwood timber frame protection with rock



The cost breakdown for installing a new Tropical hardwood timber frame protection with rock is presented below, as well as assumptions.

Table 3-54: Costing of new Tropical hardwood timber frame protection with rock

	unit	measure	rate	total
New Tropical hardwood timber framed protection - new timber frame and rock armour inside – cost for 1035m length (where timber revetment exists)				
Timber frame	-	-	-	-
Pile (for vertical elements): 250mm x 250mm x 4m	nr	5175.0	£312.50	£1,617,188
Driving piles	m	13455.0	£5.91	£79,519
Planks (for horizontal elements): 225mm x 100mm x 4m length	m	4140.0	£28.13	£116,438
Bolts, nuts and washers for connections. M10x50.	nr	41400.0	£2.78	£115,092
Total				***£1,928,236***
Rock placed inside timber frame - using up to 1t rock	-	-	-	-
Imported armour stones up to 1t each using backacter	m^3	5806.4	£56.59	£328,581
Total				***£328,581***
Rock placed inside timber frame - using up to 3t rock	-	-	-	-
Imported armour stones up to 3t each using backacter	m^3	5806.4	£60.95	£353,897
Total				***£353,897***
Total Cost Using up to 1 Tonne Rock				
Total	-	-	-	***£2,256,817***
Preliminary cost at 35%				**£3,046,703**
+30% optimism bias				**£3,960,715**
Total Cost Using up to 3 Tonne Rock				
Total	-	-	-	***£2,282,133***
Preliminary cost at 35%				**£3,080,880**
+30% optimism bias				**£4,005,144**

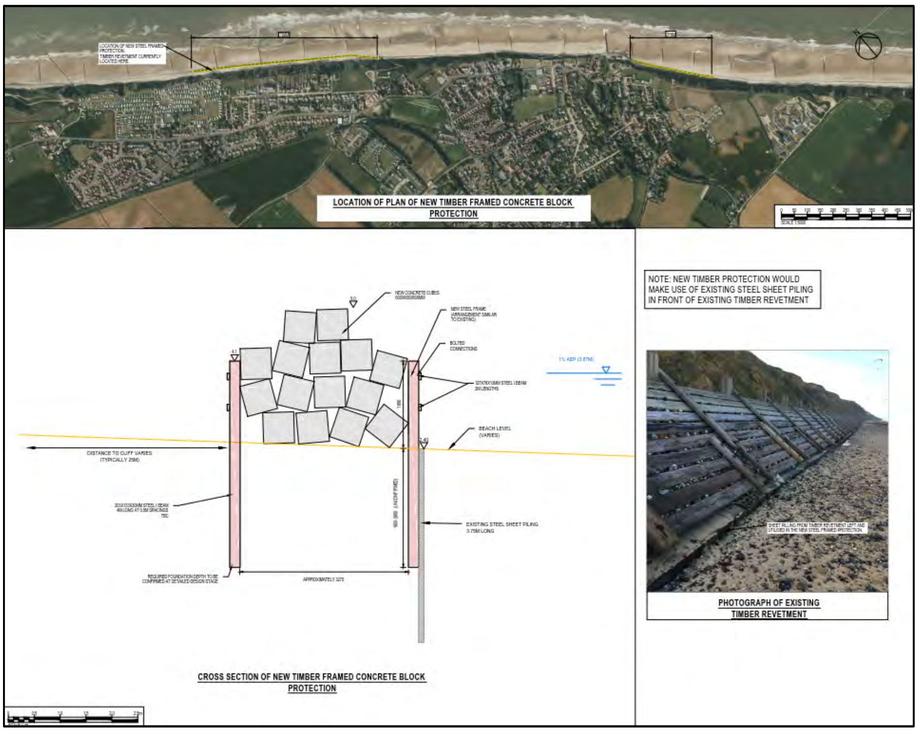
Table 3-55: Total cost of new Tropical hardwood timber frame protection with rock

Total Cost Using up to 1 Tonne Rock	£2,256,817	£2,180 per metre
Preliminary cost at 35%	£3,046,703	£2,944 per metre
+30% optimism bias	£3,960,715	£3,827 per metre
Total Cost Using up to 3 Tonne Rock	£2,282,133	£2,205 per metre
Preliminary cost at 35%	£3,080,880	£2,977 per metre
+30% optimism bias	£4,005,144	£3,870 per metre

Table 3-56: Assumptions for the costing of new Tropical hardwood timber frame protection with rock

	Assumptions
Timber frame	
Pile (for vertical elements): 250mm x 250mm x 4m	Measure - 2 rows, spaced at 0.4m intervals, 465m length Rate - from quote Gilmour & Aitken, 2016
Driving piles	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.286
Planks (for horizontal elements): 225mm x 100mm x 4m length	Measure - 2 rows on front and 2 rows on back across 1035m length Rate - from quote Gilmour & Aitken 2016
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Rock placed inside timber frame - using up to 1 tonne	
Imported armour stones up to 1t each using backacter	Measure - 5.6m^2 from AutoCAD (x1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Rock placed inside timber frame - using up to 3 tonne	
Imported armour stones up to 3t each using backacter	Measure - 5.6m^2 from AutoCAD (x1035m length) Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)

3.5.9 New Oak timber frame protection with concrete blocks



The cost breakdown for installing a new oak timber frame protection with concrete blocks is presented below, as well as assumptions.

Table 3-57: Costing of new Oak timber frame protection with concrete blocks

	unit	measure	rate	total
New oak timber framed protection - new oak timber frame and concrete blocks inside – cost for 1035m length (where timber revetment exists)				
Timber frame	-	-	-	-
Pile (for vertical elements): 250mm x 250mm x 4m	nr	5175.0	£200.00	£1,035,000
Driving piles	m	13455.0	£5.91	£79,519
Planks (for horizontal elements): 225mm x 100mm x 4m length	m	4140.0	£18.00	£74,520
Bolts, nuts and washers for connections. M10x50.	nr	41400.0	£2.78	£115,092
Total				***£1,304,131***
Concrete blocks placed inside timber frame	-	-	-	-
Concrete blocks 600x600mm - 'ConectaBloc'	m^3	3483.8	£242.59	£845,122
Installation cost	m^3	3483.8	£4.55	£15,851
Total				***£860,973***
Total	-	-	-	***£2,165,104***
Preliminary cost at 35%				**£2,922,891**
+30% optimism bias				**£3,799,758**

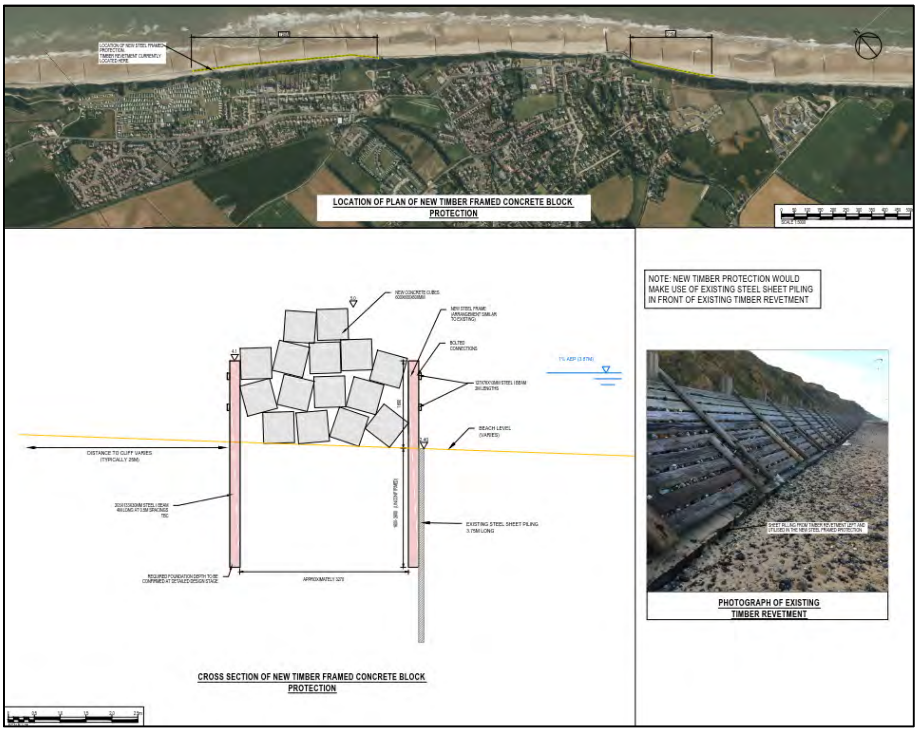
Table 3-58: Total cost of new Oak timber frame protection with concrete blocks

Total	£2,165,104	£2,092 per metre
Preliminary cost at 35%	£2,922,891	£2,824 per metre
+30% optimism bias	£3,799,758	£3,671 per metre

Table 3-59: Assumptions for the costing of new Oak timber frame protection with concrete blocks

	Assumptions
Timber frame	
Pile (for vertical elements): 250mm x 250mm x 4m	Measure - 2 rows, spaced at 0.4m intervals, 465m length Rate - from quote Gilmour & Aitken, 2016
Driving piles	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.286
Planks (for horizontal elements): 225mm x 100mm x 4m length	Measure - 2 rows on front and 2 rows on back across 1035m length Rate - from quote Gilmour & Aitken 2016
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Concrete blocks placed inside timber frame	
Concrete blocks 600x600mm - 'ConectaBloc'.	Measure - 3.3x1.7 = 5.61m^2, with a void ratio of 40% (x 0.6) Rate - quote from Carter-Concrete (material and delivery)
Installation cost	Measure – same as above Rate - used same labour/plant rate as for rock armour up to 1t from SPONS16 p.417

3.5.10 New tropical hardwood timber frame protection with concrete blocks



The cost breakdown for installing a new tropical hardwood timber frame protection with concrete blocks is presented below, as well as assumptions.

Table 3-60: Costing of new tropical hardwood timber frame protection with concrete blocks

	unit	measure	rate	total
New tropical hardwood timber framed protection - new tropical hardwood timber frame and concrete blocks inside – cost for 1035m length (where timber revetment exists)				
Timber frame	-	-	-	-
Pile (for vertical elements): 250mm x 250mm x 4m	nr	5175.0	£312.50	£1,617,188
Driving piles	m	13455.0	£5.91	£79,519
Planks (for horizontal elements): 225mm x 100mm x 4m length	m	4140.0	£28.13	£116,438
Bolts, nuts and washers for connections. M10x50.	nr	41400.0	£2.78	£115,092
Total				***£1,928,236***
Concrete blocks placed inside timber frame	-	-	-	-
Concrete blocks 600x600mm - 'ConectaBloc'	m^3	3483.8	£242.59	£845,122
Installation cost	m^3	3483.8	£4.55	£15,851
Total				***£860,973***
Total	-	-	-	***£2,789,209***
Preliminary cost at 35%				**£3,765,432**
+30% optimism bias				**£4,895,062**

Table 3-61: Total cost of new tropical hardwood timber frame protection with concrete blocks

Total	£2,789,209	£2,695 per metre
Preliminary cost at 35%	£3,765,432	£3,638 per metre
+30% optimism bias	£4,895,062	£4,730 per metre

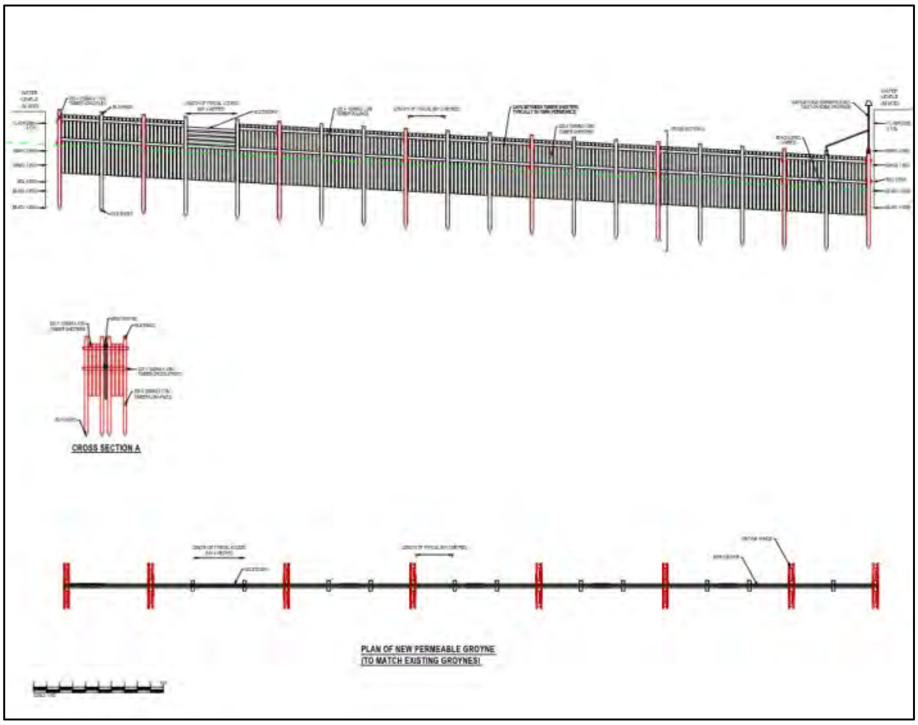
Table 3-62: Assumptions for the costing of new tropical hardwood timber frame protection with concrete blocks

	Assumptions
Timber frame	
Pile (for vertical elements): 250mm x 250mm x 4m	Measure - 2 rows, spaced at 0.4m intervals, 465m length Rate - from quote Gilmour & Aitken, 2016
Driving piles	Measure - each beam driven 2.6m bgl Rate - SPONS16 p.286
Planks (for horizontal elements): 225mm x 100mm x 4m length	Measure - 2 rows on front and 2 rows on back across 1035m length Rate - from quote Gilmour & Aitken 2016
Bolts, nuts and washers for connections. M10x50.	Measure - 4 bolts per connection, 2 connections on each vertical beam (i.e. 8 x no. of vertical beams) Rate - SPONS16 p.276
Concrete blocks placed inside timber frame	
Concrete blocks 600x600mm - 'ConectaBloc'.	Measure - 3.3x1.7 = 5.61m^2, with a void ratio of 40% (x 0.6) Rate - quote from Carter-Concrete (material and delivery)
Installation cost	Measure – same as above Rate - used same labour/plant rate as for rock armour up to 1t from SPONS16 p.417

3.6 Option 8: Groynes

Option 8 is to either install new timber groynes measuring 63m (same length as average length of existing) or to refurbish the existing permeable timber groynes. There are multiple options below for the type of new groyne.

3.6.1 New permeable timber groyne



The cost breakdown for a new permeable timber groyne is presented below, as well as assumptions.

Table 3-63: Costing of enhancement of new permeable timber groyne

	unit	measure	rate	total
New permeable timber groyne				
Main groyne installation	-	-	-	-
Timber piles. 250x250mmx7.5m long.	nr	40	£585.94	£23,438
Supply and fit pile rings and shoes	nr	40	£175.00	£7,000
Driving of piles through sand to 5m.	nr	40	£29.55	£1,182
Timber sheeters. 225x100mmx4.5m long.	nr	209	£126.56	£26,452
Timber walings. 225x100mmx7.0m long.	nr	36	£196.88	£7,088
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	578	£15.92	£9,202
Total				***£74,360***
Installation of 'wings'	-	-	-	-
Timber piles. 250x250mmx7.5m long.	nr	16	£585.94	£9,375
Supply and fit pile rings and shoes	nr	16	£175.00	£2,800
Driving of piles through sand to 5m.	nr	16	£29.55	£473
Timber sheeters. 225x100mmx4.0m long.	nr	48	£112.50	£5,400
Timber cross struts. 225x100mmx3.5m long.	nr	32	£98.44	£3,150
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	160	£15.92	£2,547
Total				***£23,745***
Total	-	-	-	***£98,105***
Preliminary cost at 35%				**£132,442**
+30% optimism bias				**£172,175**

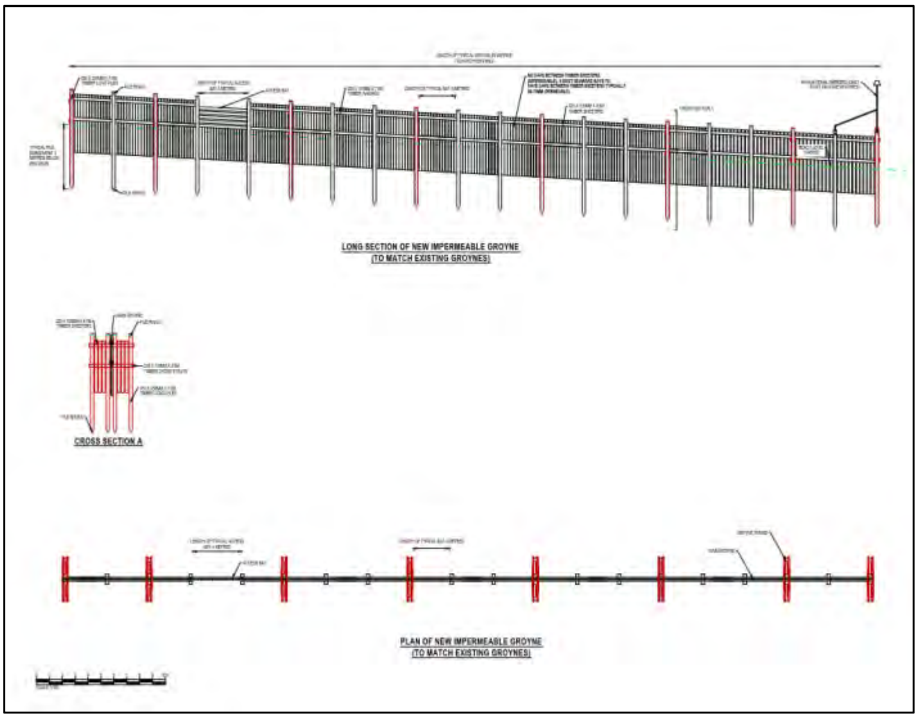
Table 3-64: Total cost of enhancement of new permeable timber groyne

Total	£98,105	£1,557 per metre
Preliminary cost at 35%	£132,442	£2,102 per metre
+30% optimism bias	£172,175	£2,733 per metre

Table 3-65: Assumptions for the costing of enhancement of new permeable timber groyne

	Assumptions
Main groyne installation	
Timber piles. 250x250mmx7.5m long.	Measure - quantity taken from AutoCAD Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Supply and fit pile rings and shoes	Measure - same as number of timber piles Rate - quote from Gilmour & Aitken, 2014
Driving of piles through sand to 5m.	Measure -same as number of timber piles Rate - SPONS16 p.286 Spons (£5.91/m)
Timber sheeters. 225x100mmx4.5m long.	Measure - 11 sheeters per bay x 19 bays - from AutoCAD (assumes access bay is all sheeters) Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Timber walings. 225x100mmx7.0m long.	Measure - 4 no. walings per groyne, 63m length of groyne = 252/7m long planks = 36 planks Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Measure - 1 bolt for every sheeter connection to waling = 2 per sheeter (connections to 2 walings) and 4 per pile (connections to 2 walings) Rate - material quote from Gilmour & Aitken,2014 (£11.25) + labour rate from SPONS16 p.277 (£4.67)
Installation of 'wings'	
Timber piles. 250x250mmx7.5m long.	Measure - 2 piles per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Supply and fit pile rings and shoes	Measure - same as number of timber piles Rate - quote from Gilmour & Aitken, 2014
Driving of piles through sand to 5m.	Measure -same as number of timber piles Rate - SPONS16 p.286 spons (£5.91/m)
Timber sheeters. 225x100mmx4.0m long.	Measure - 6 per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Timber cross struts. 225x100mmx3.5m long.	Measure - 4 per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Measure - 1 bolt for every sheeter connection to cross struts = 2 per sheeter (connections to 2 cross struts) and 4 per pile (connections to 2 walings) Rate - material quote from Gilmour & Aitken, 2014 (£11.25) + labour rate from SPONS16 p.277 (£4.67)

3.6.2 New impermeable timber groyne



The cost breakdown for a new impermeable timber groyne is presented below, as well as assumptions.

Table 3-66: Costing of enhancement of new impermeable timber groyne

	unit	measure	rate	total
New impermeable timber groyne				
Main groyne installation	-	-	-	-
Timber piles. 250x250mmx7.5m long.	nr	40	£585.94	£23,438
Supply and fit pile rings and shoes	nr	40	£175.00	£7,000
Driving of piles through sand to 5m.	nr	40	£29.55	£1,182
Timber sheeters. 225x100mmx4.5m long.	nr	266	£126.56	£33,666
Timber walings. 225x100mmx7.0m long.	nr	36	£196.88	£7,088
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	692	£15.92	£11,017
Total				***£83,389***
Installation of 'wings'	-	-	-	-
Timber piles. 250x250mmx7.5m long.	nr	16	£585.94	£9,375
Supply and fit pile rings and shoes	nr	16	£175.00	£2,800
Driving of piles through sand to 5m.	nr	16	£29.55	£473
Timber sheeters. 225x100mmx4.0m long.	nr	48	£112.50	£5,400
Timber cross struts. 225x100mmx3.5m long.	nr	32	£98.44	£3,150
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	nr	160	£15.92	£2,547
Total				***£23,745***
Total	-	-	-	***£107,134***
Preliminary cost at 35%				**£144,631**
+30% optimism bias				**£188,021**

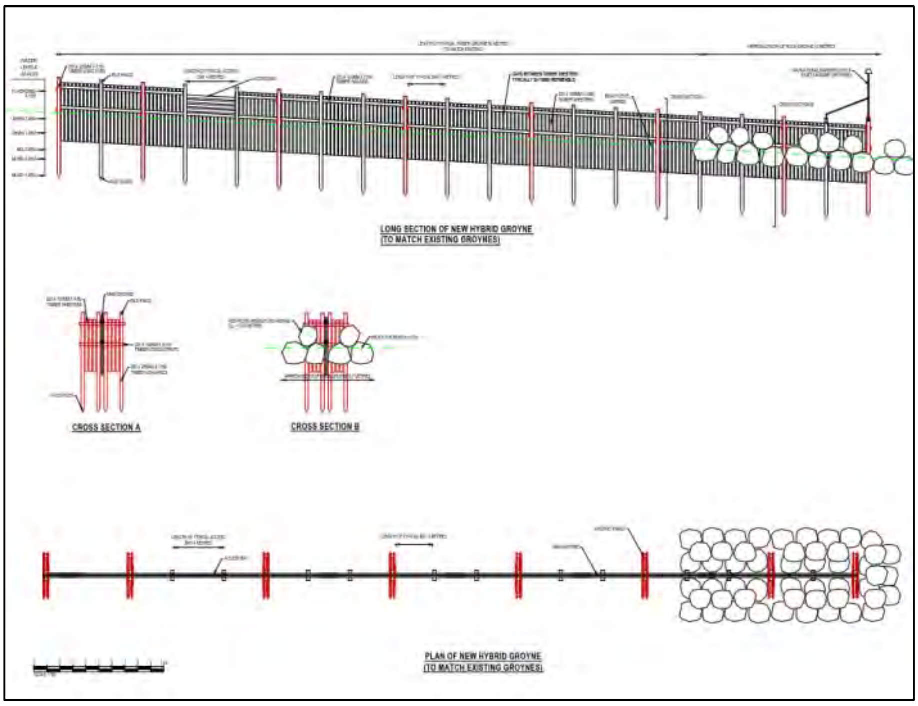
Table 3-67: Total cost of enhancement of new impermeable timber groyne

Total	£107,134	£1,701 per metre
Preliminary cost at 35%	£144,631	£2,296 per metre
+30% optimism bias	£188,021	£2,984 per metre

Table 3-68: Assumptions for the costing of enhancement of new impermeable timber groyne

	Assumptions
Main groyne installation	
Timber piles. 250x250mmx7.5m long.	Measure - quantity taken from AutoCAD Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Supply and fit pile rings and shoes	Measure - same as number of timber piles Rate - quote from Gilmour & Aitken, 2014
Driving of piles through sand to 5m.	Measure -same as number of timber piles Rate - SPONS16 p.286 (£5.91/m)
Timber sheeters. 225x100mmx4.5m long.	Measure - 14 sheeters per bay x 19 bays - from AutoCAD (assumes access bay is all sheeters) Rate - quote from Gilmour & Aitken, 2014
Timber walings. 225x100mmx7.0m long.	Measure - 4 no. walings per groyne, 63m length of groyne = 252/7m long planks = 36 planks Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Measure - 1 bolt for every sheeter connection to waling = 2 per sheeter (connections to 2 walings) and 4 per pile (connections to 2 walings) Rate - material quote from Gilmour & Aitken,2014 (£11.25) + labour rate from SPONS16 p.277 (£4.67)
Installation of 'wings'	
Timber piles. 250x250mmx7.5m long.	Measure - 2 piles per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Supply and fit pile rings and shoes	Measure - same as number of timber piles Rate - quote from Gilmour & Aitken, 2014
Driving of piles through sand to 5m.	Measure -same as number of timber piles Rate - SPONS16 p.286 (£5.91/m)
Timber sheeters. 225x100mmx4.0m long.	Measure - 6 per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Timber cross struts. 225x100mmx3.5m long.	Measure - 4 per wing x 8 wings Rate - quote from Gilmour & Aitken, 2016 (£1250/m^3)
Bolted connections. 25mm diameter bolt and washer up to 525mm long.	Measure - 1 bolt for every sheeter connection to cross struts = 2 per sheeter (connections to 2 cross struts) and 4 per pile (connections to 2 walings) Rate - material quote from Gilmour & Aitken,2014 (£11.25) + labour rate from SPONS16 p.277 (£4.67)

3.6.3 New permeable timber groyne with rock armour at toe



The cost breakdown for a new permeable timber groyne with rock armour at toe is presented below, as well as assumptions.

Table 3-69: Costing of enhancement of new permeable timber groyne with rock armour at toe

	unit	measure	rate	total
New permeable timber groyne with rock armour at toe				
Permeable groyne installation (same cost as above)	-	-	-	-
Total				***£98,105***
Excavation of beach material	-	-	-	-
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 1.0-1.5m	m^3	115	£4.21	£482
Total				***£482***
Excavation of beach material	-	-	-	-
Imported armour stones 1t each using backacter	m^3	260	£56.59	£14,713
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	m^2	170	£58.35	£9,920
Total				***£32,548***
Total	-	-	-	***£123,220***
Preliminary cost at 35%				**£166,347**
+30% optimism bias				**£216,251**

Table 3-70: Total cost of enhancement of new permeable timber groyne with rock armour at toe

Total	£123,220	£1,956 per metre
Preliminary cost at 35%	£166,347	£2,640 per metre
+30% optimism bias	£216,251	£3,433 per metre

Table 3-71: Assumptions for the costing of enhancement of new permeable timber groyne with rock armour at toe

	Assumptions
Excavation of beach material	
Excavate material other than topsoil, rock or artificial hard material to maximum depth of 1.0-1.5m	Measure - 144.5m3 (17m x 8.5m^2) from AutoCAD Rate - SPONS16 p.185
Excavation of beach material	
Imported armour stones up to 1t each using backacter	Measure - 260m3 (17m x 15.3m^2) from AutoCAD Rate - SPONS16 p.417 (assumes 30% void ratio and includes aggregate tax)
Trimming of filled surfaces, rock inclined at an angle of 10-45° to horizontal	Measure - 10m length of rock face (x 17m length) Rate - SPONS16 p.190

3.6.4 Refurbishment of existing timber groyne

As well as considering the costs of new groynes, the cost of refurbishing the existing groynes has been considered. Three levels of groyne maintenance have been considered based on the number of elements of a groyne which need replacing. On average is has been estimated that the proportion of timber elements on the existing groynes requiring replacement is 20%, 10% and 30% have also been considered to cover a range of conditions.

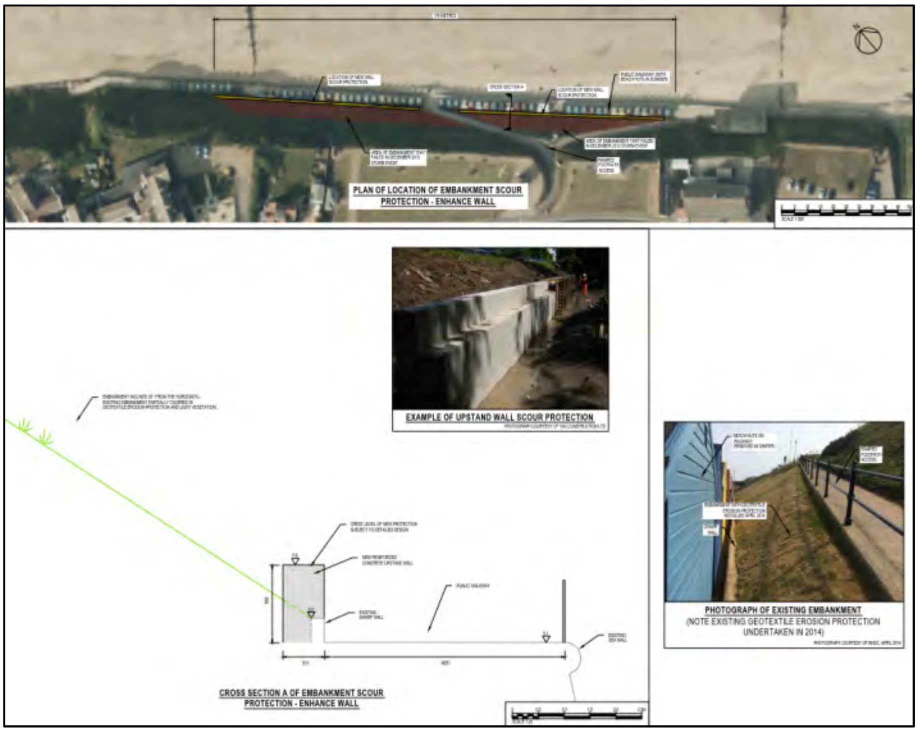
Table 3-72: Total cost of groyne refurbishment

Total cost of refurbishing 10%	£9,811	per groyne
Preliminary cost at 35%	£13,244	per groyne
+30% optimism bias	£17,217	per groyne
Total cost of refurbishing 20%	£19,621	per groyne
Preliminary cost at 35%	£26,488	per groyne
+30% optimism bias	£34,435	per groyne
Total cost of refurbishing 30%	£29,432	per groyne
Preliminary cost at 35%	£39,733	per groyne
+30% optimism bias	£51,652	per groyne

3.7 Option 11: Scour protection

Option 11 is to provide scour protection to the embankment behind the seawall measuring 220m. There are multiple options below for the type of scour protection.

3.7.1 New upstand wall



The cost breakdown for the new upstand wall is presented below, as well as assumptions.

Table 3-73: Costing of new upstand wall

	unit	measure	rate	total
New upstand wall – 220m length				
Upstand wall	-	-	-	-
Upstand wall	-	-	-	-
Formwork, fair finish, plane vertical, width exceeding 1.22m	m^2	550.0	£70.88	£38,984
Cost of concrete (C40@20mm aggregate)	m^3	236.5	£102.47	£24,234
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	m^3	236.5	£8.67	£2,050
Placing of reinforced concrete, walls, thickness exceeding 500mm	m^3	236.5	£41.43	£9,798
Plain steel bars, 12mm nominal size	tn	8.8	£1,563.09	£13,755
Dowels	nr	220.0	£2.81	£618
Total				***£89,440***
Preliminary cost at 35%				**£120,744**
+30% optimism bias				**£156,968**

Table 3-74: Total cost of new upstand wall

Total	£89,440	£407 per metre
Preliminary cost at 35%	£120,744	£549 per metre
+30% optimism bias	£156,968	£713 per metre

Table 3-75: Assumptions for the new upstand wall

	Assumptions
Formwork, fair finish, plane vertical, width exceeding 1.22m	Measure - rear formwork is 1.5m high, front formwork is 1m high, 220m length Rate - SPONS16 p.212
Cost of concrete (C40@20mm aggregate)	Measure - area of concrete from AutoCAD 1.075m^2, 220m length Rate - SPONS16 p.203
Pumping from ready mix truck to point of placing at the rate of 25m³/hour	Measure - same as measure of concrete Rate - SPONS16 p.202 (most expensive rate selected)
Placing of reinforced concrete, walls, thickness exceeding 500mm	Measure - same as measure of concrete Rate - SPONS16 p.206
Plain steel bars, 12mm nominal size	Measure - One way, length of wall 220m, assume 0.15m spacing = 1467 bars of 3.3m length = 4840m. Other way, length of wall reinf. 3.3m, assume 0.15m spacing = 22 bars of 220m length = 4840m. Area of rebar = pi x 36 = 0.000113m^2. Volume = area (0.000113m^2 x length of rebar (4840x2)= 1.1m^3. Mass = volume x density (assume worst case 8050kg/m^3). Rate - SPONS16 p.215
Dowels	Measure - dowels occur at 1m spacing Rate - SPONS16 p.218

3.7.2 New sprayed concrete protection

The cost breakdown for the new sprayed concrete protection is presented below, as well as assumptions.

Table 3-76: Costing of new sprayed concrete protection

	unit	measure	rate	total
New sprayed concrete protection – 220m length				
Sprayed concrete	-	-	-	-
100mm thick concrete with mesh	m^2	968.00	£52.08	£50,413
Drainage pipes (every 3m)	nr	73.33	£12.99	£953
Total				£51,366
Total	-	-	-	***£50,853***
Preliminary cost at 35%				**£66,776**
+30% optimism bias				**£86,809**

Table 3-77: Total cost of new sprayed concrete protection

Total	£50,853	£233 per metre
Preliminary cost at 35%	£66,776	£304 per metre
+30% optimism bias	£86,809	£395 per metre

Table 3-78: Assumptions for the new sprayed concrete protection

	Assumptions
100mm thick concrete with mesh	Measure - 4.4m width, 220m length Rate - from 2011 quote (£47.37/m^2) and updated for inflation, includes material and labour costs
Drainage pipes (every 3m)	Measure - 3m spacing / 220m length Rate - SPONS16 p.240

3.7.3 New concrete block revetment

The cost breakdown for the new concrete block revetment is presented below, as well as assumptions.

Table 3-79: Costing of new concrete block revetment

	unit	measure	rate	total
New concrete block revetment – 220m length				
Concrete block revetment	-	-	-	-
100mm thick, solid block	m^2	968.0	£50.00	£48,400
New geotextile for filtration, inclined at an angle of 10-45° to the horizontal	m^2	968.0	£4.23	£4,095
Total				***£52,495***
Total	-	-	-	***£52,495***
Preliminary cost at 35%				**£68,243**
+30% optimism bias				**£88,716**

Table 3-80: Total cost of new concrete block revetment

Total	£52,495	£239 per metre
Preliminary cost at 35%	£68,243	£310 per metre
+30% optimism bias	£88,716	£403 per metre

Table 3-81: Assumptions for the new concrete block revetment

	Assumptions
100mm thick, solid block	Measure - 4.4m width, 220m length Rate - £35/m^3 approx. material supply (Dycel 101) and deliver from quote + £15/m^3 labour and plant estimated.
New geotextile for filtration, inclined at an angle of 10-45° to the horizontal	Measure - 4.4m width, 220m length Rate - SPONS16 p.418

3.7.4 New gabion protection

The cost breakdown for the new gabion protection is presented below, as well as assumptions.

Table 3-82: Costing of new gabion protection

	unit	measure	rate	total
New gabion protection – 220m length				
Gabions	-	-	-	-
Heavy galvanized wire mesh gabions 1.0 x 1.0 m	nr	1100.00	£139.88	£153,868
Total				***£153,868***
Total	-	-	-	***£153,868***
Preliminary cost at 35%				**£200,028**
+30% optimism bias				**£260,037**

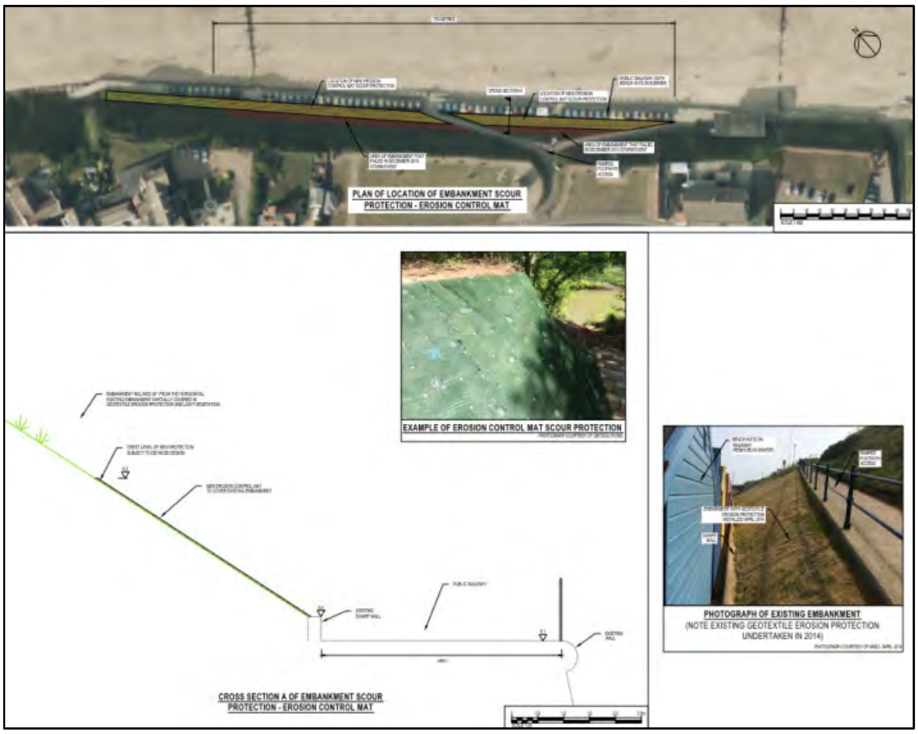
Table 3-83: Total cost of new gabion protection

Total	£153,868	£699 per metre
Preliminary cost at 35%	£200,028	£909 per metre
+30% optimism bias	£260,037	£1,182 per metre

Table 3-84: Assumptions for the new gabion protection

	Assumptions
Heavy galvanized wire mesh gabions 1.0 x 1.0 m	Measure - 5 gabions per metre, 220m length Rate - SPONS16 p.362

3.7.5 New geogrid protection



The cost breakdown for the new geogrid protection is presented below, as well as assumptions.

Table 3-85: Costing of new geogrid protection

	unit	measure	rate	total
New geogrid protection – 220m length				
Geogrid protection	-	-	-	-
4.9m length	m^2	968.00	£14.75	£14,278
Total				***£14,278***
Total	-	-	-	***£14,278***
Preliminary cost at 35%				**£19,275**
+30% optimism bias				**£25,058**

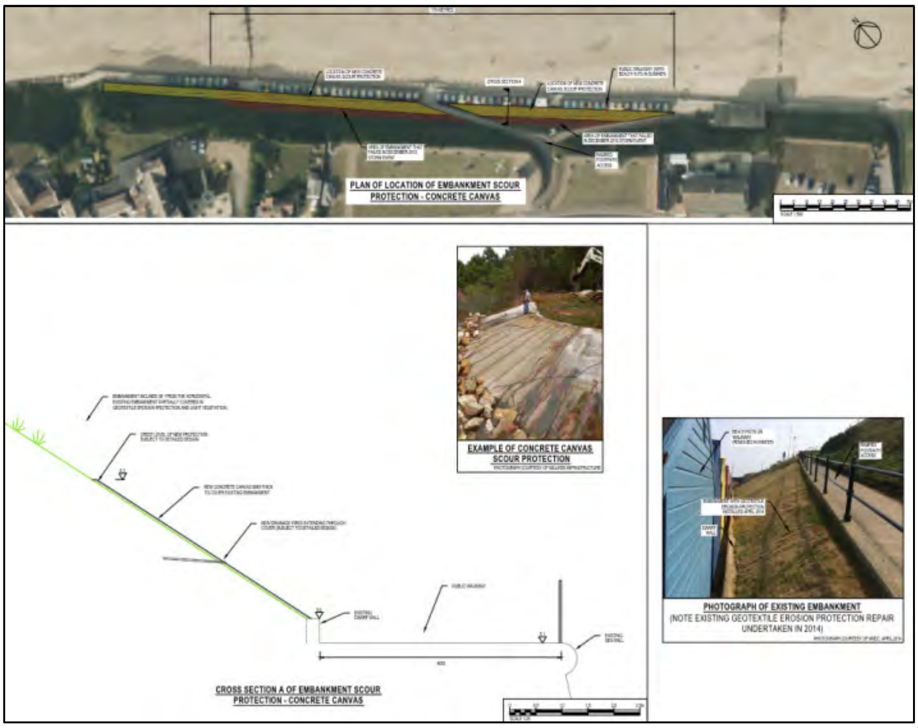
Table 3-86: Total cost of new geogrid protection

Total	£14,278	£65 per metre
Preliminary cost at 35%	£19,275	£88 per metre
+30% optimism bias	£25,058	£114 per metre

Table 3-87: Assumptions for the new geogrid protection

	Assumptions
4.9m length	Measure - 4.4m width, 220m length Rate - from quote from Tensar

3.7.6 New concrete canvas protection



The cost breakdown for the new concrete canvas protection is presented below, as well as assumptions.

Table 3-88: Costing of new concrete canvas protection

	unit	measure	rate	total
New concrete canvas protection – 220m length				
Concrete canvas	-	-	-	-
5mm concrete canvas	m2	1056.00	£33.41	£35,281
Drainage pipes (every 3m)	nr	73.3	£12.99	£953
Total				***£33,293***
Total	-	-	-	***£33,293***
Preliminary cost at 35%				**£43,282**
+30% optimism bias				**£56,266**

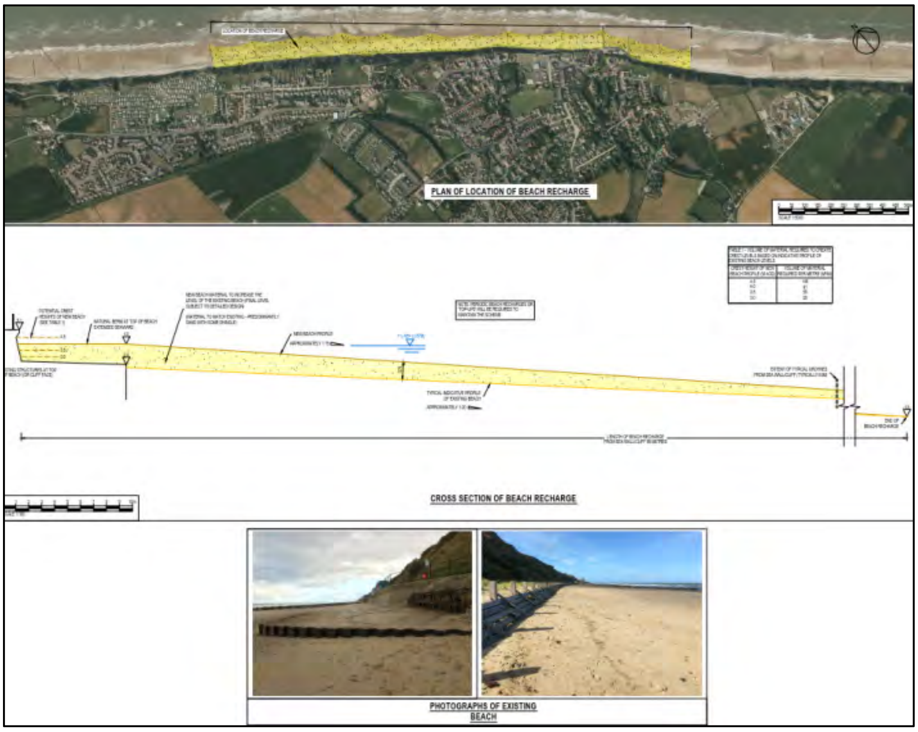
Table 3-89: Total cost of new concrete canvas protection

Total	£33,293	£151 per metre
Preliminary cost at 35%	£43,282	£197 per metre
+30% optimism bias	£56,266	£256 per metre

Table 3-90: Assumptions for the new concrete canvas protection

	Assumptions
5mm concrete canvas	Measure - 4.4m, 220m length Rate - from 2011 quote (£30.39/m^2) and updated for inflation, includes delivery and installation
Drainage pipes (every 3m)	Measure - 3m spacing / 220m length Rate - SPONS16 p.240

3.8 Option 12: Beach Recharge



The cost breakdown for the supply of material to increase the beach level across the 1854m frontage is presented below, as well as assumptions.

Table 3-91: Costing of beach recharge

	unit	measure	rate	total
Beach recharge – 1854m length (whole frontage)				
Beach recharge	-	-	-	-
Beach material	m^3	209502	£20.00	£4,190,040
Total	-	-	-	***£4,190,040***
Preliminary cost at 35%				**-**
+30% optimism bias				**£5,447,052**

Table 3-92: Total cost of beach recharge

Total	£4,190,040	£2,260 per metre
Preliminary cost at 35%	-	-
+30% optimism bias	£5,447,052	£2,938 per metre

Table 3-93: Assumptions for the beach recharge

	Assumptions
Beach recharge	Measure - quantity of material required taken from cross section drawing for outline design (113m^2 area x 1854m length) Rate - INCLUDES preliminaries, average of rates from a number of previous projects - average rate used updated for inflation. Rate does not include cost for future 'top-ups'.

3.9 Capital cost summary

The table below shows a summary of the capital costs of the different options.

Table 3-94: Summary of capital costs of the options

Defence option	Length (m)	Cost (£)*	Rate (£/m)*
Option 1 - Seawall section 1 (wall and 8m width apron)	84	£258,208	£3,074
Option 1 - Seawall section 2 (wall and 2.2m width apron)	200	£348,821	£1,744
Option 1 - Seawall section 3 (3.2m width apron only)	95	£75,215	£792
Option 1 - Seawall section 4 (wall and 2.3m width apron)	25	£43,042	£1,722
Option 1 - Seawall section 5 (wall and 3.2m width apron)	20	£40,083	£2,004
Option 1 - Seawall section 6 (wall and 6.6m width apron)	100	£295,790	£2,957
Option 1 - Seawall section 6 with rock armour (wall and 6.6m width apron)	100	£378,129	£3,781
Option 3 - Rock revetment	1355	£3,123,338	£2,305
Option 5 - Placed rock protection	1035	£1,992,854	£1,925
Option 6 - Oak timber revetment	1035	£1,331,990	£1,287
Option 6 - Tropical hardwood timber revetment	1035	£1,865,434	£1,802
Option 7 - Enhance existing steel frame with rock (up to 1t)	465	£834,362	£1,794
Option 7 - Enhance existing steel frame with rock (up to 3t)	465	£841,834	£1,810
Option 7 - Enhance existing steel frame with concrete	465	£980,053	£2,108
Option 7 - Enhance existing steel frame with rock (up to 1t) and increase height	465	£949,817	£2,043
Option 7 - Enhance existing steel frame with rock (up to 3t) and increase height	465	£966,184	£2,078
Option 7 - Enhance existing steel frame with concrete and increase height	465	£1,277,005	£2,746
Option 7 - New steel frame with rock (up to 1t)	1035	£3,704,199	£3,579
Option 7 - New steel frame with rock (up to 3t)	1035	£3,748,628	£3,622
Option 7 - New steel frame with concrete	1035	£4,059,685	£3,922
Option 7 - New oak timber frame with rock (up to 1t)	1035	£2,865,410	£2,769
Option 7 - New oak timber frame with rock (up to 3t)	1035	£2,909,839	£2,811
Option 7 - New tropical hardwood timber frame with rock (up to 1t)	1035	£3,960,715	£3,827
Option 7 - New tropical hardwood timber frame with rock (up to 3t)	1035	£4,005,144	£3,870
Option 7 - New oak timber frame with concrete	1035	£3,799,758	£3,671
Option 7 - New tropical hardwood timber frame with concrete	1035	£4,895,062	£4,730
Option 8 - Permeable timber groyne	63	£172,175	£2,733
Option 8 - Impermeable timber groyne	63	£188,021	£2,984
Option 8 - Permeable timber groyne with rock armour toe	63	£216,251	£3,433
Option 8 - Refurbish existing groyne 10%	63	£17,217	-
Option 8 - Refurbish existing groyne 20%	63	£34,435	-
Option 8 - Refurbish existing groyne 30%	63	£51,652	-
Option 11 - Upstand wall scour protection	220	£156,968	£713
Option 11 - Spayed concrete scour protection	220	£86,809	£395
Option 11 - Concrete block revetment scour protection	220	£88,716	£403
Option 11 - Gabions scour protection	220	£260,037	£1,182
Option 11 - Geogrid scour protection	220	£25,058	£114
Option 11 - Concrete canvas scour protection	220	£56,266	£256

*includes both preliminaries and optimism bias

4. Costs for Maintenance / Ongoing Works

Maintenance costs and costs of ongoing works (i.e. repeat interventions) have been developed. These costs are on top of the capital costs of the various elements which have been presented above and are necessary in order to develop whole life costs of the combinations of interventions or 'scheme options'. The assumptions used and the estimated maintenance/ongoing costs of the various interventions are presented in the tables below.

4.1 Option 1: Seawall / apron re-facing

Table 4-1: Seawall / apron re-facing maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Maintenance of rock placed in Section 6	10 years	£1,809	Cost for repositioning any displaced rock
Refurbishment (encasement) of entire seawall structure	After 30 years and then every 50 years	£1,194,943	
Refurbishment (encasement) of entire seawall structure following beach recharge	After 30 years and then every 50 years	£721,503	Only 50% of Section 6 apron requires refurbishment because of increased beach level

4.2 Option 3: Rock revetment

Table 4-2: Rock revetment maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Maintenance of mass rock revetment (entire frontage but not along seawall)	10 years	£148,025	Assumed to be 10% of the original rock placement cost

4.3 Option 6: Timber revetment

Table 4-3: Timber revetment maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Minor refurbishment of timber revetment	5 years	£192,326	Based on assumption that 10% of the structure will require replacing due to storm damage
Major refurbishment	20 years	£634,677	Based on assumption that one third of the structure will require replacing due to storm damage

4.4 Option 7: Steel framed protection

Table 4-4: Steel frame protection maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Maintenance of enhanced steel frame structure	10 years	£45,445	Based on assumption that 5% of the enhanced steel frame structure will need replacing
Refurbishment of enhanced steel frame structure	30 years	£927,112	Based on assumption that all the steel elements of the enhanced frame will need replacing

4.5 Option 8: Groyne refurbishment

Table 4-5: Groyne maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Minor refurbishment of groynes	10 years	£230,766	Based on assumption that 10% of the elements of the groynes will require replacing
Major refurbishment of groynes	50 years	£692,298	Based on assumption that 30% of the elements of the groynes will require replacing
Maintenance of rock placed at ends of groynes	10 years	£11,309	Cost for repositioning any displaced rock

4.6 Option 11: Scour protection

Table 4-6: Scour protection maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Maintenance of articulated concrete block revetment	10 years	£9,498	Based on assumption that minor maintenance of concrete block revetment will be required. Based on 10% of original cost.
Replacement of articulated concrete block revetment	30 years	£94,984	Assumed that articulated concrete block revetment will require replacing at the end of design life

4.7 Option 12: Beach recharge

Table 4-7: Beach recharge maintenance / ongoing costs and assumptions

Ongoing works (after Year 1 works)	Frequency	Cost each time	Cost assumption
Recycling	5 years	£280,786	Mechanical movement of beach material from areas of accretion to erosion. Assumed to be 5% of the overall cost
Re-nourishments	20 years	£1,403,978	Addition of some new beach material, but less than originally provided. Assumed to be 25% of the overall cost

4.8 General maintenance along the frontage

North Norfolk District Council currently spends approximately £310,000 each year maintaining 21 miles of coastline. This annual maintenance budget typically covers the cost of the following:

- Inspection and surveys of coastal defence assets;
- Repairs (maintenance) of assets to account for wear and tear;
- Minor Storm damage clear up and minor repairs (for major repairs additional emergency funding is applied for);
- Repairs to address health and safety hazards, particularly regarding failing structures.

For the purposes of economic appraisal, and in order to estimate the Present Value (PV) whole life costs, the general annual maintenance costs for Mundesley have been calculated based on the Council's current yearly spend (which is based on their annual budget) and the proportion of the 21 miles of coastline that the Mundesley frontage represents. This equates to £19,000 a year for the Mundesley frontage, which NNDC have committed to maintaining throughout the 50 year appraisal period (a PV total of £465,411).

5. Whole Life Costing

5.1 Overview

5.1.1 Scheme solutions

The options presented above were subject to further appraisal to arrive at a short list of options. As none of the options could 'stand-alone' and be adopted to protect the entire frontage for the whole appraisal period, it was necessary to produce various combinations of interventions from the shortlisted options. Each combination provides a complete defence solution for a scheme for the whole frontage and lays out the different option combinations and the timings of each intervention. This process is fully described in the Outline Business Case report.

In total 9 different combinations of the various short listed options were considered. These are listed below and fully described in the Outline Business Case.

1. Do Nothing
2. Do Minimum
3. Rock Revetment
4. Maintain Existing
5. Partial Rock Placement A
6. Partial Rock Placement B
7. Full Rock Placement
8. Beach Re-nourishment
9. Adaptive Option

5.1.2 Discounting and present value

Discounting is a technique used to compare costs that occur at different points in time over the appraisal period or over the whole life of an option. Standard discount rates have been used to convert all costs to 'Present Value' (PV). FCERM-AG recommends using HM Treasury Green Book and the following variable discount rates (expressed as a %) have been used within the whole life costing; 3.5% for years 0 to 30, 3% for years 31-75 and 2.5% for years 76-99. Using these discount rates of the 100 year appraisal period, a total PV cost for each option combination was determined. The discount rates applied are the same as those applied to the economic damages and benefits and therefore the PV costs of options and benefits are directly comparable.

5.1.3 Cost uplift

All cost estimates presented in this section are valid to January 2018. The capital costs presented in section 3 have been uplifted to January 2018 prices using Construction Price Indices.

5.1.4 Updated rock prices

Several of the scheme options utilise rock armour. In order to capitalise on potential bulk ordering cost efficiencies all of the rock could be combined into one order. Therefore to improve the quality of the cost estimates for rock armour a quotation has been sought from Stema Shipping UK. The estimate received quoted their 2016 prices for 1-3 tonne rock armour (including aggregate tax) of £46.5/tonne. It was also recommended that a £10/tonne handling and placement cost also be applied. Therefore the revised cost estimate for a bulk purchase of rock armour of £56.5/tonne (which has since been uplifted to January 2018 prices using Construction Price Indices) has been applied to each of the scheme options detailed in this section that require rock armour.

5.1.5 Option duration

Scheme option combinations have been developed for appraisal periods lasting 50 and 100 years. Option benefits have also been developed for these periods which are directly comparable and are presented in the economic damages report and OBC.

5.2 Scheme Option 1 – Do Nothing

The Do Nothing option would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course. The Do Nothing option is the baseline against which all other options are compared.

Without defence maintenance the existing defences will deteriorate over time until they eventually fail, resulting in the increased exposure of the cliffs to wave action (the primary driver of erosion). This coupled, with future climate change predictions, which forecasts increases in both sea levels and the frequency of large storm events, will result in the rate of erosion increasing in the future. Over the course of the next century the cliffs would be expected to recede by up to approximately 245m due to erosion. The cost implementing the Do Nothing scenario is £0.

5.3 Scheme Option 2 – Do Minimum

The Do Minimum option involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works. In effect, the Do Minimum approach is delayed Do Nothing, as it will also eventually allow the defences to fail and nature to take its course.

The annual cost associated with maintaining the existing defences as best as possible with minimal investment has been estimated to be £19,000 per year. This is the general maintenance cost described in section 4.8. Over the 50 year appraisal period this corresponds with a total cash (undiscounted) cost of £950k and a PV cost of £465k. Over the 100 year appraisal period this corresponds with a total cash (undiscounted) cost of £1,900k and a PV cost of £567k.

Table 5-1: Cash and PV costs for Do Minimum

Appraisal Period	Capital Costs	Maintenance	Cash Costs (undiscounted)	PV Costs
50 Year	£-	£950,000	£950,000	£465,411
100 Year	£-	£1,900,000	£1,900,000	£567,364

5.4 Scheme Option 3 – Rock Revetment

This option is comprised of constructing a rock armour revetment at the toe of the cliff across the entire frontage (except where the existing seawall is), prolonging the life of the existing seawall and groyne structures through maintenance, and protection of the embankment at risk of scour.

Table 5-2: Elements of Scheme Option 3

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Rock revetment	In Year 1 a rock revetment will be placed along the entire frontage, except where the seawall exists. This will replace the timber revetment and steel framed structure protection. Maintenance of the rock revetment will occur every 10 years.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-3: Whole life costing for Scheme Option 3 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£11,895,578	£950,000	£12,845,578	£10,339,879
100 Year	£15,730,064	£1,900,000	£17,630,064	£10,883,802

5.5 Scheme Option 4 – Maintain Existing

This option is to maintain all of the existing defences which will include reinforcing the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes. Vulnerable sections will be protected with rock armour and scour protection.

Table 5-4: Elements of Scheme Option 4

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Timber revetment	In Year 1 refurbish the timber revetment (50%). Minor refurbishments (10%) to be carried out every 5 years. Additional major refurbishments (33%) carried out every 20 years, in Years 39, 59, 79 and 99.
Steel framed structure	In Year 1 an additional frame is built in front of the existing and filled with rock armour to enhance the existing defence. Maintenance (5%) will take place every 10 years. More major refurbishments to replace any steel elements will occur every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-5: Whole life costing for Scheme Option 4 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£9,965,369	£950,000	£10,915,369	£6,723,062
100 Year	£17,858,249	£1,900,000	£19,758,249	£7,701,400

5.6 Scheme Option 5 – Partial Rock Placement A

This option involves placing rock armour protection along the length of the existing timber revetment, reinforcing the existing steel structure and to undertake seawall, apron and groyne refurbishments. This approach includes protecting vulnerable sections of the frontage with rock armour and scour protection.

Table 5-6: Elements of Scheme Option 5

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Place rock behind timber revetment	In Year 1 import and position rock behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
Steel framed structure	In Year 1 an additional frame is built in front of the existing and filled with rock armour to enhance the existing defence. Maintenance (5%) will take place every 10 years. More major refurbishments to replace any steel elements will occur every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-7: Whole life costing for Scheme Option 5 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£8,072,240	£950,000	£9,022,240	£6,232,996
100 Year	£13,332,216	£1,900,000	£15,232,216	£6,920,107

5.7 Scheme Option 6 – Partial Rock Placement B

This option involves placing rock armour along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes. This approach includes protecting vulnerable sections of the frontage with rock armour and scour protection.

Table 5-8: Elements of Scheme Option 6

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Timber revetment	In Year 1 refurbish the timber revetment (50%). Minor refurbishments (10%) to be carried out every 5 years. Additional major refurbishments (33%) carried out every 20 years, in Years 39, 59, 79 and 99.
Place rock in front of steel framed structure	In Year 1 import and position rock in front of the existing steel framed structure to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-9: Whole life costing for Scheme Option 6 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£8,324,295	£950,000	£9,274,295	£5,763,265
100 Year	£14,262,805	£1,900,000	£16,162,805	£6,536,128

5.8 Scheme Option 7 – Full Rock Placement

This option involves placement of rock armour protection along the full length of the frontage, except for where the existing seawall is located. This option also includes seawall, apron and groyne refurbishments and using rock armour and scour protection to protect vulnerable sections.

Table 5-10: Elements of Scheme Option 7

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Place rock in front of steel framed structure and behind timber revetment	In Year 1 import and position rock in front of the existing steel framed structure and behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-11: Whole life costing for Scheme Option 7 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£6,431,166	£950,000	£7,381,166	£5,273,198
100 Year	£9,736,772	£1,900,000	£11,636,772	£5,754,835

5.9 Scheme Option 8 – Beach Re-nourishment

This option involves nourishing the beach with a significant quantity of sediment to raise the beach level. This option also includes seawall (not apron) and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

Table 5-12: Elements of Scheme Option 8

Element	Description
Beach recharge	In Year 1 carry out beach re-nourishment to increase the beach level. Every 5 years carry out beach recycling and every 20 years carry out partial nourishment to sustain new beach level. Because of the beach recharge the timber revetment and steel framed structure will not be replaced at the end of their design life.
Wall/apron re-facing	In Year 1 carry out re-facing of seawall as per other options, with the exception of Section 6, where no re-facing of the apron is initially required because of the additional protection the increased beach level provides. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81, however only 50% of the Section 6 apron will be re-faced as it is assumed that the lower section of apron will be protected by the maintained beach levels.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-13: Whole life costing for Scheme Option 8 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£13,841,872	£950,000	£14,791,872	£10,196,191
100 Year	£21,508,064	£1,900,000	£23,408,064	£11,175,526

5.10 Scheme Option 9 – Adaptive Option

This option is similar to Option 7 (full rock placement) but includes the placement of rock armour along the remainder of the frontage. The placement is however limited to 1 shipment of rock (i.e. 25,000 tonnes). This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

Table 5-14: Elements of Scheme Option 9

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall and apron where required only, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 approximately every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock refurbishment will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Steel framed structure and timber revetment	In Year 1 import and position rock in front of the existing steel framed structure and behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
Rock placement	In Year 1 import and place rock armour in front of steel framed protection, behind timber revetment, along Section 6 of seawall and at end of groynes. In Year 11 import some additional rock armour to ensure continued protection when the remainder of the timber revetment fails.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 5-15: Table 5-16: Whole life costing for Scheme Option 9 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£6,250,744	£950,000	£7,200,744	£4,994,538
100 Year	£9,505,687	£1,900,000	£11,405,687	£5,470,208

5.11 Summary of whole life costs

Table 5-17: Summary of the whole life costs (cash and PV) for the scheme options

Appraisal period	Option	Cash costs (undiscounted)	PV costs
50yrs	1 – Do Nothing	£0	£0
	2 – Do Minimum	£950,000	£465,411
	3 – Rock Revetment	£12,845,578	£10,339,879
	4 – Maintain Existing	£10,915,369	£6,723,062
	5 – Partial Rock Placement A	£9,022,240	£6,232,996
	6 – Partial Rock Placement B	£9,274,295	£5,763,265
	7 – Full Rock Placement	£7,381,166	£5,273,198
	8 – Beach Re-nourishment	£14,791,872	£10,196,191
	9 – Adaptive Option	£7,200,744	£4,994,538
100yrs	1 – Do Nothing	£0	£0
	2 – Do Minimum	£1,900,000	£567,364
	3 – Rock Revetment	£17,630,064	£10,883,802
	4 – Maintain Existing	£19,758,249	£7,701,400
	5 – Partial Rock Placement A	£15,232,216	£6,920,107
	6 – Partial Rock Placement B	£16,162,805	£6,536,128
	7 – Full Rock Placement	£11,636,772	£5,754,835
	8 – Beach Re-nourishment	£23,408,064	£11,175,526
	9 – Adaptive Option	£11,405,687	£5,470,208

Options - Development and Appraisal

Mundesley Outline Business Case

North Norfolk District Council

60519091

June 2018

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

Quality information

Prepared by	Checked by	Approved by
George Batt Engineer	Dan Glasson Associate	Paul Norton Technical Director

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Distribution List

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×	✓	North Norfolk District Council

Prepared for:

North Norfolk District Council 01263 513811 (Out of hours: 01223 849782)

North Norfolk District Council
Council Offices
Holt Road
Cromer
Norfolk
NR27 9EN

Prepared by:

AECOM Infrastructure & Environment UK Limited
Midpoint
Alençon Link
Basingstoke
Hampshire RG21 7PP
UK

T: +44(0)1256 310200

Table of Contents

1. Introduction 1
   1.1 Introduction 1
   1.2 Background 1
   1.3 The Problem 1
   1.4 Purpose of the report 2
2. Existing Defences 3
   2.1 Summary of Condition Assessment 5
3. Option Development 7
   3.1 Long list 7
   3.2 Coastal management approaches 7
   3.3 Long list options 7
   3.4 Long list option assessment 8
   3.5 Short list options 10
   3.6 Embankment scour protection 19
4. Initial shortlist option costing 22
   4.1 Approach to capital construction activities 22
   4.2 Preliminary costs and optimism bias 22
   4.3 Summary of option costs 23
5. Initial shortlist option appraisal 25
   5.1 Comparison of short listed options 25
6. Revised longlist option appraisal for OBC 31
   6.1 Revised longlist option appraisal 31
7. Revised shortlist options appraisal for OBC 34
   7.1 No Active Intervention (Do Nothing) 34
   7.2 Do Minimum 34
   7.3 Active Intervention Options 35
   7.4 Shortlisted Rock Armour Revetment Option 37
   7.5 Shortlisted Rock Armour Placement Options 38
   7.6 Shortlisted Timber Revetment Options 39
   7.7 Shortlisted Steel framed structure options 42
   7.8 Shortlisted Timber Groyne Options 44
   7.9 Shortlisted Beach Nourishment Option 46
   7.10 Shortlisted Scour Protection Options 47
8. Scheme option costs 50
   8.1 Scheme solutions 50
   8.2 Costing approach 50
   8.3 Scheme Option 1 – Do Nothing 51
   8.4 Scheme Option 2 – Do Minimum 51
   8.5 Scheme Option 3 – Rock Revetment 52
   8.6 Scheme Option 4 – Maintain Existing 52
   8.7 Scheme Option 5 – Partial Rock Placement A 53
   8.8 Scheme Option 6 – Partial Rock Placement B 53
   8.9 Scheme Option 7 – Full Rock Placement 54
   8.10 Scheme Option 8 – Beach Re-nourishment 55
   8.11 Scheme Option 9 – Adaptive Option 55
   8.12 Summary of scheme option costs 56
9. Option appraisal 57
   9.1 Economic appraisal 57
   9.2 Critical success appraisal 59
   9.3 Non-financial benefit appraisal 60
   9.4 Selection of preferred scheme option 62

10. Comparison of funding 63
10.1 Partnership Funding 63
10.2 Funding summary 63
11. Preferred option 64
11.1 Preferred option 64

Appendix A – Coastal Erosion Protection Option Drawings 66
Appendix B – Embankment Scour Protection Option Drawings 67
Appendix C – Economic Assessment Report 68
Appendix D – Costing Report 69
Appendix E – Partnership Funding Calculator 70
Appendix F – Shortlist Option Drawings 71
Appendix G – Preferred Option Overview Plan 72

1. Introduction

1.1 Introduction

AECOM Infrastructure and Environment UK Limited have been appointed by North Norfolk District Council (NNDC) to develop an Outline Business Case (OBC) and seek funding to implement the preferred management policy for the Mundesley frontage within the framework of the adopted Shoreline Management Plan.

1.2 Background

The Mundesley frontage forms part of the 'Kelling to Lowestoft Ness Shoreline Management Plan' (SMP6) which was completed in 2010 and fully adopted later in 2012. The preferred management policy for Mundesley, Unit 6.08, involves 'Holding the Line' (HTL) until 2055 before transitioning to a policy of 'No Active Intervention' (NAI).

Following the adoption of SMP6, NNDC in partnership with the Environment Agency, commissioned the Cromer to Winterton Ness Coastal Management Study which was completed in 2013. The purpose of that study was to provide recommendations for coastal management works to be taken forward to the OBC stage.

The Cromer to Winterton Ness Coastal Management Study found that coastal defence schemes could be technically and economically justified for the Mundesley frontage under each of the following three scenarios:

- The SMP6 policy (50 year HTL);
- The Modified SMP6 (100 year HTL);
- The SMP6 (50 year HTL) with Sediment Nourishment.

It was noted that the resulting 100-year coastline geometry under the Modified SMP6 and SMP6 through Sediment Nourishment scenarios are expected to result in a less stable coastline compared to that of the SMP6 Scenario, however, all scenarios were found to be technically and economically justified over the 100-year appraisal period.

The resulting OBC will build upon the Cromer to Winterton Ness Coastal Management Study and identify the technically, economically and environmentally preferred option and seek Grant in Aid (GiA) funding to implement the adopted SMP6 management policy. Although only 38 years remain until the end of the 'Hold the Line' policy in 2055, the Cromer to Winterton Ness Coastal Management Study found that the original SMP policy (first drafted in 2005) of HTL for 50 years is still economically justified if commenced in the present day. Consequently, at the request of NNDC both the appraisal period and the 50 year HTL policy will commence in 2017, therefore the transition to a policy of 'No Active Intervention' will occur in 2067.

1.3 The Problem

The Mundesley frontage is currently protected by a number of different types of coastal defences. These defences offer different levels of protection and are in varying conditions; (see Section 2.1 for a summary of the conditions of the structures) many are now reaching or have surpassed the end of their original intended design life. With future climate predictions indicating increases in sea levels and frequency of large storm events there is a need to address the coastal defences along the frontage in order to implement the HTL policy.

1.3.1 Coastal erosion

The primary concern is the recession of the cliffs along this frontage. Whilst the centre of Mundesley is protected by a reinforced concrete sea wall, to either side the cliffs have been gradually receding over time. This has occurred even with the presence of existing defences such as timber revetments and concrete rubble filled steel framed structures. The condition of the sea wall will also deteriorate over time and will require increasing levels of maintenance in the future.

Figure 1-1: Photograph of cliff failure (erosion) following December 2013 storm event (courtesy of NNDC)

1.3.2 Embankment scour

During the December 2013 storm event the embankment above the sea wall (and below the public access ramp) failed. This was caused by water overtopping the sea wall, impacting the embankment and scouring away material from the embankment. A repair was made to the embankment in March 2014. The repair involved the replacement of material and then covering of the slope with a geotextile; however, this was only ever intended as a temporary repair and if another event like the December 2013 storm were to occur then the scour failure is likely to be repeated.

Figure 1-2: Photograph of embankment scour failure following December 2013 storm event (courtesy of NNDC)

1.4 Purpose of the report

This document outlines the process of the option development and appraisal for the 1.9 km Mundesley frontage. The aim of this document is to demonstrate that a robust option development process has been undertaken to inform selection of preferred options for managing this section of coastline.

2. Existing Defences

There are a number of different existing defences along the Mundesley coastline. A Coastal Defence Condition Survey Update carried out by AECOM in November 2016 gives a detailed assessment of the types of structure present on the frontage, their location and condition, a summary of this report is presented in Section 2.1.

The principal types of defences existing on the frontage are:

- **Timber groynes**
  Timber groynes existing along the frontage acting to trap sediment and increase beach levels. Typically they are 60-70 m long and permeable.

- **Sea wall**
  A concrete sea wall protects approximately 580 m of the frontage. The area landward of this protection is the most heavily built-up part of Mundesley. The sea wall varies in design with different types of recurve detail and widths of apron.

- **Timber revetment**
  Two sections of hardwood timber revetment protect the frontage. The section southeast of the sea wall measures approximately 230m and the section northwest of the sea wall measures approximately 675m.

- **Steel framed structure**
  A steel framed structure filled with concrete blocks and rubble exists along approximately 465 m of the frontage.

2.1 Summary of Condition Assessment

Table 2-1: Summary of Condition Assessment

Defence Reference	Defence Description	SCAPE Location	SMP Unit	Approximate Location	Previous Condition Grade	Current Condition Grade	Residual Life Without Maintenance (Years)	Residual Life With Maintenance (Years)
G2	Timber Groyne	47	6.09	TG31865 36308	Good/ Fair	Fair	5	10
S2	Timber Revetment	47	6.09	TG31825 36348	Good	Fair	3	8
G3	Timber Groyne	47	6.09	TG31784 36400	Good/Fair	Fair	5	10
S3	Timber Revetment (Boat Park)	47	6.09	TG31738 36460	Good	Fair	3	8
G4	Timber Groyne	48	6.08	TG31730 36523	Good/ Fair	Good	8	15
S4	Concrete Seawall	48	6.08	TG31706 36530	Good	Good	15	30
G5	Timber Groyne (Concrete Outfall)	48	6.08	TG31664 36588	Good/ Fair	Fair	5	10
S5	Concrete Seawall	48	6.08	TG31607 36613	Good	Good	15	30
G6	Timber Groyne	48	6.08	TG31546 36706	Good/ Fair	Poor	1	5
S6	Concrete Seawall	48	6.08	TG31466 36736	Good	Fair	10	20
G7	Timber Groyne	48	6.08	TG31390 36843	Good/ Fair	Poor	1	5
S7t	Concrete Seawall	48	6.08	TG31358 36832	Good	Fair	10	20
S7t	Framed Structure	49	6.08	TG31301 36884	Poor	Poor	2	5

Defence Reference	Defence Description	SCAPE Location	SMP Unit	Approximate Location	Previous Condition Grade	Current Condition Grade	Residual Life Without Maintenance (Years)	Residual Life With Maintenance (Years)
G8	Timber Groyne	49	6.08	TG31284 36911	Good/ Fair	Fair	5	10
S8	Framed Structure	49	6.08	TG31241 36919	Poor	Fair	5	10
G9	Timber Groyne	49	6.08	TG31144 37002	Good/ Fair	Good	8	15
S9	Framed Structure	49	6.08	TG31055 37076	Poor	Poor	2	5
G10	Timber Groyne	49	6.08	TG31011 37111	Good/ Fair	Fair	5	10
S10t	Framed Structure	49	6.08	TG31016 37118	Poor	Poor	2	5
S10t	Timber Revetment	50	6.08	TG30902 37208	Good	Fair	3	8
G11	Timber Groyne	50	6.08	TG30886 37223	Good/ Fair	Fair	5	10
S11	Timber Revetment	50	6.08	TG30822 37269	Good	Fair	3	8
G12	Timber Groyne	50	6.08	TG30747 37319	Good/ Fair	Good	5	10
S12	Timber Revetment	50	6.08	TG30685 37366	Good	Fair	3	8
G13	Timber Groyne	50	6.08	TG30608 37422	Good/ Fair	Fair / (Poor at the seaward end)	5	10
							1	5
S13	Timber Revetment	51	6.07	TG30533 37470	Good	Fair	3	8
G14	Timber Groyne (Piped Outfall)	51	6.07	TG30473 37505	Good/ Fair	Fair	5	10

Note: The updated condition assessment took place in October 2016, i.e. before the winter storms of 2016/17 took place.

3. Option Development

3.1 Long list

In order to develop a robust business case and to ensure that no potential options were overlooked the option development process initially involved creating a long list of potential coastal management approaches and options available to manage the erosion risk along the frontage, this list could then be used to facilitate production of a short list of options to be appraised in more detail.

Note: at long list stage options to address the scour problem of the embankment (Section 1.3.2) were not included.

3.2 Coastal management approaches

Before considering options, the overall approach to management of the coast had to be considered. The potential approaches to coastal management considered were:

- **Approach A – Do Nothing**
  The Do Nothing approach would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course. The Do Nothing approach is a baseline against which all other options will be compared.

  This approach is **discounted** because it is not compliant with the 'Hold the Line' policy and will lead to large damages, but it will be used as a baseline to judge other options.

- **Approach B – Do Minimum**
  The Do Minimum approach involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works.

  This approach is **discounted** because it is not compliant with the 'Hold the Line' policy and will also lead to large damages.

- **Approach C – Maintain Existing Defences – maintain what's already there**
  This involves the continued monitoring and maintenance of the existing defences, as well as allowing for the like-for-like replacement of failed or failing structures. However, this option does not include enhancing or improving the defences so accepts the level of protection will fall over time due to climate change.

  This approach may be suitable for some defences on the frontage and **options should be developed** to explore this approach further.

- **Approach D – Maintain or Improve Existing Protection – keeping the protection level the same or improving the protection level**
  This involves monitoring and maintaining existing defences as well as raising or enlarging the current defences to improve the level of protection.

  This approach may be suitable for some defences on the frontage and **options should be developed** to explore this approach further.

3.3 Long list options

The long list options were chosen based upon typical coastal erosion defences found on the UK coastline and in North Norfolk. The long list options included:

- **Option 1 – Concrete Sea wall –** A reinforced concrete sea wall along the toe of the cliff in unprotected areas, extension of existing sea wall.
- **Option 2 – Off-shore Rock Armour Breakwater –** Multiple offshore rock armour breakwaters.
- **Option 3 – Rock Armour Revetment –** Rock armour along the toe of the cliff in unprotected areas.
- **Option 4 – Concrete Block Revetment –** A revetment formed of concrete block mattresses along the toe of the cliff in unprotected areas.

- **Option 5 – Placed Rock Armour Protection –** A rock armour ‘berm’ located on the beach seaward of the existing defences.
- **Option 6 – Extend/Enhance/Replace Timber Revetments –** Extend the existing timber revetment defences by replicating the current structure.
- **Option 7 – Enhance/Extend/Replace Steel Framed Concrete Blocks –** Extend the existing steel framed concrete block defences by replicating the current structure.
- **Option 8 – Enhance/Replace Timber Groyne Field –** Improve the existing groynes by making repairs and improvements to make the groynes impermeable.
- **Option 9 – Rock Armour Groyne Bays –** Rock armour groynes extending further offshore than at present and replacing the current timber groynes.
- **Option 10 – Gabion Toe Protection –** Gabion baskets along the toe of the cliff in unprotected areas.
- **Option 11 – Beach Nourishment –** Placing of sand directly onto the beach.
- **Option 12 – Cliff Stabilisation –** Install steel mesh fixed with soil nails (dowels) on the face of areas of unprotected cliff.

3.4 Long list option assessment

The selection of the most appropriate options from the long list to be taken to the short list was guided in a number of ways:

- An assessment of the advantages and disadvantages of each option (Table 3-1);
- The value of ‘Do Nothing’ damages were used to identify the unaffordable options based on the funding system;
- A client workshop with North Norfolk District Council provided feedback on the options and agreed the options to be taken forward to the short list.

Table 3-1: Long list options advantages and disadvantages

Option Name	Advantages	Disadvantages
Option 1 - Concrete Sea wall	• Will prevent erosion in the long term • Potential opportunities for recreational/amenity benefits • Most effective defence at preventing wave action impacting cliffs	• Relatively very expensive • Will change aesthetics of this section of coastline • Potential to lower beach levels with less sediment from cliff entering environment
Option 2 - Off-shore Rock Armour Breakwater	• Will absorb wave energy • Potentially will increase beach levels • Reduced rate of cliff erosion • Potentially could create off-shore habitat	• Will impact offshore environment and coastal processes • Relatively very expensive • Potentially will have to be combined with other beach management options
Option 3 - Rock Armour Revetment	• Will significantly reduce cliff erosion by dissipating wave energy • Requires little maintenance • Can be repositioned if displaced or required elsewhere	• Typically rock is not used in this area – change in aesthetics • Potential to lower beach levels with less sediment from cliff entering environment • Potential health and safety risk – people climbing on revetment • Large quantity of rock required
Option 4 - Concrete Block Revetment	• Will protect the toe of the cliff • Requires little maintenance	• Smooth surface of defence promotes wave run-up, not suitable for steep cliff • Offers no beach management – risk of beach lowering • Will have to be combined with another option to protect toe of defence from scour • Potential to lower beach levels with less sediment from cliff entering environment
Option 5 - Rock Armour Protection	• Will significantly reduce cliff erosion by dissipating wave energy • Requires little maintenance • Can be repositioned if displaced or required elsewhere • Will impact on beach management	• Can create health and safety risks (changing beach levels will hide/expose rocks) • Typically rock is not used in this area – change in aesthetics • Will have a footprint on the beach that will potentially impact recreation activities/amenity benefit of beach • Potential to lower beach levels with less sediment from cliff entering environment

		• Large quantity of rock required • Will effectively 'split' the beach • Will affect the local coastal processes
Option 6 - Enhance/Extend/Replace Timber Revetments	• Relatively inexpensive • Will trap more sediment to increase beach levels and absorb wave action • Popular structure type on North Norfolk Coast – will not change appearance of frontage	• There will still be erosion as displayed with existing structures • Reduced amenity area • Will require continuous maintenance
Option 7 - Enhance/Extend/Replace Steel Framed Concrete Blocks	• Relatively inexpensive • Will trap more sediment to increase beach levels and absorb wave action • Matches existing defences • Simple construction method • Will act to protect cliffs from wave and slow rate of erosion	• There will still be some erosion behind the structure as currently experienced • Will require continuous maintenance • Offers no beach management • Additional visual impact • Reduced amenity area
Option 8 - Enhance/Replace Timber Groyne Field	• Relatively inexpensive (construction can be staggered) • Will trap more sediment to increase beach levels and absorb wave action • In keeping with existing defences • Will improve amenity area of the beach	• Will further disturb natural movement of sediment – could cause problems elsewhere • Potential health and safety issues with large changes in beach levels over groynes • Further modelling studies would be required to determine effectiveness
Option 9 - Rock Armour Groynes	• Will trap more sediment to increase beach levels and absorb wave action • Potentially create new habitats • Will improve amenity area of the beach	• Will impact offshore environment • Further modelling studies would be required to determine effectiveness • Can create significant health and safety risks (changing beach levels will hide expose rocks) • Will impact aesthetics and potentially use of beach – large footprint • Will affect coastal processes • Large quantity of rock required
Option 10 - Gabion Toe Protection	• Gabions placed behind existing defences could have improved lifespan and be more effective than if left exposed to wave climate • Will absorb wave action • Relatively inexpensive • Usually less intrusive, can be removed and relocated if required	• Gabions lifespan dependent on wave climate, typically short in strong wave climates • Potentially expensive to maintain • Potential to lower beach levels with less sediment from cliff entering environment • Offers no beach management
Option 11 - Beach Nourishment	• Will increase beach levels – a more natural approach to protection • Aesthetically pleasing (no hard structures) • Potentially beneficial for recreation/amenity	• Will have to be reoccurring to maintain beach levels –expensive in long term • Further modelling studies would be required to determine effectiveness • To prolong effectiveness it must be combined with other beach management techniques • Will potentially impact on local ecology
Option 12 - Cliff Stabilisation	• Will reduce amount of material lost from cliff due to weathering erosion • Will not have a footprint on the beach • Relatively cheap	• Will have to be combined with another option to protect the toe of the cliff from wave action • Potential to lower beach levels with less sediment from cliff entering environment • Will cover cliff face – location of geological interest • Aesthetically poor • Health and safety risks of construction work at height • Environmentally detrimental to cliff

3.5 Short list options

The following short list options were chosen through the process described in Section 3.4. In order to develop a business case to implement the preferred management policy the option development process involved producing outline designs of the options, costings of the options (see Section 4) and assessing the whole life-cycle risks associated with these options as well as the advantages and disadvantages of each option.

The short list of options primarily included options to deal with the coastal erosion of the frontage. However, the client during the options workshop also requested for a range of options to be developed to address the isolated scour of an embankment behind the sea wall caused by overtopping. The options to address the isolated embankment scour problem are presented separately in Section 3.6.

Drawings showing the outline designs of the options are presented in Appendix A. Note that any dimensions or types of materials shown on drawings are based on engineering judgement for costing purposes only.

3.5.1 Option 1 - Sea wall and apron encasement

The sea wall and apron option is to encase the sea wall and apron in areas which are in poor condition (condition of sea wall and apron varies due to maintenance/repair activities). The material used to encase the existing structures is reinforced concrete; this will be connected to the existing structure using embedded dowels.

At the detailed design stage the recurve at the top of the wall should be developed, the outline design recommends that to avoid construction issues the existing recurve at the top of the wall should be broken out. The apron encasement is to also cover over the top of the steel sheet pile, this is to protect this area from erosion and slow the rate of deterioration.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Will protect the existing structure and extend its residual life. • No significant change in footprint of structure. • Has been successfully implemented at nearby Cromer, NNDC has recent experience of managing this type of scheme. • Will widen the promenade, improving accessibility. • Will reduce overtopping of the seawall	• Works will disrupt public access to promenade. • Different re-curve shapes on the sea wall potentially requiring different shutters for each type of curve. • In-situ concrete works present an environmental risk in the tidal environment. Precast concrete could reduce this risk, but is not suitable in this application.

Table 3-2. Sea wall and Apron Encasement Advantages and Disadvantages

3.5.2 Option 3 – Rock Revetment

The rock revetment option is to construct a double layer of rock armour protection at the toe of the cliff. The rock armour will be built on a geotextile underlayer and a large size of rock, or 'keystone', will be placed at the seaward extent of the revetment. Where there are existing defences that would interfere with the width of the bottom of the revetment the rock could either be extended to the existing defence and terminated or alternatively the existing defence could be removed. Even if the existing defences are to remain in place isolated sections will have to be removed in order to gain access to the cliff. To design for the variable steepness of the toe of the cliff the profile of the front face of the rock revetment should be kept consistent and the area behind filled with rock or granular fill material.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Effective at dissipating wave energy therefore reducing the amount of wave energy impacting the cliff. • Will not interfere with the main area of beach used by the public, the area at the top of the beach behind existing defences is not currently accessible to the public. • Rock is relatively easy to move around, can be	• A very large amount of rock required, cost implications. • Will have to remove some of existing defences to gain access to cliff. • Will last longer than the 2055 date where SMP policy changes to Managed Realignment, will give public 'false hope' that Council intends to prevent cliff retreat.

repositioned if displaced or required elsewhere. • Requires little maintenance.	• Slowing cliff erosion will reduce sediment input into the environment and reduce sediment supply to the beach and other sites down drift. • Use of rock armour in this area is limited; this will lead to a change in aesthetics.

Table 3-3. Rock Revetment Advantages and Disadvantages

3.5.3 Option 5 – Placed rock armour protection (behind timber revetment)

The placed rock armour option is to place rock armour directly behind the timber revetment. This would be located prioritising the areas of timber revetment with poorest condition. As the timber revetment failed this new structure would offer protection. The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Prioritises areas most in need of additional protection. • Effective at dissipating wave energy therefore reducing the amount of wave energy impacting the cliff. • Will not interfere with the main area of beach used by the public, the area behind existing defences is not currently accessible to the public. • Rock is relatively easy to move around, can be repositioned if displaced or required elsewhere. • Requires little maintenance.	• A very large amount of rock required, cost implications. • Will have to remove some of existing defences to gain access behind. • Will last longer than the 2055 date where SMP policy changes to Managed Realignment, will give public 'false hope' that Council intends to prevent cliff retreat. • Slowing cliff erosion will reduce sediment input into the environment and reduce sediment supply to the beach and other sites down drift. • Use of rock armour in this area is limited; this will lead to a change in aesthetics.

Table 3-4. Placed Rock Armour Protection Advantages and Disadvantages

3.5.4 Option 6 – Timber revetment

New oak timber revetment

The new oak timber revetment option is to replace the current timber revetment with a new oak timber revetment which utilises the existing steel sheet piling. The outline design of the timber revetment has been based on the arrangement and dimensions of the existing structure. The existing defence would be removed and replaced, apart from the buried steel sheet piling acting as scour protection for the structure which would be incorporated into the new design. The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing steel sheet pile structure. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Cheaper alternative to tropical hardwood.	• Option assumes the condition of the existing sheet pile will provide scour protection. Condition is currently unknown because it is below beach level. Detailed design stage would have to investigate condition further and if improvement works are required this will lead to additional cost. • If beach level falls waves will reflect off sheet piling leading to increased scour in front of the structure. • Timber (particularly oak) has a relatively short residual life and as a consequence is expensive to maintain; as experienced with existing structure. • Not very effective at dissipating wave energy. • Oak not considered suitable for marine environment unless embedded because it will disintegrate quickly.

Table 3-5. New Oak Timber Revetment Advantages and Disadvantages

New tropical hardwood timber revetment

The new tropical hardwood timber revetment option is to replace the current timber revetment with a new tropical hardwood timber (i.e. Greenheart or Ekki) revetment which utilises the existing steel sheet piling. The outline design of the timber revetment has been based on the arrangement and dimensions of the existing structure. The existing defence would be removed and replaced, apart from the buried steel sheet piling acting as scour protection for the structure which would be incorporated into the new design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing steel sheet pile structure. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Tropical hardwood effective in marine environments.	• Option assumes the condition of the existing sheet pile will provide scour protection. Condition is currently unknown because it is below beach level. Detailed design stage would have to investigate condition further and if improvement works are required this will lead to additional cost. • If beach level falls waves will reflect off sheet piling leading to increased scour in front of the structure. • Timber has a relatively short residual life and as a consequence is expensive to maintain; as experienced with existing structure. • Not very effective at dissipating wave energy. • Environmental implications of importing tropical timber (and added cost of ensuring sustainable source).

Table 3-6. New Tropical Hardwood Timber Revetment Advantages and Disadvantages

Refurbishment of revetment using tropical hardwood

The refurbishment of timber revetment option is to, instead of completely replacing the timber revetment, only carry out isolated replacement or refurbishment. No significant changes would be made to the design of the revetment. Replacement of timber elements would use tropical hardwood timber. Two levels of refurbishment have been considered, replacing 50% of the structure or replacing 25% of the structure.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Extends the life of the existing structures. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Tropical hardwood effective in marine environments.	• Option assumes the condition of the existing sheet pile will provide scour protection. Condition is currently unknown because it is below beach level. Detailed design stage would have to investigate condition further and if improvement works are required this will lead to additional cost. • If beach level falls waves will reflect off sheet piling leading to increased scour in front of the structure. • Timber has a relatively short residual life and as a consequence is expensive to maintain, as experienced with existing structure. • Continual maintenance over time might lead to higher costs than just replacing the structure. • Not very effective at dissipating wave energy. • Environmental implications of importing tropical timber (and added cost of ensuring sustainable source).

Table 3-7. Refurbishment of Revetment Advantages and Disadvantages

3.5.5 Option 7 – Steel framed structure

Enhancement of existing steel framed protection (with concrete blockwork)

The enhancement of existing steel framed protection option is to add another steel frame in front of the existing structure. This has two purposes: firstly to contain new concrete cubes placed in the new frame in order to improve wave dissipation and also to contain the existing concrete cubes as the existing steel structure fails. Where possible (in areas not immediately adjacent to the cliff) new rock armour will be placed behind the existing structure, this is primarily to help retain the existing concrete cubes (rock armour units will be of a larger size than the existing concrete cubes) and also provides additional wave dissipation. The specifics of the enhanced frame to be completed in detailed design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing structure and will extend its residual life. • If level of beach falls the concrete blocks will also fall and continue to dissipate wave energy. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Concrete blocks are cast with lifting loops for easy installation, potential supplier in nearby Cromer. • Concrete blocks being a regular cube size have the advantage over rock armour of allowing the spacing between the vertical steel frame members to be increased.	• When existing structure fails (expected even with additional protection) any broken corroded steel could be lifted out of structure and be deposited on the beach creating health and safety risks. • Line of existing defence is set forward from cliff; generally new defences are designed to be at the top of the beach next to the cliff. • Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Trucks transporting concrete blocks from nearby Cromer will have to travel through Mundesley potentially causing traffic and noise disruption. • The placement of the concrete cubes needs to be controlled so that there are sufficient gaps between the blocks and a 'random' arrangement is formed to prevent the cubes effectively forming a vertical sea wall which potentially will lead to scour problems due to high wave reflection. • Mixture of materials that effectively are being used for the same purpose (concrete cubes and rock armour) will lead to reduced quantities and potentially higher unit costs.

Table 3-8. Enhancing of Existing Steel Framed Protection (Concrete Blockwork) Advantages and Disadvantages

Enhancement of existing steel framed protection (with rock armour)

The enhancement of existing steel framed protection option is to add another steel frame in front of the existing structure. This has two purposes: firstly to contain new rock armour placed in the new frame in order to improve wave dissipation and also to contain the existing concrete cubes as the existing steel structure fails. Where possible (in areas not immediately adjacent to the cliff) new rock armour will be placed behind the existing structure, this is primarily to help retain the existing concrete cubes (rock armour units will be of a larger size than the existing concrete cubes) and also provides additional wave dissipation. The specifics of the enhanced frame to be completed in detailed design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing structure and will extend its residual life. • If the level of the beach falls the rocks will also fall and continue to dissipate wave energy.	• When existing structure fails (expected even with additional protection) any broken corroded steel could be lifted out of structure and be deposited on the beach creating health and safety risks.

• Type of protection exists on the frontage and therefore affects are known (proven technique). • Rock could be transported to the site via the sea and therefore avoid disrupting Mundesley with added traffic. • Use of one material rock to dissipate wave energy will increase quantities and potentially lower unit costs. • Rock can be dumped into new steel frame with little controlled placement required.	• Line of existing defence is set forward from cliff; generally new defences are designed to be at the top of the beach next to the cliff. • Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Because of the varying size and dimensions of rock the spacing between the vertical steels will have to be reduced to hold the rock in place or controlled via the rock length to thickness ratio and size of rock, this will potentially lead to increased costs.

Table 3-9. Enhancing of Existing Steel Framed Protection (Rock Armour) Advantages and Disadvantages

Enhancement of existing steel framed protection (with concrete blockwork) by increasing height

The enhancement of existing steel framed protection option is to add another steel frame in front of the existing structure, at a shorter distance than that of the other enhancement option. This will firstly contain new concrete cubes placed in the new frame in order to improve wave dissipation and also to contain the existing concrete cubes as the existing steel structure fails. Concrete cubes will be placed on top of the existing structure to increase the overall height of the defence. Where possible (in areas not immediately adjacent to the cliff) new rock armour will be placed behind the existing structure, this is primarily to help retain the existing concrete cubes (rock armour units will be of a larger size than the existing concrete cubes) and also provides additional wave dissipation. The specifics of the enhanced frame to be completed in detailed design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing structure and will extend its residual life. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Concrete blocks are cast with lifting loops for easy installation, potential supplier in nearby Cromer. • Concrete blocks being a regular cube size have the advantage over rock armour of allowing the spacing between the vertical steel frame members to be increased. • Will have a smaller footprint than the alternative enhancement of steel frame steel option because the new steel frame is placed closer to the existing structure steel frame. • Higher structure level should lead to increased dissipation of incoming wave energy, reducing energy impacting cliffs.	• When existing structure fails (expected even with additional protection) any broken corroded steel could be lifted out of structure and be deposited on the beach creating health and safety risks. • Line of existing defence is set forward from cliff; generally new defences are designed to be at the top of the beach next to the cliff. • Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Trucks transporting concrete blocks from nearby Cromer will have to travel through Mundesley potentially causing traffic and noise disruption. • The placement of the concrete cubes needs to be controlled so that there are sufficient gaps between the blocks and a ‘random’ arrangement is formed to prevent the cubes effectively forming a vertical sea wall which potentially will lead to scour problems due to high wave reflection. • Mixture of materials that effectively are being used for the same purpose (concrete cubes and rock armour) will lead to reduced quantities and potentially higher unit costs. • Increasing height of the concrete cubes will increase the risk of them being forced out of steel frame by wave action. • Placement of more concrete blocks onto the existing structure could potentially damage the existing concrete blocks and/or the existing steel works.

Table 3-10. Enhancing of Existing Steel Framed Protection (Concrete Blockwork) with increased height Advantages and Disadvantages

Enhancement of existing steel framed protection (with rock armour) by increasing height

The enhancement of existing steel framed protection option is to add another steel frame in front of the existing structure, at a shorter distance than that of the other enhancement option. This will firstly contain the new rock armour placed in the new frame in order to improve wave dissipation and also to contain the existing concrete cubes as the existing steel structure fails. Rock armour will be placed on top of the existing structure to increase the overall height of the defence. Where possible (in areas not immediately adjacent to the cliff) new rock armour will be placed behind the existing structure, this is primarily to help retain the existing concrete cubes (rock armour units will be of a larger size than the existing concrete cubes) and also provides additional wave dissipation. The specifics of the enhanced frame to be completed in detailed design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing structure and will extend its residual life. • If the level of the beach falls the rocks will also fall and continue to dissipate wave energy. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Rock could be transported to the site via the sea and therefore avoid disrupting Mundesley with added traffic. • Use of one material rock to dissipate wave energy will increase quantities and potentially lower unit costs. • Rock can be dumped into new steel frame with little controlled placement required. • Higher structure level should lead to increased dissipation of incoming wave energy, reducing energy impacting cliffs.	• When existing structure fails (expected even with additional protection) any broken corroded steel could be lifted out of structure and be deposited on the beach creating health and safety risks. • Line of existing defence is set forward from cliff; generally new defences are designed to be at the top of the beach next to the cliff. • Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Because of the varying size and dimensions of rock the spacing between the vertical steels will have to be reduced to hold the rock in place or controlled via the rock length to thickness ratio and size of rock, this will potentially lead to increased costs. • Increasing height of the rock will increase the risk of them being forced out of steel frame by wave action. • Placement of the rock onto the existing structure could potentially damage the existing concrete blocks and/or the existing steel works.

Table 3-11. Enhancing of Existing Steel Framed Protection (Rock Armour) Advantages and Disadvantages

New steel framed protection (with concrete blockwork)

The new steel framed concrete blockwork protection option is to replace the existing defence structures or place in undefended areas with a new steel framed structure similar to the existing steel framed protection. The structure will consist of two rows of steel vertical members forming a frame structure that will be filled with randomly placed concrete cubes to dissipate wave energy.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• If level of beach falls the concrete blocks will also fall and continue to dissipate wave energy. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Concrete blocks are cast with lifting loops for easy installation, potential supplier in nearby Cromer. • Concrete blocks being a regular cube size have the advantage over rock armour of allowing the spacing between the vertical steel frame members to be increased.	• Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost, this design would require purchase of new steel at a much greater cost and a large amount of steel will be required. • Trucks transporting concrete blocks from nearby Cromer will have to travel through Mundesley potentially causing traffic and noise disruption.

• Can be designed to be next to toe of cliff, will be at a higher level and therefore more effective than current alignment. • Higher structure level should lead to increased dissipation of incoming wave energy, reducing energy impacting cliffs.	• The placement of the concrete cubes needs to be controlled so that there are sufficient gaps between the blocks and a 'random' arrangement is formed to prevent the cubes effectively forming a vertical sea wall which potentially will lead to scour problems due to high wave reflection. • Mixture of materials that effectively are being used for the same purpose (concrete cubes and rock armour) will lead to reduced quantities and potentially higher unit costs.

Table 3-12. New Steel Framed Protection (Concrete Blockwork) Advantages and Disadvantages

New steel framed protection (with rock armour)

The new steel framed rock protection option is to replace the existing defence structures or place in undefended areas with a new steel framed structure similar to the existing steel framed protection. The structure will consist of two rows of steel vertical members forming a frame structure that will be filled rock armour to dissipate wave energy.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Makes use of existing structure and will extend its residual life. • If the level of the beach falls the rocks will also fall and continue to dissipate wave energy. • Type of protection exists on the frontage and therefore affects are known (proven technique). • Rock could be transported to the site via the sea and therefore avoid disrupting Mundesley with added traffic. • Use of one material rock to dissipate wave energy will increase quantities and potentially lower unit costs. • Rock can be dumped into new steel frame with little controlled placement required. • Can be designed to be next to toe of cliff, will be at a higher level and therefore more effective than current alignment.	• Steel will corrode over time and is not aesthetically pleasing. • The existing structure was constructed using left-over steel acquired at a cheaper cost, this design would require purchase of new steel at a much greater cost and a large amount of steel will be required. • Because of the varying size and dimensions of rock the spacing between the vertical steels will have to be reduced to hold the rock in place or controlled via the rock length to thickness ratio and size of rock, this will potentially lead to increased costs.

Table 3-13. New Steel Framed Protection (Rock Armour) Advantages and Disadvantages

3.5.6 Option 8 – Timber groynes

Refurbish existing groynes

The refurbish existing groynes option is to repair the current groyne field by replacing timber elements that are damaged or missing with hardwood like-for-like replacements. No significant changes would be made to the design of the groynes, they would still be permeable. The majority of the timber elements that require replacing are located on the seaward ends of the groynes. Three levels of refurbishment have been considered, replacing 30% of the structure (major), replacing 20% of the structure (mean) and replacing 10% of the structure (minor).

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Will extend the residual life of existing structures. • Construction can be staggered; through condition assessment different elements can be prioritised and planned at intervals. • Effectiveness of this arrangement is known from experience.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations. • Can be technically challenging to replace elements – with the groynes partially hidden beneath the beach and with changing beach levels it can be difficult to assess the condition of the structure. Also, because of corrosion of fixings between connecting elements when a part needs to

	be replaced often additional planks have to be cut and removed and replaced leading to additional cost. • Timber required for replacement is tropical hardwood which has environmental implications. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and also cost through an extended programme. • Timber has a short residual life in marine environment.

Table 3-14. Refurbish Existing Groynes Advantages and Disadvantages

Refurbish and enhance existing groynes

The refurbish and enhance existing groynes option is to repair the current groyne field by replacing timber elements that are damaged or missing with hardwood like-for-like replacements (as above). Following repair the groynes would also be enhanced to make them trap more sediment. This would be achieved by adding extra timber planks to one side of the groynes to make them impermeable. The lower bays of the groyne would be left permeable to allow longshore drift of sediment along the beach.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Will extend the residual life of existing structures. • Construction can be staggered; through condition assessment different elements can be prioritised and planned at intervals. • Will trap more sediment to increase beach levels and absorb wave energy.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations (more than repair only option). • Can be technically challenging to replace elements – with the groynes partially hidden beneath the beach and with changing beach levels it can be difficult to assess the condition of the structure. Also, because of corrosion of fixings between connecting elements when a part needs to be replaced often additional planks have to be cut and removed and replaced leading to additional cost. • Timber required for replacement is tropical hardwood which has environmental implications. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and also cost through an extended programme. • Increased amount of timber will be required compared to repair only, will lead to additional cost. • Potentially the groynes being impermeable could lead to large changes of beach levels over groynes and cause safety issues. • Further modelling studies are potentially required to determine the effectiveness of this new arrangement. • Timber has a short residual life in marine environment.

Table 3-15. Refurbish and Enhance Existing Groynes Advantages and Disadvantages

Replacing with new permeable timber groynes

The replacing with new permeable groynes option is to replace all the current groynes with permeable groynes (like the existing). It is anticipated that this would take place after the existing groynes have failed. For the purposes of outline design it has been assumed that a like-for-like replacement would take place. However, it is expected that at detailed design stage further studies would need to be undertaken to decide on how to optimise the spacing and length of the new groynes.

The advantages and disadvantages of this option are:

Advantages	Disadvantages

• Will trap sediment to increase beach levels and absorb wave energy. • Can be designed to have a design life which ties in with SMP policy of the frontage. • Effectiveness of this arrangement is known from experience. • Technically feasible – less uncertainty than refurbishing of existing structures.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations. • Large amount of tropical hardwood timber required for new structure which has environmental implications as well as cost. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and also cost through an extended programme. • Current groynes would need to be removed leaving some elements, i.e. timber piles, in place could cause health and safety issues. • Timber has a short residual life in marine environment.

Table 3-16. Replace with New Permeable Timber Groyne Advantages and Disadvantages

Replacing with new impermeable timber groynes

The replacing with new impermeable groynes option is to replace all the current groynes with impermeable groynes. It is anticipated that this would take place after the existing groynes have failed. For the purposes of outline design it has been assumed that a similar sized structure to the existing would be constructed. However, it is expected that at detailed design stage further studies would need to be undertaken to decide in how to optimise the spacing and length of the new groynes. The lower bays of the groyne would be left permeable to allow longshore drift of sediment along the beach.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Will trap more sediment to increase beach levels and absorb wave action, more than existing permeable groynes. • Can be designed to have a design life which ties in with SMP policy of the frontage. • Technically feasible – less uncertainty than refurbishing of existing structures.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations (would be more significant than permeable groynes). • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and also cost through an extended programme. • Potentially the groynes being impermeable could lead to large changes of beach levels over groynes and cause safety issues. • Further modelling studies are potentially required to determine the effectiveness of this new arrangement. • Current groynes would need to be removed leaving some elements, i.e. timber piles, in place could cause health and safety issues. • Large amount of tropical hardwood timber required for new structure which has environmental implications as well as cost. • Timber has a short residual life in marine environment.

Table 3-17. Replacing with New Impermeable Timber Groyne Advantages and Disadvantages

Refurbish and modify existing groynes (hybrid timber/rock groynes)

The refurbish and modify existing groynes option is to repair the top (landward end) of the current groyne field by replacing timber elements that are damaged or missing with hardwood like-for-like replacements, at the bottom of the groyne (seaward end) the existing structure will be replaced with a rock groyne arrangement. The idea behind this new arrangement is the majority of damage to the groynes is confined to the seaward end of the groynes and therefore should be protected with rock which is more robust than timber. For the purposes of outline design it has been assumed that a similar sized structure to the existing would be constructed. However, it is expected that at detailed design stage further studies would need to be undertaken to decide whether shortening or lengthening the groyne could improve the design.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Will extend the residual life of existing structures. • Construction can be staggered; through condition assessment different elements can be prioritised and planned at intervals. • Effectiveness of the timber element of this arrangement is known from experience. • Most vulnerable part of groyne will be a more robust design.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations. • Can be technically challenging to replace elements – with the groynes partially hidden beneath the beach and with changing beach levels it can be difficult to assess the condition of the structure. Also, because of corrosion of fixings between connecting elements when a part needs to be replaced often additional planks have to be cut and removed and replaced leading to additional cost. • Timber required for replacement is tropical hardwood which has environmental implications. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and also cost through an extended programme. • Rock generally more expensive than timber. • Further modelling studies are potentially required to determine the effectiveness of this new arrangement.

Table 3-18. Refurbish and Modify Existing Groynes Advantages and Disadvantages

3.5.7 Option 11 – Beach nourishment

The beach nourishment/recharge option involves the addition of new material to the beach to increase the level of the beach. The beach recharge would supply material via spraying from a barge onto the beach; the material would match the existing beach material. The increase in level of beach will cause waves to break 'earlier' and therefore the amount of wave energy reaching the cliff is reduced. The outline design of the option includes increasing the level of the top of the beach to a greater height than the present day 1 in 100 year water level (annual exceedance probability). The scheme will require periodic beach recharge or 'top-ups' to maintain the scheme and account for the removal of the material as the beach returns to its natural levels.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• A more 'natural' approach than introducing hard structures (less invasive). • Aesthetically pleasing. • Potentially beneficial for recreation/amenity use. • Introducing sediment to this frontage will be a benefit for down drift locations.	• Beach will tend to return to its natural level over time, will require periodic 'top-ups' leading to extra cost. • To be effective the height of groynes will have to be increased, altering the groynes will lead to additional cost. • Will potentially impact negatively on local environment by changing habitat. • Further modelling studies would be required to determine effectiveness. • Due to the dynamic nature of beaches even with modelling there will be an element of uncertainty, potentially one large storm event might return the beach to original levels.

Table 3-19. Beach Recharge Advantages and Disadvantages

3.6 Embankment scour protection

Drawings showing the outline designs of the options are presented in Appendix B. Note that any dimensions or types of materials shown on drawings are based on outline design and have been used for the costing.

3.6.1 Scour protection wall

The new scour protection wall option is to install a new reinforced concrete wall at the landward side of the walkway along the edge of the existing promenade. There is already a dwarf wall in this location of works, but a higher wall would reduce the amount of overtopping. To prevent the amenity use of the walkway being impacted (location of beach huts in the summer) the new wall would be built 'into' the embankment to reduce its footprint.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Wall height can be designed to limit overtopping to an acceptable amount – eliminates cause of problem. • Prevents problem from occurring rather than protecting against it.	• Will change the aesthetics of the frontage. • Construction would cause disruption to the walkway. • Likely that wall height will have to be substantial and wall will therefore have added cost and visual impact to limit overtopping to an acceptable level. Or, option will have to be combined with another leading to further cost.

Table 3-20. New Scour Protection Wall Advantages and Disadvantages

3.6.2 Scour protection sprayed concrete

The new scour protection involves using sprayed concrete on the embankment. A steel mesh would be fixed to the embankment first before concrete is sprayed to it. This would protect against wave impacts on the embankment. Drainage pipes would potentially have to be incorporated to increase drainage from the embankment.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Impermeable scour protection. • Requires low maintenance. • Offers a high level of protection against wave impacts. • Easy installation.	• Not environmentally friendly. • Will change the aesthetics of the frontage (high visual impact). • Will encourage wave run-up (smooth surface); meaning protection level would have to be higher than other options.

Table 3-21. New Scour Protection Sprayed Concrete Advantages and Disadvantages

3.6.3 Scour protection concrete block revetment

The new scour protection involves the placing of a cabled concrete solid block revetment on the embankment. The crest height of the new protection has been designed by examining the height the embankment failed to in the December 2013 storm event; this would have to be refined at detailed design stage. A geotextile would have to be placed below the concrete block revetment for filtration purposes (or alternatively a granular material layer).

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Requires low maintenance. • Offers a high level of protection against wave impacts.	• Will change the aesthetics of the frontage (high visual impact). • Will encourage wave run-up (smooth surface); meaning protection level would have to be higher than other options. • Would be difficult to install because of varying distance between access ramp and bottom of slope.

Table 3-22. New Scour Protection Concrete Block Revetment Advantages and Disadvantages

3.6.4 Scour protection erosion control mat

The new scour protection involves covering the embankment with an erosion control mat pegged into the embankment. The crest height of the new protection has been assessed by examining the height the embankment failed to in the December 2013 storm event; this would have to be refined at detailed design stage.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Vegetation can grow on mat, can be seeded.	• Will not withstand as large wave forces as other options – is not much of an improvement on existing solution. • Life span is lower than other options (temporary measure).

Table 3-23. New Scour Protection Erosion Control Mat Advantages and Disadvantages

3.6.5 Scour protection gabions

The new scour protection involves removing some embankment material and installing gabions along the toe of the embankment. The crest height of the new protection has been designed by examining the height the embankment failed to in the December 2013 storm event; this would have to be refined at detailed design stage.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Some of the embankment will appear as it does now. • Will act to prevent run-up and dissipate wave energy.	• Will not withstand as large wave forces as other options. • The steel cages will corrode over time, or stainless steel can be provided but at added cost. • If overtopping analysis results in a solution being required that extends to a high level then many gabions would be required this would lead to high costs and negative visual impact.

Table 3-24. New Scour Protection Gabions Advantages and Disadvantages

3.6.6 Scour protection concrete canvas

The new scour protection involves the placing of a concrete canvas on the embankment. The crest height of the new protection has been designed by examining the height the embankment failed to in the December 2013 storm event; this would have to be refined at detailed design stage. Drainage pipes would potentially have to be incorporated to increase drainage from the embankment.

The advantages and disadvantages of this option are:

Advantages	Disadvantages
• Low maintenance. • Offers a high level of protection against wave impacts. • Impermeable scour protection.	• Not environmentally friendly. • Will change the aesthetics of the frontage (high visual impact). • Due to the shape of the areas, the laying of the canvas would likely lead to wastage. • Will encourage wave run-up (smooth surface); meaning protection level would have to be higher than other options. • If drainage pipes are required they would potentially be difficult to incorporate into the design.

Table 3-25. New Scour Protection Concrete Block Revetment Advantages and Disadvantages

4. Initial shortlist option costing

In order to compare the relative economic merits of the options and to generate the benefit cost ratios against the 'Do Nothing' baseline scenario, costs for the different options have been estimated.

4.1 Approach to capital construction activities

The cost estimations for capital works were undertaken using the best available information from a variety of sources. In the first instance where costing information was available from previous projects, published data or supplier quotations, these costs were used as a basis to cost the options.

In the absence of this information, values have been estimated from rates provided in civil engineering price books (e.g. SPONS 2016) and Environmental Agency guidance, coupled with experience of costs from similar projects. The indicative costs are valid as of December 2017.

For a number of the options considered the cost is dependent on the dimensions of the existing structures. This information was obtained using a combination of methods: LiDAR data (1m grid), historic drawings and topographic survey (sea wall/apron only).

4.1.1 Assumptions

The costs have been produced assuming:

- No services will require diverting;
- The land is not contaminated;
- VAT and any other taxes or duties are excluded;
- Site surveys and investigations are excluded;
- Statutory authority charges such as planning approval, services etc. are excluded;
- An allowance for unknown site or ground conditions is excluded;
- Where required (if past projects are used) inflation in cost has been based on Bank of England calculations;
- Cost of detailed design and developing a full business case is excluded.

4.2 Preliminary costs and optimism bias

4.2.1 Preliminary costs

To cost for items which are not typically accounted for in build-up of costs by tasks using price books; a preliminary cost of 35% has been applied. The following items are considered to be included in this cost:

- Establishment and running costs of contractors site offices, toilets, mess facilities act;
- Mobilisation and demobilisation of construction equipment;
- Provision of site vehicles;
- Contractor's site management team;
- Provision of stores and warehousing including labour and plant;
- Surveys, permits and insurances;
- Contractor's profit;
- Contractual requirements i.e. insurance;
- Detailed design fees.

4.2.2 Optimism bias

In line with FCERM-AG policy, an optimism bias of 30% was applied to the present value whole life costs for each option. According to Environmental Agency guidance, optimism bias;

"***is the tendency for appraisers to be overly optimistic in early assessment of project costs, time scales and benefits in comparison to the final values. To counter this HM Treasury issues guidance in the form of a percentage to increase the costs depending on the uncertainty surrounding the estimates. At the more detailed project stage, a figure of 30% is more commonly used. This percentage is added to the original estimate and used in the cost-benefit calculations.***"[1]

4.3 Summary of option costs

Table 4-1: Summary of Option Costs

Existing structure on frontage		Short listed options	Costing (£/m)
Sea wall		Sea wall and apron encasement	Various between (£792 - £3,074/m (depending on the section of wall and apron)
Timber revetment or Steel framed structure	Steel framed structure only	Enhancement of existing steel framed protection (with concrete blockwork)	£2,108/m*
		Enhancement of existing steel framed protection (with rock armour)	£1,794 -£1,810/m (depending on rock size)*
		Enhancement of existing steel framed protection (with concrete blockwork) by increasing height	£2,746/m
		Enhancement of existing steel framed protection (with rock armour) by increasing height	£2,043 - £2,078/m (depending on rock size)*
	Timber revetment or Steel framed structure	New steel framed protection (with concrete blockwork)	£3,922/m*
		New steel framed protection (with rock armour)	£3,579 - £3,622/m (depending on rock size)*
		Beach nourishment	£2,938/m
		Rock revetment	£2,305/m
		New oak timber revetment	£1,287/m
		New tropical hardwood timber revetment	£1,802/m
	Timber revetment only	Placed rock armour protection behind timber revetment	£1,925/m
		Major refurbishment of revetment with tropical hardwood (assume 50% of material requires replacing)	£901/m

[1] Flood and Coastal Erosion Risk Management appraisal guidance, Environment Agency, 2010

Existing structure on frontage		Short listed options	Costing (£/m)
		Minor refurbishment of revetment with tropical hardwood (assume 25% of material requires replacing)	£450/m
Timber groynes		Minor refurbishment of existing groynes (assume 10% of material requires replacing)	£273/m
		Medium refurbishment of existing groynes (assume 20% of material requires replacing)	£547/m
		Major refurbishment of existing groynes (assume 30% of material requires replacing)	£820/m
		Refurbish (20%) and enhance existing groynes (make impermeable)	£730/m
		Replace with new permeable timber groynes	£2,733/m
		Replace with new impermeable timber groynes	£2,984/m
		Refurbish (20%) and modify existing groynes (hybrid timber/rock groynes)	Refurbish = £820/m New permeable groyne = £2,733/m Addition of rock = £57,968/groyne
Embankment (scour protection)		Scour protection wall	£713/m
		Scour protection sprayed concrete	£395/m
		Scour protection concrete block revetment	£403/m
		Scour protection erosion control mat	£114/m
		Scour protection gabions	£1,182/m
		Scour protection concrete canvas	£256/m

*The costs of the options involving the introduction of further steel frame are conservative based on the prices of new steel. Going forward, there might be potential opportunities to reduce this cost by using recycled steel (e.g. railway tracks) instead of the new steel; this is considered further following the option appraisal.

5. Initial shortlist option appraisal

5.1 Comparison of short listed options

With the short listed options having been described, assessed on advantages and disadvantages, outline designed and costed it is useful to compare the options against some key parameters (Table 5-1):

- Functionality (technical performance);
- Technical feasibility;
- Future maintenance;
- Environmental impacts;
- Costing (£/m);
- Health and safety (only key risks listed);
- Risks (only key risks listed);
- Public acceptance.

Options have been grouped to separate options for the different types of existing structures: sea walls, timber groynes, timber revetment, steel framed structure; and the potential new scour protection to the embankment.

Table 5-1: Short listed options compared against key parameters

Existing structure on frontage		Short listed options	Functionality (technical performance)	Technical feasibility	Future maintenance	Environmental impacts	Costing (£/m)	Health and safety	Risks	Public acceptance
Sea wall		Sea wall and apron encasement	• Will protect the existing structure which is providing erosion protection and extend its residual life.	• Has successfully implemented in nearby locations, NNDC has recent experience of managing this type of scheme.	• Without this new encasement the existing sea wall will require increasingly expensive repairs to extend its residual life.	• No significant environment impacts beyond construction, no significant change in footprint of structure.	Various between (£792 - £3,074/m (depending on the section of wall and apron)	• Working at height at the top of the wall.	• Requires investigation into the current stability of the sea wall, to confirm whether encasement is suitable. However, this has not been found to be a significant issue at nearby sites.	• Expected to have no opposition from the public, other than potential disruption of promenade and access during works.
Timber revetment or Steel framed structure	Steel framed structure only	Enhancement of existing steel framed protection (with concrete blockwork)	• Will extend the benefits of the existing structure. • Standard of protection will fall over time.	• Is feasible. Scheme would have to be designed to account for the eventual failure of the existing structure.	• As the existing structure fails there would be a cost in ensuring health and safety compliance (i.e. removal of any broken corroded steel deposited on the beach).	• No significant environment impacts, no significant change in footprint of structure.	£2,108/m	• As the existing structure fails then any broken steel could be lifted out of the structure and be deposited on the beach creating hazards.	• Working in close vicinity to the existing structure that in places is in poor condition.	• Might be some opposition due to the transportation of concrete block material through the town potentially causing noise and traffic disruption. • However, structure will be in keeping with what already exists.
		Enhancement of existing steel framed protection (with rock armour)	• Will extend the benefits of the existing structure. • Standard of protection will fall over time.	• Is feasible. Scheme would have to be designed to account for the eventual failure of the existing structure.	• As the existing structure fails there would be a cost in ensuring health and safety compliance (i.e. removal of any broken corroded steel deposited on the beach).	• No significant environment impacts, no significant change in footprint of structure.	£1,794 -£1,810/m (depending on rock size)	• As the existing structure fails then any broken steel could be lifted out of the structure and be deposited on the beach creating hazards.	• Working in close vicinity to the existing structure that in places is in poor condition.	• The structure will be in keeping with what already exists.
		Enhancement of existing steel framed protection (with concrete blockwork) by increasing height	• Will extend the benefits of the existing structure. • Increasing the crest height will provide increased erosion protection.	• Is feasible. Scheme would have to be designed to account for the eventual failure of the existing structure.	• As the existing structure fails there would be a cost in ensuring health and safety compliance (i.e. removal of any broken corroded steel deposited on the beach).	• No significant environment impacts, no significant change in footprint of structure.	£2,746/m	• As the existing structure fails then any broken steel could be lifted out of the structure and be deposited on the beach creating hazards.	• Placement of concrete blocks onto the existing structure for added height could damage the existing structure. • Working in close vicinity to the existing structure that in places is in poor condition.	• Might be some opposition due to the transportation of concrete block material through the town potentially causing noise and traffic disruption. • However, structure will be in keeping with what already exists, although higher.
		Enhancement of existing steel framed protection (with rock armour) by increasing height	• Will extend the benefits of the existing structure. • Increasing the crest height will provide increased erosion protection.	• Is feasible. Scheme would have to be designed to account for the eventual failure of the existing structure.	• As the existing structure fails there would be a cost in ensuring health and safety compliance (i.e. removal of any broken corroded steel deposited on the beach).	• No significant environment impacts, no significant change in footprint of structure.	£2,043 - £2,078/m (depending on rock size)	• As the existing structure fails then any broken steel could be lifted out of the structure and be deposited on the beach creating hazards.	• Placement of rock onto the existing structure for added height could damage the existing structure. • Working in close vicinity to the existing structure that in places is in poor condition.	• The structure will be in keeping with what already exists, although higher.
	ment or Steel fram	New steel framed protection (with concrete blockwork)	• This type of protection already exists on the	• Is feasible.	• If the design is similar to the existing structure	• No significant environment impacts.	£3,922/m	• No significant health and safety risks.	• Blocks must be placed to avoid high reflection	• Might be some opposition due to the

Existing structure on frontage		Short listed options	Functionality (technical performance)	Technical feasibility	Future maintenance	Environmental impacts	Costing (£/m)	Health and safety	Risks	Public acceptance
			frontage and therefore affects are known (proven technique).		then in large storm events blocks might be lifted out and maintenance would be required to restore them.				that could cause scour.	transportation of concrete block material through the town potentially causing noise and traffic disruption. • Steel will corrode over time and will not be aesthetically pleasing.
		New steel framed protection (with rock armour)	• This type of protection already exists on the frontage and therefore affects are known (proven technique).	• Is feasible.	• If the design is similar to the existing structure then in large storm events blocks might be lifted out and maintenance would be required to restore them.	• No significant environment impacts.	£3,579 - £3,622/m (depending on rock size)	• No significant health and safety risks.	• Blocks must be placed to avoid high reflection that could cause scour.	• Might be some opposition due to the transportation of concrete block material through the town potentially causing noise and traffic disruption. • Steel will corrode over time and will not be aesthetically pleasing.
		Beach nourishment	• Further modelling studies would be required to determine effectiveness.	• Is feasible.	• Periodic recharges or 'top-ups' would be required leading to additional cost.	• Changing habitat will potentially impact negatively on local environment.	£2,938/m	• Risks associated with working at sea in potentially rough conditions. • Public must be clearly informed of works and site boundary.	• Suitability cannot be adequately assessed at current time. • Potentially would require an increase in groyne height to be effective.	• The increase in beach material could potentially improve recreation/amenity use of the beach, likely to be widely accepted.
		Rock revetment	• Effective as reducing the amount of wave energy impacting the cliff.	• Is feasible. Although, a potentially large amount of rock will be required. • Will potentially have to remove some of the existing defences to gain access to the cliff.	• Little maintenance is anticipated. An advantage of this type of defence is that rock is relatively easy to reposition if required.	• No significant environment impacts on foreshore • Will impact on the designated cliff	£2,305/m	• Working next to unstable cliff face during construction.	• No significant risks.	• Use of rock armour in this area is limited; this will lead to a change in aesthetics.
		New oak timber revetment	• Will have a relatively short design life – type of timber not suitable for marine environment. • Relatively not very effective at dissipating wave energy.	• Is feasible. Proven technique shown by existing timber revetment structure.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts.	£1,287/m	• No significant health and safety risks.	• Option assumes existing steel sheet pile will provide continued scour protection – would have to be investigated further. • If the beach level falls waves fill reflect off the sheet piling leading to increased scour.	• Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Type of protection is a familiar sight along the frontage.
		New tropical hardwood timber revetment	• Relatively not very effective at dissipating wave energy.	• Is feasible. Proven technique shown by existing timber revetment structure.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£1,802/m	• No significant health and safety risks.	• Option assumes existing steel sheet pile will provide continued scour protection – would have to be investigated further. • If the beach level falls waves fill reflect off the	• Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Type of protection is a

Existing structure on frontage		Short listed options	Functionality (technical performance)	Technical feasibility	Future maintenance	Environmental impacts	Costing (£/m)	Health and safety	Risks	Public acceptance
									sheet piling leading to increased scour.	familiar sight along the frontage.
	Timber revetment only	Placed rock armour protection					£1,925/m	• Working in vicinity of existing structure which has areas in poor condition.		
	Timber revetment only	Major refurbishment of revetment with tropical hardwood (assume 50% of material requires replacing)					£901/m	• Working in vicinity of existing structure which has areas in poor condition.		
	Timber revetment only	Minor refurbishment of revetment with tropical hardwood (assume 25% of material requires replacing)					£450/m	• Working in vicinity of existing structure which has areas in poor condition.		
Timber groynes		Minor refurbishment of existing groynes (assume 10% of material requires replacing)	• Will extend the residual life of existing structures. • Effectiveness of this arrangement is known from experience.	• Is feasible. Construction can be staggered to prioritise works. • Can be technically challenging to replace elements – condition of embedded structure hard to assess and often because of corroded fixings additional planks have to be cut and removed.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£273/m (or £17,217/ Groyne)	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Type of protection is a familiar sight along the frontage.
Timber groynes		Medium refurbishment of existing groynes (assume 20% of material requires replacing)	• Will extend the residual life of existing structures. • Effectiveness of this arrangement is known from experience.	• Is feasible. Construction can be staggered to prioritise works. • Can be technically challenging to replace elements – condition of embedded structure hard to assess and often because of corroded fixings additional planks have to be cut and removed.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£547/m (or £34,435/ Groyne)	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Type of protection is a familiar sight along the frontage.
Timber groynes		Major Refurbishment of existing groynes (assume 30% of material requires replacing)	• Will extend the residual life of existing structures. • Effectiveness of this arrangement is known from experience.	• Is feasible. Construction can be staggered to prioritise works. • Can be technically challenging to replace elements – condition of embedded structure hard to assess and often because of corroded fixings	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£820/m (or £51,652/ Groyne)	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Type of protection is a familiar sight along the frontage.

Existing structure on frontage	Short listed options	Functionality (technical performance)	Technical feasibility	Future maintenance	Environmental impacts	Costing (£/m)	Health and safety	Risks	Public acceptance
			additional planks have to be cut and removed.						
	Replace with new permeable timber groynes	• Effectiveness of this arrangement is known from experience.	• Is feasible. Construction can be staggered to prioritise works.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£2,733/m	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Type of protection is a familiar sight along the frontage.
	Replace with new impermeable timber groynes	• Effectiveness of this arrangement is known from experience. • An impermeable groyne arrangement will retain more sediment.	• Is feasible. Construction can be staggered to prioritise works.	• Timber is generally expensive to maintain as experienced with existing structure.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	£2,984/m	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Type of protection is a familiar sight along the frontage.
	Refurbish (30%) or new permeable groyne with the addition of protective rock (hybrid timber/rock groynes)	• Will extend the residual life of existing structures. • A rock groyne arrangement will retain more sediment and have a longer residual life than the timber alternative.	• Is feasible. Construction can be staggered to prioritise works.	• Will be reduced by using rock instead of timber at the most exposed section of the groynes.	• No significant environment impacts. Although the timber is tropical hardwood and will have associated environmental implications.	Refurbish = £820/m New permeable groyne = £2,733/m Addition of Rock = £57,968/ Groyne	• The groynes extent down the beach means that there will be a reduced tidal window to work in.	• Increasing the amount of sediment retained on this frontage will cause less sediment to be available in down drift locations.	• Rock groynes would change the aesthetics of the frontage.
Embankment (scour protection)	Scour protection – Upstand wall	• A wall could limit the overtopping to remove the problem.	• For the wall to limit the overtopping to an acceptable amount it is likely that it would have to be substantially high. Or alternatively, a lower wall could be used in combination with another protection method (leading to additional cost).	• Little future maintenance would be required.	• No significant environment impacts beyond construction.	£713/m	• Lifting of materials.	• Removing material from the embankment could cause geotechnical instability during construction. • Assumes stability of the existing embankment	• Depending on the dimensions of the structure it could cause some of the walkway to be lost and change aesthetics of the frontage. • Construction would cause disruption to the walkway.
	Scour protection - sprayed concrete	• Will create an impermeable surface offering protection against wave impacts. • Smooth surface would encourage wave run-up meaning crest height would have to be relatively high.	• Easy installation.	• Requires little maintenance.	• Potential spread of concrete outside of intended area during installation. • The grass habitat will be removed.	£395/m	• Lifting of materials.	• Assumes stability of the existing embankment.	• Will change the aesthetics of the frontage (negative visual impact). • Construction would cause disruption to the walkway.
	Scour protection - concrete block revetment	• Offers a high level of protection against wave	• Would be difficult to install because of the	• Requires little maintenance.	• The grass habitat will be removed.	£403/m	• Lifting of materials.	• Assumes stability of the existing embankment.	• Will change the aesthetics of the

Existing structure on frontage	Short listed options	Functionality (technical performance)	Technical feasibility	Future maintenance	Environmental impacts	Costing (£/m)	Health and safety	Risks	Public acceptance
		impacts. • Smooth surface would encourage wave run-up meaning crest height would have to be relatively high.	varying distance between access ramp and bottom of slope.						frontage (negative visual impact). • Construction would cause disruption to the walkway.
	Scour protection erosion control mat	• Will not withstand as large wave forces as other options – is not a significant improvement on existing solution (can be regarded as another temporary measure).	• A similar solution already exists on the embankment slope.	• Life span is relatively low in comparison to other options.	• Vegetation can grow on mat, can be seeded.	£114/m	• Lifting of materials.	• In the event of a large storm event the control mat might not protect the underlying ground from scour. • Assumes stability of the existing embankment.	• Will not change the aesthetics of the frontage. • Construction would cause disruption to the walkway.
	Scour protection gabions	• Would remove the problem by removing the receptor. • Will prevent run-up and dissipate wave energy.	• Gabion baskets are only suitable with wave heights up to a certain level, further investigation would be required.	• Future maintenance costs would depend on the wave climate.	• Some of the grass habitat will be removed.	£1,182/m	• Lifting of materials.	• If overtopping analysis results in a high crest level being required then this would lead to a high cost and further visual impact. • Assumes stability of the existing embankment.	• Will change the aesthetics of the frontage (negative visual impact). If non stainless steel cages are used then they will corrode, if they are used this will lead to additional cost. • Construction would cause disruption to the walkway.
	Scour protection - Concrete canvas	• Will create an impermeable surface offering protection against wave impacts. • Smooth surface would encourage wave run-up meaning crest height would have to be relatively high.	• Easy installation, although due to the shape of the area the laying of mats would likely lead to wastage. • If drainage pipes are required they would potentially be difficult to incorporate into the design.	• Requires little maintenance.	• Potential spread of concrete outside of intended area during installation. • The grass habitat will be removed.	£256/m	• Lifting of materials.	• Assumes stability of the existing embankment.	• Will change the aesthetics of the frontage (negative visual impact). • Construction would cause disruption to the walkway.

6. Revised longlist option appraisal for OBC

6.1 Revised longlist option appraisal

As outlined in Sections 2 and 3 there are a number of potential management approaches and solutions for the Mundesley frontage. Following an initial investigation and identification of all the outline design constraints a revised longlist of potential coastal management measures was established in collaboration with NNDC.

This amended longlist was then subjected to a qualitative multi-criteria feasibility appraisal, supported by the preliminary environmental assessment in order to develop a short-list of options (comprising packages of management measures) to take forward and investigate further. Each of the longlist options were assessed in terms of the following parameters:

- Functionality (technical performance)
- SMP compliance
- Buildability
- Future maintenance
- Environmental impacts/benefits
- Comparative (indicative) costing
- Health and Safety
- Risks
- Public acceptance

A summary of the revised longlist appraisal results along with the primary reasons for either shortlisting or rejecting each of the options is presented in Table 6.1 below.

Table 6.1 – Revised Longlist Options for OBC

Option name	Description	**Short-listed ?**	**Reason for shortlist or rejection**
Do Nothing	This option involves no further spending on defences and ceases all existing maintenance.	Yes	**Dismissed** as a potential option, however, **shortlisted** for further analysis as the baseline against which to compare all other options.
Do Minimum	This option allows for routine maintenance only until the defences reach the end of their residual life and fail, then all spending and maintenance will cease.	Yes	This option is also **dismissed** as a potential option as it is effectively a delayed 'Do Nothing' option and provides minimal benefits and does not address the erosion problem. However, it is **shortlisted** in accordance with FCERM guidance for comparison purposes.
Option 1 – Seawall			
Option 1A: Maintain the existing seawall and construct new seawall along the rest of the frontage	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. Also includes the construction of a new seawall along the entire frontage to protect the cliffs from wave attack.	No	Although this option would protect the cliffs from any further erosion, it is both cost prohibitive and would be significantly detrimental to the environment and is therefore **dismissed** as a potential option.
Option 1B: Maintain the existing seawall and apron through concrete encasement	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance.	Yes	Effective and proven way of extending the life of the existing seawall structure and is therefore **shortlisted** for further analysis.
Option 1C - Concrete Sea wall and Apron Encasement with additional rock armour protection	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. But also includes the additional protection of a particularly exposed section with rock armour protection.	Yes	Similar to Option 1B in that it aims to extend the life of the existing structure. However, this option proposes to have additional rock armour protection at a particularly vulnerable section and is therefore also **shortlisted** for further analysis
Option 1 D – Raise the existing seawall in line with climate change	This option involves prolonging the life of the existing seawall through concrete encasement and continued maintenance. But also includes for raising the existing seawall in line with climate change projections to maintain the existing standard of protection.	No	Since the seawall only protects part of the frontage, there are no significant assets at risk of flooding and the objective of the scheme is to reduce the risk of erosion, there is very limited value in raising the existing seawall in line with climate change (when compared to the potential costs involved). In addition, it would be technically challenging and would rely on the integrity of the existing structure and is therefore **dismissed** as a potential option.
Option 2 - Off-shore Rock Armour Breakwater	This option involves constructing off-shore breakwaters made of rock armour to protect the coastline from the worst of the coastal conditions	No	This option would potentially have a detrimental impact on environmental and coastal processes. It would also be technically difficult to implement and very expensive and is therefore **dismissed** as a potential option.
Option 3 - Rock Armour Revetment	This option involves constructing a new rock armour revetment at the toe of the cliff along the length of the frontage (except along the existing seawall) protecting the cliff from wave action.	Yes	The rock armour will effectively dissipate wave energy and can be repositioned if required or if displaced. The revetment would be fairly expensive and impact on both the environment although would provide a more natural aesthetic than the concrete alternative. **Shortlisted** for further analysis.
Option 4 - Concrete Block Revetment	This option involves constructing a new concrete block revetment at the toe of the cliff along the length of the frontage (except along the existing seawall) protecting the cliff from wave action.	No	Although this option would protect the cliffs from any further erosion, it would be technically difficult to implement and is both cost prohibitive and would be significantly detrimental to the environment and is therefore **dismissed** as a potential option.
Option 5 - Rock Armour Protection Sill (placed on beach)	This option involves placing rock armour at the top of the beach along the length of the frontage (except along the existing seawall) protecting the cliff from wave action.	Yes	The rock armour will effectively dissipate wave energy and can be repositioned if required or if displaced. The sill would be cheaper than a rock amour revetment, and significantly more durable than a timber revetment. It would also provide a more natural aesthetic than the concrete alternative. **Shortlisted** for further analysis.
Option 6 – Timber Revetment			
Option 6A - Replace Timber Revetment with Oak	This option involves replacing the existing structure as it approaches the end of its residual life with a new like-for-like oak replacement.	No	The existing timber revetments have effectively defended the cliffs from the worst of the wave energy. The price of a new structure is expensive and durability of an oak structure is questionable resulting in the on–going maintenance costs also being high, it is therefore **dismissed** as a potential option.
Option 6B - Replace Timber Revetment with tropical hardwood	This option involves replacing the existing structure as it approaches the end of its residual life with a like-for-like tropical hardwood replacement	No	The existing timber revetments have effectively defended the cliffs from the worst of the wave energy. The price of a new structure is expensive (more so than oak) and the long-term durability of tropical hardwood structure (although better than oak) is also questionable therefore the on–going maintenance costs will also be high, it is therefore **dismissed** as a potential option.
Option 6C – Refurbish existing revetment with oak	This option involves maintaining the existing structure through significant refurbishment using oak timbers	Yes	Although the replacement of this structure is not been found to be economically viable, the prolonging of the existing structure through refurbishment is being **shortlisted** for further analysis.
Option 6D – Refurbish existing revetment with tropical hardwood	This option involves maintaining the existing structure through significant refurbishment using tropical hardwood timbers	Yes	Although the replacement of this structure is not been found to be economically viable, the prolonging of the existing structure through refurbishment is being **shortlisted** for further analysis.
Option 7 – Steel Framed Structure			
Option 7A – Reinforce existing Steel Framed structure - Concrete Blocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front of the existing structure and filling the void with pre-cast concrete blocks.	Yes	The existing steel framed structure has proved a very effective method of reducing erosion therefore this option is being **shortlisted** for further analysis as will effectively prolong the existing structures life.
Option 7B - Reinforce existing Steel Framed structure - Rock	This option is similar to Option 7A; however, the void is filled with natural rock armour instead of pre-cast concrete blocks.	Yes	The existing steel framed structure has proved a very effective method of reducing erosion therefore this option is being **shortlisted** for further analysis as will effectively prolong the existing structures life.
Option 7C – Reinforce and raise existing structure – concrete blocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front of the existing structure and filling the void and raising the entire structure with pre-cast concrete blocks.	No	The addition of raising the structure to increase the level of protection offered provides very limited additional benefits over the life of the structure (at this time) and it therefore **dismissed** as a potential option. However, this option could be relooked at in the future if Option 7A is implemented.
Option 7D - Reinforce and raise existing structure – Rocks	This option involves reinforcing the existing structure by constructing an additional steel frame approximately 2m in front of the existing structure and filling the void and raising the entire structure with rock armour.	No	The addition of raising the structure to increase the level of protection offered provides very limited additional benefits over the life of the structure (at this time) and it therefore **dismissed** as a potential option. However, this option could be relooked at in the future if Option 7B is implemented.
Option 7E – New steel framed structure – with concrete blocks	This option involves constructing a new steel frame structure filled with pre-cast concrete blocks in place of the existing timber revetment.	No	The steel framed structure has proved a very effective method of reducing erosion in the past. The high costs associated with this option combined with the aesthetic impact on the landscape have resulted in this option being **dismissed**.
Option 7F - New steel framed structure – with rocks	This option involves constructing a new steel frame structure filled with rock armour in place of the existing timber revetment.	No	The steel framed structure has proved a very effective method of reducing erosion in the past. The high costs associated with this option combined with the aesthetic impact on the landscape have resulted in this option being **dismissed**.
Option 8 – Timber Groynes			
8A Maintain through refurbishment	This option involves prolonging the life of the existing timber groynes through refurbishment and continued maintenance.	Yes	Despite their current state of disrepair the existing groynes are still very effective at retaining material on the beach; therefore prolonging the existing structures lives through refurbishment is being **shortlisted** for further analysis.
8B Replace with like for like	This option involves replacing the existing groynes with a new	No	Due to the effectiveness of the existing structure and the expense of replacing it,

	like-for-like timber structure.		this option has been **dismissed** as a potential option
8C Refurbish and enhance to impermeable structure	This option involves enhancing and prolonging the life of the existing timber groynes by refurbishing them whilst also creating impermeable structures, also includes continued maintenance.	No	Whilst enhancing the groynes (making them impermeable) will improve their ability to retain material, this option is unlikely to be acceptable to Natural England and other stakeholders as it will interfere with the existing coastal processes. It is therefore **dismissed** as a potential option.
8DReplace with an impermeable structure	This option involves replacing the existing groynes with a new impermeable timber structure.	No	Whilst enhancing the groynes (making them impermeable) will improve their ability to retain material, this option is both expensive and unlikely to be acceptable to Natural England and other stakeholders as it will interfere with the existing coastal processes. It is therefore **dismissed** as a potential option.
8E Maintain through refurbishment with rock protection	This option involves prolonging the life of the existing timber groynes through refurbishment and continued maintenance. Whilst also further protecting the vulnerable seaward ends with rock armour protection.	Yes	Like option 8A this option aims to prolong the life of the existing structures through refurbishment, in addition this option also aims to make the structure more durable to coastal condition and is therefore **shortlisted** for further analysis.
Option 9 - Rock Armour Groynes	This option involves installing new rock armour groynes along the frontage to trap more sediment to raise the level of the existing beach and therefore offer greater protection to the cliffs by reducing their exposure to wave action.	No	Although this option would potentially enhance the existing protection by raising beach levels, it would be both very expensive and change the aesthetics of the existing landscape. In addition it does not make the best use of the existing timber groynes. It is therefore **dismissed** as a potential option.
Option 10 - Gabion Toe Protection	This option involves installing rock filled gabion baskets along the toe of the cliffs protecting them from wave action.	No	The durability of gabion baskets in a marine and tidal environment is poor and the baskets are not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
Option 11 - Beach Nourishment	This option involves importing beach material to raise the level of the existing beach and therefore offer greater protection to the cliffs by reducing their exposure to wave action.	Yes	Although this option is likely to be very expensive to both implement and maintain, and it would need to be supplemented by improvements to the existing beach management structures, it is being **shortlisted** for further analysis as it would improve the amenity value of the existing beach and is popular with the public.
Option 12 - Cliff Stabilisation	This option involves incorporates various cliff stabilisation techniques (such as anchor bolts and wire netting) to stabilise the face of the cliffs and limit the amount of erosion.	No	Since the cliffs are a SSSI and designated due to their geological interest, any cliff stabilisation works would be environmentally detrimental and unlikely to be supported by the public or other stakeholders, it is therefore **dismissed** as a potential option.
Option 13 - Embankment Scour Protection			
A - Scour protection gabions	This option involves installing rock filled gabion baskets along the toe of the embankment protecting the slope from overtopping waves.	No	The durability of gabion baskets in a marine and tidal environment is poor and the baskets are not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
B - Upstand wall	This option involves replacing the existing dwarf wall on the landward side of the promenade with a small upstand wall to shelter the embankment from overtopping waves.	Yes	This option has been **shortlisted** for further analysis as it will successfully prevent scour, has a straight forward construction method, is low maintenance and will have limited impact on the existing slope.
C - Interlocking porous concrete block/ mattress revetment	This option involves placing a porous concrete mattress and geotextile layer on the face of the embankment to protect the soil from overtopping waves	Yes	This option has been **shortlisted** for further analysis as it will successfully prevent scour, is relatively cheap, easy to install, low maintenance and will allow vegetation to grow through the mattress which will improve the visual impact of the defence.
D - Scour protection concrete canvas	This option involves placing a non-porous concrete canvas on the face of the embankment to protect the soil from overtopping waves.	No	Reject for various reasons: • Will detrimentally impact on the aesthetics of the embankment • Will destroy existing vegetation on the embankment • Will interfere with existing surface water drainage.
E - erosion control mat	This option involves attaching an erosion control mat (hessian or similar) to the face of the embankment to protect the soil from overtopping waves.	No	The durability of erosion control mat in a marine and tidal environment is poor and it is not expected to be able to withstand the wave forces required and will need to be continuously maintained and regularly replaced, it is therefore **dismissed** as a potential option.
F - Sprayed concrete protection	This option involves spraying the slopes of the embankment with a liquid concrete (shotcrete or similar) to provide the embankment with a protective layer to protect the soil from overtopping waves.	No	Reject for various reasons: • Will detrimentally impact on the aesthetics of the embankment • Construction methodology caries a significant pollution risk • Will destroy existing vegetation on the embankment • Will interfere with existing surface water drainage.

7. Revised shortlist options appraisal for OBC

An overview of the revised shortlist option appraisal (updated for the OBC) is provided below:

7.1 No Active Intervention (Do Nothing)

The Do Nothing approach would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course.

Works – None

7.2 Do Minimum

The Do Minimum approach involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works.

Initial Works - The Do Minimum option has no initial capital works.

Future Works - The only future works included in this option is the continuation of on-going routine maintenance on an annual basis until the end of the defences' residual life, then all works will cease. However, please note for price comparison purposes it has conservatively been assumed that some form of maintenance will continue throughout the appraisal period.

Technical assessment
The technical advantages and disadvantages of the No Active Intervention and Do Minimum Options are listed in Table **7-1** below:

Table 7-1: No Active Intervention & Do Minimum Options - Advantages and Disadvantages.

Advantages	Disadvantages
• Both options are very cheap to adopt. • Both options will allow nature to take its course once the existing defences fail.	• Both options will result in significant damage, loss of infrastructure and potential loss of life and injuries. • Failure of defences will potentially lead to additional health and safety risks. • Neither option is compliant with the approved SMP policy.

Environmental assessment
The environmental impacts of this option are summarised in the Table 7-2 below:

Table 7-2: No Active Intervention Options & Do Minimum – Environmental Impacts.

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Will allow nature to take its course. • Potential expansion of the intertidal area • As cliffs erode sediment will enter into the coastal system, potentially benefitting neighbouring sites. • Avoids construction works	• Significant loss of designated habitats • Significant social and economic damage •	• None.

Cost assessment
The estimated capital and whole life costs are summarised in Table **7-3** below:

Table 7-3: No Active Intervention & Do Minimum Options – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost (50 yrs.)	PV Whole Life Cost (50 yrs.)	Whole Life Cash Cost (100 yrs.)	PV Whole Life Cost (100 yrs.)
Do Nothing	-	£0	£0	£0	£0	£0	£0
Do Minimum	0	£0	£0	£950,000	£465,411	£1,900,000	£567,364

SUMMARY

The No Active Intervention Option and Do Minimum options are summarised below:

The Do Nothing approach is the baseline against which all other options will be compared. This approach is discounted because it is not compliant with the 'Hold the Line' policy and will ultimately lead to large damages, but it will be used as a baseline to judge other options.

The Do Minimum approach is effectively a delayed Do Nothing option, as it will also eventually allow the defences to fail and nature to take its course. This approach is also discounted because it is not compliant with the 'Hold the Line' policy and will also lead to large damages, but it has been considered within this OBC in line with the FCERM guidance.

7.3 Active Intervention Options

Shortlisted Seawall Options

Option 1B – Maintaining the existing seawall and apron through concrete encasement
This option proposes to maintain the existing seawall and apron throughout the desired benefit period by encasing the existing structure in reinforced concrete when necessary.

Initial Works
Initial works include encasing the areas of the seawall and apron where the condition grade is lower, therefore improving the residual life to match the rest of the seawall, which is typically in a good condition. Where necessary the design will include for the addition of a new wave recurve at the top of the wall to help reduce future overtopping. The design also assumes that the apron encasement be extended to also cover the top of the sheet piled foundation to protect the piles from exposure to attrition and wave action and slow their rate of deterioration. The material proposed for encasing the existing structures is reinforced concrete; which will be connected to the existing structure using embedded dowels.

Future Works
Future works will include for the continuation of on-going routine maintenance on an annual basis. It will also allow for the further concrete encasement of the entire structure as it approaches the end of its residual life.

Technical assessment
The technical advantages and disadvantages of this option are listed in Table 7-4 below:

Table 7-4: Sea wall and Apron Encasement and Protection - Advantages and Disadvantages

Advantages	Disadvantages
• Will protect the existing structure and extend its residual life. • No significant change in footprint of structure. • Visual landscape of the frontage will be unaffected. • Has already been successfully implemented elsewhere on the frontage. • NNDC has recent experience of managing these types of works. • Standard formwork and shuttering can be efficiently used across several locations. • Addresses areas of the wall that need attention and	• Works will disrupt public access to promenade and beach throughout the works. • Different re-curve shapes on the sea wall potentially requiring different shutters for each type of curve. • In-situ concrete works present an environmental risk in the tidal environment. Precast concrete could reduce this risk, but is not suitable in this application. • Works will not improve the level of protection offered by the seawall. • Construction works will be exposed to tidal activity. • Design relies on the structural stability of the existing

avoids those don't need attention.	structure • Only addresses the seawall frontage, does not address the other defences. • Does not address the issue of slope scour resulting from the existing seawall being overtopped, and would have to be implemented in conjunction with some form of scour protection.

Option 1C – Maintaining the existing seawall and apron through encasement & rock protection

Like Option 1B this option proposes to maintain the existing seawall and apron throughout the desired benefit period by encasing the existing structure in reinforced concrete when necessary, however, this option also proposes to provide additional rock armour protection to particularly vulnerable sections of the structure, therefore extending the residual life and reducing the need for future works.

Initial Works

This option involves the same works as Option 1B (above) with the addition of the placement of some rock armour where the seawall is particularly exposed to wave action due to variability of beach levels (i.e. Section 6). This rock armour will provide additional protection and therefore reduce future maintenance costs.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis and the repositioning of rock armour every 10 years. It will also allow for the further concrete encasement of the entire structure as it approaches the end of its residual life.

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-5 below:

Table 7-5: Sea wall and Apron Encasement and Rock Protection - Advantages and Disadvantages

Advantages	Disadvantages
• Will protect the existing structure and extend its residual life. • No significant change in footprint of structure. • Has already been successfully implemented elsewhere on the frontage. • NNDC has recent experience of managing these types of works. • Standard formwork and shuttering can be efficiently used across several locations. • Addresses areas of the wall that need attention and avoids those don't need attention. • Rock armour will provide additional protection to the most vulnerable/exposed part of the structure, reducing the future maintenance needs.	• Works will disrupt public access to promenade and beach throughout the works. • Different re-curve shapes on the sea wall potentially requiring different shutters for each type of curve. • In-situ concrete works present an environmental risk in the tidal environment. Precast concrete could reduce this risk, but is not suitable in this application. • Works will not improve the level of protection offered by the seawall. • Construction works will be exposed to tidal activity. • Design relies on the structural stability of the existing structure • Only addresses the seawall frontage, does not address the other defences. • Does not address the issue of slope scour resulting from the existing seawall being overtopped, and would have to be implemented in conjunction with some form of scour protection. • Rock armour is likely to be internationally sourced.

Environmental assessment

The environmental impacts of these seawall options are summarised in the Table 7-6 below:

Table 7-6: Sea wall and Apron Encasement and Protection – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Will enable the seawall to continue protecting socio-economic receptors against erosion • Likely to be supported by the public. • No significant change in the footprint/aesthetic of the structure. • Rock armour will potentially provide new habitats	• Some disruption to public access of the promenade and beach during the construction works. • Potential release of contaminants during construction. • Will not enhance the natural environment.	• Standard construction techniques therefore appropriate environmental mitigation measures can be employed during construction. • Will potentially enable NNDC to improve access to the beach in parallel with works. •

Cost assessment

The estimated capital and whole life costs are summarised in Table 7-7 below:

Table 7-7: Seawall and apron encasement and rock protection – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
1B	1	£645,671	£623,836	£2,210,054	£1,184,710	£3,774,438	£1,324,535
1C	1	£724,111	£699,624	£1,926,023	£1,116,047	£3,129,677	£1,216,541

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY

Option 1C: Maintaining the existing seawall and apron through encasement & rock will cost effectively ensure that the seawall is retained throughout the required benefit period and will therefore be carried forward to be considered as part of the final solution, as this option will have to be delivered in combination with other management options (i.e. where there is no seawall) to protect the entire frontage. Although Option 1B is initially the cheaper option, because of its additional maintenance requirements it is less cost effective over the entire appraisal period and will therefore not be considered in combination with other options to potentially form part of the final solution.

7.4 Shortlisted Rock Armour Revetment Option

Option 3 – Rock Revetment

This option is comprised of constructing a rock armour revetment at the toe of the cliff across the entire frontage (except where the existing seawall is).

Initial Works

Initial works for this option would be comprised of constructing a double layer of rock armour protection at the toe of the cliff. The rock armour will be laid over both a granular fill material and a geotextile underlayer. Also a large rock, or ‘keystone’, will be placed at the seaward extent of the revetment.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis and the repositioning of rock armour every 10 years (assumes a 10% re-build cost).

Technical assessment

A rock revetment against the cliff would act to dissipate wave energy and would effectively stop erosion. One of the negatives is that to access the cliff face some of the existing defences would have to be removed before the works. One advantage of using rock is that it can be repositioned if/when required or if it is displaced. However, there is a significant health and safety risk of working next to the unstable cliff during construction.

The technical advantages and disadvantages of this option are listed in Table 7-8 below:

Table 7-8: Rock Revetment - Advantages and Disadvantages

Advantages	Disadvantages
• Will effectively dissipate all the wave energy therefore preventing any further erosion of the cliff due to wave action. • Revetment footprint will not interfere with the main amenity area of beach used by the public. • Rock can easily be moved around, can therefore be repositioned if displaced or required elsewhere. • Requires little maintenance. • The revetment will have a very long design life. • Can be designed to offer a continuous level of protection in line with climate change predictions. • By removing the need for timber revetments and the rubble filled steel framed structures this option will effectively increase the amount of public amenity space that is available on the beach.	• Large amount of rock required, with significant cost implications. • Will have to remove a significant proportion of existing defences to gain access to cliff. • Will have to be implemented in conjunction with seawall maintenance to protect the entire frontage. • The design life will extend beyond anticipated change in SMP policy preventing the planned managed realignment. • Effectively stopping cliff erosion will prevent the existing sediment inputs into the environment and therefore reduce sediment supply to the beach and other sites down drift. • This option will not assist in maintaining beach levels and would have to be implemented in conjunction with some form of beach management option. • Environmentally detrimental to the designated cliffs

Environmental assessment

The environmental impacts of this option are summarised in the Table 7-9 below:

Table 7-9: Rock Revetment – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• No significant impacts to the foreshore (will not reduce access / amenity use of the beach). • Will stop the cliff receding and therefore protect socio-economic receptors against erosion. • The rock armour is a natural material • Rock Armour revetment will potentially create a new habitat along the frontage • Will not inhibit tourism	• The location of the revetment against the cliff will have a significant detrimental impact on the designated habitats located on the cliff. • Use of rock armour in this area is limited; this will lead to a significant change in landscape aesthetics. • By effectively stopping cliff erosion will prevent sediments inputs into the environment and therefore reduce sediment supply to the beach and other sites down drift.	• By removing the need for timber revetments and the rubble filled steel framed structures this option could effectively increase the amount of public amenity space that is available on the beach. • Reduces the need for regular maintenance of defences.

Cost assessment
The estimated capital and whole life costs are summarised in Table 7-10 below:

Table 7-10: Rock Revetment – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
3	1	£6,709,302	£6,482,417	£7,279,474	£6,735,260	£7,992,189	£6,819,197

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY
Option 3: the Rock armour revetment will effectively protect the cliffs from erosion throughout the required benefit period and will limit the need for future maintenance. However, it will be extremely expensive to implement and will significant impact on both the designated cliff and sediment supplies to local coastal processes. However, it will be considered in combination with other options to potentially form part of the final solution.

7.5 Shortlisted Rock Armour Placement Options

Option 5 – Placed rock armour protection

Description
This option proposes to place rock armour protection along the frontage (except where the existing seawall is) on the beach in front of the cliffs, either supplementing or (in time) replacing the existing defences. For pricing purposes the following three variations of this option have been considered:

A. Placed along the entire length (except where the existing seawall is).
B. Placed to supplement and in time replace the timber revetment only.
C. Placed to supplement the steel framed structure only.

Initial Works
Initial works include for the importation and placement of rock armour protection along the frontage effectively creating a rock sill.

Future Works
Future works will include the continuation of on-going routine maintenance on an annual basis. It will also allow for the repositioning of rock armour every 10 years (assuming a 10% re-build cost).

Technical assessment
The technical advantages and disadvantages of this option are listed in Table 7-11 below:

Table 7-11: Placed Rock Armour Protection - Advantages and Disadvantages

Advantages	Disadvantages
• Prioritises areas most in need of additional protection. • Effective at dissipating wave energy therefore reducing the amount of wave energy impacting the cliff. • Will have only a limited impact on the main area of beach used by the public, as most rock will be placed behind existing defences, which is not currently accessible to the public. • Rock is relatively easy to move around, can be repositioned if	• Large amount of rock required, with significant cost implications. • Will have to remove a significant proportion of existing defences to gain access to cliff. • Will have to be implemented in conjunction with seawall maintenance to protect the entire frontage. • The design life will extend beyond anticipated

displaced or required elsewhere. • Requires little maintenance. • The revetment will have a very long design life. • Can be designed to offer a continuous level of protection in line with climate change predictions.	change in SMP policy preventing the planned managed realignment. • Slowing cliff erosion will reduce sediment input into the environment and reduce sediment supply to the beach and other sites down drift. • This option will not assist in maintaining beach levels and would have to be implemented in conjunction with some form of beach management option. • Use of rock armour in this area is limited; this will lead to a change in aesthetics. • Rock works will potentially have a relatively large foot print on the beach

Environmental assessment
The environmental impacts are summarised in the Table below:

Table 7-12: Placed Rock Armour Protection – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• No significant impacts to the foreshore (will not reduce access / amenity use of the beach). • Will slow the cliff receding and therefore protect socio-economic receptors against erosion. • The rock armour is a natural material • Rock Armour will potentially create a new habitat along the frontage • Will not inhibit tourism • The location of the rock armour away from the cliff will avoid any significant impact on the designated habitats located on the cliff.	• Use of rock armour in this area is limited; this will lead to a significant change in landscape aesthetics. • By slowing cliff erosion sediment inputs into the environment will be reduced and therefore reduce sediment supply to the beach and other sites down drift. • Rock works will potentially have a relatively large foot print on the beach	• Reduces the need for regular maintenance of timber defences.

Cost assessment
The estimated capital and whole life costs are summarised in Table 3.16 below:

Table 3.16 – Seawall and apron encasement and rock protection – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
5A	1	£1,831,576	£1,769,638	£1,994,315	£1,841,805	£2,197,739	£1,865,762
5B	1	£1,517,815	£1,466,488	£1,652,676	£1,526,292	£1,821,253	£1,546,146
5C	1	£313,760	£303,150	£341,639	£315,513	£376,486	£319,617

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY
Option 5: Placed rock armour protection will effectively reduce the rate of cliff erosion throughout the required benefit period and will limit the need for future maintenance. When compared to the Rock Revetment they are relatively cheap to implement and will have only limited impact on the designated cliffs. All three variants (A, B & C) of the placed rock options will be considered in combination with other options to potentially form part of the final solution.

7.6 Shortlisted Timber Revetment Options

Option 6C – Refurbish Timber revetment using oak

Description
This option proposes to refurbish and maintain the existing timber revetment with locally sourced oak. It is assumed that the existing design of the timber revetment will be maintained and will continue to utilise the existing steel sheet piling.

Initial Works
Based on the current condition of the timber revetment it is assumed that this refurbishment option will initially require a 50% replacement of existing timbers.

Future Works
Future works will include the continuation of on-going routine maintenance on an annual basis. It will also include for an additional 20% of timbers to be replacement every 5 years due to general deterioration and storm damage. Future works also include for a further 50% of timbers to be replaced in a major refurbishment every 20 years.

Technical Assessment
The existing timber revetment is very effective at breaking waves and protecting the cliffs from the worst of the waves energy, however, despite being relatively locally sourced and cheaper than alternative tropical timbers, oak is considerably less resilient in the coastal environment and as a result is expected to require significant levels of on-going maintenance and replacement.

The existing structure utilises a steel sheet pile to prevent the structure from being undermined, however, the condition of this pile is unknown, and no allowance has yet been made for replacing the piling at this stage. Potentially if the steel sheet pile is in poor condition, the cost and complexity of this option would significantly increase.

The technical advantages and disadvantages of this option are listed in Table 6-13 below:

Table 7-13: Timber Revetment (Oak) - Advantages and Disadvantages

Advantages	Disadvantages
• Existing structure is very effective at breaking waves and protecting the cliffs, refurbishing will prolong the life of the existing structure. • Makes use of existing steel sheet pile structure. • Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Oak can be sourced relatively locally. • Cheaper alternative to tropical hardwood. • Know method of construction	• Option assumes the condition of the existing sheet pile will provide scour protection; however, the condition is currently unknown. Further investigation may result in additional costs associated with replacing the sheet piling. • If beach level falls waves will reflect off sheet piling leading to increased scour in front of the structure. • Timber (particularly oak) has a comparatively short residual life and as a consequence is expensive to maintain; as experienced with existing structure. • Timber revetment structures have a relatively large foot print on the beach

Option 6D - Refurbishment of revetment using tropical hardwood

Description
Similar to Option 6C this option also proposes to refurbish and maintain the existing timber revetment, however, with imported tropical hardwood rather than oak. Again it is assumed that the existing design of the timber revetment will be maintained and will continue to utilise the existing steel sheet piling.

Initial Works
Based on the current condition of the timber revetment it is assumed that this refurbishment option will initially require a 50% replacement of existing timbers.

Future Works
Future works will include the continuation of on-going routine maintenance on an annual basis. Future works also include for an additional 10% of timbers to be replacement every 5 years due to general deterioration and storm damage. Future works also include for a further 33% of timbers to be replaced in a major refurbishment every 20 years.

Technical Assessment
The existing timber revetment is very effective at breaking waves and protecting the cliffs from the worst of the waves energy, and although more expensive than locally sourced timbers, tropical timbers are comparatively far more resilient in the coastal environment and although on-going maintenance and replacement are still expected to be high, they are significantly lower than those expected for the oak alternative.

As in Option 6C the existing timber structure utilises a steel sheet pile to prevent the structure from being undermined, however, the condition of this pile is unknown, and no allowance has yet been made for replacing the piling at this stage. Potentially if the steel sheet pile is in poor condition the cost and complexity of this option would significantly increase.

The technical advantages and disadvantages of this option are listed in Table 7-14 below:

Table 7-14: Timber Revetment (Tropical Hardwood) - Advantages and Disadvantages

Advantages	Disadvantages
• Existing structure is very effective at breaking waves and protecting the cliffs, refurbishing will prolong the life of the existing structure. • Aesthetically the same appearance as the existing defences and therefore will have less impact than a change to rock or concrete filled steel cage structure. • Tropical hardwood is comparatively more effective in marine environments. • Makes use of existing steel sheet pile structure. • Known method of construction • Works will avoid impacting on the designated cliff face.	• Option assumes the condition of the existing sheet pile will provide scour protection; however, the condition is currently unknown. Further investigation may result in additional costs associated with replacing the sheet piling. • If beach level falls waves will reflect off sheet piling leading to increased scour in front of the structure. • Although better than oak, tropical timber still has a relatively short residual life and as a consequence is expensive to maintain, as experienced with existing structure. • Environmental implications of importing tropical timber (and added cost of ensuring sustainable source). • Timber revetment structures have a relatively large foot print on the beach

Environmental assessment
The environmental impacts are summarised in Table 7-15 below:

Table 7-15: Timber Revetment – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Aesthetically the same appearance as the existing defences, i.e. will not significantly impact on the existing landscape. • No significant impacts to the foreshore (will not further reduce access / amenity use of the beach). • Will continue to slow the cliff receding and therefore protect socio-economic receptors against erosion. • Will not inhibit tourism • The location of the timber revetments away from the cliff will avoid any significant impact on the designated habitats located on the cliff.	• By slowing cliff erosion sediment inputs into the environment will be reduced and therefore reduce sediment supply to the beach and other sites down drift. • Timber revetments will continue to have a relatively large foot print on the beach • Tropical hardwoods have to be imported with significant carbon footprint. • Sourcing sustainably managed tropical hardwood is difficult/expensive	• By opting for tropical hardwood it reduces the impact of future maintenance activities when compared to oak.

Cost assessment
The estimated capital and whole life costs are summarised in Table 7-16 below:

Table 7-16: Timber Revetment – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
6C	1	£661,210	£638,850	£3,835,017	£2,016,197	£7,273,309	£2,397,273
6D	1	£926,015	£894,701	£3,444,777	£1,969,256	£6,148,741	£2,269,549

*Note Whole Life Costs exclude general maintenance at this stage.

SUMMARY
The refurbishing and maintaining of the existing timber revetment will ensure that the cliffs receive continued protection throughout the required benefit period. Although oak is initially cheaper, in the longer term tropical hardwood is more cost effective due to the anticipated reduction in maintenance needs. Therefore Option 6D, the tropical hardwood option will be considered in combination with other options to potentially form part of the final solution further assessment.

7.7 Shortlisted Steel framed structure options

Option 7A – Reinforce/enhance existing steel framed protection (with concrete blockwork)

Description

The reinforcement of the existing steel framed protection option is to add another steel frame approximately 2m in front of the existing structure. This has two purposes: firstly to contain new prefabricated concrete blockwork placed in the new frame in order to improve wave dissipation, and secondly to support/contain the existing concrete cube/rock filled steel structure.

Initial Works

Initial works include installing the new steel structure, filled with prefabricated concrete blocks, in front of the existing structure, which is assumed to be left in-situ.

Future Works

Future works will include the continuation of on-going routine maintenance on an annual basis. It will also allow for the repositioning of concrete blockwork every 10 years (assumes a 5% re-build cost). Future works also allow for the removal and replacement of the steel elements every 30 years.

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-17 below:

Table 7-17: Steel Framed Structure (Concrete Blocks) - Advantages and Disadvantages

Advantages	Disadvantages
• Existing structure is very effective at breaking waves and protecting the cliffs, reinforcing the structure will prolong the life of the existing structure. • Remove the public safety risk associated with the failure of the existing steel structure. • The design will allow the concrete blocks to also fall and continue to dissipate wave energy if the level of beach falls. • Concrete blocks are cast with lifting loops for easy installation. • The concrete blocks can be sourced locally. • Pre-cast concrete blocks have the advantage of being made in controlled conditions and should be made to a consistent quality. • Construction methodology is straight forward. • The additional structure will be similar in appearance to the existing defence and therefore will have only limited impact on the visual landscape. • Works will avoid impacting on the designated cliff face. • The footprint increase of the defence will only have a limit impact on the amenity space on the beach.	• The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Steel will corrode over time and is not aesthetically pleasing. • Trucks transporting concrete blocks from nearby Cromer will have to travel through Mundesley potentially causing traffic and noise disruption. • The placement of the concrete cubes needs to be controlled so that there are sufficient gaps between the blocks and a 'random' arrangement is formed to aid in the breaking of wave energy and to prevent forming a vertical sea wall. • Placing the new structure in front of the existing steel framed structure will inevitably mean that there will be a clash with existing groynes along the frontage. • Pre-cast concrete block are not a natural product and will have an impact on the local landscape and potentially some consenting issues. • Piling of the structure during construction will result in vibrations that may have a negative impact on the stability of the cliff.

Option 7B – Reinforce existing steel framed protection (with rock armour)

Description

This option is the same option 7A, however rather than fill the proposed steel structure with prefabricated concrete, this option will use imported rock armour.

Initial Works

Initial works include installing the new steel structure, filled with rock armour, adjacent to the existing structure, which is assumed to be left in-situ.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis. It will also allow for the repositioning of rock armour every 10 years (assumes a 5% re-build cost). Future works also allow for the removal and replacement of the steel elements every 30 years.

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-18 below:

Table 7-18: Steel Framed Structure (Rocks) Advantages and Disadvantages

Advantages	Disadvantages
• Existing structure is very effective at breaking waves and protecting the cliffs, reinforcing the structure will prolong the life of the existing structure. • Remove the public safety risk associated with the failure of the existing steel structure. • The design will allow the rocks to also fall and continue to dissipate wave energy if the level of beach falls. • Construction methodology is straight forward. • The irregular nature of rock will allow them to be placed into the new steel frame with ease. • The additional structure will be similar in appearance to the existing defence and therefore will have only limited impact on the visual landscape. • Rocks are a natural product and will have less visual impact on the local landscape then concrete blocks. • Works will avoid impacting on the designated cliff face. • The footprint increase of the defence will only have a limit impact on the amenity space on the beach. • Rocks could be transported to the site via the sea and therefore avoid disrupting Mundesley with additional traffic.	• The existing structure was constructed using left-over steel acquired at a cheaper cost; this design would require purchase of new steel at a much greater cost. • Steel will corrode over time and is not aesthetically pleasing. • Placing the new structure in front of the existing steel framed structure will inevitably mean that there will be a clash with existing groynes along the frontage. • Piling of the structure during construction will result in vibrations that may have a negative impact on the stability of the cliff. • The varying size and dimensions of rock could result in the spacing between the vertical steels potentially having to be reduced to hold the rock in place adding to the construction cost.

Environmental assessment

The environmental impacts of both Options 7A & 7B are summarised in Table 7-19 below:

Table 7-19: Steel Framed Structure – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Aesthetically the same appearance as the existing defences, i.e. will not significantly impact on the existing landscape. • No significant impacts to the foreshore (only a limited impact on amenity use of the beach). • Will continue to slow the cliff receding and therefore protect socio-economic receptors against erosion. • Will not inhibit tourism • The location of the steel framed structures will remain away from the cliff and therefore avoid any significant impact on the designated habitats located on the cliff.	• Steel will corrode over time, will not be aesthetically pleasing and will present a hazard to the public as the structure fails. • If the concrete block option is selected there might be opposition due to the transportation of concrete block material through the village potentially causing noise and traffic disruption. • Prefabricated concrete blocks have a significant carbon footprint • Rock will have to be imported internationally. • By slowing cliff erosion sediment inputs into the environment will be reduced and therefore reduce sediment supply to the beach and other sites down drift. • Steel framed structures will continue to have a relatively large foot print on the beach • Piling of the structure during construction will result in vibrations that may have a negative impact on the stability of the designated cliff. • Footprint of new structure will clash with existing groynes that are required to maintain beach levels.	• If Option 7B is selected rock deliveries can be made via the sea and scheduled to avoid sensitive times. • Potential new habitats could be formed within the structure. • Health and safety risk to the public (of existing structure collapsing) is removed.

Cost assessment

The estimated capital and whole life costs are summarised in Table 7-20 below:

Table 7-20: Steel Framed Structure – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
7A	1	£1,119,395	£1,081,541	£2,180,079	£1,470,272	£4,133,537	£1,676,896
7B	1	£875,232	£845,634	£1,899,291	£1,216,933	£3,816,125	£1,418,902

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY

Reinforcing the existing steel framed structure will ensure that the cliffs receive continued protection throughout the required benefit period. Option 7B provides both the cheapest and most natural (aesthetically) way of filling the new steel structure and will therefore be considered in combination with other options to potentially form part of the final solution further assessment. However, there remain significant cost, construction issues and potential clashes with existing structures that will have to be resolved if this option is progressed.

7.8 Shortlisted Timber Groyne Options

Option 8A – Maintain the existing groynes through refurbishment

Description

This option proposes to maintain the existing timber groynes by refurbishment, which will include replacing the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. No significant changes would be made to the design of the groynes and they would remain permeable. Typically, the majority of the timber elements that need replacing are located at the seaward end of the groynes.

Initial Works

The initial works include undertaking a major refurbishment of each of the 13 groynes that allows for replacing 30% of the existing timbers.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis. Future works will also allow for additional refurbishment of the groynes at the following intervals throughout the benefit period:

- Minor refurbishment every 5 years (allowing for 7.5% timber replacement)
- Additional major refurbishments every 40 years (allowing for an additional 40% timber replacement)

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-21 below:

Table 7-21: Timber Groyne - Advantages and Disadvantages

Advantages	Disadvantages
• Existing structure is very effective at maintaining beach levels in front of the cliffs, refurbishing will prolong the life of the existing structure. • Refurbishing the existing groynes will improve their performance retaining beach levels. • Construction can be staggered; through condition assessment different elements can be prioritised and planned at intervals. • The additional structure will be similar in appearance to the existing defence and therefore will have only limited impact on the visual landscape. • Known construction methodology • Tropical hardwood is comparatively more effective in marine environments than locally sourced oak. • Works will avoid impacting on the designated cliff face.	• Refurbishing the existing groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. • Construction can be technically challenging particularly with the groynes partially hidden beneath the beach. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and cost through an extended programme. • Although better than oak, tropical timber still has a relatively short residual life and as a consequence is expensive to maintain, as experienced with existing structure. • Environmental implications of importing tropical timber (and added cost of ensuring sustainably sourced).

Option 8E – Maintain the existing groynes through refurbishment and enhance resilience through rock armour protection

Description

Like Option 8A this options also includes a 'major' refurbishment of the existing timber groynes by replacing 30% of the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. However, this option also includes placing rock armour protection around the more vulnerable seaward end of the existing groynes in order to reduce the future maintenance requirements.

Initial Works

Like Option 8A the initial works also include undertaking a major refurbishment of each of the 13 groynes that allows for replacing 30% of the existing timbers. However the initial works also include the placement of approximately 480 tonnes of rock armour around the seaward end of each of the groynes (approximately 6,250 tonnes in total), i.e. offering protection to the most vulnerable section.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis. It will also allow for the repositioning of rock armour every 10 years (assumes a 10% re-build cost). The future works will also include for additional refurbishment of the groynes at the following intervals throughout the benefit period:

- Minor refurbishment every 10 years (allowing for 7.5% timber replacement)
- Additional major refurbishments every 50 years (allowing for an additional 30% timber replacement)

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-22 below:

Table 7-22: Timber Groyne & Rock Armour- Advantages and Disadvantages

Advantages	Disadvantages
• Rock armour will provide additional protection to the most vulnerable/exposed part of the structure, reducing the future maintenance needs, particularly in the inter-tidal areas. • Existing structure is very effective at maintaining beach levels in front of the cliffs, refurbishing will prolong the life of the existing structure. • Refurbishing the existing groynes will improve their performance retaining beach levels. • Construction can be staggered; through condition assessment different elements can be prioritised and planned at intervals. • The additional structure will be similar in appearance to the existing defence and therefore will have only limited impact on the visual landscape. • Known construction methodology • Tropical hardwood is comparatively more effective in marine environments than locally sourced oak. Works will avoid impacting on the designated cliff face.	• Refurbishing the existing groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. • Construction can be technically challenging particularly with the groynes partially hidden beneath the beach. • The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and cost through an extended programme. • Although better than oak, tropical timber still has a relatively short residual life and as a consequence is expensive to maintain, as experienced with existing structure. • Environmental implications of importing tropical timber (and added cost of ensuring sustainably sourced). • Potentially further modelling studies will be required to determine the effectiveness and impact of this new arrangement at the toe of the structure. • Potential consenting issues if placement of rock is deemed to interfere with coastal processes. • Rock armour is likely to be internationally sourced. • The addition of rock armour increases the amount of inter tidal work during construction.

Environmental assessment

The environmental impacts of both Options 8A & 8E are summarised in the Table below:

Table 7-23: Timber Groynes – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• The continued use of permeable groynes will avoid interfering with existing coastal processes • Aesthetically similar in appearance to the existing defences, i.e. will not significantly impact on the existing landscape. • No significant change to the footprint of the structure • No significant impacts to the amenity use of the beach.	• Using rock to protect the timber groynes will impact on the visual landscape of the frontage. • Rock armoured toe could potentially impact on existing coastal processes. • Both tropical timbers and rock armour are likely to be sourced internationally with large carbon footprints. • Construction will cause significant disruption on the beach.	• The placing of rock protection in the inter-tidal zone will potentially create a new marine habitat. • The rock protection will reduce the need for future maintenance activities.

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Will enable the groynes to continue to retain beach levels to protect the cliff and therefore protect socio-economic receptors against erosion. • Maintaining beach level will benefit local tourism (beyond construction)		

Cost assessment

The estimated capital and whole life costs are summarised in
Table 7-24 below:

Table 7-24: Timber Groynes – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
8A	1	£666,657	£644,113	£2,888,848	£1,512,196	£5,277,703	£1,756,012
8E	1	£1,156,908	£1,117,785	£2,089,344	£1,531,274	£3,699,327	£1,753,658

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY

By maintain the existing groynes through refurbishment it will ensure that the existing groynes are retained throughout the required benefit period, which is crucial for maintaining beach levels in front of the other defences. The addition of rock armour protection (8E) around the seaward end of the existing groynes will enhance the groynes ability to withstand increasing pressures resulting from climate change and therefore reduce maintenance requirements.

Although the PV cost benefits of reducing future maintenance through rock armour protection are not realised until beyond the 50 year benefit period, the difference is minimal and this option will significantly reduce the need for maintenance and therefore reducing the risk to workers in the inter-tidal zone. Therefore Option 8E will be considered in combination with other options to potentially form part of the final solution.

7.9 Shortlisted Beach Nourishment Option

Option 11 – Beach Nourishment

Description

The beach nourishment/recharge option involves the addition of new material to the beach to increase its level. The beach recharge would supply material via spraying from a barge onto the beach; the material would match the existing beach material. The increase in level of beach will cause waves to break ‘earlier’ and therefore the amount of wave energy reaching the cliff is reduced. The outline design of the option includes increasing the level of the top of the beach to a greater height than the present day 1 in 100 year water level (annual exceedance probability). The scheme will require periodic beach recharge or ‘top-ups’ to maintain the scheme and account for the removal of the material as the beach returns to its natural levels.

Initial Works

Initial works involve importing and distributing a large quantity (over 200,000m^3) of new beach material across the frontage.

Future Works

In addition the continuation of on-going routine maintenance on an annual basis, future works will also include for recycling activities to redistribute beach material across the frontage every 5 years and it is estimated that every 20 years an additional re-nourishment (importing over 50,000m^3) will be required to replace potential losses.

Technical assessment

The technical advantages and disadvantages of this option are listed in

Table 7-25 below:

Table 7-25: Beach Nourishment - Advantages and Disadvantages

Advantages	Disadvantages
• Raising beach levels will reduce the wave climates at the toe of the cliffs and therefore reduce the potential erosion. • It is perceived to be a more 'natural' approach to coastal defence, when compared to introducing hard structures. • Likely to have appositive impact on the local landscape. • Will be beneficial for recreation/amenity use and could potentially enhance local tourism. • Introducing additional sediment to this frontage will be a benefit for down drift locations. • Very popular with the general public.	• Beach re-nourishment activities are very expensive and will create significant disruption to the beach during construction. • The beach is likely to return to its natural level over time, therefore continued management and 'top-ups' will be required. • Will need to be delivered in conjunction with enhancements to the existing groynes resulting in additional costs. • Will potentially impact negatively on local environment by changing habitats. • Will interfere with existing coastal processes. • Further modelling studies would be required to determine the long term effectiveness. • Due to the dynamic nature of beaches even with modelling there will be an element of uncertainty, potentially one large storm event might return the beach to original levels.

Environmental assessment
The environmental impacts are summarised in the Table below:

Table 7-26: Beach Nourishment – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Likely to have appositive impact on the local landscape. • Will enhance the amenity use of the beach. • Enhanced beach levels will offer the cliffs greater protection and therefore protect socio-economic receptors against erosion. • Enhancing beach levels will benefit local tourism (beyond construction) • Works will not directly impact on the designated cliffs. • Introducing additional sediment to this frontage will be a benefit for down drift locations.	• Re-nourishment activities are likely to have a negative impact on local environment by changing habitats. • Re-nourishment activities are likely to interfere with existing coastal processes. • Significant disruption during construction	• Increased levels are likely to enhance the amenity value of the beach and enhance local tourism. • Likely to have appositive impact on the local landscape. •

Cost assessment
The estimated capital and whole life costs are summarised in Table 7-27 below:

Table 7-27: Beach Nourishment – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
11	1	£5,615,911	£5,426,001	£10,389,435	£7,409,838	£15,443,754	£7,972,889

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY
Option 11: Beach nourishment is very expensive, will interfere with existing coastal processes and local inter-tidal habitats and will have to be carried out in conjunction with on-going maintenance of the existing groynes to be effective. However, it will act to reduce the impact of wave action on the cliffs and will enhance the public amenity value of the existing beach. Therefore it will be considered in combination with other options to potentially form part of the final solution further assessment, however, the high costs involved in implementing this option mean it is unlikely to be progressed.

7.10 Shortlisted Scour Protection Options

Since none of the other shortlisted options allow for the raising or enhancing of the existing seawall it is necessary to protect the existing cliff face and access track behind the seawall from scour that results from significant overtopping events. The shortlisted scour protection options are detailed below:

Option 13B – Upstand Wall

Description

The new scour protection wall option is to install a new reinforced concrete wall at the landward side of the existing promenade (effectively raising the height of the existing seawall). There is already a dwarf wall in this location, but a higher wall would reduce the amount of overtopping. To prevent the amenity use of the walkway being impacted (location of beach huts in the summer) the new wall would be built 'into' the embankment to reduce its footprint on the promenade.

Initial Works

To construct the wall using engineered blocks, designed to withstand the impact of overtopping waves.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis and will also allow for the wall to be refurbished every 10 years, at an assumed cost equivalent to 10% of the installed cost. It is also assumed that the wall will be replaced every 30 years.

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-28 below:

Table 7-28: Timber Groyne - Advantages and Disadvantages

Advantages	Disadvantages
• A wall will effectively protect the slope from overtopping • The wall height can be designed to limit overtopping to an acceptable amount. • The wall will require limited future maintenance. • The footprint of the wall will not encroach on to the existing promenade. • The construction methodology is well known and there are unlikely to be any access issues.	• Construction would cause disruption to the walkway. • Wall height will potentially have to be substantial and could therefore have a significant visual impact. • Potential planning constraints • Surface water drainage from the embankment will have to be incorporated into the design. • Footprint and foundations of the wall will encroach into the existing embankment. • Excavation during construction will potentially cause geological instability. • A wall will not act to stabilise the existing slope, merely protect it from overtopping.

Environmental assessment

The environmental impacts are summarised in the Table below:

Table 7-29: Upstand Wall – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Construction methodology is fairly un-intrusive and relatively low risk. • Beyond construction there are no significant environmental impacts. • Protecting the embankment from overtopping will enable continued public access to the promenade and beach. • Limited maintenance required. • When constructed the wall will not reduce the available amenity space on the promenade.	• Potential surface water drainage (from embankment) to be addressed. • The wall's footprint and foundations encroach in the existing embankment resulting in a minor loss of vegetation. • Excavation during construction will potentially cause geological instability. • The wall will impact on the visual landscape of the frontage; the scale of the impact will depend on the size of the wall. • Construction would cause disruption to the walkway.	• Protecting the slope from overtopping will allow for vegetation and new habitats to establish.

Option 13 C - Concrete block mattress

Description

This option involves the placing of a cabled concrete solid block mattress over the lower end of the embankment. The crest height of the new protection will be designed to accommodate increasing levels of overtopping due to climate change. The mattress will be laid over a geotextile for drainage/filtration purposes. The use of porous 'Armorflex' blocks (or similar) will allow for vegetation to establish through the blocks improving the aesthetics of the protective slope.

Initial Works

To strip back the existing vegetation and anchor the concrete mattresses upon the geotextile on the existing slope.

Future Works

Future works will include for the continuation of on-going routine maintenance on an annual basis and will also allow for the mattresses to be refurbished every 10 years, at an assumed cost equivalent to 10% of the installed cost. It is also assumed that the protective mattresses will be replaced every 30 years.

Technical assessment

The technical advantages and disadvantages of this option are listed in Table 7-30 below:

Table 7-30: Blockwork Mattress - Advantages and Disadvantages

Advantages	Disadvantages
• The mattresses will provide a high level of protection against wave impacts. • The mattresses will act to help stabilise the existing slope. • The protective mattresses require only limited maintenance. • The porous nature of the concrete mattresses and the geotextile will allow surface water runoff from the embankment to freely drain (as in the current situation). • Following construction the mattresses will not encroach on to the existing promenade. • Construction methodology is well known. • The porous concrete blocks of the mattress can be utilised to plant vegetation.	• The mattresses will impact on the visual landscape of the frontage. • Construction would cause disruption to the walkway. • Access during construction could be problematic as significant lift equipment will be required. • Design relies on the existing embankment being relatively stable, for anchoring purposes. • Footprint of the mattresses is quite large and will incur the loss of all vegetation beneath it. • Anchoring will have to be sufficiently deep to avoid land slips of other geological instability.

Environmental assessment

The environmental impacts are summarised in Table 7-31 below:

Table 7-31: Blockwork Mattress – Environmental Impacts

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
• Beyond construction there are no significant environmental impacts. • Protecting the embankment from overtopping will enable continued public access to the promenade and beach. • Limited maintenance required. • When constructed the mattress will not reduce the available amenity space on the promenade. • Surface water drainage maintained	• The mattresses' footprint will encroach on the embankment resulting in a loss of vegetation. • Excavation during construction will potentially cause geological instability. • The mattress will significantly impact on the visual landscape of the frontage. • Construction would cause disruption to the walkway.	• The porous concrete blocks of the mattress can be utilised to plant vegetation.

Cost assessment

The estimated capital and whole life costs are summarised in Table 7-32 below:

Table 7-32: Scour Protection – Cost Summary

Option	Year of Initial Works	Capital Cost (Cash)	PV Capital Cost	Whole Life Cash Cost* (50 yrs.)	PV Whole Life Cost* (50 yrs.)	Whole Life Cash Cost* (100 yrs.)	PV Whole Life Cost* (100 yrs.)
13B	1	£155,840	£150,570	£358,431	£226,727	£716,863	£265,012
13C	1	£91,466	£88,373	£210,372	£133,072	£420,744	£155,542

*Note Whole Life Costs exclude general maintenance at this stage

SUMMARY

Both options 13B and 13C will effectively protect the embankment behind the seawall from overtopping waves and both options will have an impact on the visual landscape, and although the Concrete Mattress has potential access issues to overcome during construction, it is the most cost effective of the two options and will therefore be considered in combination with other options to potentially form part of the final solution further assessment.

8. Scheme option costs

8.1 Scheme solutions

As none of the options presented in the sections above could ‘stand-alone’ and be adopted to protect the entire frontage for the whole appraisal period, it was necessary to produce various combinations of interventions from the shortlisted options. Each combination provides a complete defence solution for a scheme for the whole frontage and lays out the different option combinations and the timings of each intervention.

In total 9 different combinations of the various short listed options were considered. These are listed and described below.

1. **Do Nothing**: Stop all funding, no further capital works or maintenance.
2. **Do Minimum**: No capital spend, only routine maintenance until the defences reach the end of their residual life, then stop maintenance.
3. **Rock Revetment**: Includes for a rock armour revetment along the toe of the cliff for the entire frontage except along the existing seawall. This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
4. **Maintain Existing**: This option is to maintain all of the existing defences, this will including reinforcing the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
5. **Partial Rock Placement A**: Includes for rock armour protection along the length of the existing timber revetment, to reinforce the existing steel structure and to undertake seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
6. **Partial Rock Placement B**: Includes for rock armour protection along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
7. **Full Rock Placement**: Includes for rock armour protection along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes including protecting vulnerable sections with rock armour and scour protection.
8. **Beach Re-nourishment**: Including a significant quantity of beach re-nourishment to raise the level of the beach. This option also includes for seawall (not apron) and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.
9. **Adaptive Option**: Similar to Option 7 as it also includes for the placement of rock armour along the remainder of the frontage, but is limited to 1 initial shipment of rock (i.e. 25,000 tonnes). This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

8.2 Costing approach

Capital construction costs for the various scheme solutions have been developed based on measured quantities and unit rates. For a detailed breakdown of the options, showing the items of work involved, how these items are measured, the measured quantity and the £/unit rate refer to the Costing Report.

Maintenance costs and costs of ongoing works (i.e. repeat interventions) for the schemes have also been developed. These costs are on top of the capital costs of the various elements and are necessary in order to develop whole life costs. The approach and assumptions used in the development of the maintenance costs can be found in the Costing Report.

Whole life costs for the scheme options have been developed based on the combined capital and maintenance costs. The whole life costing assumptions are presented in the Costing Report and a detailed breakdown of the whole life costs of the scheme options is provided in the Costing Report appendices. Whole life cost estimates include discounting which is discussed below.

8.2.1 Discounting and present value

Discounting is a technique used to compare costs that occur at different points in time over the appraisal period or over the whole life of an option. Standard discount rates have been used to convert all costs to 'Present Value' (PV). FCERM-AG recommends using HM Treasury Green Book and the following variable discount rates (expressed as a %) have been used within the whole life costing; 3.5% for years 0 to 30, 3% for years 31-75 and 2.5% for years 76-99. Using these discount rates of the 100 year appraisal period, a total PV cost for each option combination was determined. The discount rates applied are the same as those applied to the economic damages and benefits and therefore the PV costs of options and benefits are directly comparable.

8.2.2 Option duration

Scheme option combinations have been developed for appraisal periods lasting 50 and 100 years. Option benefits have also been developed for these periods which are directly comparable and are presented later in this report.

8.2.3 Cost date

All cost estimates (capital and maintenance) presented in this section are valid to January 2018.

8.3 Scheme Option 1 – Do Nothing

The Do Nothing option would involve no further management of the existing defences, ceasing all maintenance and capital expenditure activities and allowing nature to take its course. The Do Nothing option is the baseline against which all other options are compared.

Without defence maintenance the existing defences will deteriorate over time until they eventually fail, resulting in the increased exposure of the cliffs to wave action (the primary driver of erosion). This coupled, with future climate change predictions, which forecasts increases in both sea levels and the frequency of large storm events, will result in the rate of erosion increasing in the future. Over the course of the next century the cliffs would be expected to recede by up to approximately 245m due to erosion. The cost implementing the Do Nothing scenario is £0.

8.4 Scheme Option 2 – Do Minimum

The Do Minimum option involves continuing with routine maintenance works to reduce the health and safety risk to the public and extend the current defence life as far as possible without undertaking any capital works. In effect, the Do Minimum approach is delayed Do Nothing, as it will also eventually allow the defences to fail and nature to take its course.

The annual cost associated with maintaining the existing defences as best as possible with minimal investment has been estimated to be £19,000 per year. Over the 50 year appraisal period this corresponds with a total cash (undiscounted) cost of £950k and a PV cost of £465k. Over the 100 year appraisal period this corresponds with a total cash (undiscounted) cost of £1,900k and a PV cost of £567k.

Table 8-1: Cash and PV costs for Do Minimum

Appraisal Period	Capital Costs	Maintenance	Cash Costs (undiscounted)	PV Costs
50 Year	£-	£950,000	£950,000	£465,411
100 Year	£-	£1,900,000	£1,900,000	£567,364

8.5 Scheme Option 3 – Rock Revetment

This option is comprised of constructing a rock armour revetment at the toe of the cliff across the entire frontage (except where the existing seawall is), prolonging the life of the existing seawall and groyne structures through maintenance, and protection of the embankment at risk of scour.

Table 8-2: Elements of Scheme Option 3

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Rock revetment	In Year 1 a rock revetment will be placed along the entire frontage, except where the seawall exists. This will replace the timber revetment and steel framed structure protection. Maintenance of the rock revetment will occur every 10 years.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-3: Whole life costing for Scheme Option 3 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£11,895,578	£950,000	£12,845,578	£10,339,879
100 Year	£15,730,064	£1,900,000	£17,630,064	£10,883,802

8.6 Scheme Option 4 – Maintain Existing

This option is to maintain all of the existing defences which will include reinforcing the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes. Vulnerable sections will be protected with rock armour and scour protection.

Table 8-4: Elements of Scheme Option 4

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Timber revetment	In Year 1 refurbish the timber revetment (50%). Minor refurbishments (10%) to be carried out every 5 years. Additional major refurbishments (33%) carried out every 20 years, in Years 39, 59, 79 and 99.
Steel framed structure	In Year 1 an additional frame is built in front of the existing and filled with rock armour to enhance the existing defence. Maintenance (5%) will take place every 10 years. More major refurbishments to replace any steel elements will occur every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-5: Whole life costing for Scheme Option 4 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£9,965,369	£950,000	£10,915,369	£6,723,062
100 Year	£17,858,249	£1,900,000	£19,758,249	£7,701,400

8.7 Scheme Option 5 – Partial Rock Placement A

This option involves placing rock armour protection along the length of the existing timber revetment, reinforcing the existing steel structure and to undertake seawall, apron and groyne refurbishments. This approach includes protecting vulnerable sections of the frontage with rock armour and scour protection.

Table 8-6: Elements of Scheme Option 5

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Place rock behind timber revetment	In Year 1 import and position rock behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
Steel framed structure	In Year 1 an additional frame is built in front of the existing and filled with rock armour to enhance the existing defence. Maintenance (5%) will take place every 10 years. More major refurbishments to replace any steel elements will occur every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-7: Whole life costing for Scheme Option 5 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£8,072,240	£950,000	£9,022,240	£6,232,996
100 Year	£13,332,216	£1,900,000	£15,232,216	£6,920,107

8.8 Scheme Option 6 – Partial Rock Placement B

This option involves placing rock armour along the length of the existing steel framed structure and to undertake refurbishments of the existing timber revetments, seawall, apron and groynes. This approach includes protecting vulnerable sections of the frontage with rock armour and scour protection.

Table 8-8: Elements of Scheme Option 6

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section

	6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Timber revetment	In Year 1 refurbish the timber revetment (50%). Minor refurbishments (10%) to be carried out every 5 years. Additional major refurbishments (33%) carried out every 20 years, in Years 39, 59, 79 and 99.
Place rock in front of steel framed structure	In Year 1 import and position rock in front of the existing steel framed structure to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-9: Whole life costing for Scheme Option 6 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£8,324,295	£950,000	£9,274,295	£5,763,265
100 Year	£14,262,805	£1,900,000	£16,162,805	£6,536,128

8.9 Scheme Option 7 – Full Rock Placement

This option involves placement of rock armour protection along the full length of the frontage, except for where the existing seawall is located. This option also includes seawall, apron and groyne refurbishments and using rock armour and scour protection to protect vulnerable sections.

Table 8-10: Elements of Scheme Option 7

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
Place rock in front of steel framed structure and behind timber revetment	In Year 1 import and position rock in front of the existing steel framed structure and behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-11: Whole life costing for Scheme Option 7 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£6,431,166	£950,000	£7,381,166	£5,273,198
100 Year	£9,736,772	£1,900,000	£11,636,772	£5,754,835

8.10 Scheme Option 8 – Beach Re-nourishment

This option involves nourishing the beach with a significant quantity of sediment to raise the beach level. This option also includes seawall (not apron) and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

Table 8-12: Elements of Scheme Option 8

Element	Description
Beach recharge	In Year 1 carry out beach re-nourishment to increase the beach level. Every 5 years carry out beach recycling and every 20 years carry out partial nourishment to sustain new beach level. Because of the beach recharge the timber revetment and steel framed structure will not be replaced at the end of their design life.
Wall/apron re-facing	In Year 1 carry out re-facing of seawall as per other options, with the exception of Section 6, where no re-facing of the apron is initially required because of the additional protection the increased beach level provides. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81, however only 50% of the Section 6 apron will be re-faced as it is assumed that the lower section of apron will be protected by the maintained beach levels.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock maintenance will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-13: Whole life costing for Scheme Option 8 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£13,841,872	£950,000	£14,791,872	£10,196,191
100 Year	£21,508,064	£1,900,000	£23,408,064	£11,175,526

8.11 Scheme Option 9 – Adaptive Option

This option is similar to Option 7 (full rock placement) but includes the placement of rock armour along the remainder of the frontage. The placement is however limited to 1 shipment of rock (i.e. 25,000 tonnes). This option also includes for seawall, apron and groyne refurbishments including protecting vulnerable sections with rock armour and scour protection.

Table 8-14: Elements of Scheme Option 9

Element	Description
Wall/apron re-facing	In Year 1 re-facing works to seawall and apron where required only, in some sections only the apron will initially require re-facing as the seawall has a longer residual life. Rock will also be installed to protect the more vulnerable Section 6. After 30 years the entire wall and apron of the seawall will be refaced, this will also occur in Year 81. Maintenance will occur to the rock in Section 6 approximately every 10 years.
Groyne refurb	In Year 1 the groynes will be refurbished (30%) and additionally rock will be placed at the ends of the groynes to offer additional protection. Minor groyne and rock refurbishment will occur every 10 years. In Year 51 another major refurbishment will take place.
Scour protection	In Year 1 articulated concrete block revetment scour protection to be installed on the embankment. Maintenance will take place every 10 years. The scour protection will be replaced every 30 years, in Years 31, 61 and 91.

Place rock in front of steel framed structure and behind timber revetment	In Year 1 import and position rock in front of the existing steel framed structure and behind the existing timber revetment to replace the defence. Maintenance will occur every 10 years to reposition any displaced rock.
Rock placement	In Year 1 import and place rock armour in front of steel framed protection, behind timber revetment, along Section 6 of seawall and at end of groynes. In Year 11 import some additional rock armour to ensure continued protection when the remainder of the timber revetment fails.
General maintenance	General maintenance along the frontage will take place continuously throughout the appraisal period.

Table 8-15: Whole life costing for Scheme Option 9 (cash and PV)

Appraisal Period	Capital Costs and specific maintenance	Maintenance (general)	Cash Costs (undiscounted)	PV Costs
50 Year	£6,250,744	£950,000	£7,200,744	£4,994,538
100 Year	£9,505,687	£1,900,000	£11,405,687	£5,470,208

8.12 Summary of scheme option costs

Table 8-16: Summary of whole life costs (cash and PV) for the scheme options

		Whole life cash costs (undiscounted)			**Whole life PV costs (discounted)**
Appraisal period	Option	Capital Costs and specific maintenance	Maintenance (general)	Total	Total
50yrs	1 – Do Nothing	£-	£-	£-	£-
	2 – Do Minimum	£-	£950,000	£950,000	£465,411
	3 – Rock Revetment	£11,895,578	£950,000	£12,845,578	£10,339,879
	4 – Maintain Existing	£9,965,369	£950,000	£10,915,369	£6,723,062
	5 – Partial Rock Placement A	£8,072,240	£950,000	£9,022,240	£6,232,996
	6 – Partial Rock Placement B	£8,324,295	£950,000	£9,274,295	£5,763,265
	7 – Full Rock Placement	£6,431,166	£950,000	£7,381,166	£5,273,198
	8 – Beach Re-nourishment	£13,841,872	£950,000	£14,791,872	£10,196,191
	9 – Adaptive Option	£6,250,744	£950,000	£7,200,744	£4,994,538
100yrs	1 – Do Nothing	£-	£-	£-	£-
	2 – Do Minimum	£-	£1,900,000	£1,900,000	£567,364
	3 – Rock Revetment	£15,730,064	£1,900,000	£17,630,064	£10,883,802
	4 – Maintain Existing	£17,858,249	£1,900,000	£19,758,249	£7,701,400
	5 – Partial Rock Placement A	£13,332,216	£1,900,000	£15,232,216	£6,920,107
	6 – Partial Rock Placement B	£14,262,805	£1,900,000	£16,162,805	£6,536,128
	7 – Full Rock Placement	£9,736,772	£1,900,000	£11,636,772	£5,754,835
	8 – Beach Re-nourishment	£21,508,064	£1,900,000	£23,408,064	£11,175,526
	9 – Adaptive Option	£9,505,687	£1,900,000	£11,405,687	£5,470,208

9. Option appraisal

The option appraisal has been undertaken in line with FCERM guidance. The economic case and the wider objectives / critical success factors have been considered in the option appraisal as discussed below.

9.1 Economic appraisal

9.1.1 Benefits

Direct

To quantify the direct erosion benefits to properties and assets under the ‘Do Nothing’ option and therefore establish the benefits of the ‘Do Something’ options, the erosion extents determined by the SCAPE model was used in conjunction with the National Receptor Database property dataset to determine potential property damages and benefits. Other direct damages included in the assessment are for potential damages to infrastructure such as roads and utilities.

Indirect

In addition to direct asset damages, wherever possible a range of relevant intangible damages were also quantified following the Multi-Coloured Manual guidelines this included potential damages such as traffic and risk to life.

All direct and indirect damages have been applied using the methodologies outline in the Multi-Coloured Manual. All damage values have been uplifted to January 2018. A summary of the economic benefits provided by each of the options is presented in Table 9-1. This presents the damages and benefits over the 50 year appraisal period (to match that of the scheme). For reference, the damages and benefits for a longer term 100 year appraisal period are also presented. For further information on methodologies and assumptions applied in the valuation of damages and benefits refer to the Damages Report.

Table 9-1: Present value (PV) damages and benefits

Option	PV Damages (50 yr. appraisal period)	PV Benefits (50 yr. appraisal period)	PV Damages (100 yr. appraisal period)	PV Benefits (100 yr. appraisal period)
Do Nothing	£41,235,000	-	£48,230,000	-
Do Minimum	£33,613,000	£7,622,000	£41,281,000	£6,949,000
HTL	£0	£41,235,000	£319,000	£47,910,000

9.1.2 Option ranking

As per FCERM guidance, the options have been ranked according to their average benefit cost ratio and the leading economic option has been identified. The whole life option benefits (above) have been divided by the option costs (presented in section 8) to determine the average benefit cost ratio (BCR). Incremental benefit cost ratios been options have then been determined by dividing the increase in benefits by the increase in cost. Between options with equal benefits, the incremental benefit cost ratio has been set to null (0) as it is not possible to undertake the calculation.

Table 9-2: Economic appraisal summary (50 year appraisal period)

Scheme Options	Present Value costs (£)	Present Value damages(£)	Present Value benefits (£)	Average benefit: cost ratio (BCR)	Incremental benefit: cost ratio (IBCR)	Economic leading option
1. Do Nothing	£ -	£ 41,235,000	£ -			-
2. Do Minimum	£465,411	£ 33,613,000	£7,622,000	16.38	16.38	-
9. Adaptive Option	£4,994,538	£ -	£41,235,000	8.26	7.42	Yes
7. Full Rock Placement	£5,273,198	£ -	£41,235,000	7.82	0.00	-
6. Partial Rock placement B	£5,763,265	£ -	£41,235,000	7.15	0.00	-
5. Partial Rock placement A	£6,232,996	£ -	£41,235,000	6.62	0.00	-
4. Maintain Existing	£6,723,062	£ -	£41,235,000	6.13	0.00	-
8. Beach Re-Nourishment	£10,196,191	£ -	£41,235,000	4.04	0.00	
3. Rock Revetment	£10,339,879	£ -	£41,235,000	3.99	0.00	-

*note that the PV costs in this table exclude the PV appraisal costs (£70k)

The economic appraisal (Table 9-2) shows that when assessed against the FCERM decision rules the economically preferred option for a scheme for the 50 year period is Option 9 (the Adaptive Option) as it has the best benefit to cost ratio (BCR) of 8.26:1. Although the Do Minimum (Option 2) has a higher BCR of 16.38, when Option 9 is compared incrementally against the Do Minimum option it achieves an incremental benefit cost ratio of 7.42:1, which robustly justifies the additional spend of Option 9 over that of the Do Minimum. In addition, the Do Minimum option is not in line with the SMP policy and would be detrimental to both the natural and built environments of Mundesley if implemented.

Although the scheme has an appraisal period of 50 years, which delivers the SMP policy, to test the economic case for extending protection of the frontage to year 100, the costs and benefits for such an option were also explored (Table 9-3 below).

Table 9-3: Economic appraisal summary (100yr appraisal period)

Scheme Options	Present Value costs (£'000)	Present Value damages(£'000)	Present Value benefits (£'000)	Average benefit: cost ratio (BCR)	Incremental benefit: cost ratio (IBCR)	Economic leading option
1. Do Nothing	£ -	£48,230,000	£ -			-
2. Do Minimum	£567,364	£41,281,000	£6,949,000	12.25	12.25	-
9. Adaptive Option	£5,470,208	£319,000	£47,911,000	8.76	7.13	Yes
7. Full Rock Placement	£5,754,835	£319,000	£47,911,000	8.33	0.00	-

Scheme Options	Present Value costs (£'000)	Present Value damages(£'000)	Present Value benefits (£'000)	Average benefit: cost ratio (BCR)	Incremental benefit: cost ratio (IBCR)	Economic leading option
6. Partial Rock placement B	£6,536,128	£319,000	£47,911,000	7.33	0.00	-
5. Partial Rock placement A	£6,920,107	£319,000	£47,911,000	6.92	0.00	-
4. Maintain Existing	£7,701,400	£319,000	£47,911,000	6.22	0.00	-
3. Rock Revetment	£10,883,802	£319,000	£47,911,000	4.40	0.00	-
8. Beach Re-Nourishment	£11,175,526	£319,000	£47,911,000	4.29	0.00	-

*note that the PV costs in this table exclude the PV appraisal costs (£70k)

The results show that the economically preferred option over 100 year period remains the Adaptive Option (Option 9), with a benefit to cost ratio of 8.76:1. In addition, the appraisal found that when Scheme Option 9 is compared to 'Do Minimum' it achieves an incremental benefit cost ratio of 7.13:1, which clearly demonstrates that if the 'hold the line' policy was to be extended to 100 years then the additional spend would be economically justified and outweighed by the additional benefits. This therefore demonstrates that in future revisions of the SMP or Coastal Strategy, the case to extend a hold the line policy to year 100 should be revisited and reconsidered. The delivery of such a Policy will however still remain subject to securing the required funding.

9.2 Critical success appraisal

By utilising the assessment undertaken of all the constituent scheme options detailed in Section 8 and the economic appraisal of the scheme options summarised in Section 9.1 it has been possible to measure each of the scheme options against the critical success factors that have been identified for the scheme.

Table 9-4 below summarises the critical success assessment, please note that only the scheme options with a 50 year appraisal period have been assessed in line with the SMP policy.

Table 9-4: Critical success assessment

Critical Success Factor	**Scheme Options**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
To reduce erosion risk to people, property and infrastructure for the duration of the scheme	☹	☹	☺	☺	☺	☺	☺	😐	☺
To provide cost effective and deliverable erosion risk management intervention which is technically feasible and sustainable	☺	☺	☹	😐	😐	😐	😐	☹	☺
To maintain & where possible enhance natural, historic & built environments	☹	☹	😐	☺	☺	☺	☺	😐	☺
To maintain and where possible enhance the tourist industry in Mundesley	☹	☹	😐	😐	😐	😐	😐	☺	😐
To facilitate NNDC in meeting their Development goals for Mundesley including employment and residential properties and associated infrastructure over the life of the scheme.	☹	☹	☺	☺	☺	☺	☺	☺	☺

The results of this critical success assessment support the results of the economical appraisal, as Scheme Option 9 is again the preferred option. This is because Scheme Option 9:

- Successfully reduces the erosion risk to the people, property and infrastructure of Mundesley.
- Is the most cost effective of the active intervention options.

- Is both technically feasible and sustainable.
- Protects the natural, historic & built environments without any significant impacts on local designations, Landscapes or coastal processes.
- Does not adversely impact and will help to maintain the existing tourism industry.
- Does not adversely impact and will help to facilitate NNDC's development plans for Mundesley.

9.3 Non-financial benefit appraisal

The scheme benefits outlined in Table 9-1 represent the economic damage avoided (FCERM eligible). These benefits are assessed from a national economic perspective which does not permit the inclusion of potential local benefits which are transferable and displaceable. This allows nationally consistent appraisal of scheme benefits and outcomes and provides a 'level playing field' for Partnership Funding assessments.

However, the local economic benefits of a scheme will be significantly greater than the FCERM figures and additional local economic benefits can be derived as a result of the intervention. By evaluating the potential contribution to the local economy of investing in an erosion risk protection scheme, it helps build an understanding of other positive impacts on the local economy. For Mundesley the key aspects of this include:

- Facilitation of business continuity and sustainability of business activity in an area;
- Continuation of tourism and recreation usage; and
- Continuation of maritime response/ rescue services.

Although not included in the FCERM appraisal, a high level estimated valuation of these other local economic benefits was undertaken. This further adds to the case for change and demonstrates the local value of delivering the scheme. For the assessment of additional local economic benefits a 30 year appraisal period was adopted (rather than the 50 year period for the partnership funding assessment) because, in line with best practice, the assessment should focus only on the direct impacts of the scheme intervention, not other factors that can influence the longer term behaviours and trends of commerce and tourism.

9.3.1 Qualitative impacts

Without a scheme to mitigate erosion risk there would be significant impacts to the local economy and community in Mundesley. Table 9-5 presents the non-residential assets that would be lost over the next 100 years in a Do Nothing scenario.

Table 9-5: Summary of commercial / tourism related assets at risk of erosion (Do Nothing)

Years	Assets lost	Impact of loss on local economy / community
0-10	Lifeboat station	Loss of maritime rescue service, potential increased risk to life for seafarers
11-20	60 beach huts, Restaurant / Cafeteria, shop, 2 holiday cottages, village hall, library	Loss of amenity and recreation supporting assets. Local economic impacts due to reduced visitor numbers and reduced spend due to degradation of services and accommodation etc.
21-30	Hotel, Church, Restaurant, Museum, 4 shops, other commercial, 3 holiday cottages, public toilets, amusements, parking, recycling site,	Further loss of community and visitor interest features. Direct impacts to economy through loss of retail outlets.
31-40	3 Holiday cottages	Further loss of visitor accommodation.
41-50	2 holiday cottages	Further loss of visitor accommodation.
51-60	1 holiday cottage	Further loss of visitor accommodation.

61-70	1 holiday cottage	Further loss of visitor accommodation.
71-80	3 holiday cottages / chalets, petrol station	Further loss of visitor accommodation and supporting services
81-90	6 holiday cottages / chalets, playground, other commercial enterprise	Loss of community recreation assets.
91-100	8 holiday cottages / chalets	Further loss of visitor accommodation.

The impacts identified in Table 9-5 demonstrate the importance of a scheme to prevent significant detrimental impacts to the local economy. Initially impacts would be relatively minor but without intervention from year 10, key assets for the community and visitors would be lost. Firstly the Lifeboat station will be lost to erosion and this would have major health and safety implications from seafarers as there would be no local response and rescue service for maritime users. This would therefore increase the threat to life.

Over time the blue flag beach, beach huts, critical infrastructure and services and coastal access would be adversely affected or eventually lost. Local trade would suffer considerably as many of the shops and businesses rely heavily on day trippers and holiday makers. Eventually Mundesley would become an undesirable place to live and visit and alternative locations would be sought.

9.3.2 Qualitative benefits – local tourism

Local tourism benefits provided by scheme option 9

Indicative valuations were carried out using methodologies adapted from the MCM manual, Defra GVA toolkit, and applied data from estimated tourism spend figures provided in previous tourism Study for Norfolk (Tourism Benefit & Impacts Analysis – In the Norfolk coastal area of outstanding natural beauty, 2006). Given the studies age and the lack of available detailed data, some simplistic conservative assumptions and estimates have been necessary, therefore the data presented below is likely to represent the lowest estimates and the true local economic benefit is likely to be greater.

The Mundesley Tourist Office states that “well over 7000 visitors pass through” their tourism office each year (Mundesley Visitors Centre, 2018). Many of these visitors come to use the beaches for amenity and recreation such as walking or fishing, or to see the museum. Many also use the local cafés and restaurants and many stay in the range of different tourism accommodation. Therefore without intervention to prevent erosion, from year 10, many of the features that attract and serve the visitors will begin to be lost or adversely impacted. A reduction in visitors and tourism spend has been estimated as a result and is assumed by year 30 tourism would effectively cease as alternative locations would serve their needs as Mundesley becomes unattractive and lacking in the required services and features that bring people to the village today.

The estimated cash benefit to the local economy from Scheme option 9 maintaining tourism at current day levels is £8.8m. The discounted (PV) whole life tourism benefit over the 30 years is estimated to be approximately £3.9m.

These valuations are based on an estimate of how quickly tourism would go elsewhere if erosion was unmitigated. They are also based on daily spend rates of day trippers (£40/day) and of people staying on holiday (£200/trip). The high level assessment also assumes an even split of the two types of visitor. It is likely that many more people visit the area than adopted in this valuation so the actual local economic tourism benefit associated with the scheme could be far greater. The estimates also do not account for potential increases in tourism which the preferred option could facilitate.

Table 9-6: Total economic benefits provided by Scheme Option 9

Category	PV £m
Local economic tourism benefits	3.9
FCERM Benefits for the Preferred option	41.2
Total	45.1

The conservative valuation of additional local tourism benefits totals £3.9m (PV) over the next 30 years, which equates to approximately an additional 10% of the total benefits and therefore increases the total financial benefits of the preferred option to £45.1m (Table 9-6). This qualitative assessment of the tourism benefits demonstrates that by implementing an active intervention scheme (through the preferred technical, environmental and economic option) there would be a significant benefit to the local economy.

9.4 Selection of preferred scheme option

Based on the economic appraisal and consideration of the critical success factors and non-financial benefits the leading economic option has been selected as the Option 9 - the Adaptive option. This was the leading economic option identified in the economic appraisal.

10. Comparison of funding

10.1 Partnership Funding

This section provides a comparison of the likely funding availability between the different scheme options. This analysis was completed using Defra's Partnership Funding calculator and Table 10-1 below contains a summary of the results of this analysis.

The analysis demonstrates that the preferred option is also the option with the greatest PF score and GiA funding eligibility. The preferred scheme option has a raw PF score of 87%. Assuming a contribution of £632k (committed to by funding partners) the adjusted PF score increases to 105%. The amount of GiA eligible for the scheme is approximately £2.7m.

A copy of the PF calculator of the preferred options is contained in Appendix F.

Table 10-1: Summary of the PF Calculator Analysis

Scenario	Appraisal Costs (PV) (£)	Whole Life Cost (PV) (£)	Benefits* (PV) (k)	BCR	Raw PF Score (%)	Assumed Contribution (£)	Adjusted PF Score (%)	GIA Funding (£)	Total Contribution required (£)	Contribution shortfall (£)
3	70,000	£10,339,879	41,235,000	3.96	42%	632,046	49%	0	5,088,516	4,456,470
4	70,000	£6,723,062	41,235,000	6.07	65%	632,046	81%	0	1,395,476	763,430
5	70,000	£6,232,996	41,235,000	6.54	70%	632,046	84%	0	1,369,807	737,761
6	70,000	£5,763,265	41,235,000	7.07	75%	632,046	94%	0	831,899	199,853
7	70,000	£5,273,198	41,235,000	7.72	82%	632,046	97%	0	734,410	102,364
8	70,000	£10,196,191	41,235,000	4.02	43%	632,046	52%	0	4,063,712	3,431,666
9	70,000	£4,994,538	41,235,000	8.14	87%	632,046	105%	2,714,359	450,124	-181,922

10.2 Funding summary

Table 10-1 demonstrates that only one of the derived combinations of alternative delivery methods is financially viable without a considerably large increase in the third party contributions (option 9).

11. Preferred option

11.1 Preferred option

Based on the evidence presented above Option 9 – the Adaptive option has been confirmed as the preferred scheme option. In order to protect the entire frontage, Option 9 – the Adaptive Option is comprised of 4 separate elements of work, a description of each element is summarised below along with an indicative activity schedule of capital works throughout the appraisal period.

Rock Works: This adaptive option proposes to place rock armour protection along the frontage (except where the existing seawall is) on the beach in front of the cliffs, either supplementing or (in time) replacing the existing defences. Initially for procurement efficiency the quantity of rock will be limited to 25,000 tonnes (one seaward delivery), however, as the existing defences (timber revetment and steel framed structures) reach the end of their residual life and fail the rock will be moved into place and eventually an additional supply of rocks will be required although this is not anticipated within the first 10 years.

Scour Protection: This option includes for the placing of a cabled concrete solid block mattress over the lower end of the embankment (behind the seawall). The crest height of the new protection will be designed to accommodate increasing levels of overtopping due to climate change. The mattress will be laid over a geotextile for drainage/filtration purposes. The use of porous ‘Armorflex’ blocks (or similar) will allow for vegetation to establish through the blocks eventually improving the aesthetics of the protective slope.

Timber Groynes: This option also includes for a major refurbishment of the existing timber groynes by replacing 30% of the various timber elements that are either damaged or missing with a like-for-like tropical hardwood replacement. In addition, this option also includes placing rock armour protection around the more vulnerable seaward end of the existing groynes in order to reduce the future maintenance requirements.

Seawall and apron: This option proposes to maintain the existing seawall and apron throughout the desired policy period by encasing the existing structure in reinforced concrete when necessary; initially this involves encasing only a limited number of sections of the existing wall, ensuring that the residual life of the entire seawall is uniform. In addition, this option also includes additional rock armour protection for particularly vulnerable sections of the structure, therefore reducing the need for future works.

Table 11-1: Schedule of works over the life of the scheme

Year	Schedule of Works
Year 1	Deliver and storage of 25,000 tonnes of rock armour. Install the concrete mattress scour protection behind the existing seawall. Undertake major (30%) refurbishment of timber groynes Undertake concrete encasement of relevant sections of seawall and apron. Protect vulnerable sections of seawall and timber groynes with rock armour.
Year 11+	Supply additional rock armour, as the remaining timber revetment reaches the end of its expected residual life
Every 10 years: (Years 11,21,31,41)	Undertake minor (10%) refurbishment of timber groynes Undertake maintenance of rock armour (re-position rocks etc.) Undertake maintenance of concrete mattress.
Year 31	Undertake concrete encasement of seawall. Replace concrete mattress behind the seawall

A summary of the outcome measures resulting from the implementation of the preferred option are summarised below in Table 11-2.

Table 11-2: Summary of preferred option contributions to outcome measures

Contributions to outcome measures	
Outcome 1 – Ratio of whole-life benefits to costs	
Present value benefits (£k)	£41,235
Present value costs (£k)*	£5,064,538*
Benefit: cost ratio	8.14 to 1
Outcome 2 – Households at reduced risk of flooding	n/a
Outcome 3 – Households with reduced risk of erosion	
3a – Households with reduced risk of erosion (nr)	297
Number of households in: (long term > 20 years, medium term <= 20 years)	
20% most deprived areas	Long – 0 Medium – 0
21-40% most deprived areas	Long – 131 Medium – 27
60% least deprived areas	Long – 127 Medium – 12
Outcome 4 – Water framework directive	n/a

*Please note the PV costs in this table include the PV appraisal costs (£70k).

Appendix A – Coastal Erosion Protection Option Drawings

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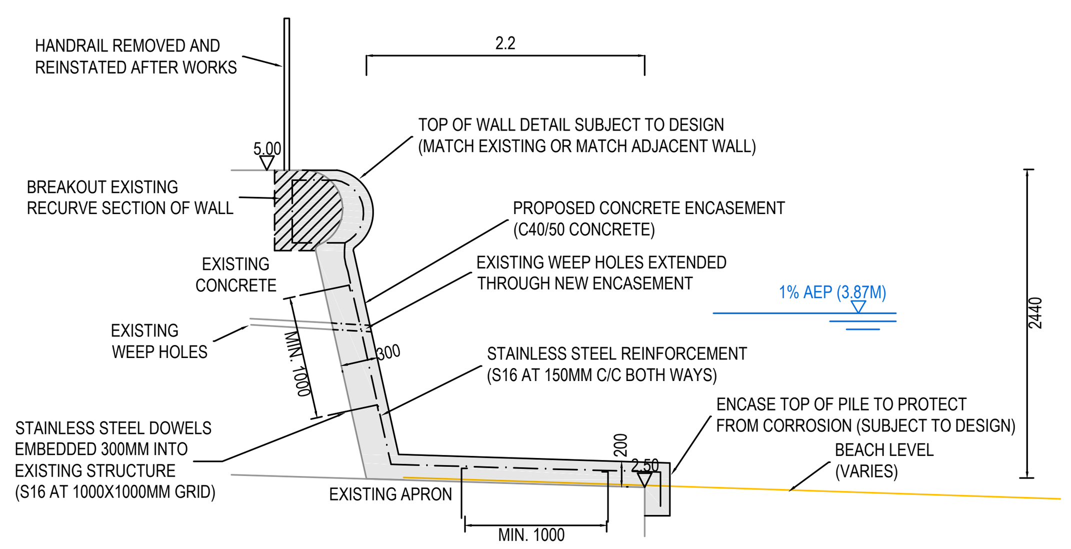
5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 1 RELATES TO THE AREA S7T FROM THE CONDITION ASSESSMENT
7. SEAWALL FRONTAGE 2 RELATES TO THE AREA S6 FROM THE CONDITION ASSESSMENT
8. SEAWALL FRONTAGE 3 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
9. SEAWALL FRONTAGE 4 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
10. SEAWALL FRONTAGE 5 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT
11. SEAWALL FRONTAGE 6 RELATES TO THE AREA S4 FROM THE CONDITION ASSESSMENT

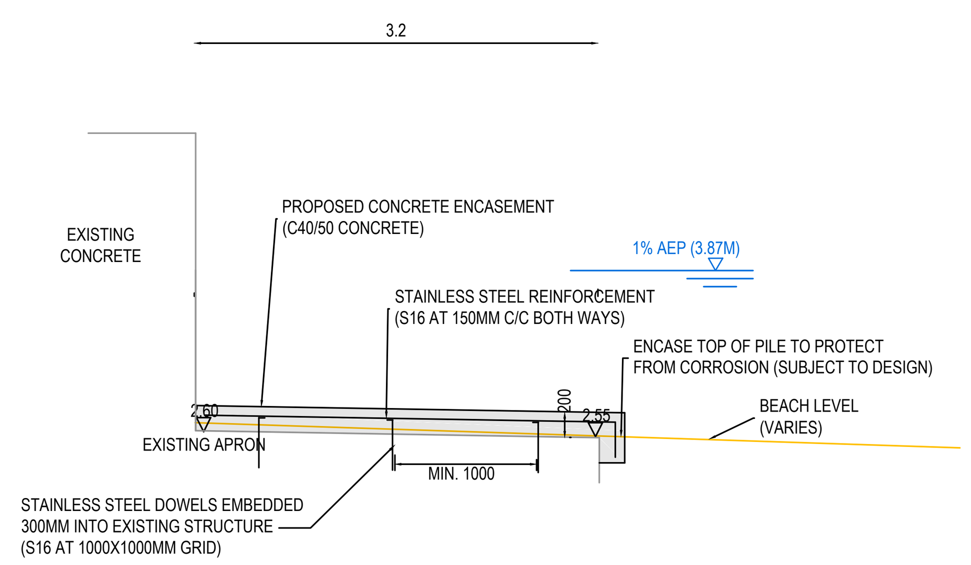
LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- ALREADY REPAIRED SEAWALL

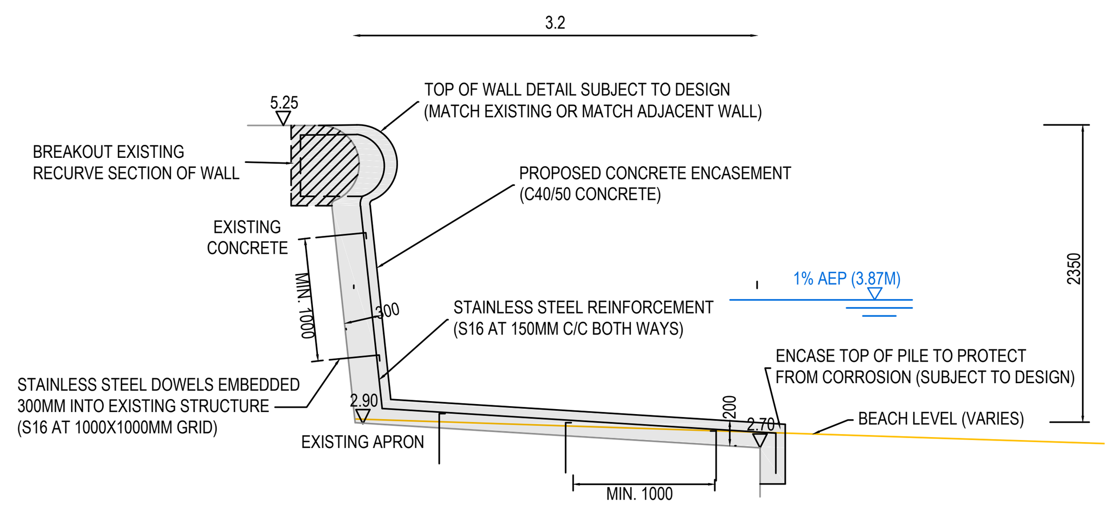
AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



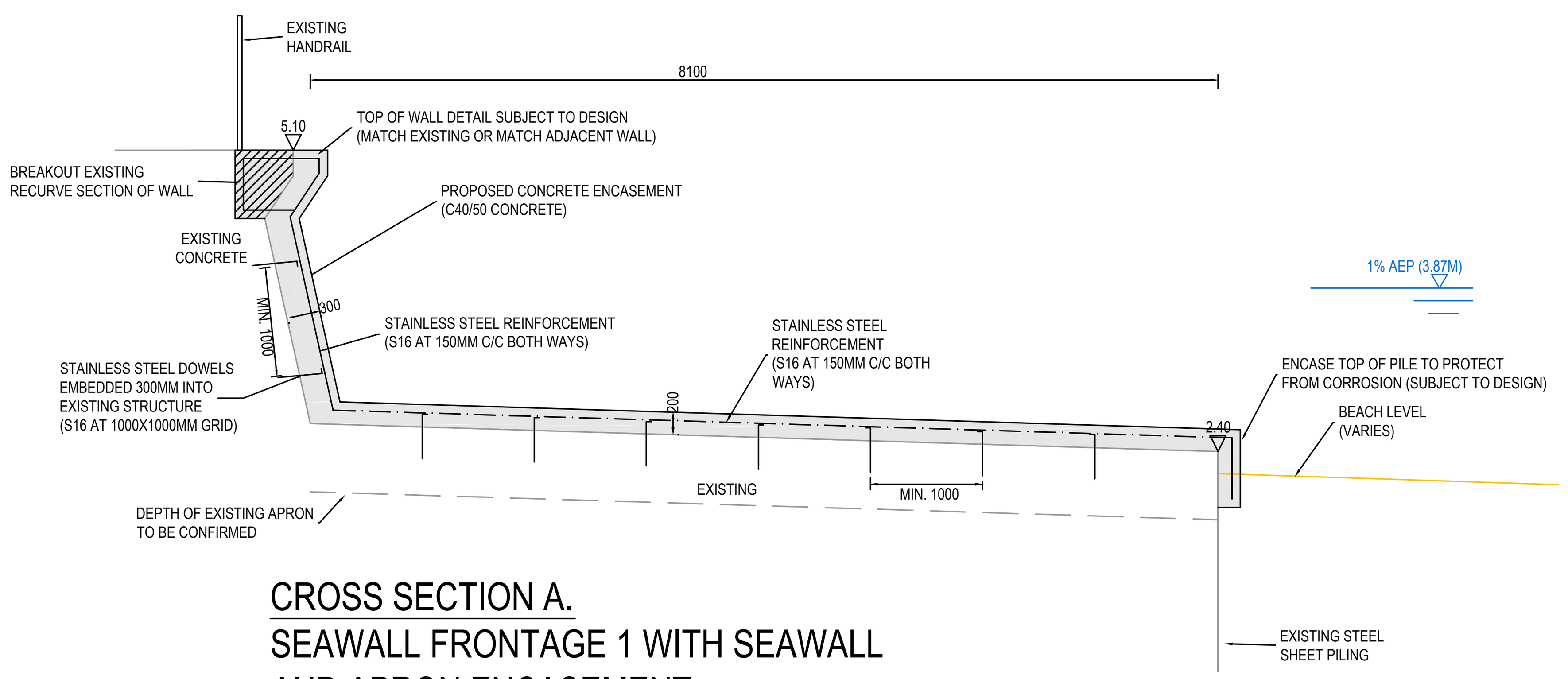
CROSS SECTION B.
SEAWALL FRONTAGE 2 WITH SEAWALL AND APRON ENCASEMENT



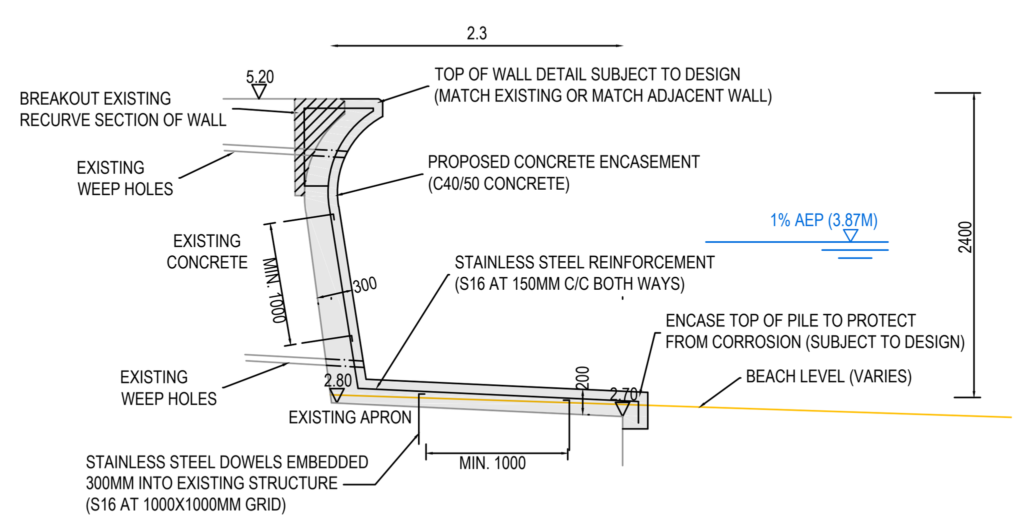
CROSS SECTION C.
SEAWALL FRONTAGE 3 WITH APRON ENCASEMENT



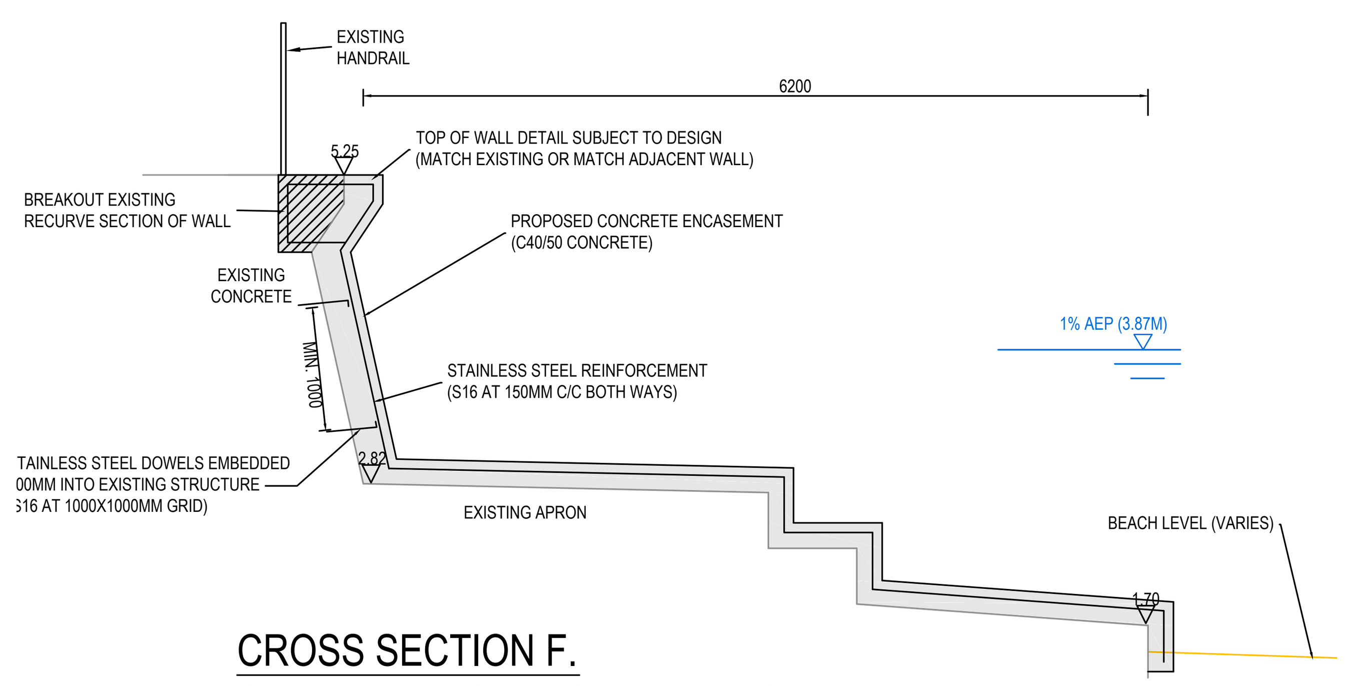
CROSS SECTION E.
SEAWALL FRONTAGE 5 WITH SEAWALL AND APRON ENCASEMENT



CROSS SECTION A.
SEAWALL FRONTAGE 1 WITH SEAWALL AND APRON ENCASEMENT



CROSS SECTION D.
SEAWALL FRONTAGE 4 WITH SEAWALL AND APRON ENCASEMENT



CROSS SECTION F.
SEAWALL FRONTAGE 6 WITH SEAWALL AND APRON ENCASEMENT

Revision Details	By / Check	Date	Suffix
LONGLIST OPTIONS ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY OUTLINE BUSINESS CASE

Drawing Title

OPTION 1 SEAWALL MAINTENANCE
OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:20 / 1:1000	-

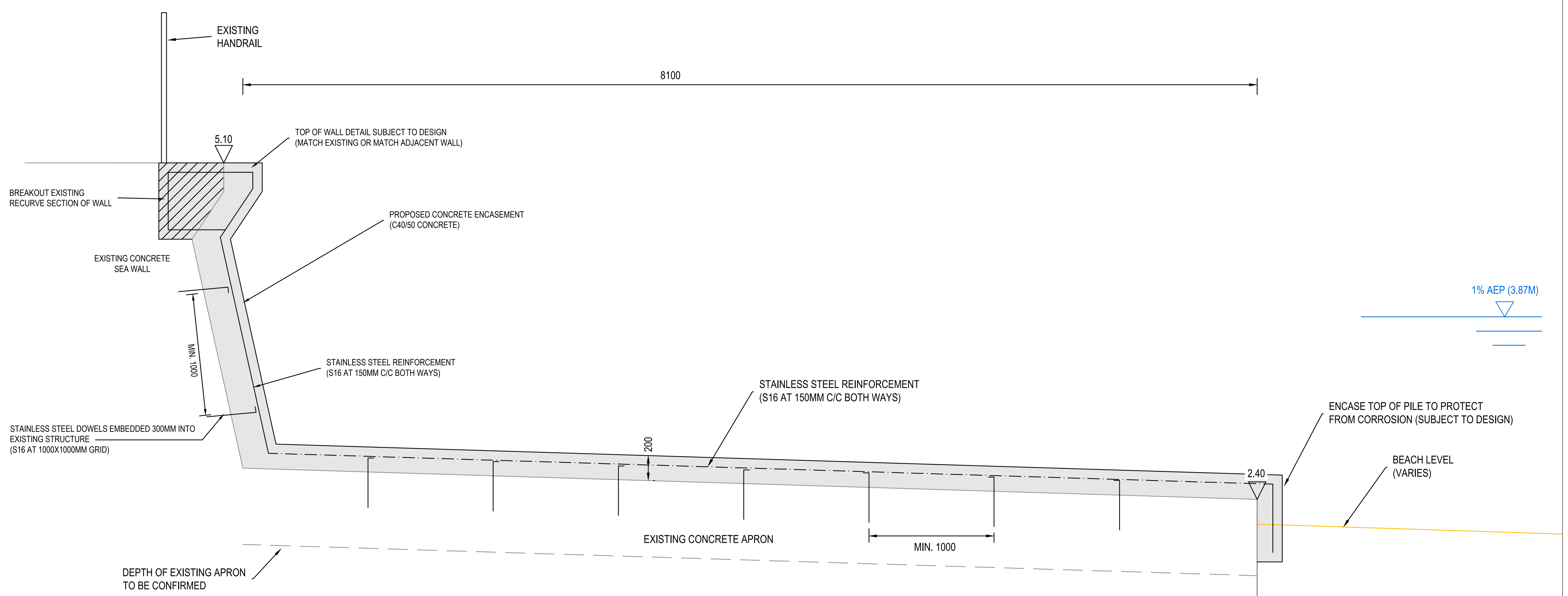
AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number: MOBC-ACM-XX-00-DR-CE-01011 | Rev: P2

Plot Date : 5/11/2018 10:14 AM
File Name : SEAWALL & APRON

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 1

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION A. SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 1

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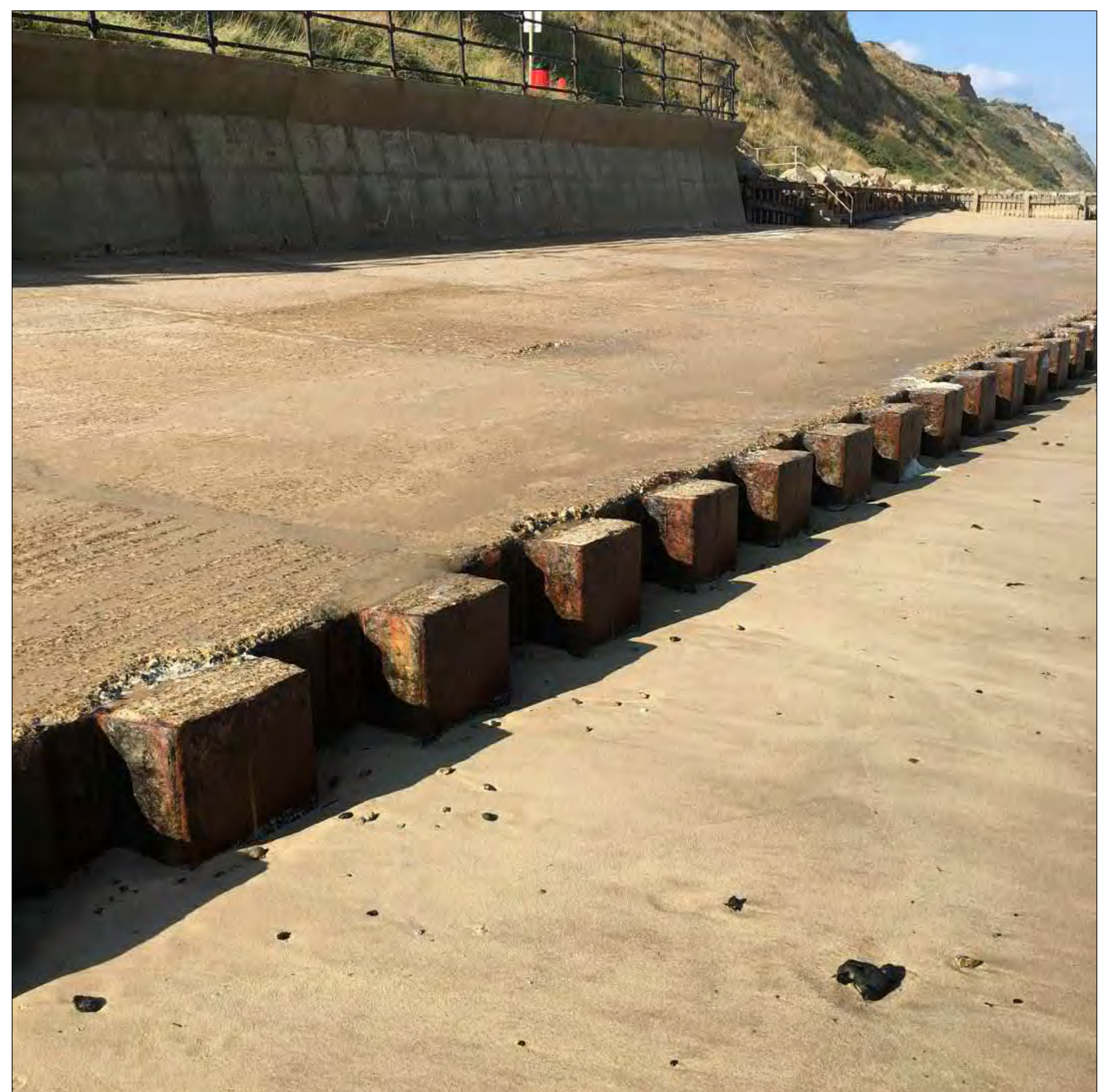

PHOTOGRAPH OF CURRENT APRON AT SEAWALL FRONTAGE 1

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6. SEAWALL FRONTAGE 1 RELATES TO THE AREA S7T FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
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- ALREADY REPAIRED SEAWALL

Revision Details	By / Check	Date	Suffix
LONGLIST OPTIONS ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 1

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

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60519091	S2
Scale @ A1	**Zone**
1:25 / 1:500	-

AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

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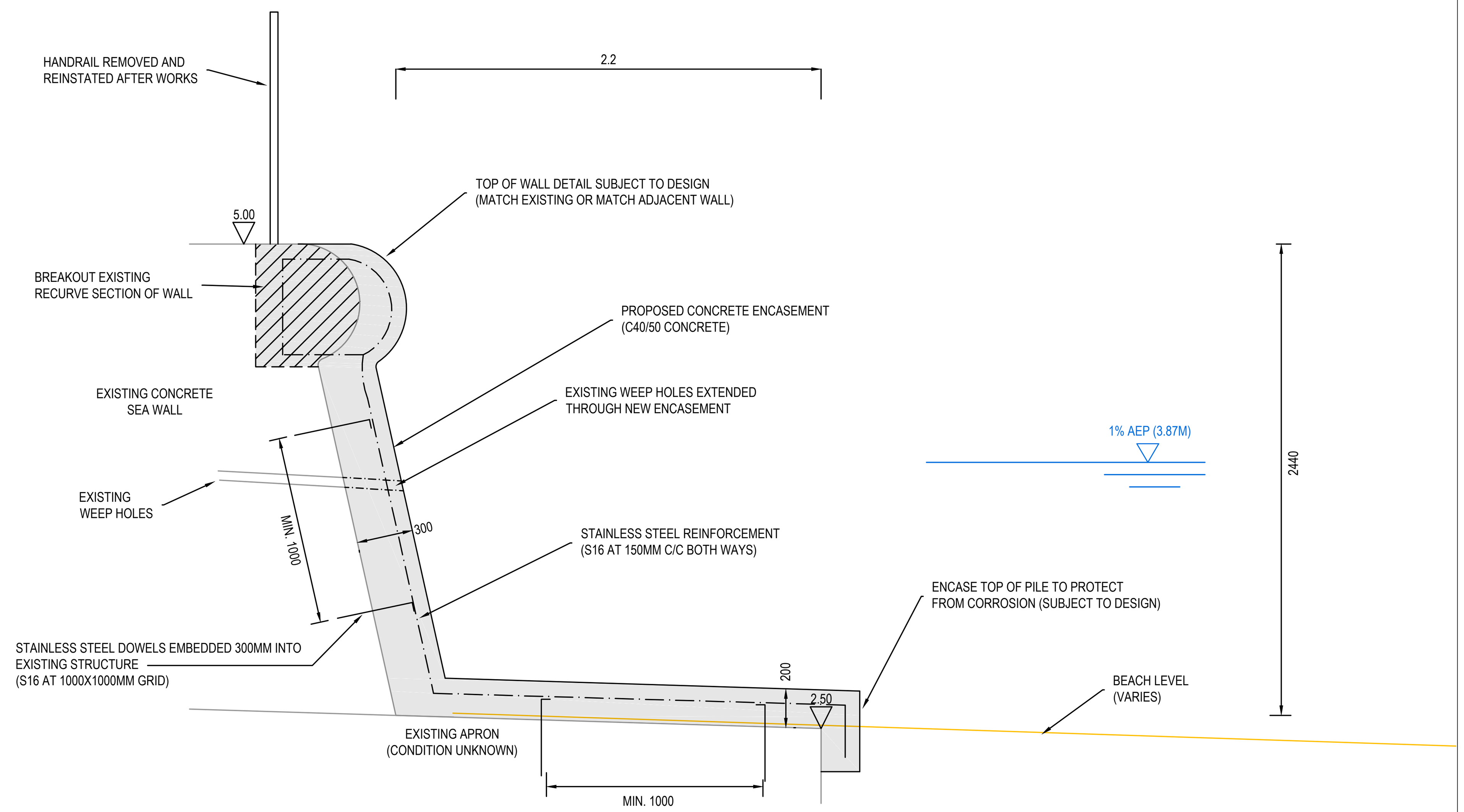
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01012	P2

Plot Date : 5/11/2018 10:16 AM
File Name : SEAWALL & APRON

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 2

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION B. SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 2

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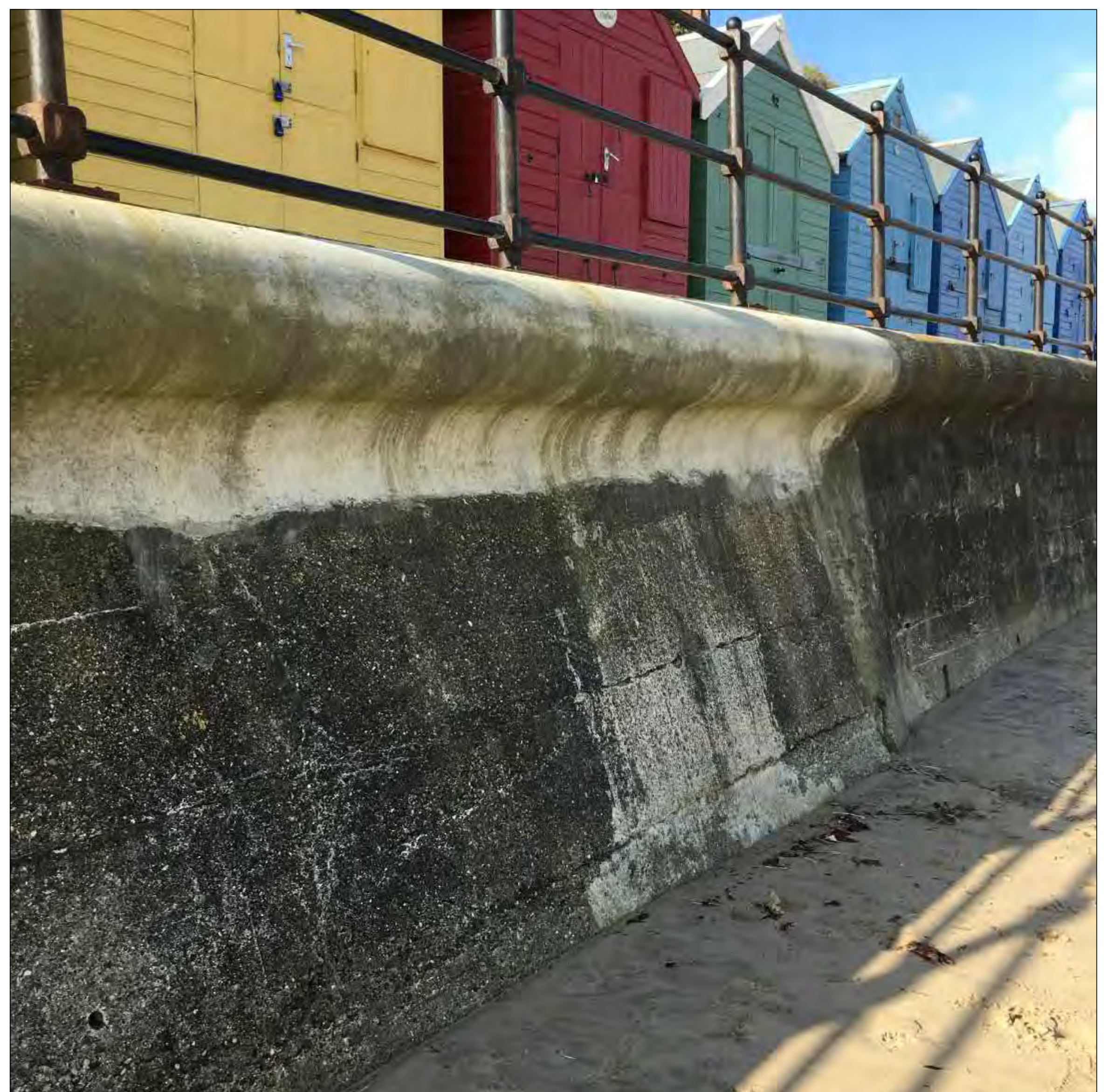

PHOTOGRAPH OF EMERGANCY REPAIR TO SEAWALL AT SEAWALL FRONTAGE 2

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LEGEND

SECTION AREAS
APRON
SEAWALL
ALREADY REPAIRED SEAWALL

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY OUTLINE BUSINESS CASE

Drawing Title

OPTION 1 SEAWALL MAINTENANCE SEAWALL FRONTAGE 2

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No. 60519091

Suitability S2

Scale @ A1 1:20 / 1:1000

Zone -

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Alencon Link
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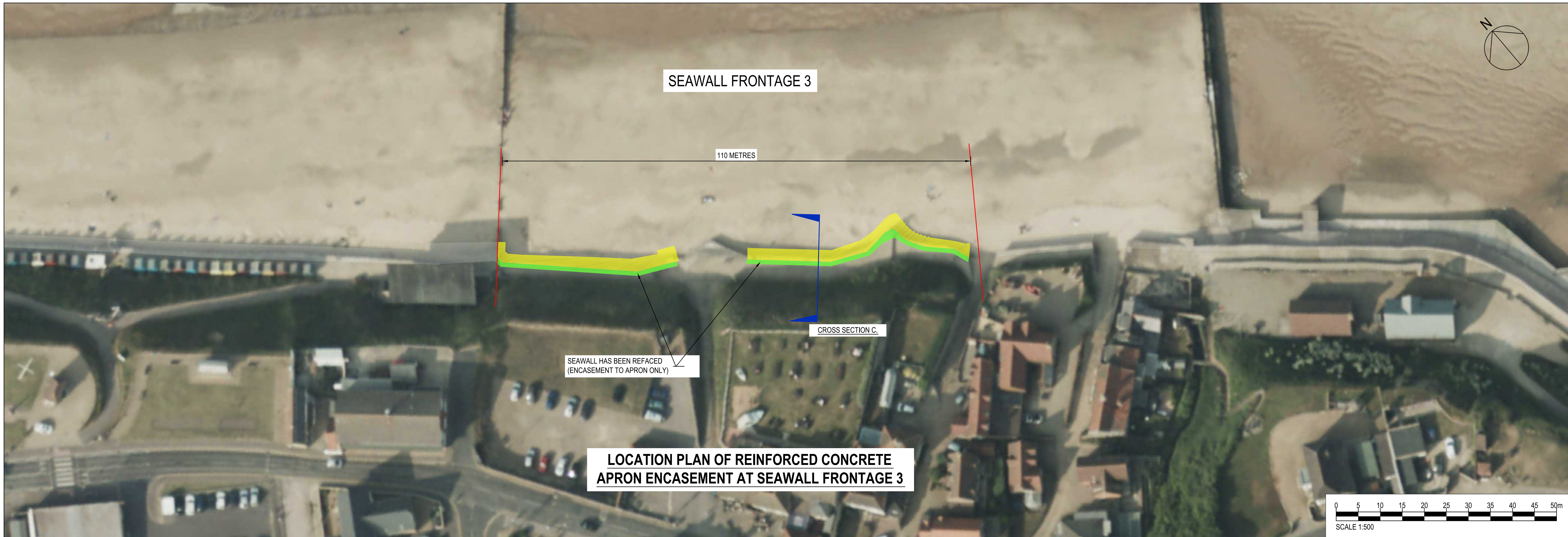
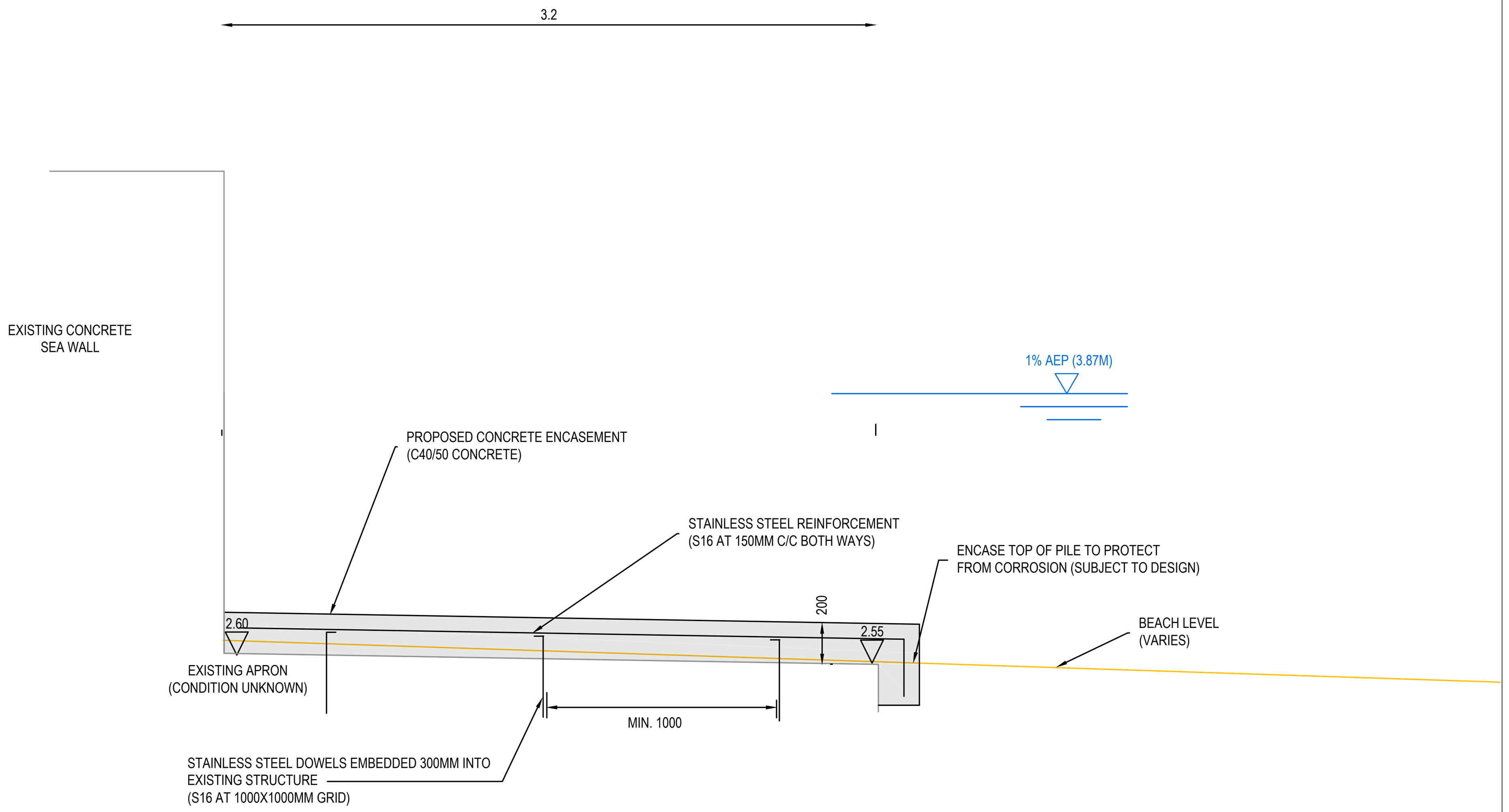
Drawing Number MOBC-ACM-XX-00-DR-CE-01013

Rev P2

Plot Date : 5/11/2018 10:18 AM
File Name : SEAWALL & APRON

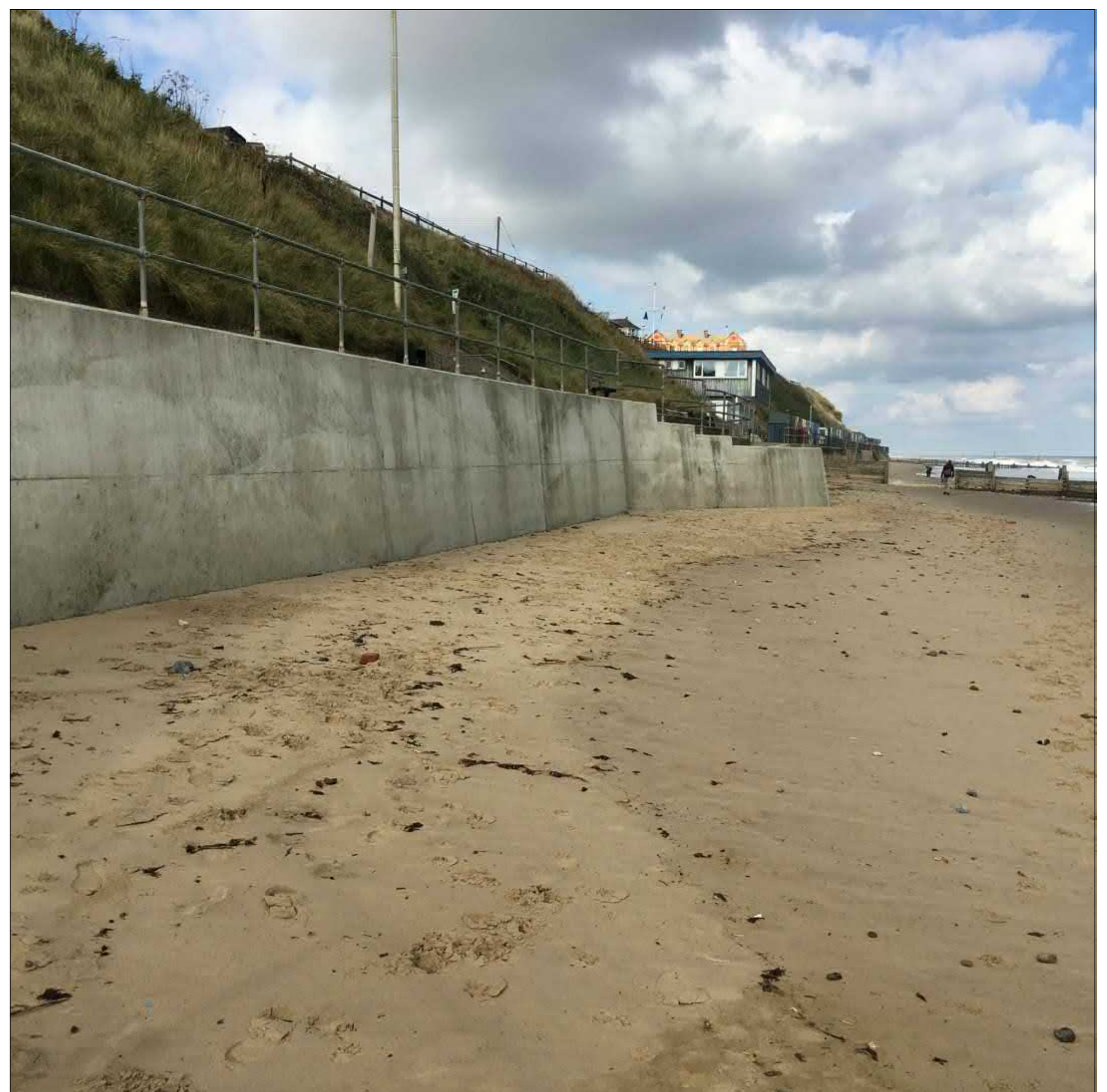


LOCATION PLAN OF REINFORCED CONCRETE
APRON ENCASEMENT AT SEAWALL FRONTAGE 3



CROSS SECTION C.
APRON ENCASEMENT AT SEAWALL FRONTAGE 3

0 400 800 1200 1600 2000mm
SCALE 1:20



PHOTOGRAPH OF RECENT REPAIRED CONCRETE
SEA WALL AT SEAWALL FRONTAGE 3

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NOTES

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 3 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- ALREADY REPAIRED SEAWALL

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 3

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:20 / 1:1000	-

AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
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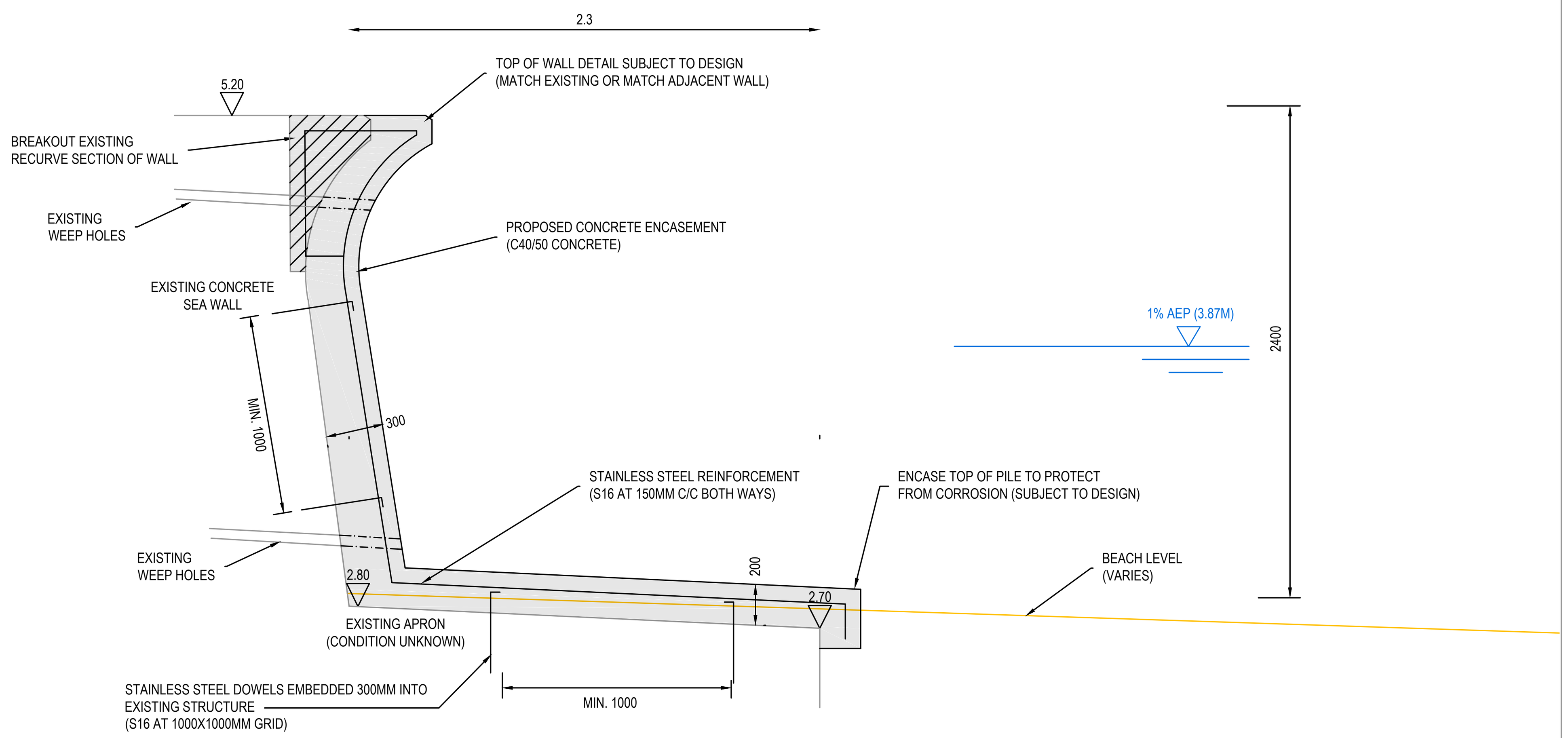
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01014	P2

Plot Date : 5/11/2018 10:19 AM
File Name : SEAWALL & APRON

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 4



CROSS SECTION D.
SEAWALL AND APRON ENCASEMENT AT
SEAWALL FRONTAGE 4

0 400 800 1200 1600 2000mm
SCALE 1:20

PHOTOGRAPH OF CURRENT SEAWALL AT SEAWALL FRONTAGE 4

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. SEAWALL FRONTAGE 4 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

SECTION AREAS
APRON
SEAWALL
ALREADY REPAIRED SEAWALL

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 4

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:20 / 1:1000	-

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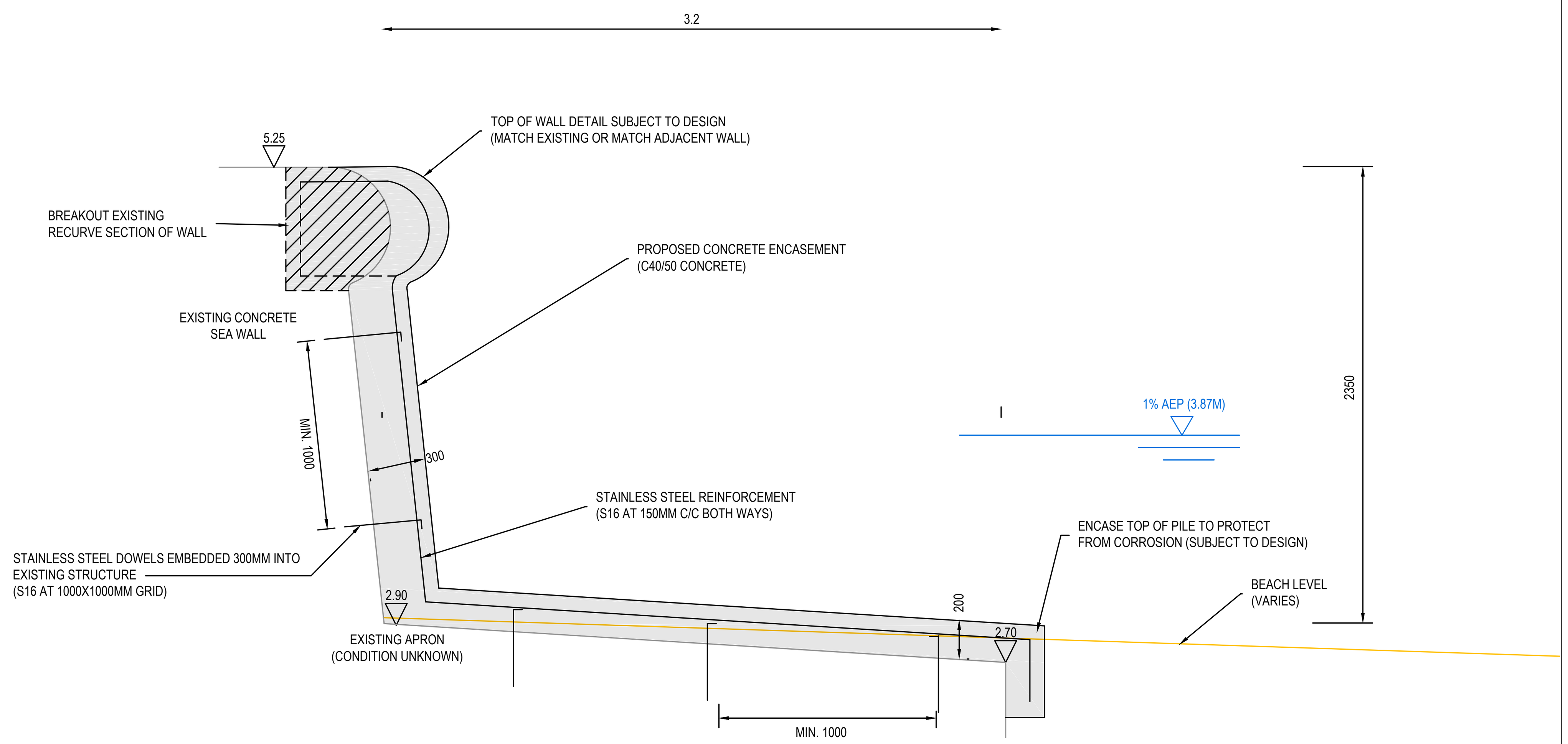
Drawing Number: MOBC-ACM-XX-00-DR-CE-01015
Rev: P2

Plot Date: 5/11/2018 10:21 AM
File Name: SEAWALL & APRON

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 5



CROSS SECTION E.
SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 5

0 400 800 1200 1600 2000mm
SCALE 1:20

PHOTOGRAPH OF CURRENT SEAWALL AT SEAWALL FRONTAGE 5

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6. SEAWALL FRONTAGE 5 RELATES TO THE AREA S5 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- ALREADY REPAIRED SEAWALL

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 5

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:20 / 1:1000	-

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Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
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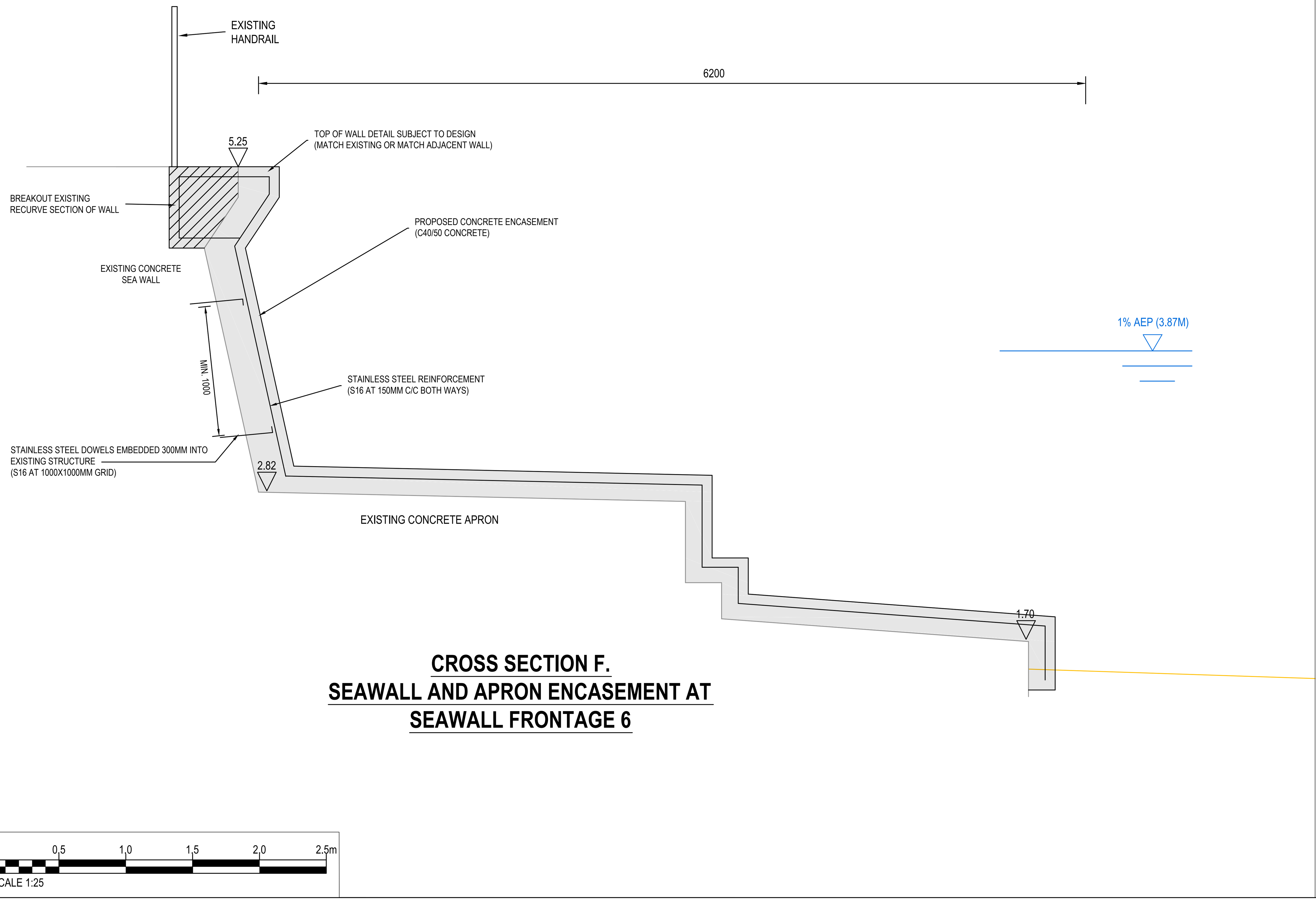
Rev
P2

Plot Date : 5/11/2018 10:22 AM
File Name : SEAWALL & APRON

LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 6



CROSS SECTION F. SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 6

PHOTOGRAPH OF CURRENT SEAWALL AND APRON AT SEAWALL FRONTAGE 6

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6. SEAWALL FRONTAGE 6 RELATES TO THE AREA S4 FROM THE CONDITION ASSESSMENT

LEGEND

- SECTION AREAS
- APRON
- SEAWALL
- ALREADY REPAIRED SEAWALL

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 6

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
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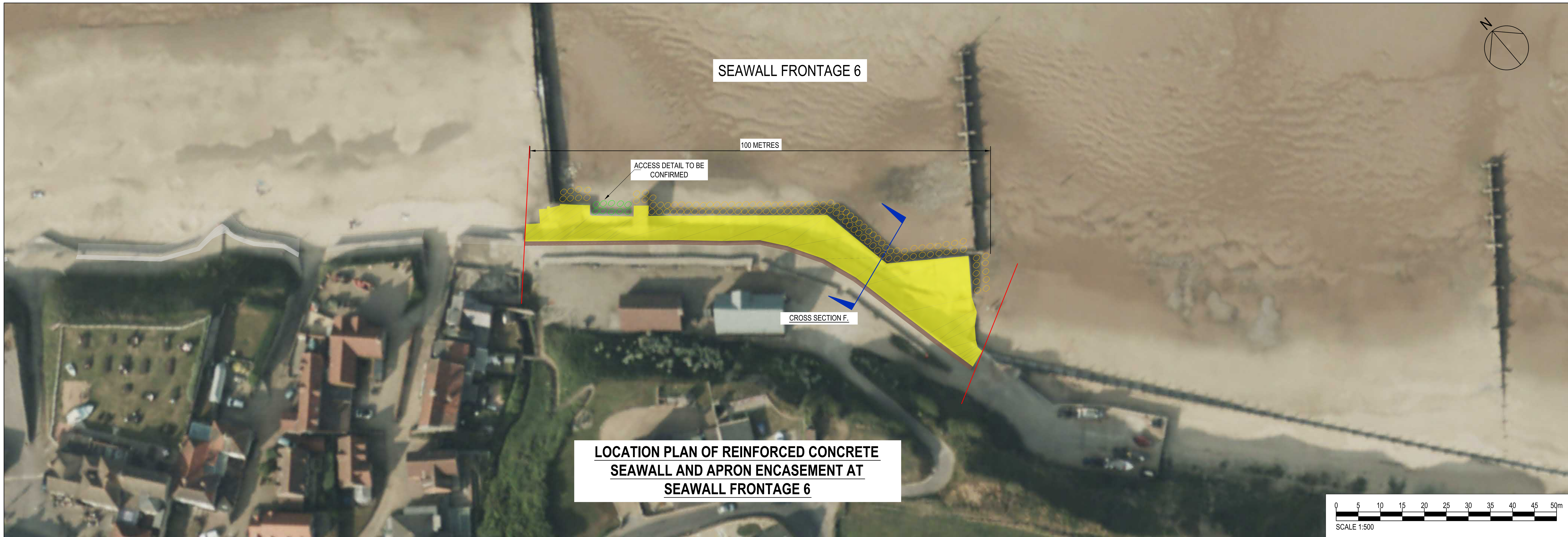
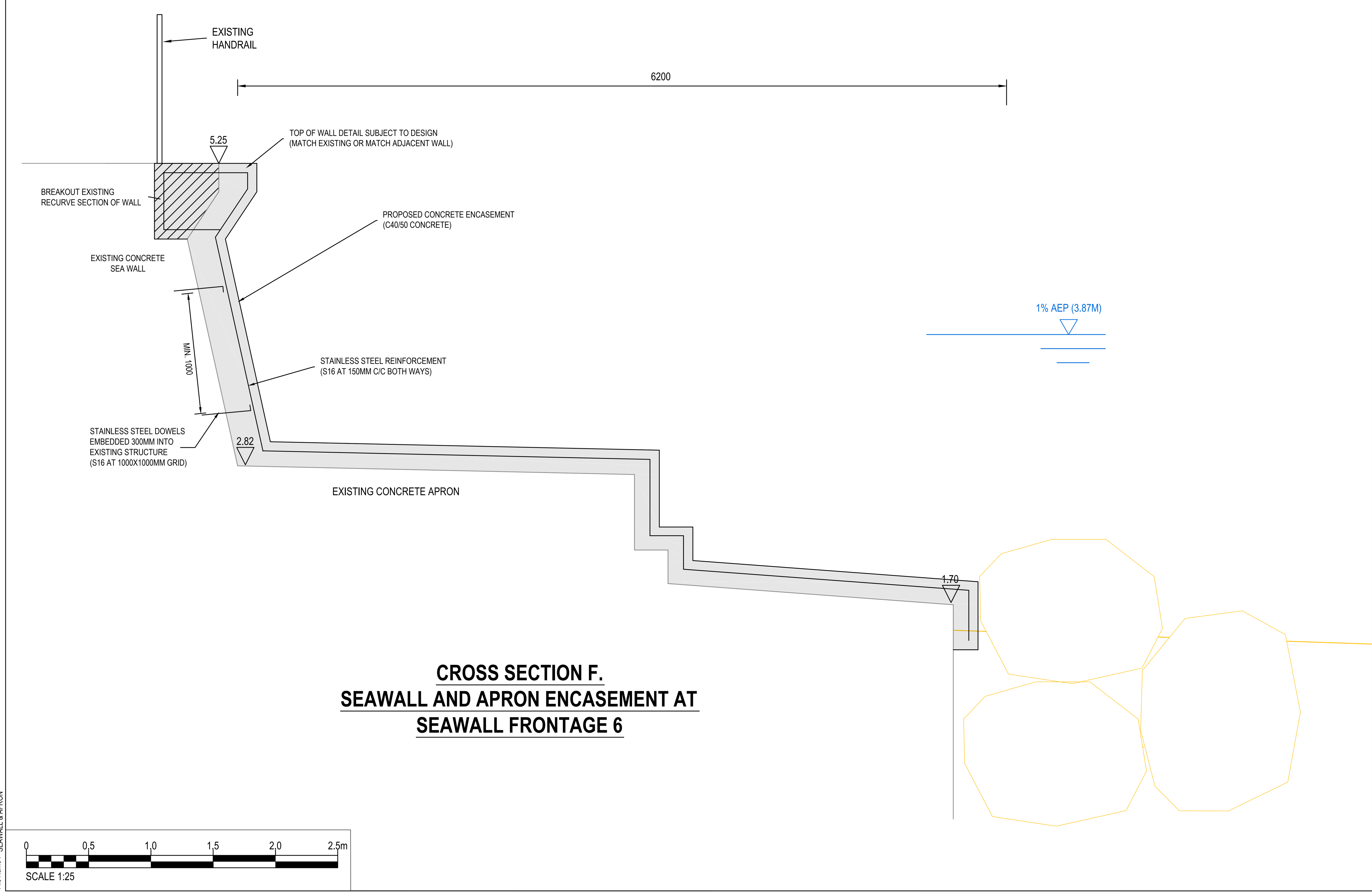
Rev: P2



LOCATION PLAN OF REINFORCED CONCRETE SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 6



CROSS SECTION F.
SEAWALL AND APRON ENCASEMENT AT SEAWALL FRONTAGE 6

PHOTOGRAPH OF CURRENT SEAWALL AND APRON AT SEAWALL FRONTAGE 6

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6. SEAWALL FRONTAGE 6 RELATES TO THE AREA S4 FROM THE CONDITION ASSESSMENT

LEGEND
- SECTION AREAS
- APRON
- SEAWALL
- ALREADY REPAIRED SEAWALL
- ROCK ARMOUR LOCATIONS
- ROCK ARMOUR LOCATION TO BE CONFIRMED

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 1
SEAWALL MAINTENANCE
SEAWALL FRONTAGE 6
WITH ROCK PROTECTION

Designed	Drawn	Checked	Approved	Date
	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:20 / 1:1000	-

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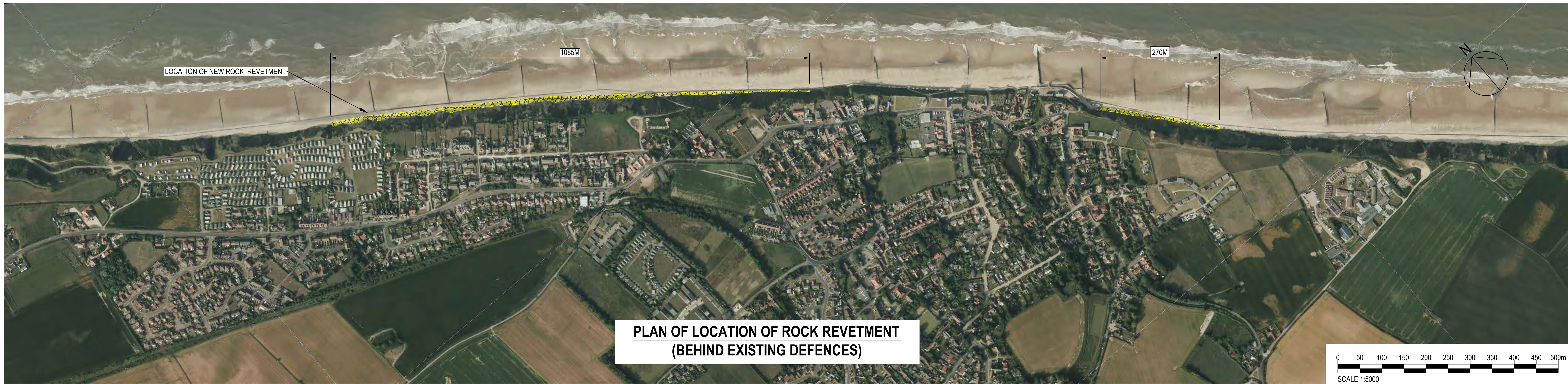
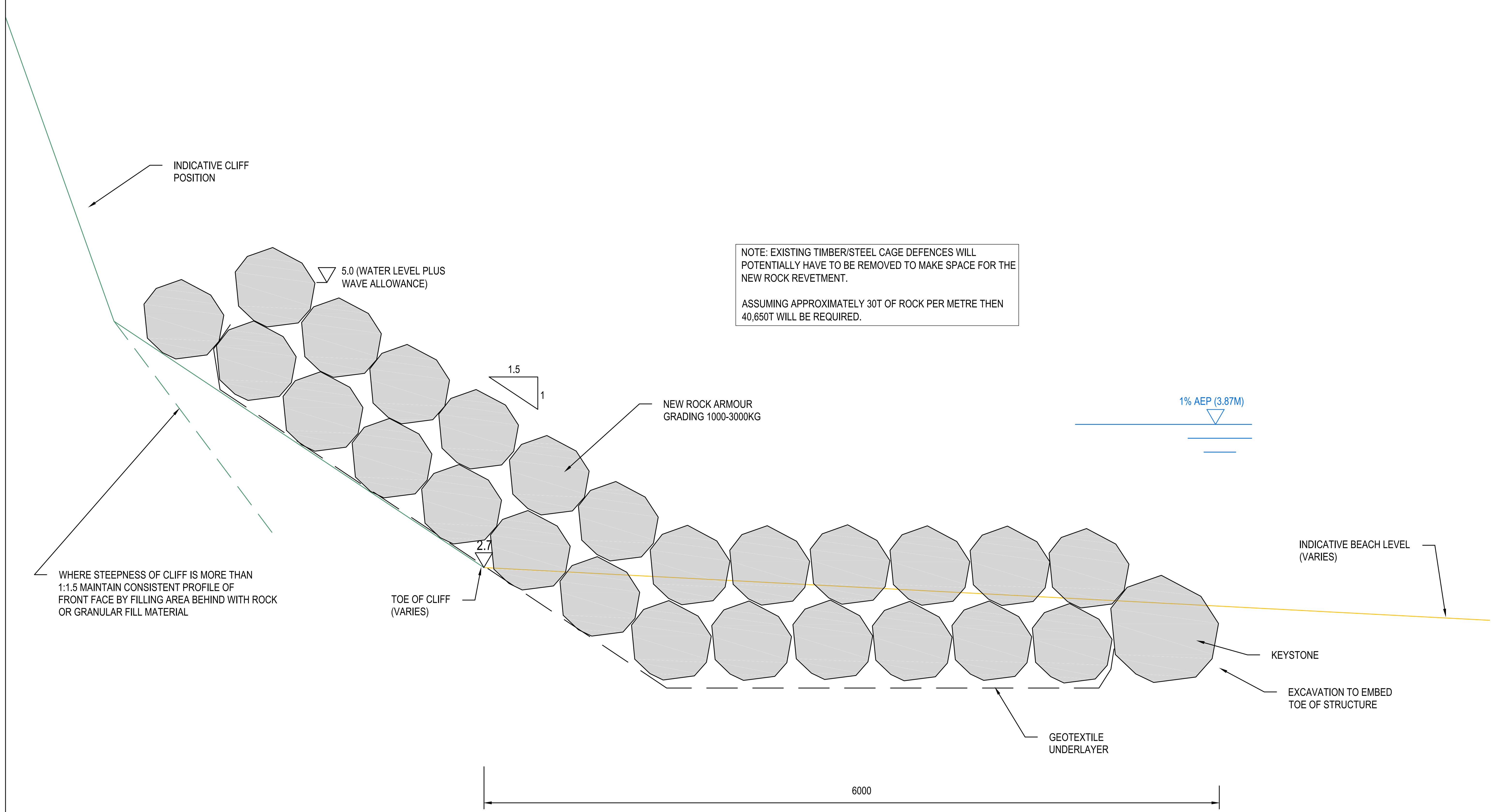
Drawing Number: MOBC-ACM-XX-00-DR-CE-01018
Rev: P2

Plot Date : 5/11/2018 10:25 AM
File Name : SEAWALL & APRON



PLAN OF LOCATION OF ROCK REVETMENT (BEHIND EXISTING DEFENCES)



CROSS SECTION OF ROCK REVETMENT (BEHIND EXISTING DEFENCES)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF CLIFF TOE SETBACK FROM EXISTING DEFENCES SHOWING PROPOSED LOCATION

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LEGEND

NEW ROCK REVETMENT LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 3
ROCK REVETMENT
OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No. 60519091 | Suitability S2
Scale @ A1 1:25 / 1:5000 | Zone -

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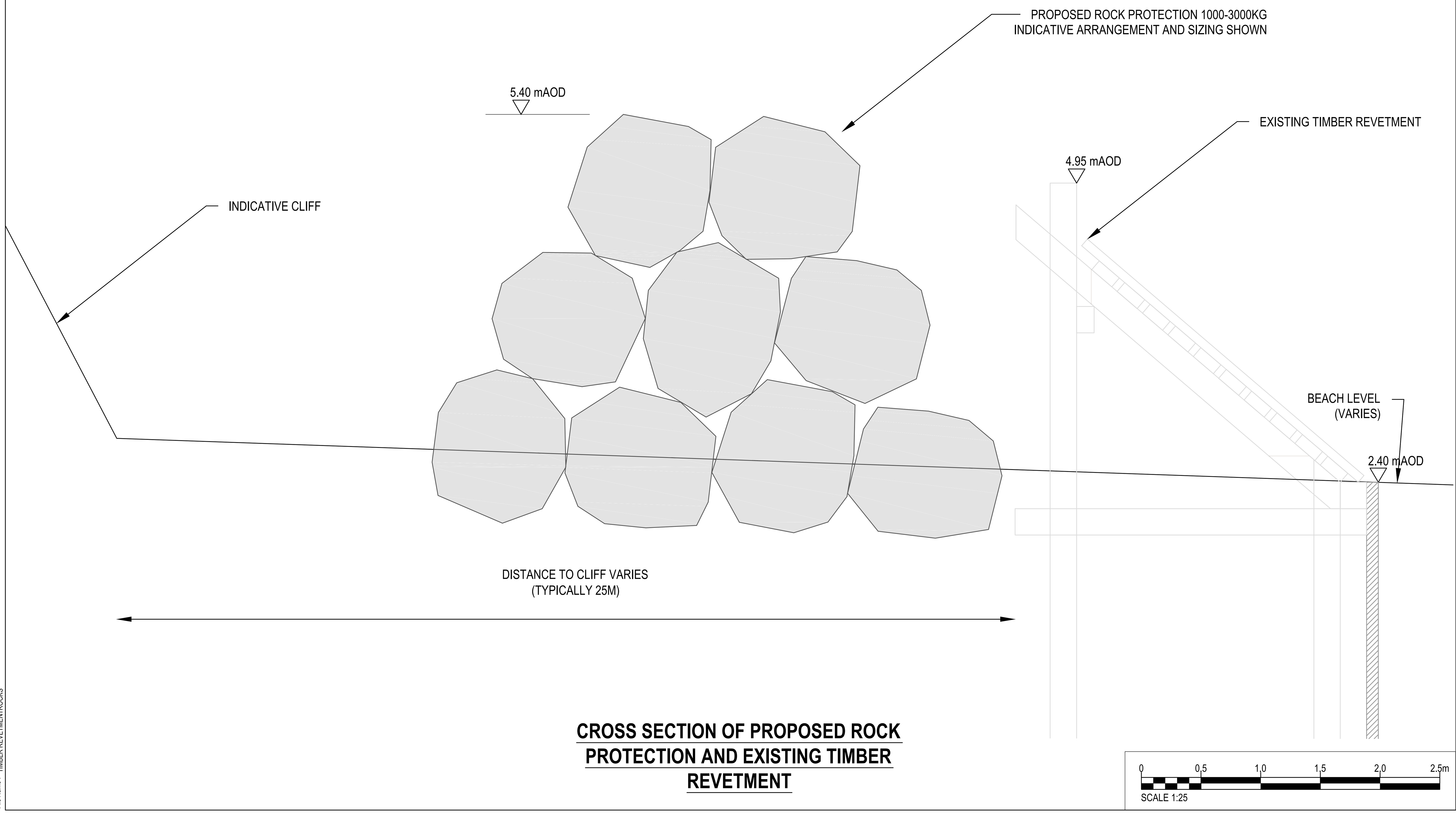
Drawing Number MOBC-ACM-XX-00-DR-CE-01031 | Rev P2

Plot Date : 5/11/2018 11:57 AM
File Name : ROCK REVETMENT

PLAN OF PROPOSED ROCK PROTECTION



CROSS SECTION OF PROPOSED ROCK PROTECTION AND EXISTING TIMBER REVETMENT

PROPOSED LOCATION OF ROCK PROTECTION

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
6. ALL LEVELS ARE QUOTED TO ORDNANCE DATUM NEWLYN.

LEGEND

LOCATION OF PROPOSED ROCK PROTECTION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST OPTION ISSUE	DM / DG	21/04/2017	P2
DRAFT ISSUE	DM / DG	23/03/2017	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 5
ROCK ARMOUR PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
DM	DM	DG	PN	28/04/2017

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:5000	-

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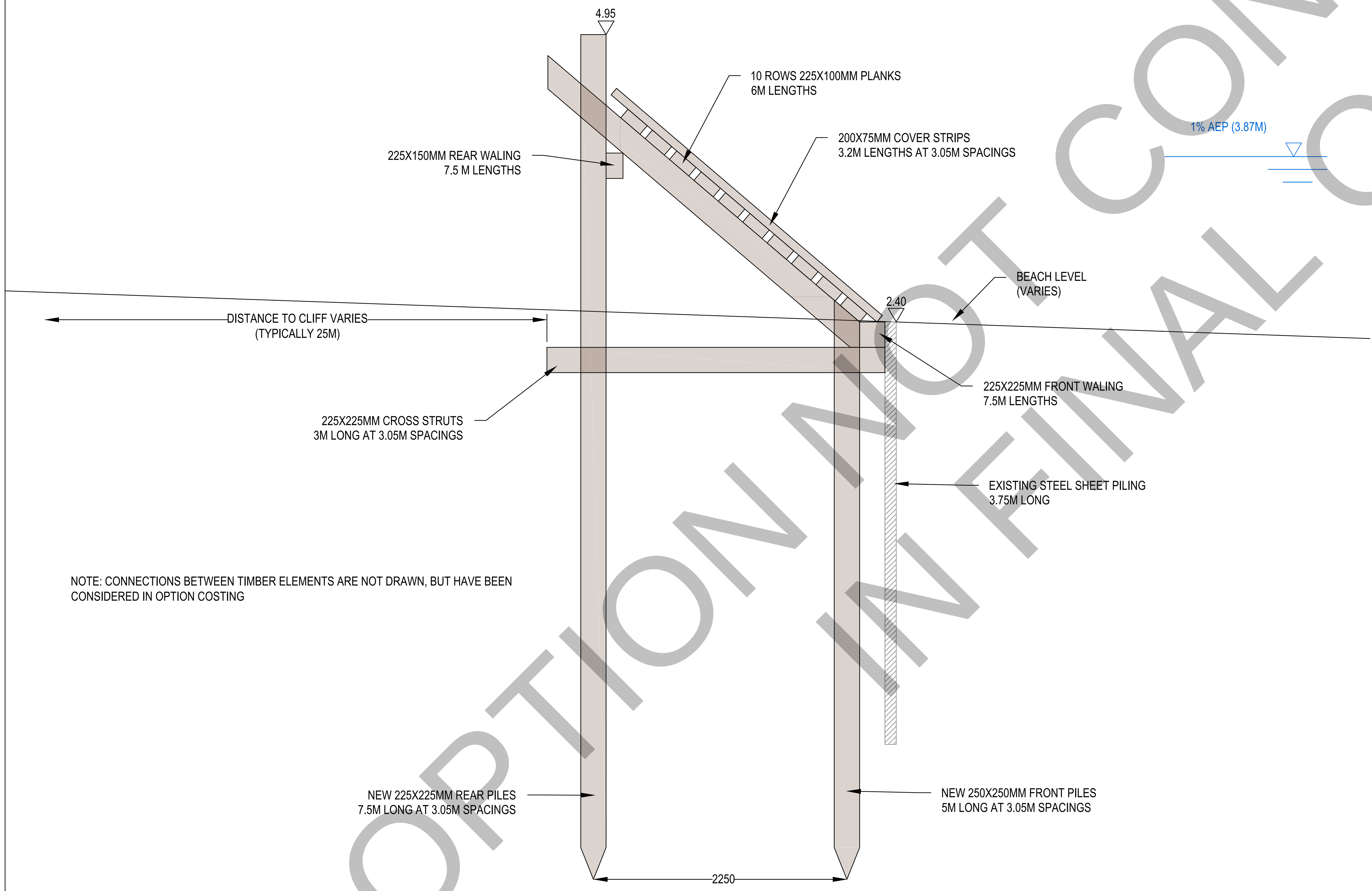
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01051	P2

Plot Date : 5/11/2018 10:44 AM
File Name : TIMBER REVETMENTROCKS

PLAN OF LOCATION OF TIMBER REVETMENT
(REPLACEMENT OF EXISTING)

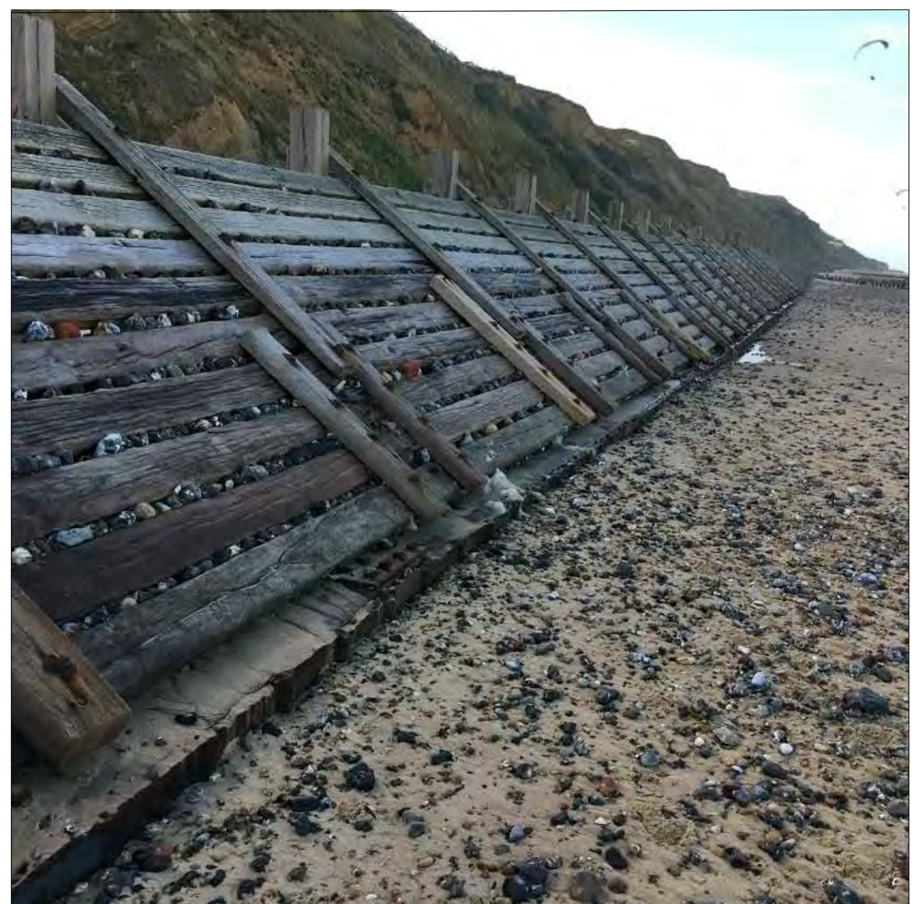


NOTE: CONNECTIONS BETWEEN TIMBER ELEMENTS ARE NOT DRAWN, BUT HAVE BEEN CONSIDERED IN OPTION COSTING

CROSS SECTION OF TIMBER REVETMENT
(REPLACEMENT OF EXISTING)

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

NOTE: NEW TIMBER REVETMENT WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING STRUCTURE.



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW TIMBER REVETMENT LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 6
TIMBER REVETMENT

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:25 / 1:5000	-

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Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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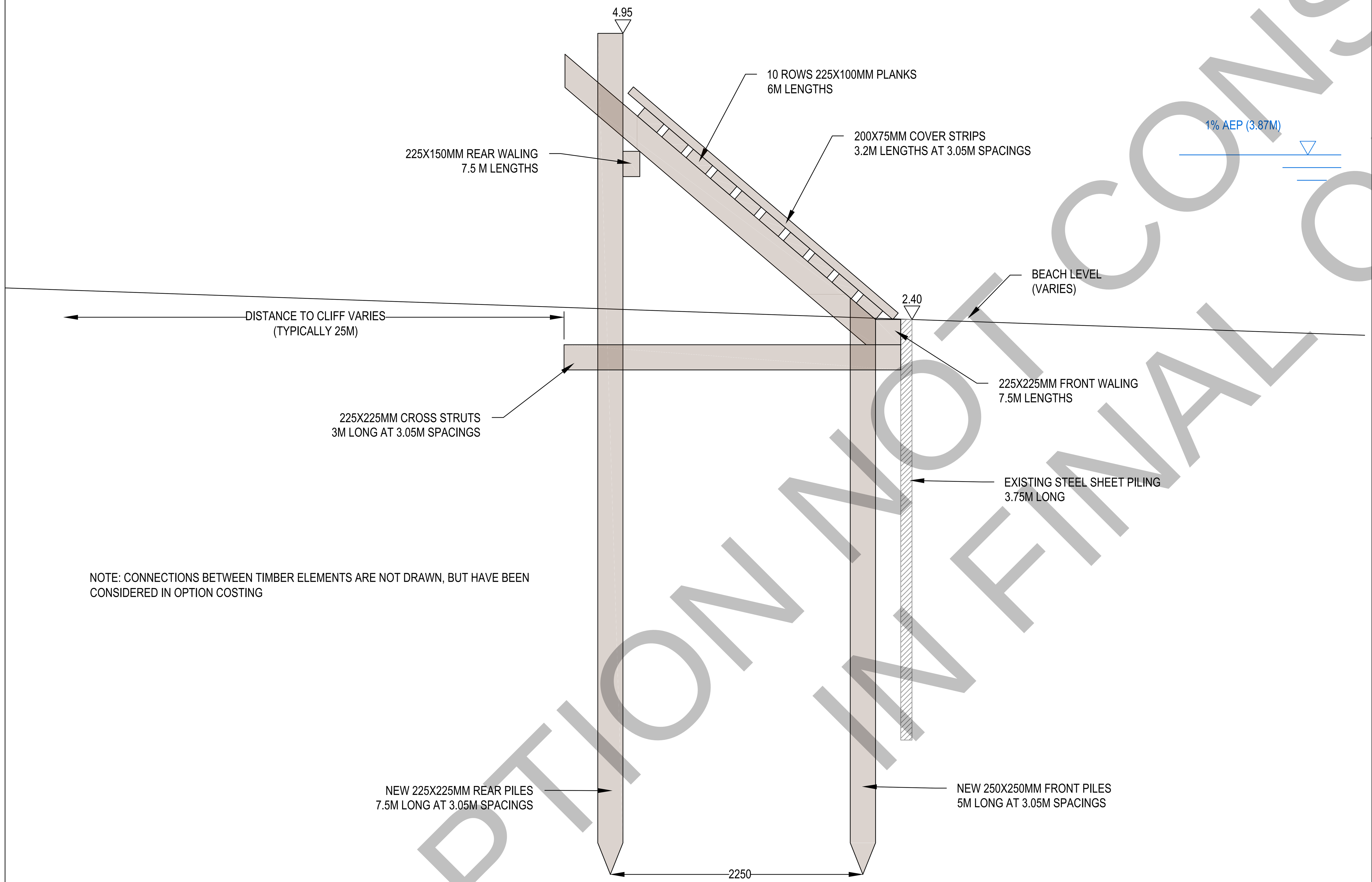
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01061	P2

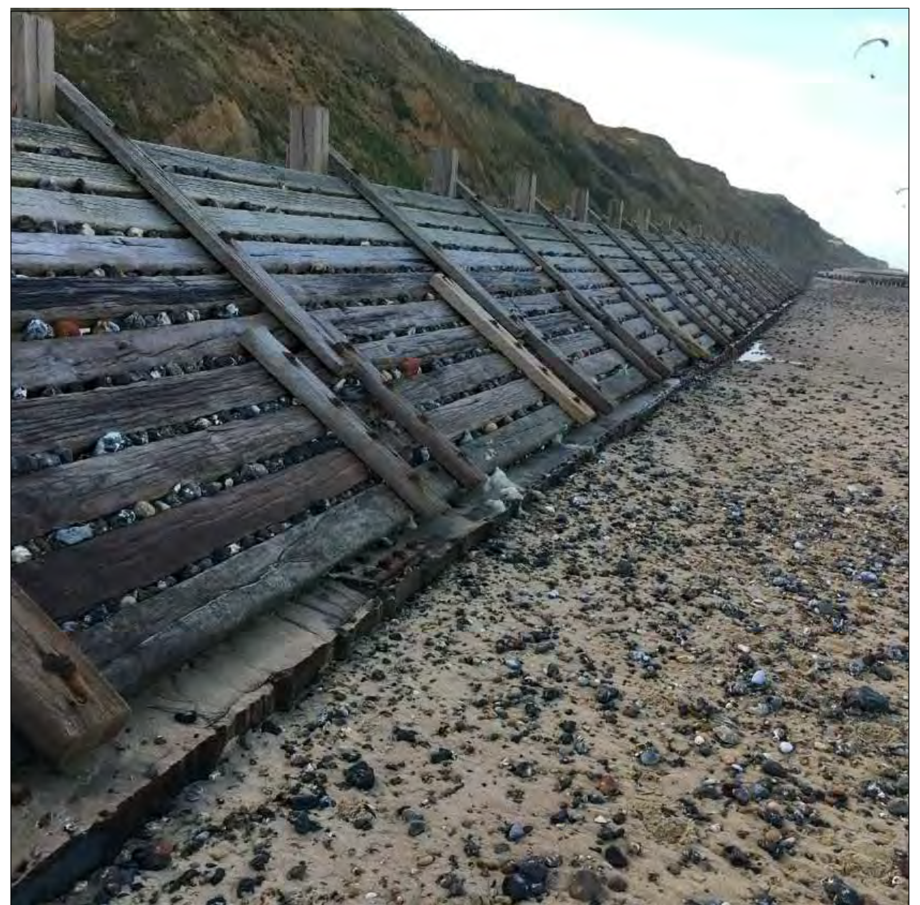
Plot Date: 5/11/2018 10:50 AM
File Name: TIMBER REVETMENT

PLAN OF LOCATION OF TIMBER REVETMENT
(REPLACEMENT OF EXISTING TIMBER REVETMENT AND IN-FRONT OF CURRENT STEEL FRAMED PROTECTION)



CROSS SECTION OF TIMBER REVETMENT
(REPLACEMENT OF EXISTING)

NOTE: NEW TIMBER REVETMENT WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING STRUCTURE.



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW TIMBER REVETMENT LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By	Check	Date	Suffix
LONGLIST ISSUE	BO	DG	21/04/17	P2
DRAFT ISSUE	BO	DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 6 - TIMBER REVETMENT FRONTING STEEL FRAMED PROTECTION

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:25 / 1:5000	-

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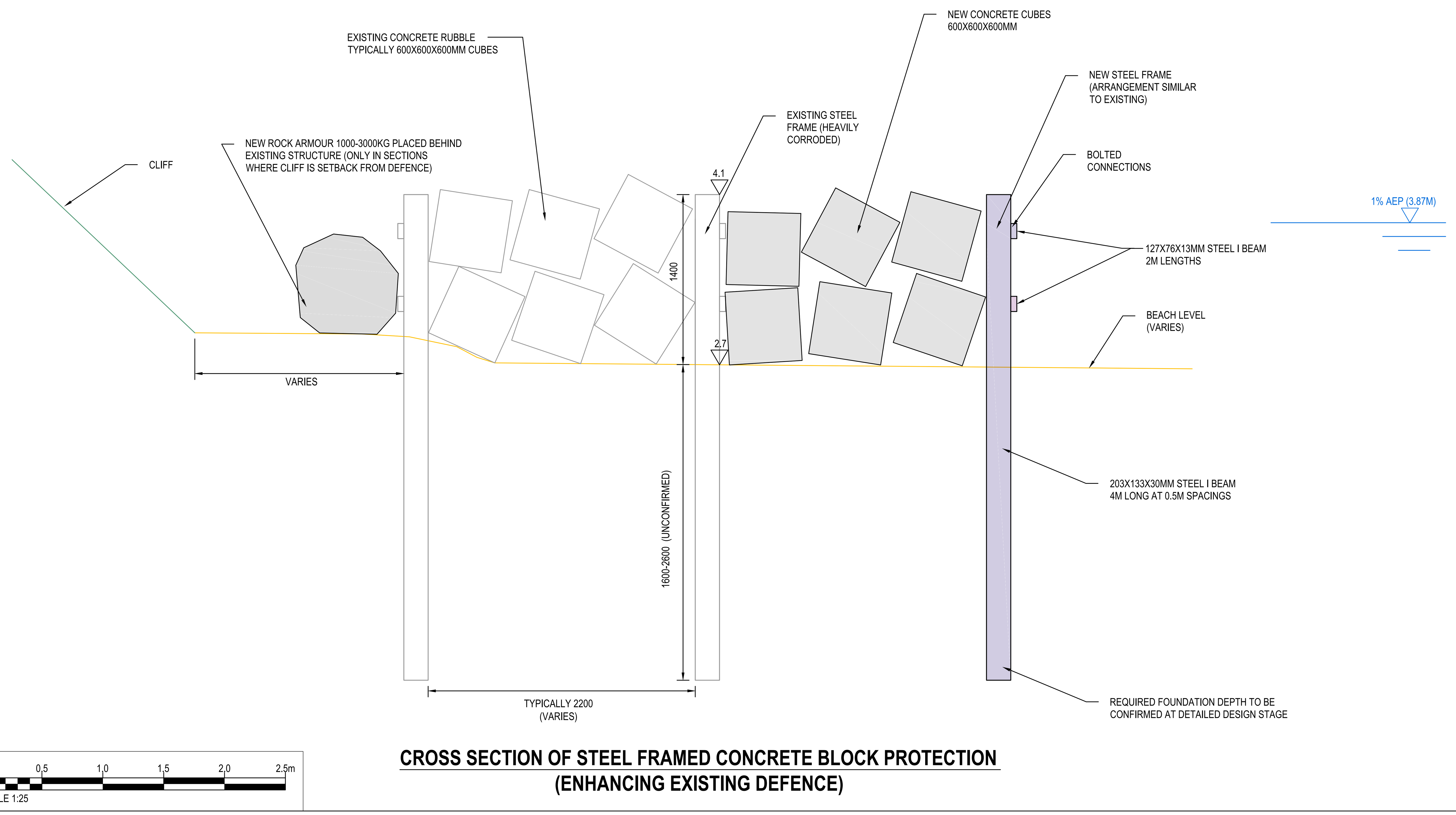
Drawing Number: MOBC-ACM-XX-00-DR-CE-01062
Rev: P2

Plot Date: 5/11/2018 10:53 AM
File Name: TIMBER REVETMENT

LOCATION OF PLAN OF STEEL FRAMED CONCRETE BLOCK PROTECTION (ENHANCING EXISTING DEFENCE)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION OF STEEL FRAMED CONCRETE BLOCK PROTECTION (ENHANCING EXISTING DEFENCE)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

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NOTES

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.
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Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH CONCRETE BLOCKS

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:1000	-

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Alencon Link
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Drawing Number: MOBC-ACM-XX-00-DR-CE-01071

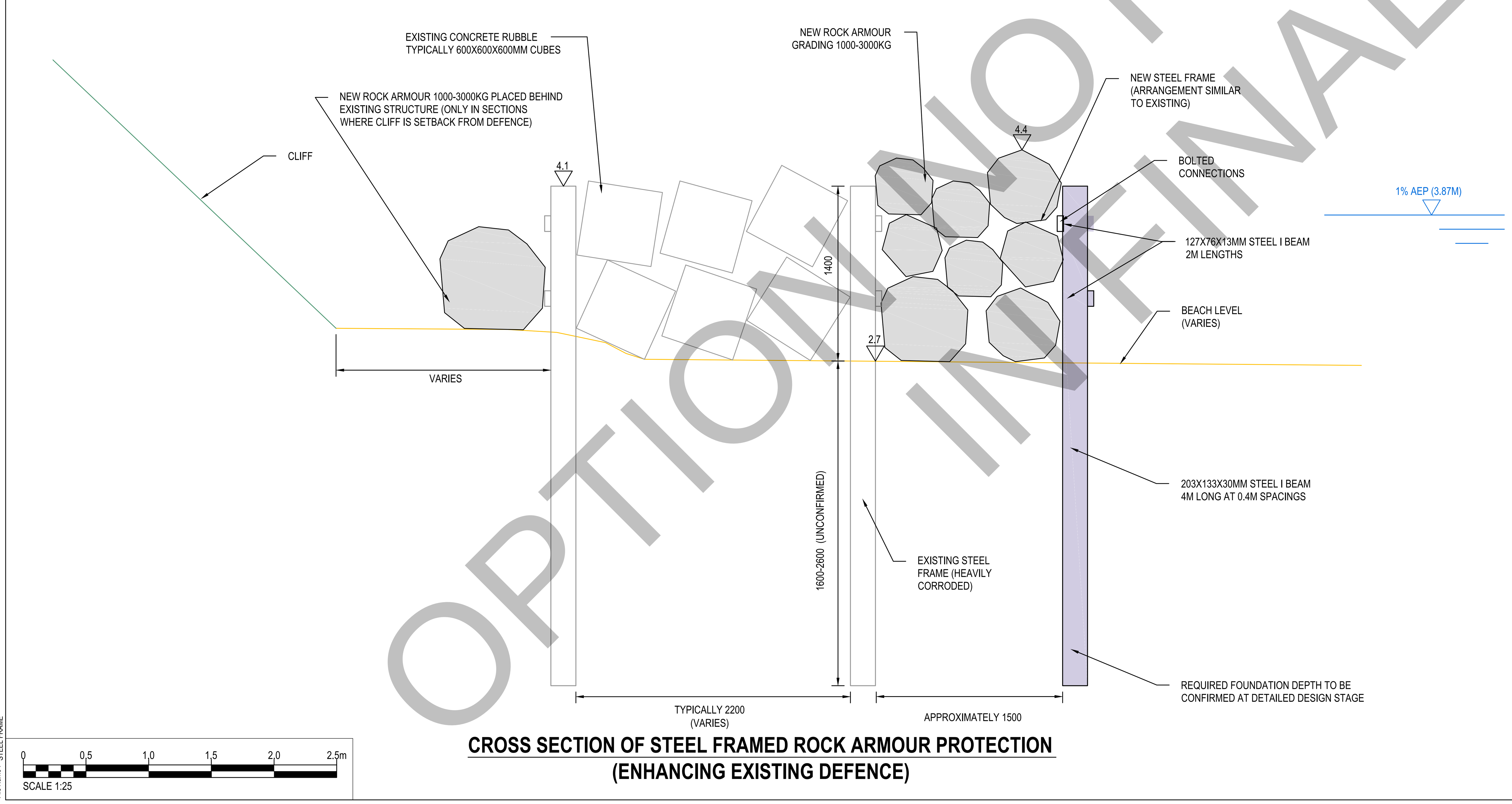
Rev: P2

Plot Date : 5/11/2018 10:58 AM
File Name : STEEL FRAME

LOCATION OF PLAN OF STEEL FRAMED ROCK ARMOUR PROTECTION (ENHANCING EXISTING DEFENCE)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

NOTE: SPACING BETWEEN NEW STEEL 'PILES' MUST BE SMALLER THAN WIDTH OF SMALLEST ROCKS TO RETAIN THEM (CAN BE ACHIEVED BY CONTROLLING: ROCK LENGTH TO THICKNESS RATIO / 'PILE' SPACING / SIZE OF ROCK)



CROSS SECTION OF STEEL FRAMED ROCK ARMOUR PROTECTION (ENHANCING EXISTING DEFENCE)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

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Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH ROCK

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
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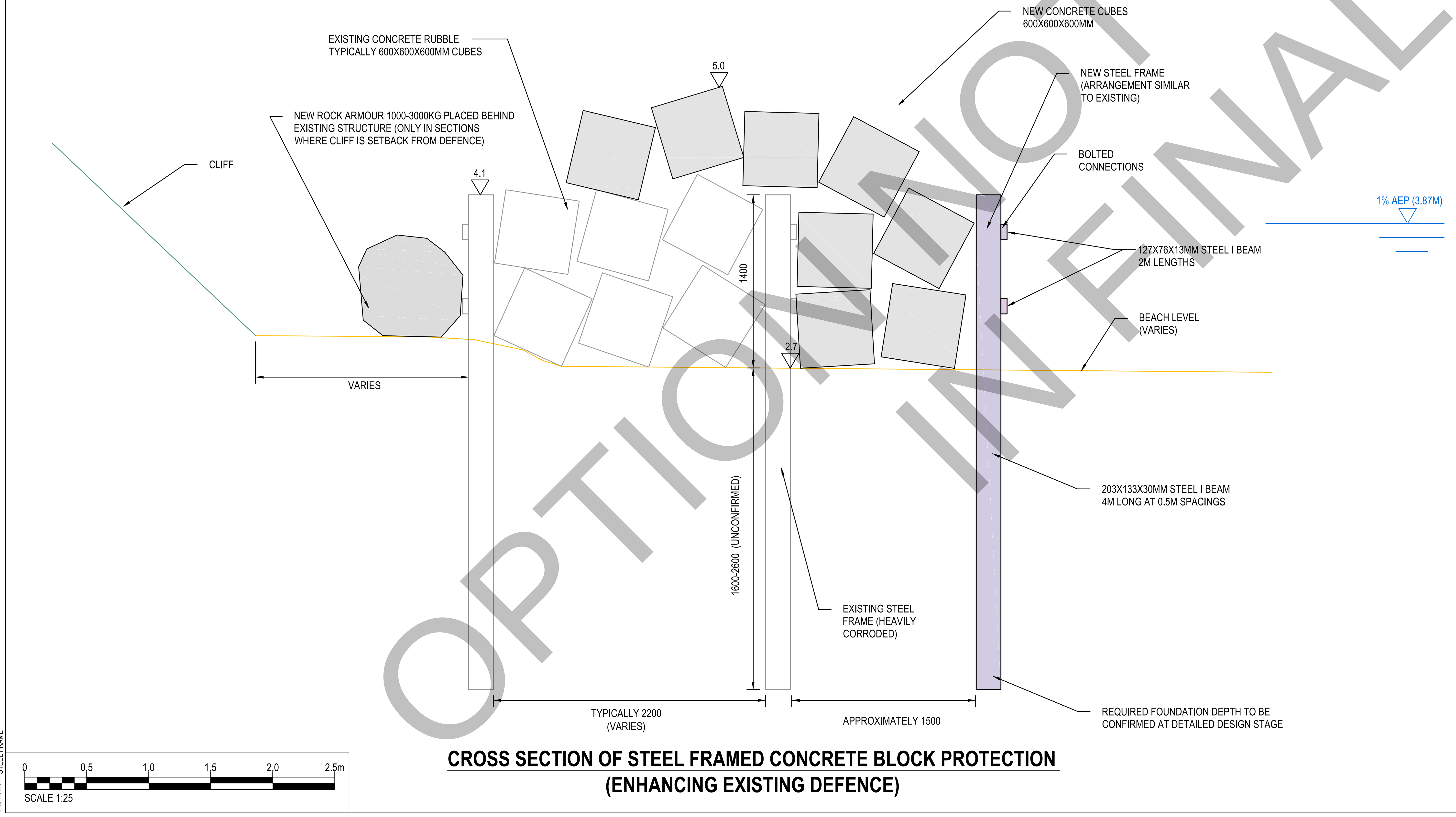
Drawing Number: MOBC-ACM-XX-00-DR-CE-01072

Rev: P2

Plot Date : 5/11/2018 10:59 AM
File Name : STEEL FRAME

LOCATION OF PLAN OF STEEL FRAMED CONCRETE BLOCK PROTECTION
(ENHANCING EXISTING DEFENCE)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



CROSS SECTION OF STEEL FRAMED CONCRETE BLOCK PROTECTION
(ENHANCING EXISTING DEFENCE)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

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Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH CONCRETE BLOCKS (INCREASED HEIGHT)

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:1000	-

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Drawing Number: MOBC-ACM-XX-00-DR-CE-01073 | Rev: P2

Plot Date : 5/11/2018 11:01 AM
File Name : STEEL FRAME

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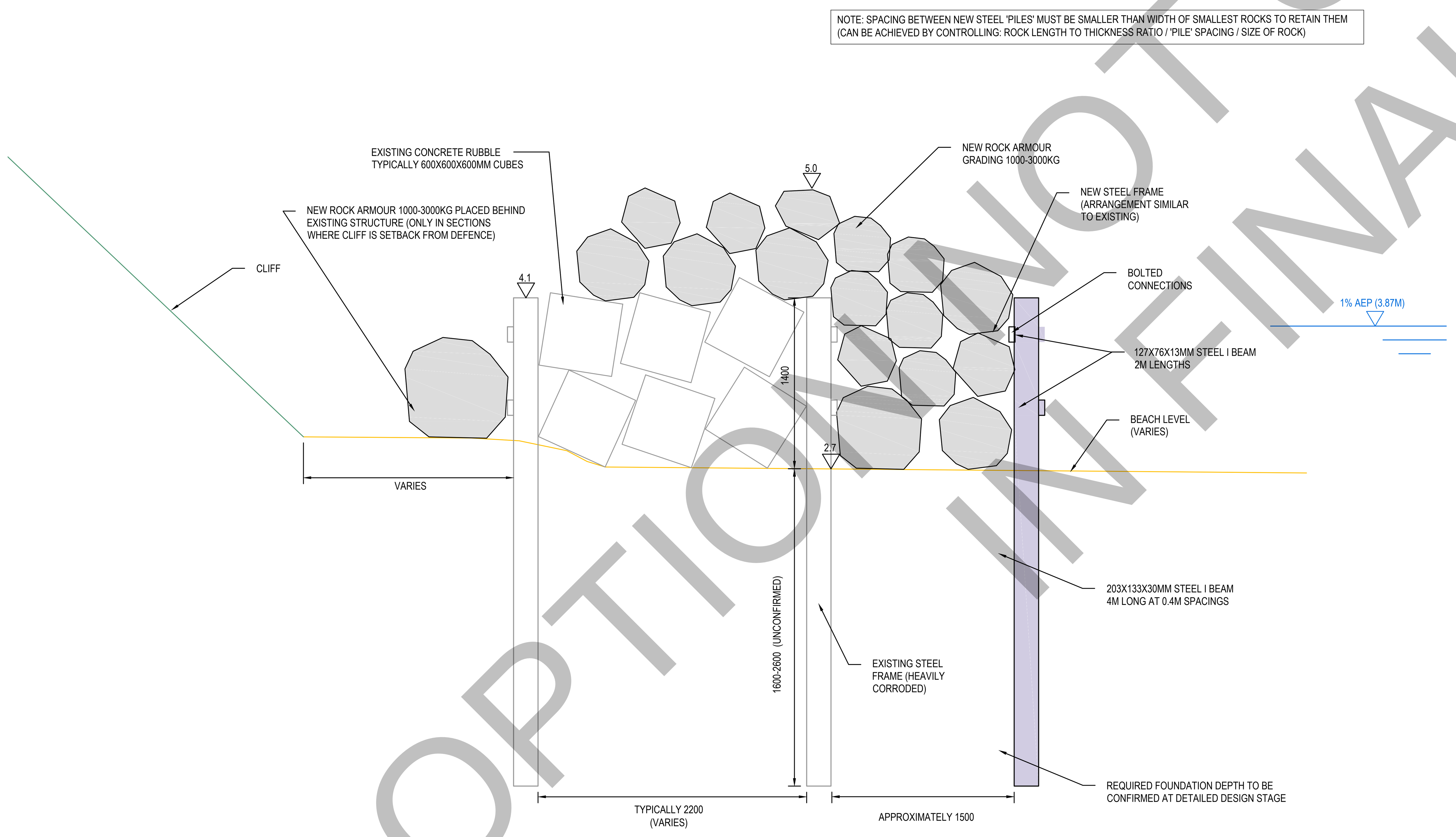
LOCATION OF PLAN OF STEEL FRAMED ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE)

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY



0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

CROSS SECTION OF STEEL FRAMED ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE)

PHOTOGRAPH OF EXISTING STEEL FRAMED DEFENCE

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 7 - ENHANCE EXISTING STEEL FRAMED PROTECTION WITH ROCK (INCREASED HEIGHT)

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
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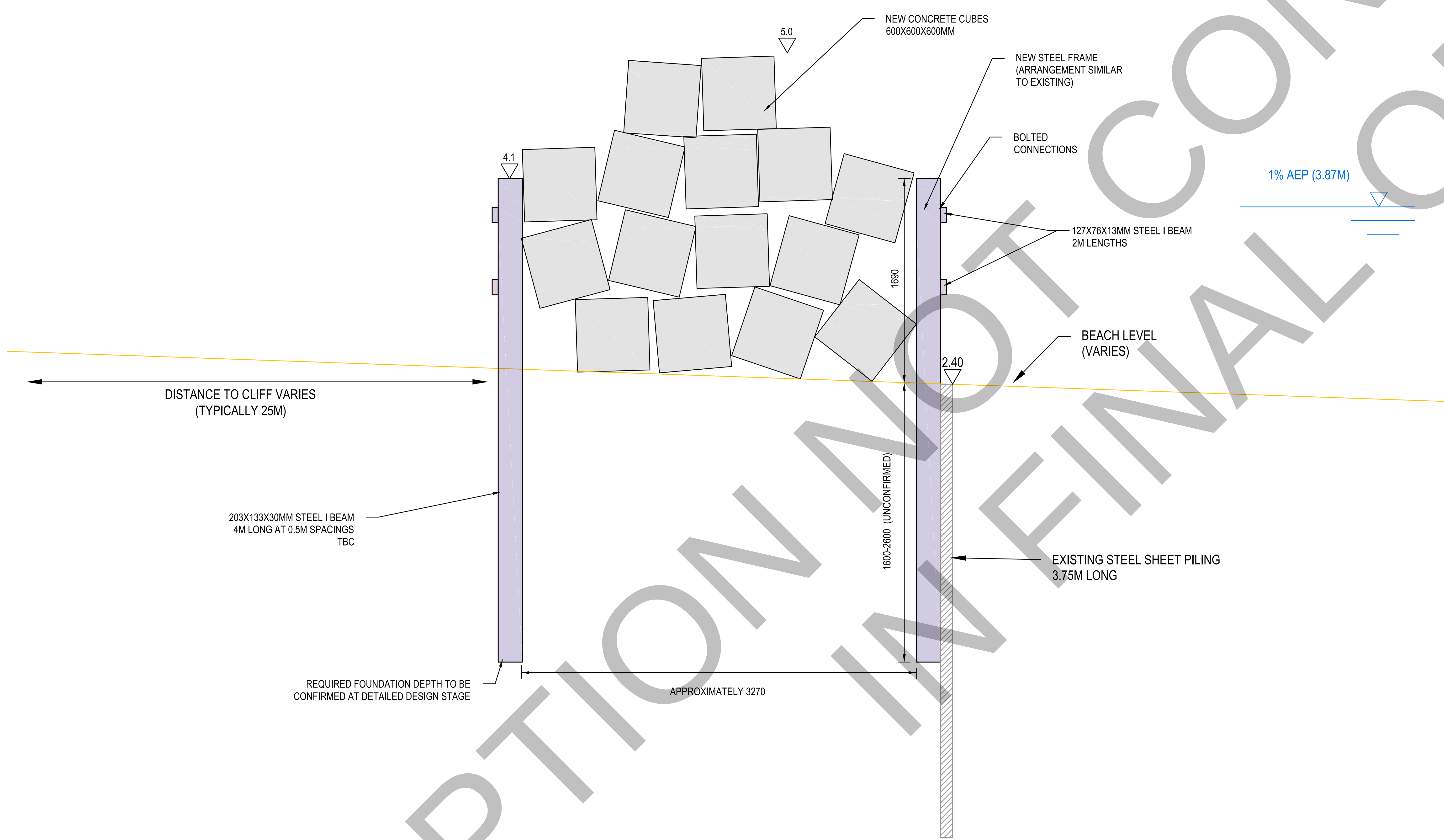
Drawing Number: MOBC-ACM-XX-00-DR-CE-01074
Rev: P2

Plot Date : 5/11/2018 11:03 AM
File Name : STEEL FRAME

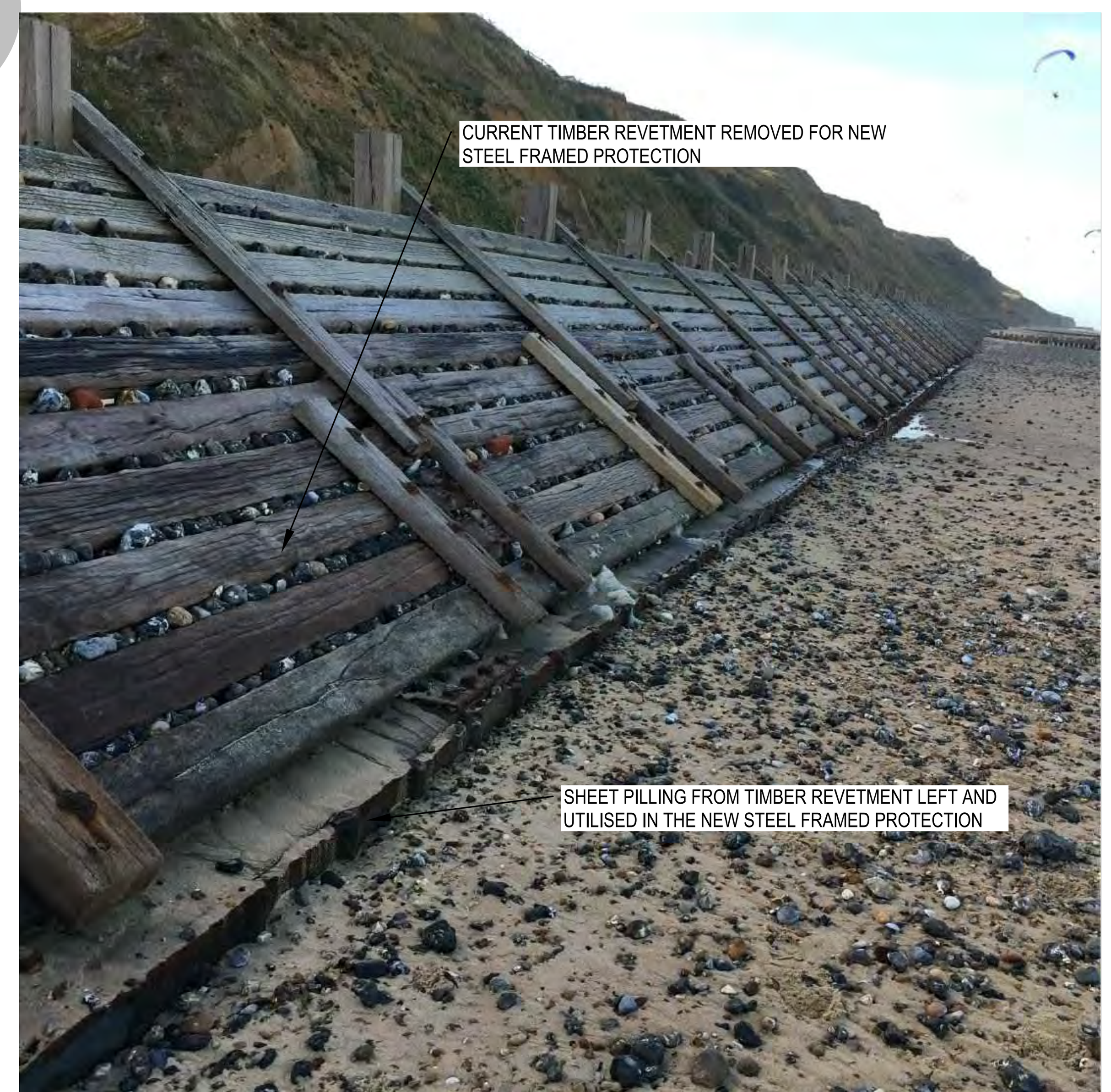
LOCATION OF PLAN OF NEW STEEL FRAMED CONCRETE BLOCK PROTECTION



CROSS SECTION OF NEW STEEL FRAMED CONCRETE BLOCK PROTECTION

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

NOTE: NEW STEEL PROTECTION WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING TIMBER REVETMENT



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

OPTION NOT CONSIDERED IN FINAL OBC

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LEGEND

NEW STEEL FRAMED PROTECTION LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY OUTLINE BUSINESS CASE

Drawing Title
OPTION 7 - NEW STEEL FRAMED CONCRETE BLOCK PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1: 1:50 / 1:1000	Zone: -

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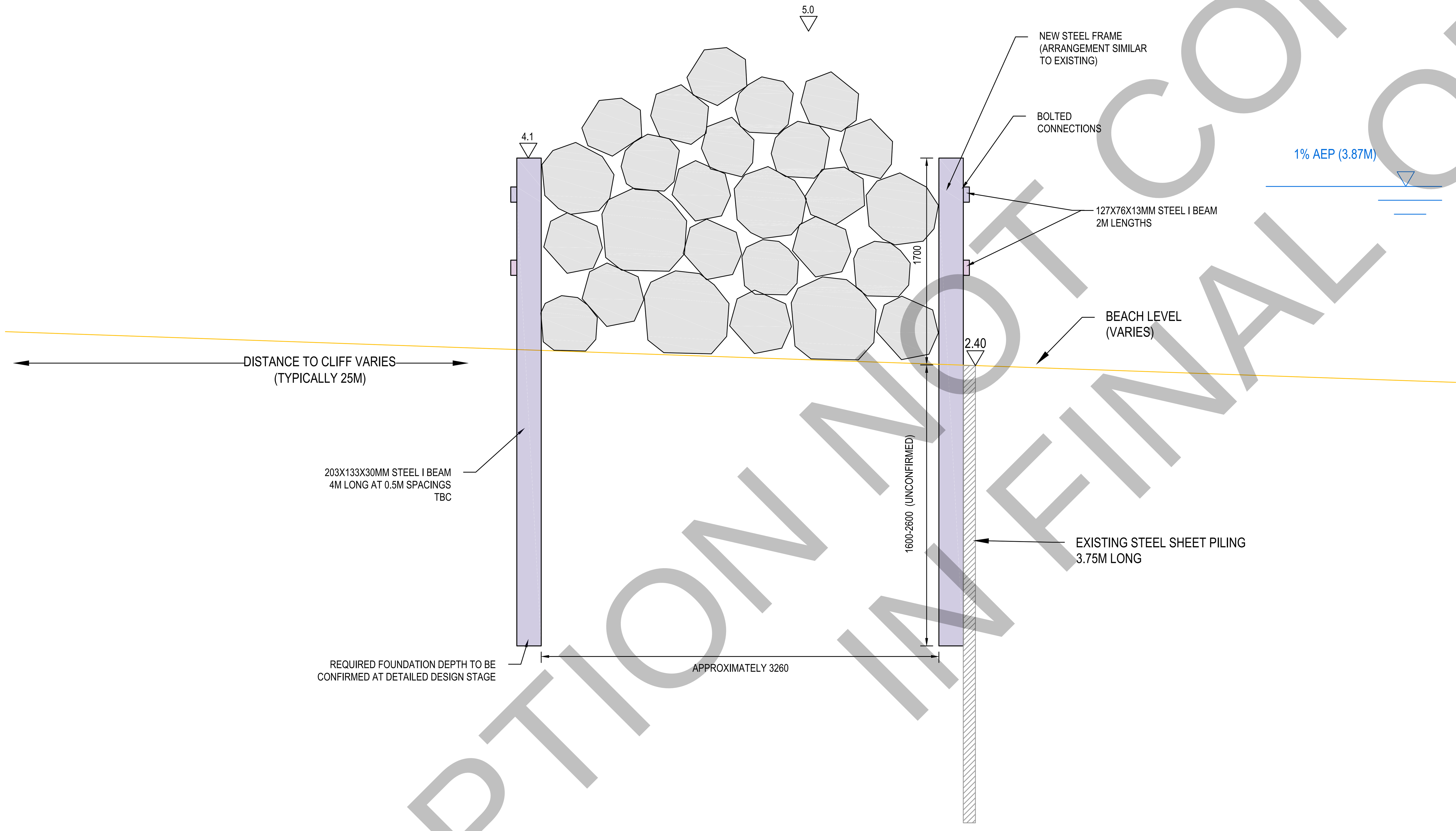
Drawing Number: MOBC-ACM-XX-00-DR-CE-01075
Rev: P2

Plot Date : 5/11/2018 11:09 AM
File Name : STEEL FRAME

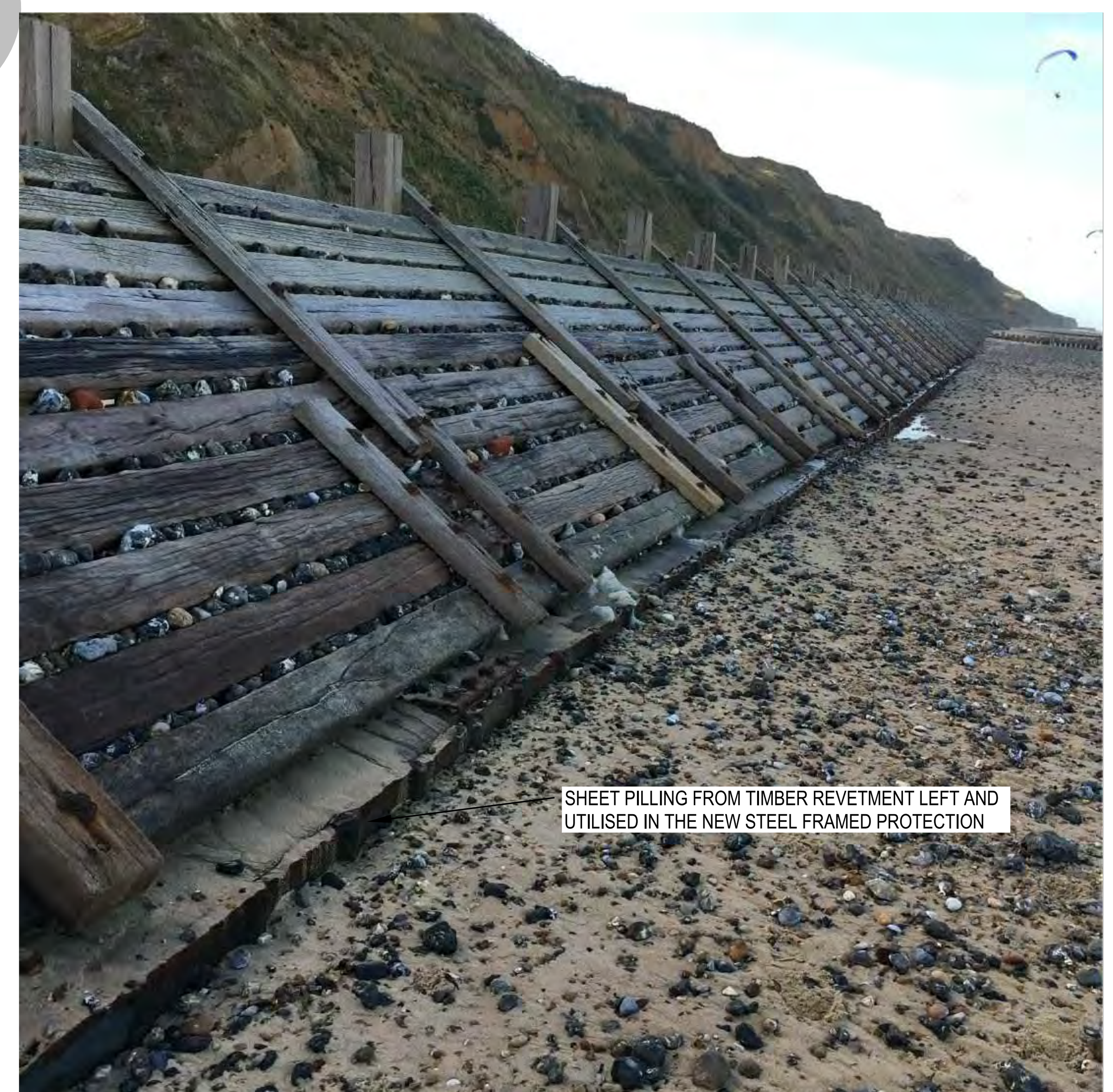
LOCATION OF PLAN OF NEW STEEL FRAMED CONCRETE BLOCK PROTECTION



CROSS SECTION OF NEW STEEL FRAMED CONCRETE BLOCK PROTECTION

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

NOTE: NEW STEEL PROTECTION WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING TIMBER REVETMENT



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW STEEL FRAMED PROTECTION LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By	Check	Date	Suffix
LONGLIST ISSUE	BO	DG	21/04/17	P2
DRAFT ISSUE	BO	DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 7 - NEW STEEL FRAMED ROCK PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
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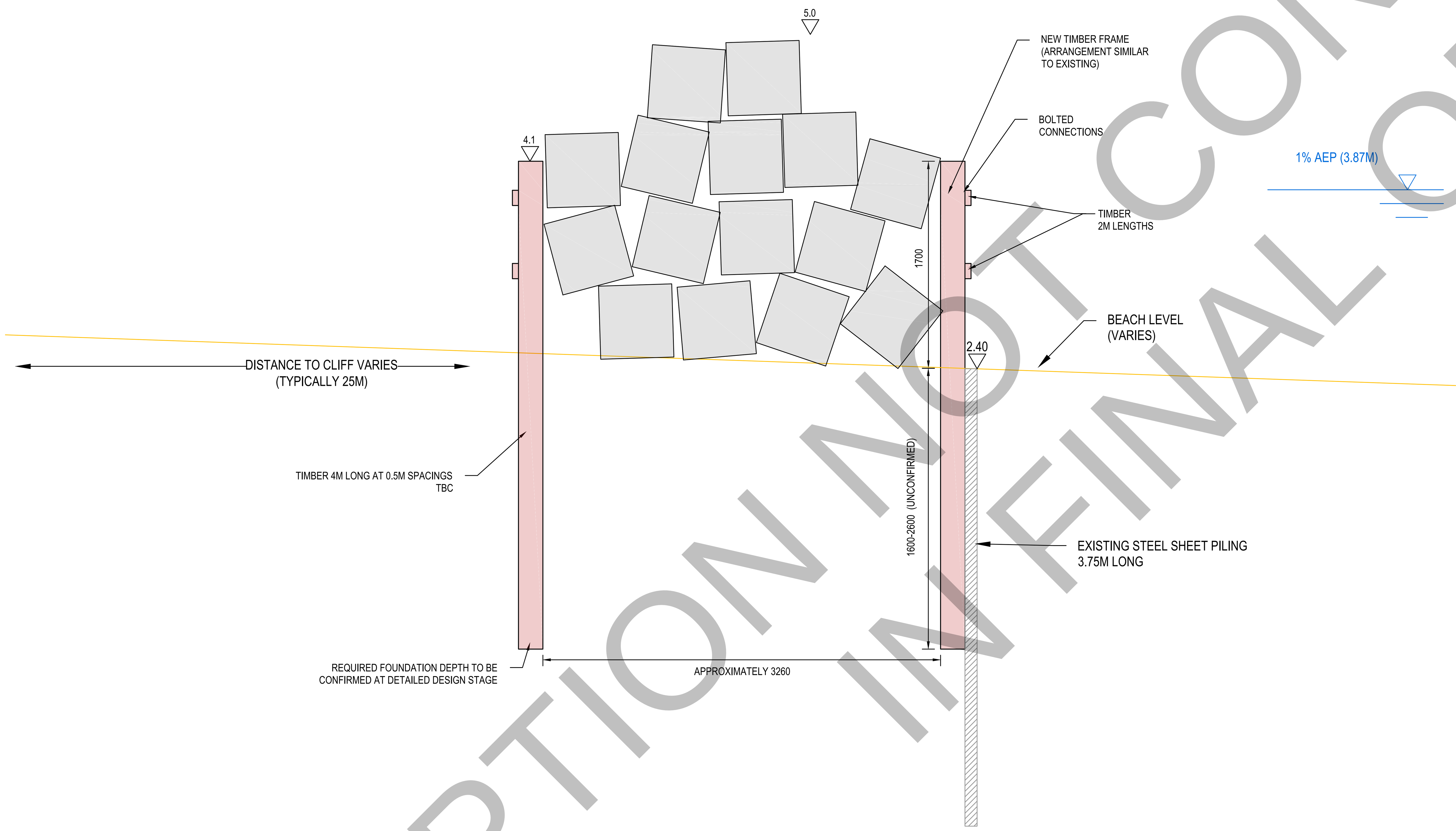
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01076	P2

Plot Date: 5/11/2018 11:11 AM
File Name: STEEL FRAME

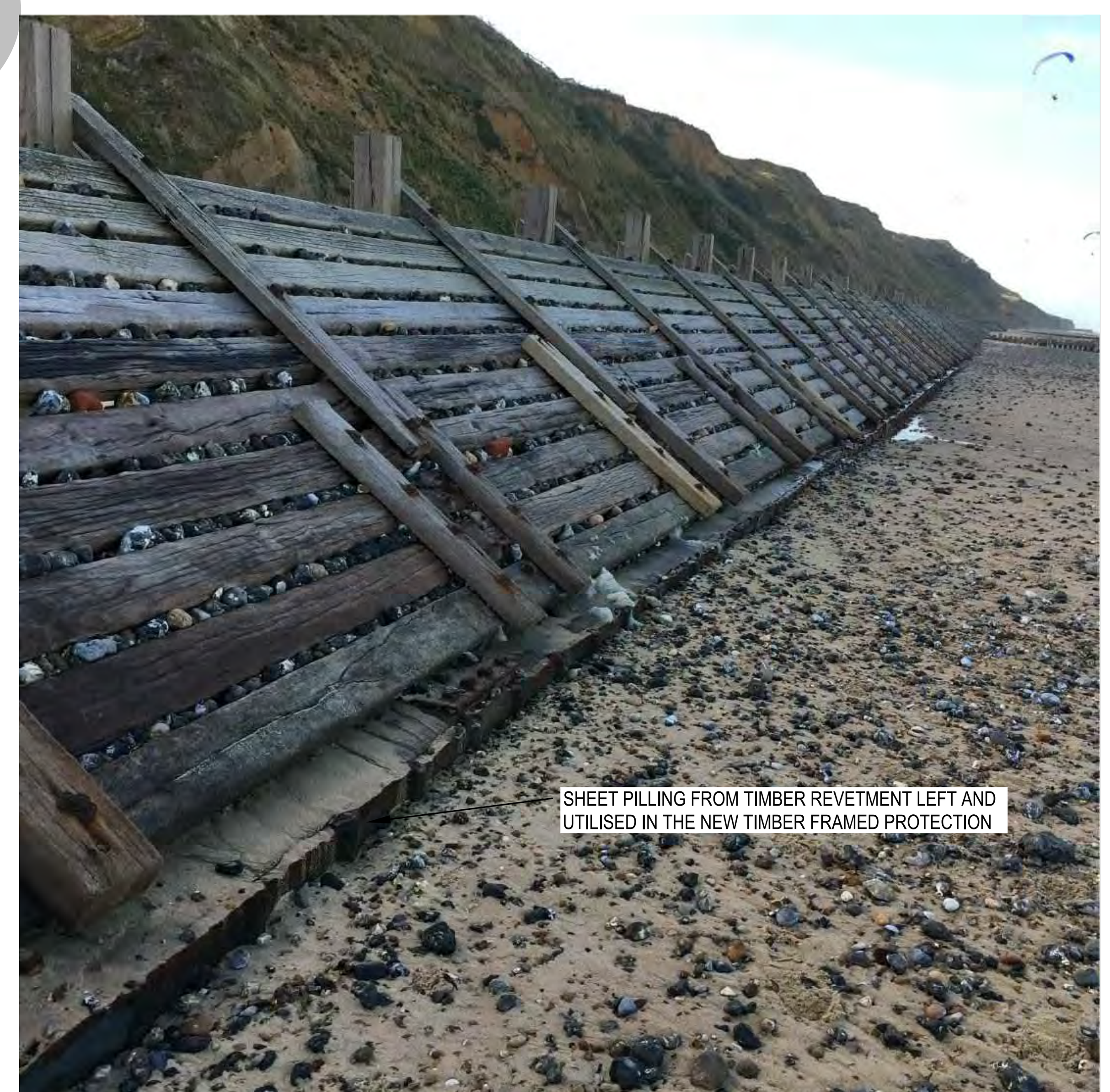
LOCATION OF PLAN OF NEW TIMBER FRAMED CONCRETE BLOCK PROTECTION



CROSS SECTION OF NEW TIMBER FRAMED CONCRETE BLOCK PROTECTION

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

NOTE: NEW TIMBER PROTECTION WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING TIMBER REVETMENT



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW TIMBER FRAMED PROTECTION LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 7 - NEW TIMBER FRAMED CONCRETE BLOCK PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
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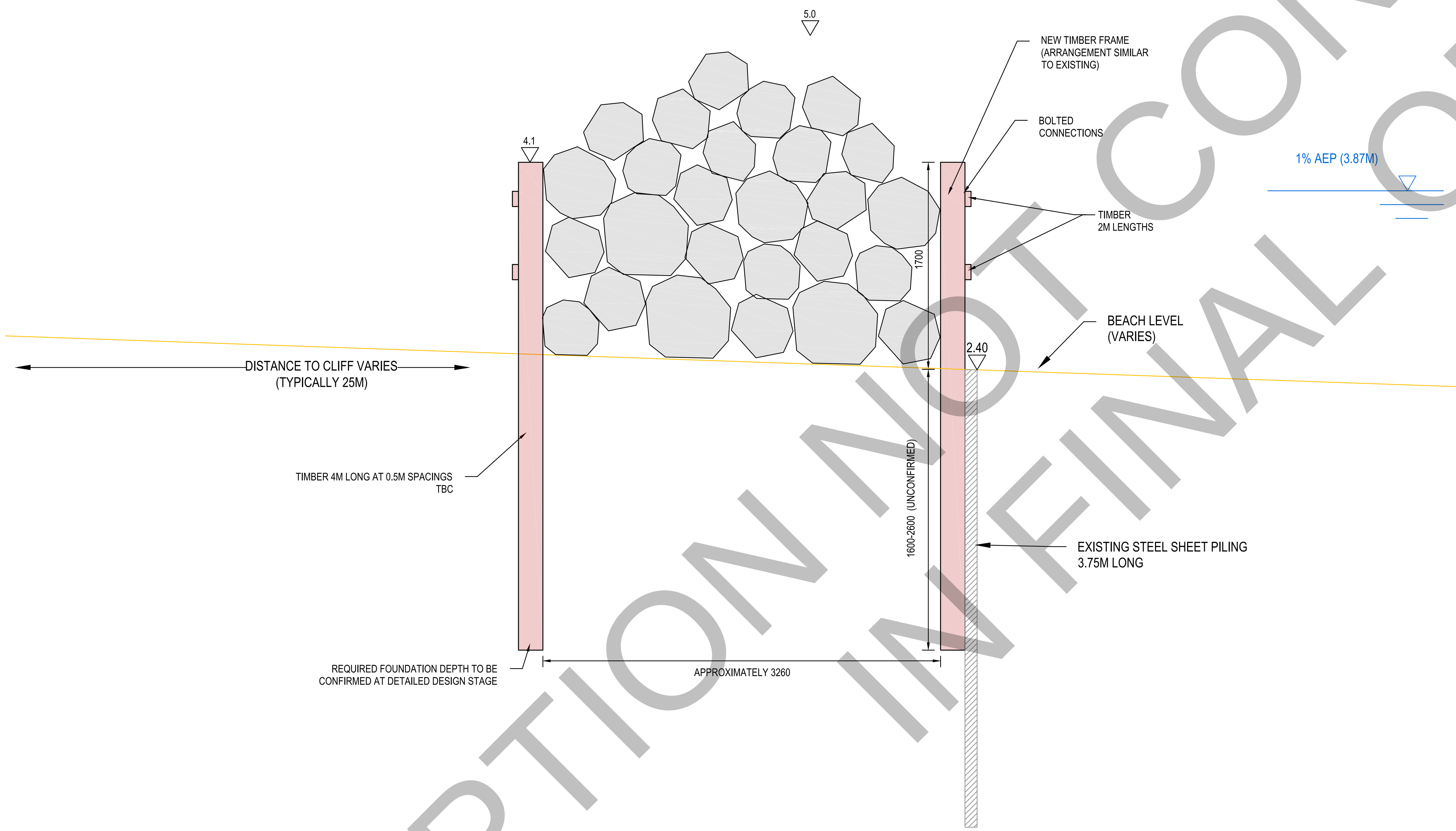
Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01077	P2

Plot Date: 5/11/2018 11:20 AM
File Name: STEEL FRAME

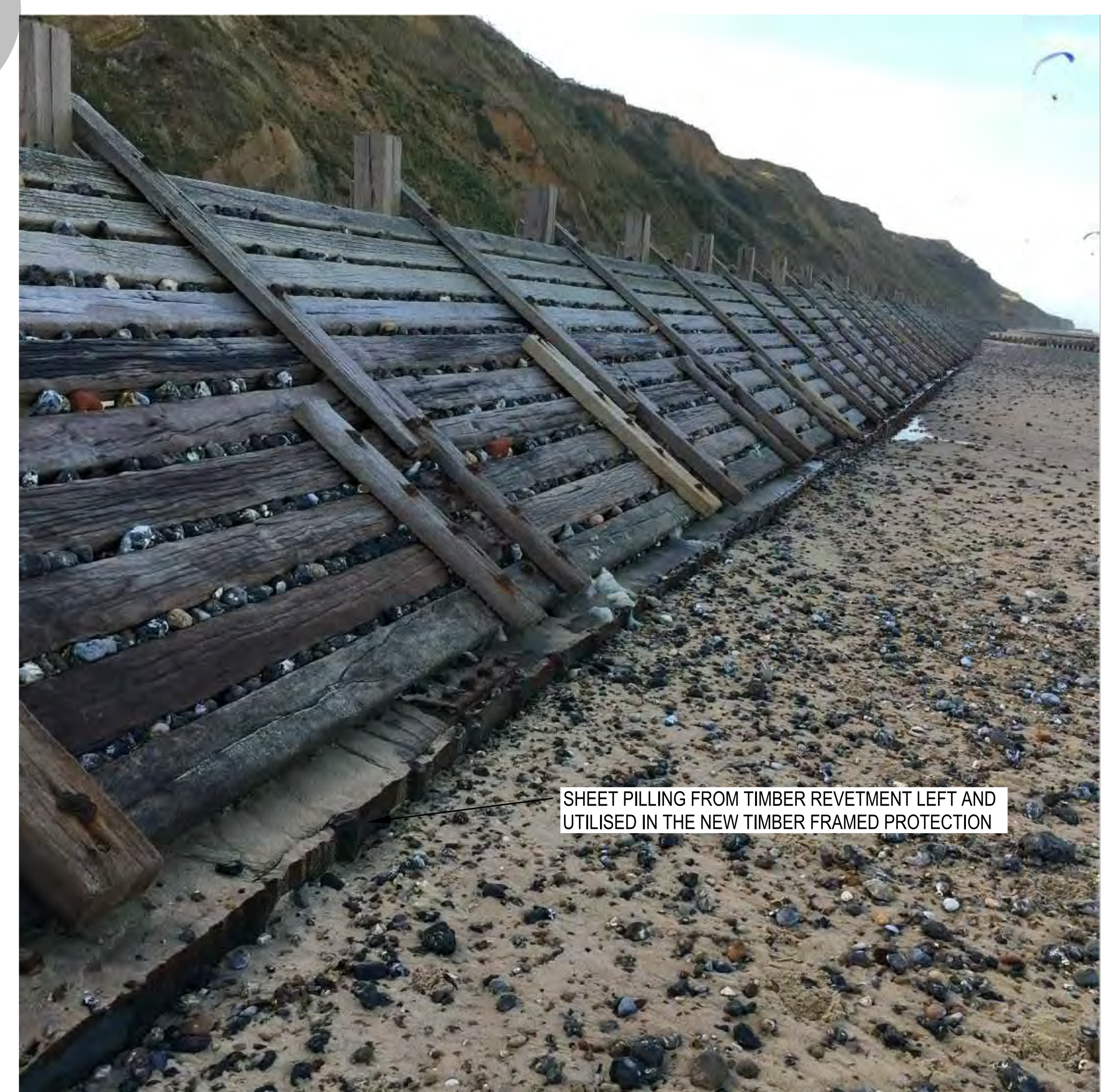
LOCATION OF PLAN OF NEW TIMBER FRAMED ROCK PROTECTION



CROSS SECTION OF NEW TIMBER FRAMED ROCK PROTECTION

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

NOTE: NEW TIMBER PROTECTION WOULD MAKE USE OF EXISTING STEEL SHEET PILING IN FRONT OF EXISTING TIMBER REVETMENT



PHOTOGRAPH OF EXISTING TIMBER REVETMENT

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LEGEND

NEW TIMBER FRAMED PROTECTION LOCATION

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - NEW TIMBER FRAMED ROCK PROTECTION

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
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1:50 / 1:1000	-

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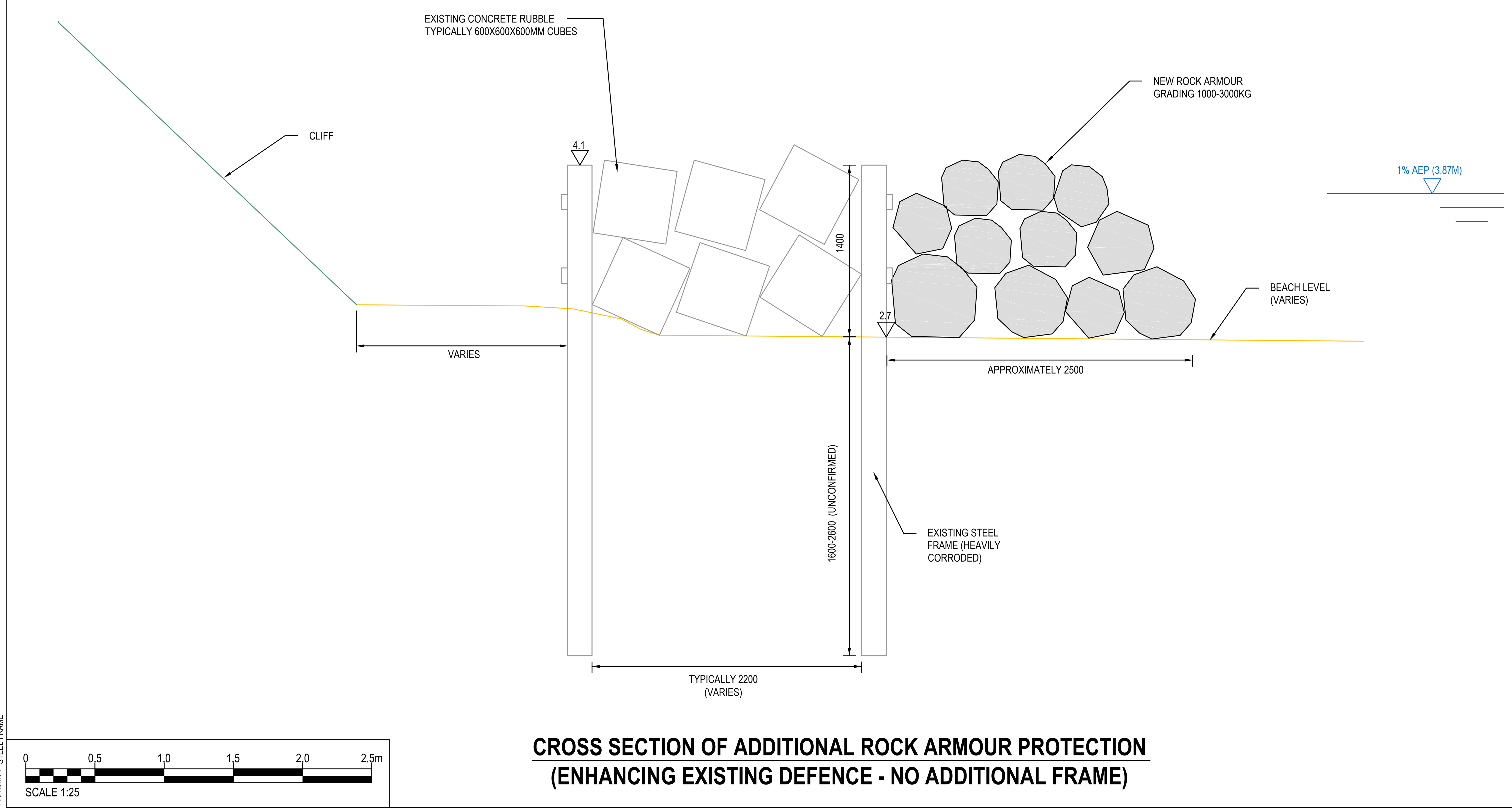
Rev: P2

Plot Date: 5/11/2018 11:24 AM
File Name: STEEL FRAME

LOCATION OF PLAN OF ADDITIONAL ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE - NO ADDITIONAL FRAME)



CROSS SECTION OF ADDITIONAL ROCK ARMOUR PROTECTION
(ENHANCING EXISTING DEFENCE - NO ADDITIONAL FRAME)

PHOTOGRAPH OF EXISTING STEEL FRAMED
DEFENCE

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AERIAL IMAGERY DATA (2013) COURTESY OF
CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 7 - ENHANCE EXISTING
STEEL FRAMED PROTECTION
WITH ROCK
(NO ADDITIONAL FRAME)

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:1000	-

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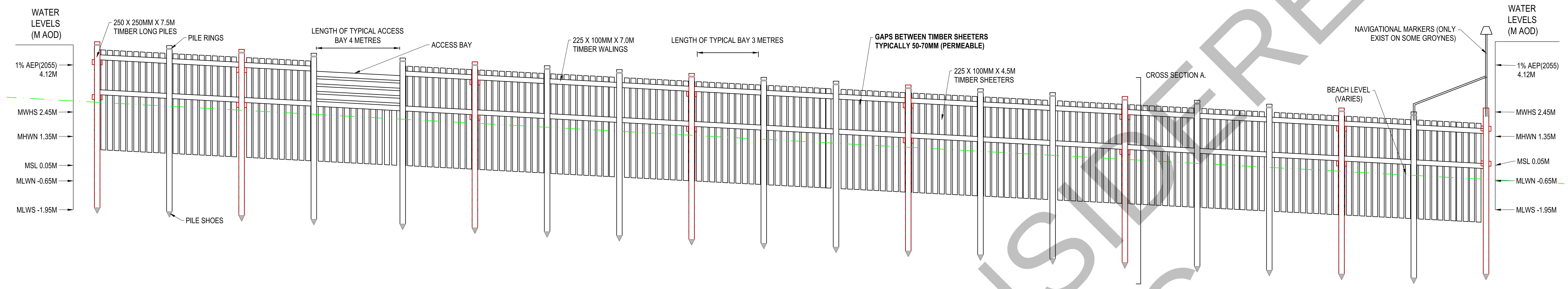
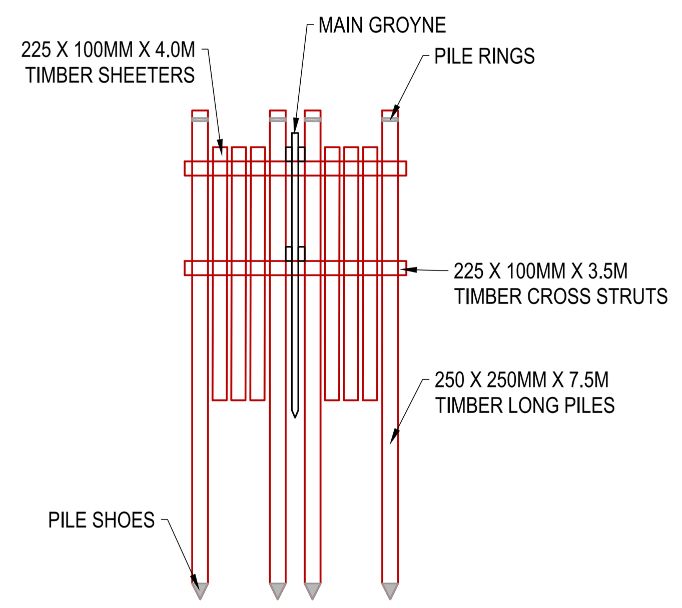
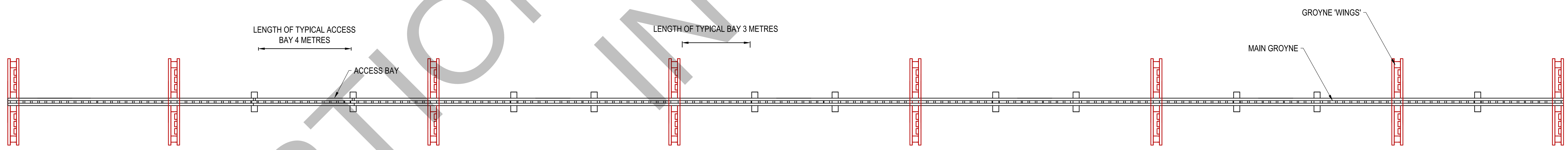
Drawing Number: MOBC-ACM-XX-00-DR-CE-01079 | Rev: P2

Plot Date : 5/11/2018 11:22 AM
File Name : STEEL FRAME

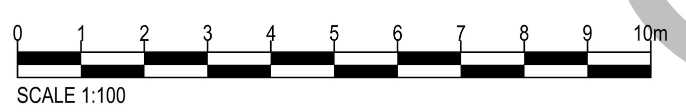




CROSS SECTION A



PLAN OF NEW PERMEABLE GROYNE (TO MATCH EXISTING GROYNES)



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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.

LEGEND

- MAIN GROYNE STRUCTURE
- 'WINGS' (SUPPORTS) OF GROYNE
- INDICATIVE BEACH LEVEL

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 8
NEW PERMEABLE GROYNES

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:100	-

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Scott House
Alencon Link
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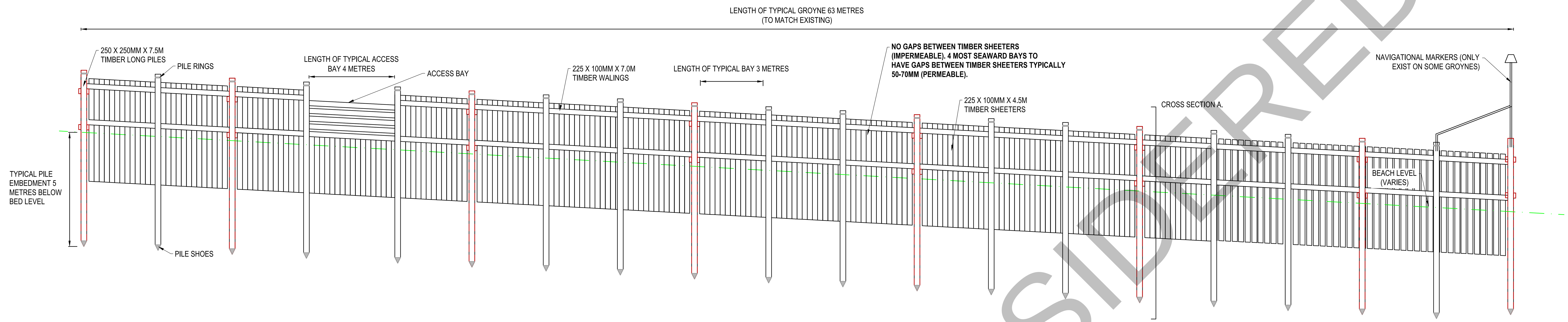
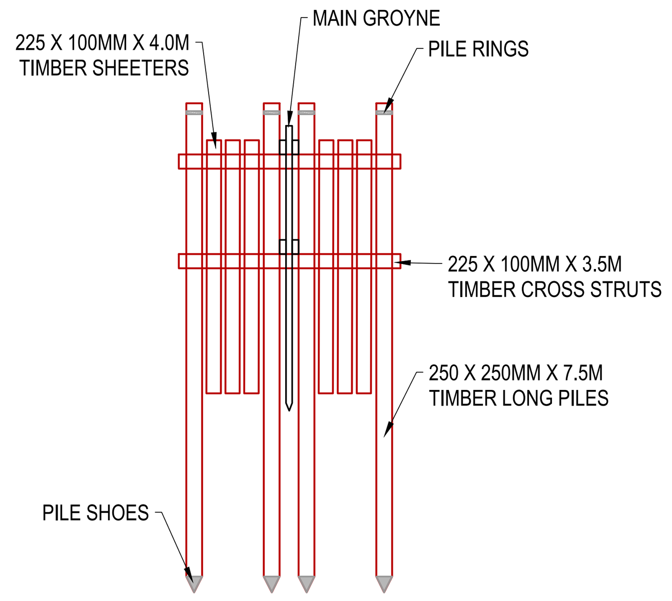
Drawing Number: MOBC-ACM-XX-00-DR-CE-01081

Rev: P2

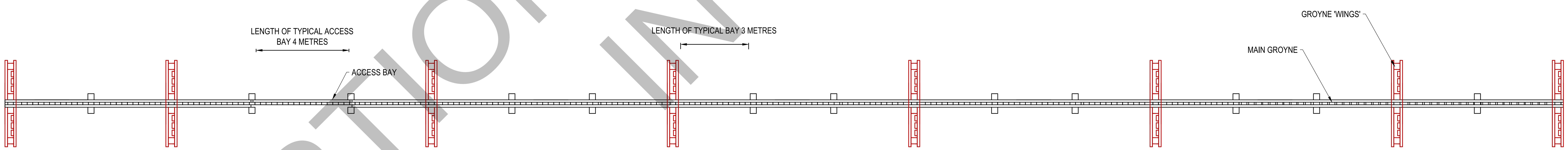
Plot Date : 5/11/2018 11:28 AM
File Name : GROYNESLEVELS



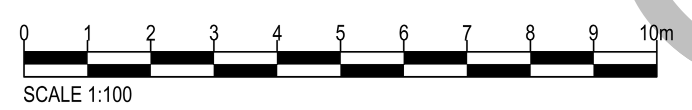
LONG SECTION OF NEW IMPERMEABLE GROYNE
(TO MATCH EXISTING GROYNES)



CROSS SECTION A



PLAN OF NEW IMPERMEABLE GROYNE
(TO MATCH EXISTING GROYNES)



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LEGEND

- MAIN GROYNE STRUCTURE
- 'WINGS' (SUPPORTS) OF GROYNE

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 8
NEW IMPERMEABLE GROYNES

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:100	-

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Scott House
Alencon Link
Hampshire, RG21 7PP
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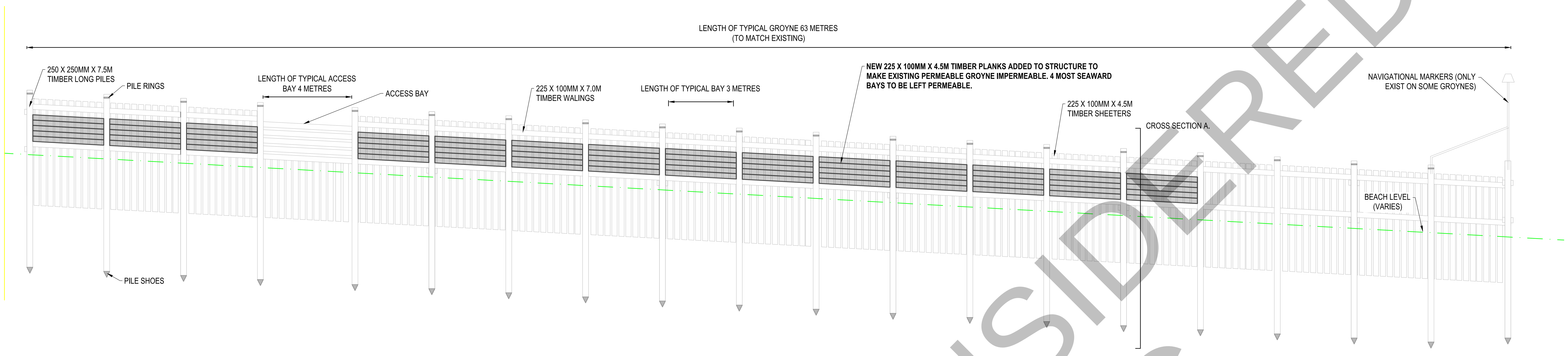
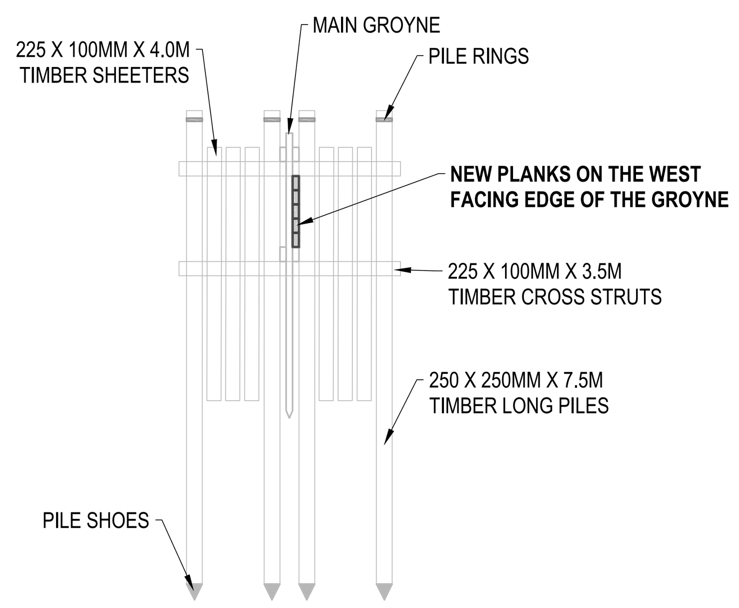
MOBC-ACM-XX-00-DR-CE-01082	P2

Plot Date : 5/11/2018 11:29 AM
File Name : GROYNESLEVELS



LONG SECTION OF ENHANCEMENT OF EXISTING GROYNE

NOTE: NEW PLANKS ARE TO BE CONNECTED TO EXISTING TIMBER. BEFORE THIS ENHANCEMENT CAN TAKE PLACE THE EXISTING STRUCTURE WILL REQUIRE REFURBISHMENT.



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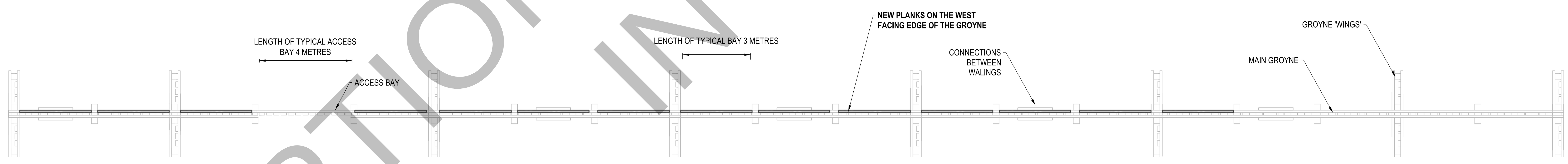

PLAN OF ENHANCEMENT OF EXISTING GROYNE

0 1 2 3 4 5 6 7 8 9 10m
SCALE 1:100

NOTES

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LEGEND

- EXISTING GROYNE STRUCTURE
- NEW TIMBER PLANKS

Revision Details	By	Check	Date	Suffix
LONGLIST ISSUE	BO	DG	21/04/17	P2
DRAFT ISSUE	BO	DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 8
EXISTING GROYNE ENHANCEMENT

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
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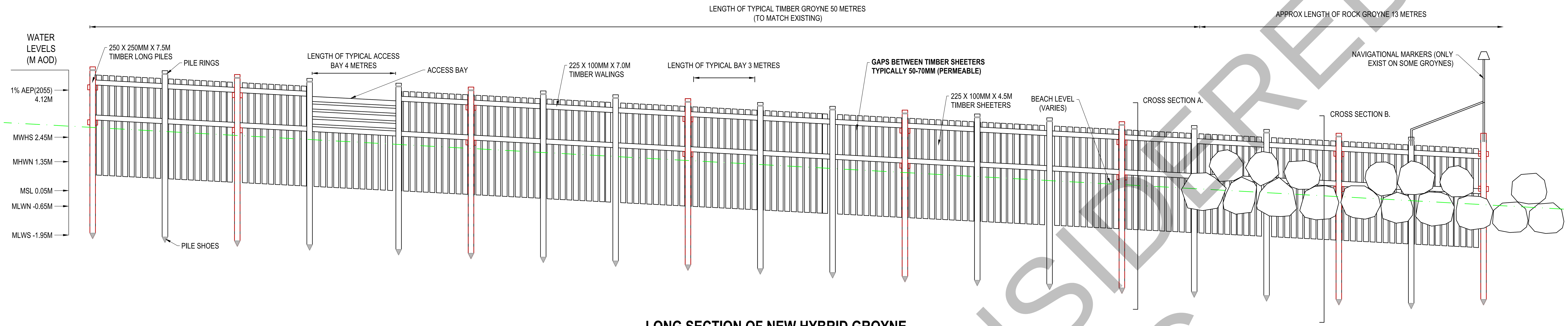
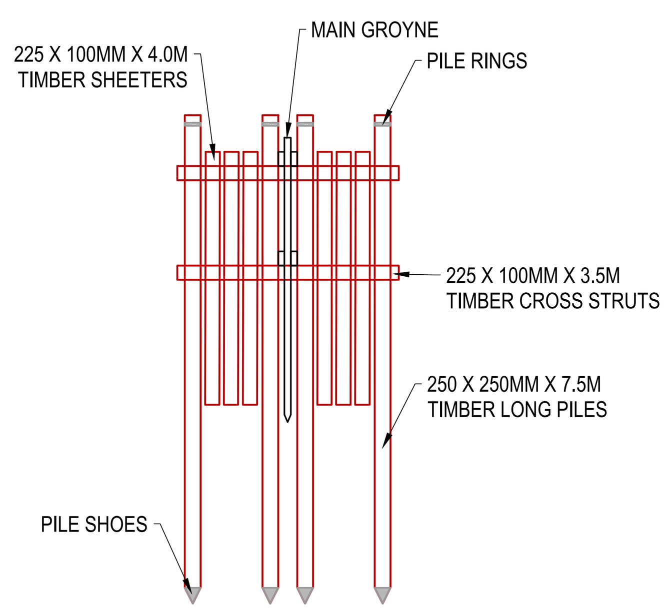
Drawing Number: MOBC-ACM-XX-00-DR-CE-01083 | Rev: P2

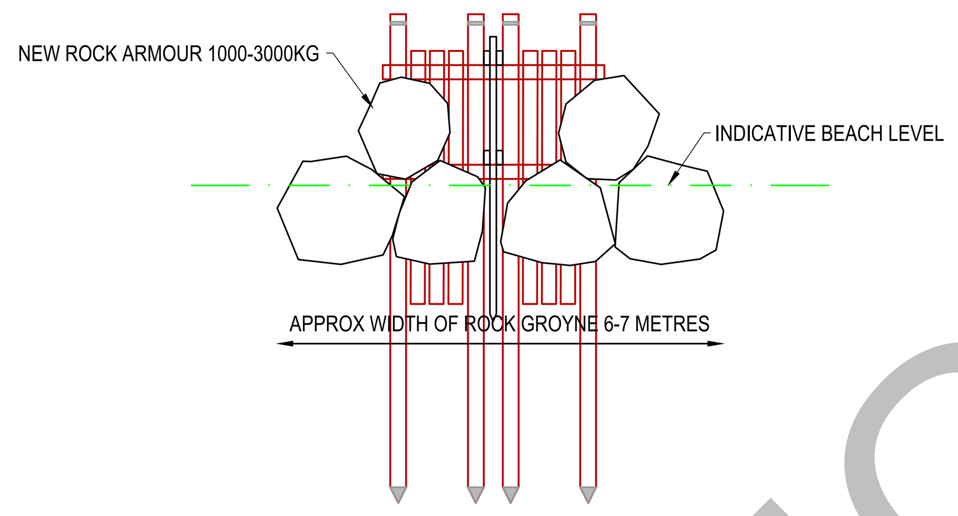
Plot Date: 5/11/2018 11:29 AM
File Name: GROYNESLEVELS



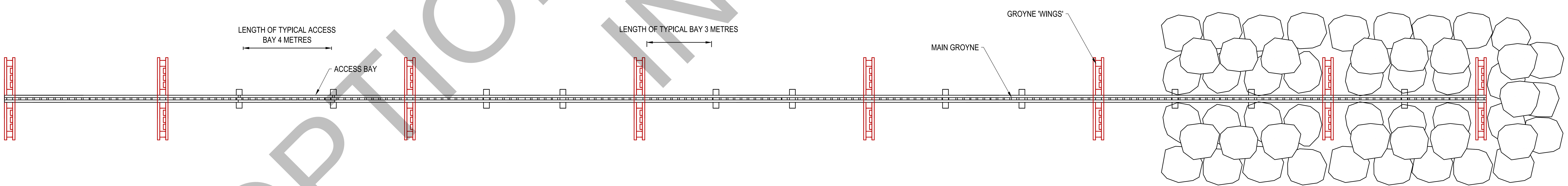
LONG SECTION OF NEW HYBRID GROYNE (TO MATCH EXISTING GROYNES)



CROSS SECTION A



CROSS SECTION B



0 1 2 3 4 5 6 7 8 9 10m

SCALE 1:100

PLAN OF NEW HYBRID GROYNE (TO MATCH EXISTING GROYNES)

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LEGEND

- MAIN GROYNE STRUCTURE
- 'WINGS' (SUPPORTS) OF GROYNE
- INDICATIVE BEACH LEVEL

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 8
NEW HYBRID GROYNES

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
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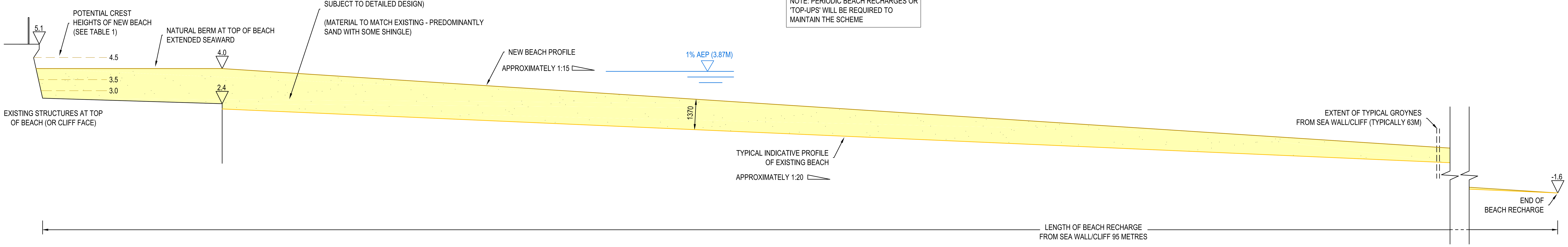
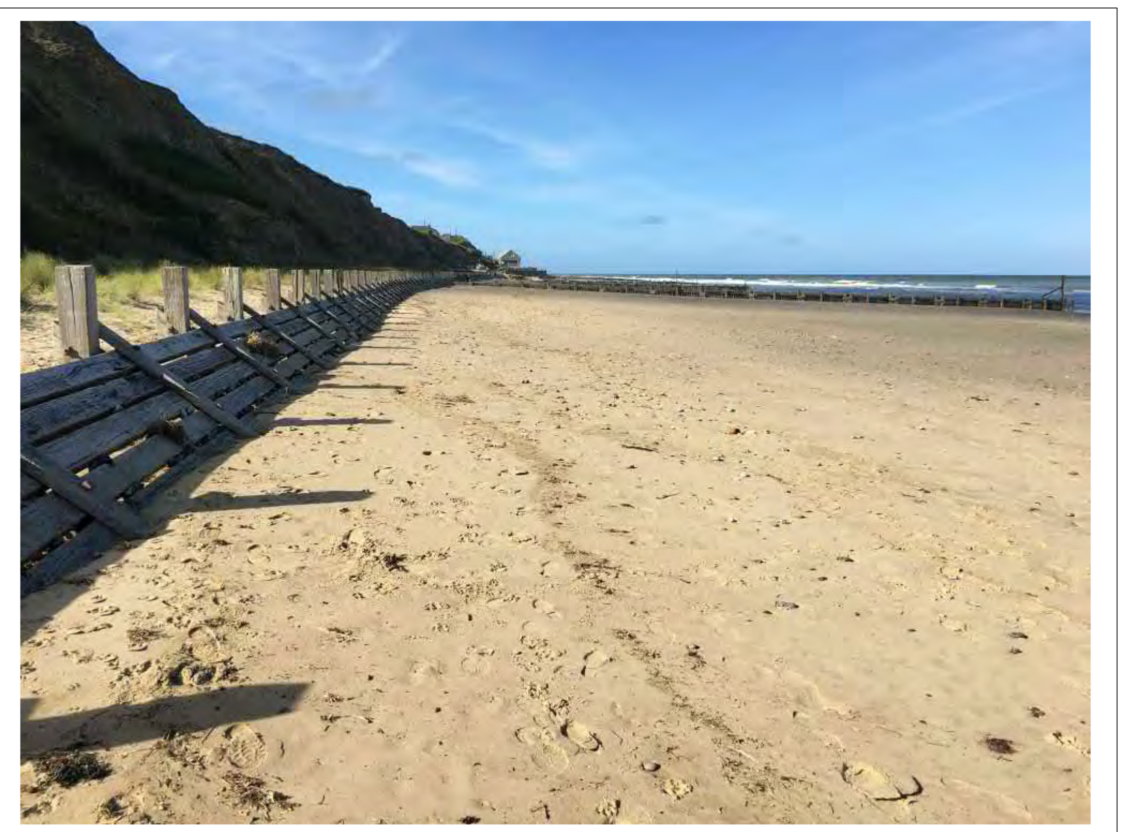
Rev: P2

PLAN OF LOCATION OF BEACH RECHARGE

TABLE 1 - VOLUME OF MATERIAL REQUIRED TO CREATE CREST LEVELS BASED ON INDICATIVE PROFILE OF EXISTING BEACH LEVELS.	
CREST HEIGHT OF NEW BEACH PROFILE (M AOD)	VOLUME OF MATERIAL REQUIRED PER METRE (M^3/M)
4.5	145
4.0	91
3.5	50
3.0	20



CROSS SECTION OF BEACH RECHARGE



PHOTOGRAPHS OF EXISTING BEACH

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LEGEND

BEACH RECHARGE AREAS

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 11
BEACH RECHARGE

OUTLINE DESIGN

Designed	Drawn	Checked	Approved	Date
GB	BO	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:100 / 1:5000	-

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Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01111	P2

Plot Date : 5/11/2018 11:36 AM
File Name : BEACH RECHARGE

Appendix B – Embankment Scour Protection Option Drawings

PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - GABIONS

0 5 10 15 20 25 30 35 40 45 50m
SCALE 1:500

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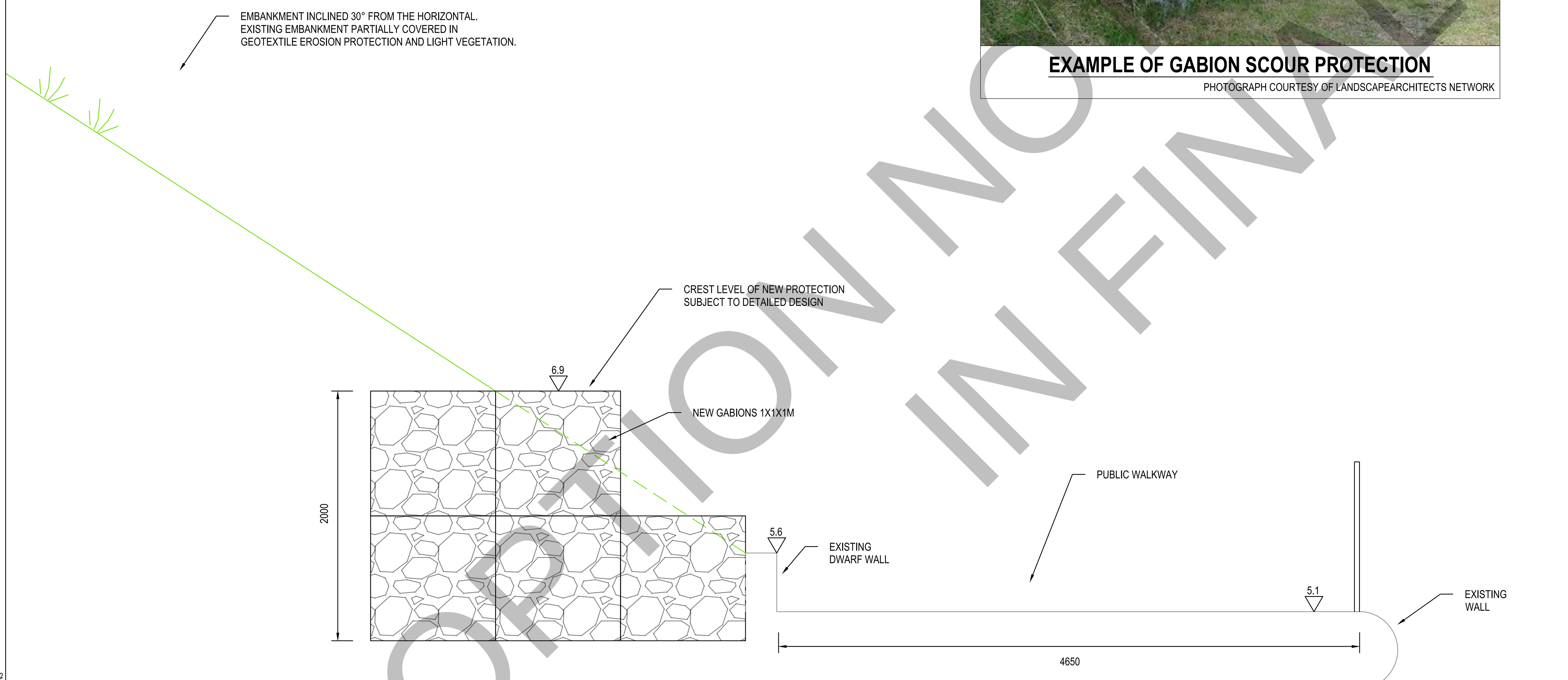
LEGEND

- AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2014 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.
- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS SCOURED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

EXAMPLE OF GABION SCOUR PROTECTION

PHOTOGRAPH COURTESY OF LANDSCAPEARCHITECTS NETWORK



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - GABIONS

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION REPAIR UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 12
EMBANKMENT SCOUR PROTECTION - GABIONS

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:500	-

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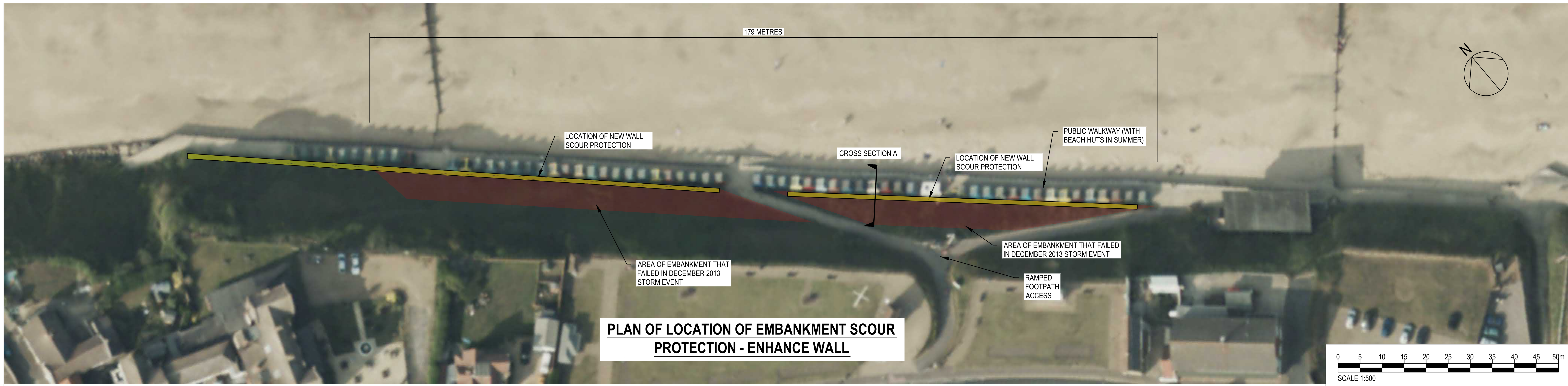
Drawing Number: MOBC-ACM-XX-00-DR-CE-01121
Rev: P2

Plot Date: 5/11/2018 11:39 AM
File Name: SCOUR PROTECTION GABIONS

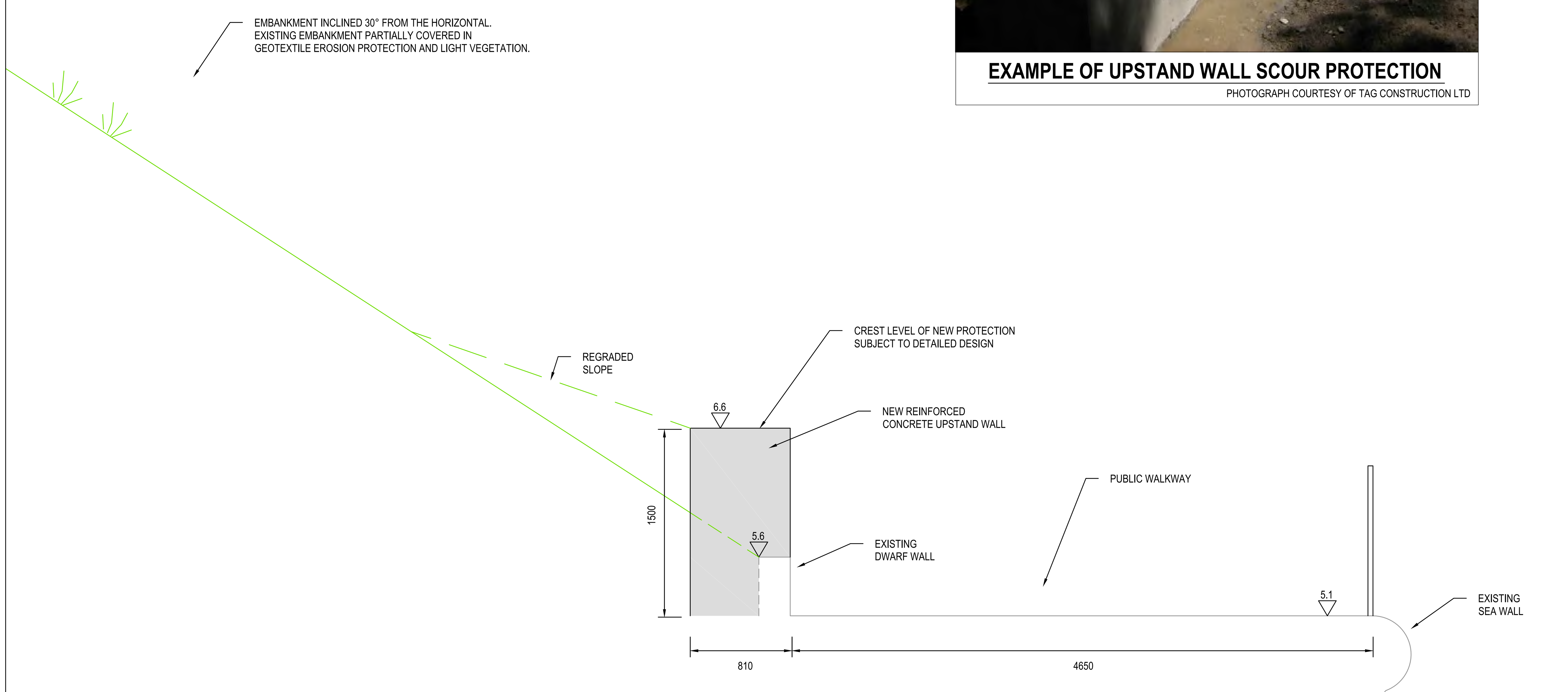


PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

0 5 10 15 20 25 30 35 40 45 50m
SCALE 1:500

EXAMPLE OF UPSTAND WALL SCOUR PROTECTION

PHOTOGRAPH COURTESY OF TAG CONSTRUCTION LTD



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

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LEGEND

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- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By	Check	Date	Suffix
LONGLIST ISSUE	BO	DG	21/04/17	P2
DRAFT ISSUE	BO	DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 12
EMBANKMENT SCOUR PROTECTION - ENHANCE WALL

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:500	-

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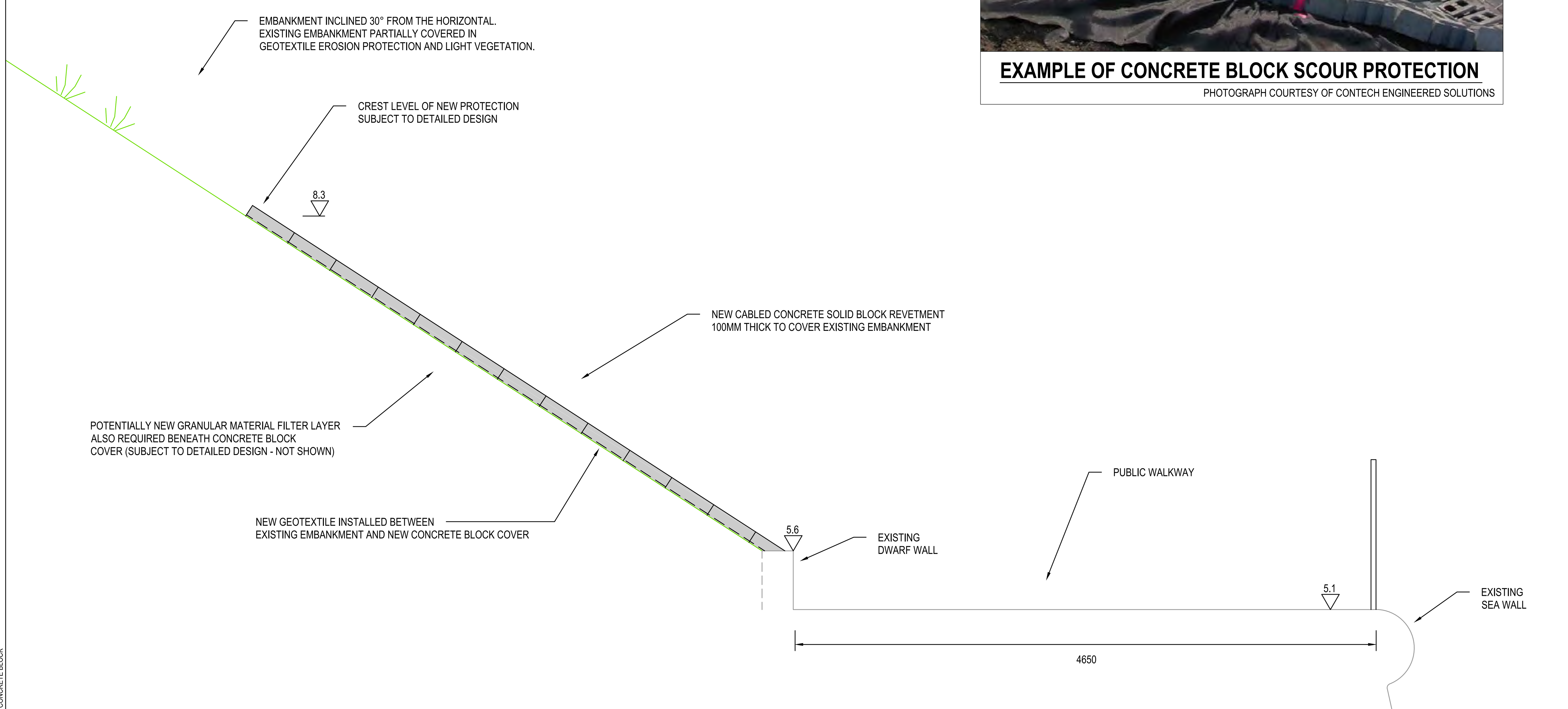
MOBC-ACM-XX-00-DR-CE-01122
Rev
P2

Plot Date : 5/11/2018 11:42 AM
File Name : SCOUR PROTECTION WALL

PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - CONCRETE BLOCK

EXAMPLE OF CONCRETE BLOCK SCOUR PROTECTION

PHOTOGRAPH COURTESY OF CONTECH ENGINEERED SOLUTIONS



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - CONCRETE BLOCK

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

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LEGEND

AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2013 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.

LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 12
EMBANKMENT SCOUR
PROTECTION - CONCRETE BLOCK

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
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1:50 / 1:500	-

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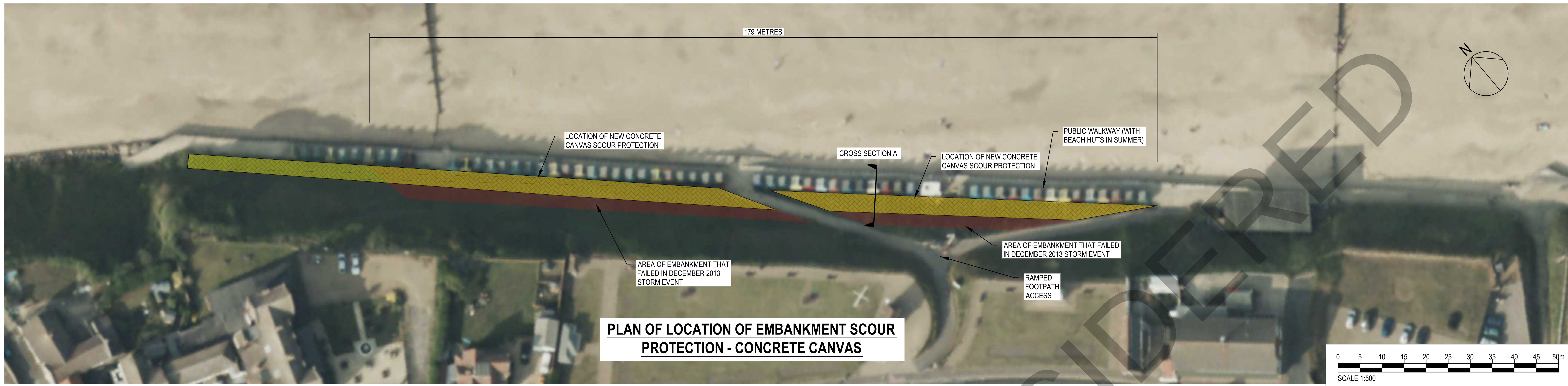
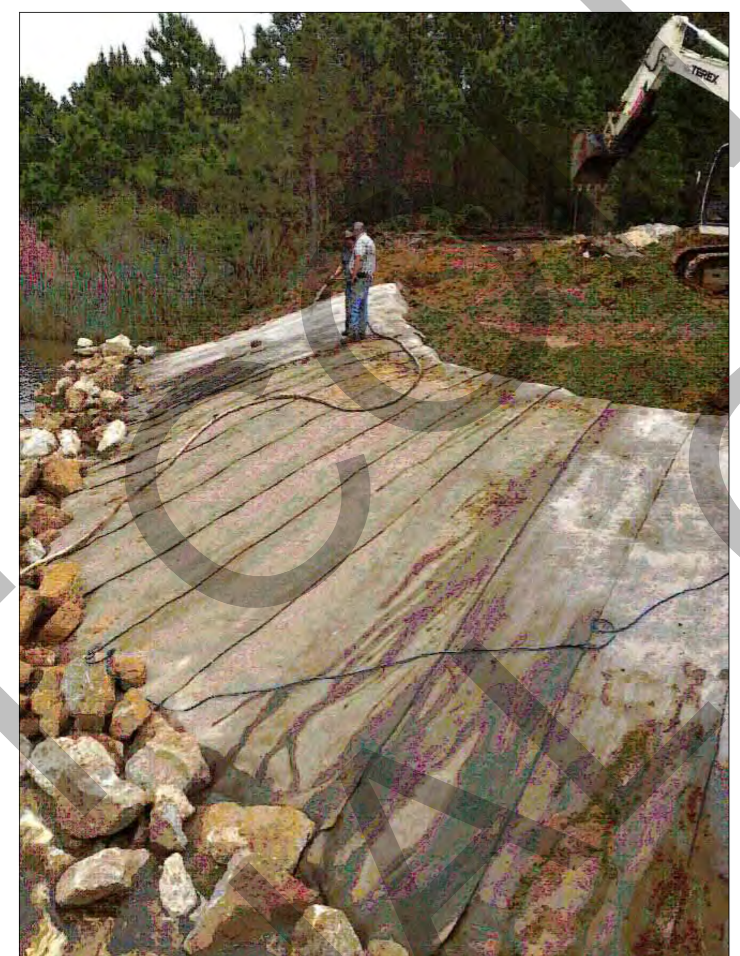
Drawing Number: MOBC-ACM-XX-00-DR-CE-01123
Rev: P2

Plot Date: 5/11/2018 11:44 AM
File Name: SCOUR PROTECTION CONCRETE BLOCK

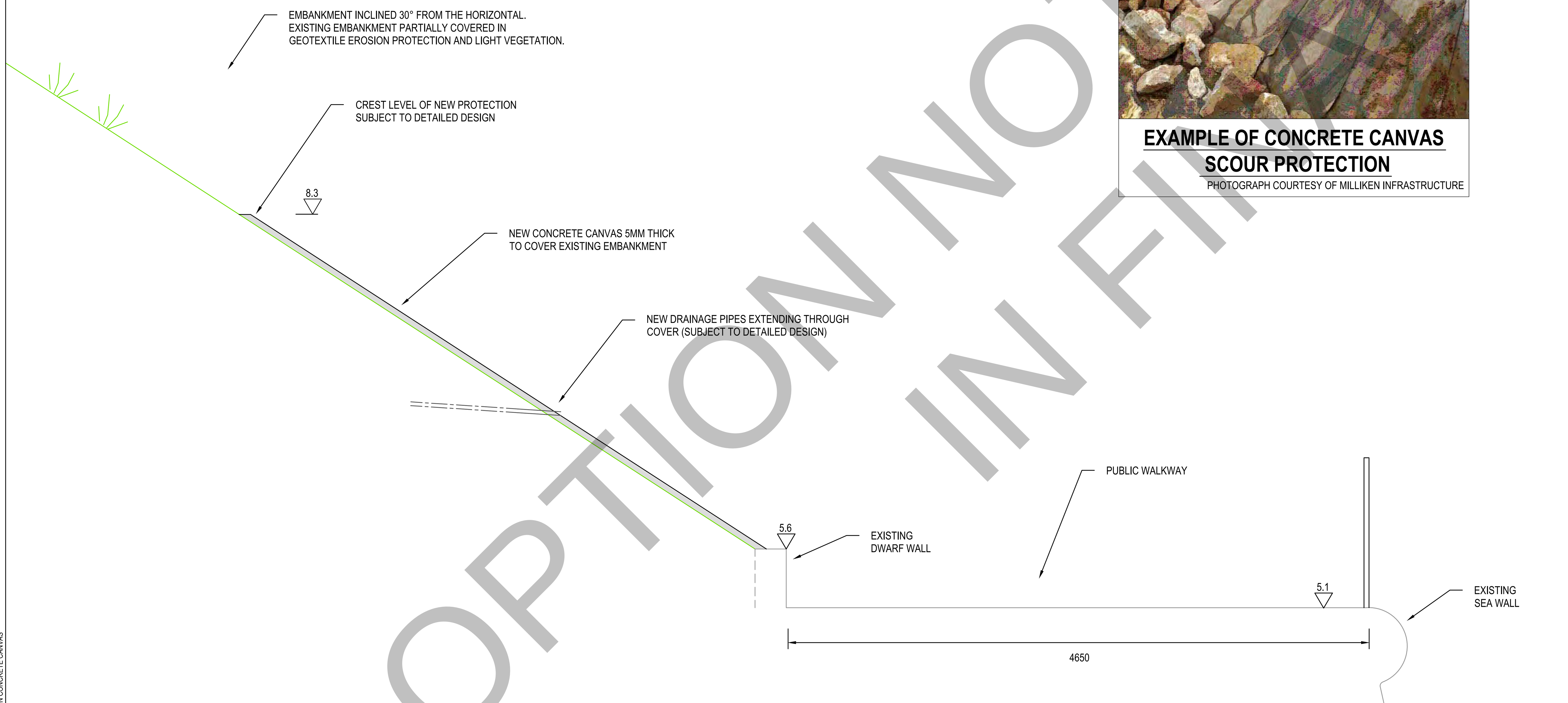


PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - CONCRETE CANVAS



EXAMPLE OF CONCRETE CANVAS SCOUR PROTECTION

PHOTOGRAPH COURTESY OF MILLIKEN INFRASTRUCTURE



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - CONCRETE CANVAS

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION REPAIR UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

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AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue
FOR OPTION APPRAISAL

Client
NORTH NORFOLK DISTRICT COUNCIL

Project Title
MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title
OPTION 12
EMBANKMENT SCOUR
PROTECTION - CONCRETE CANVAS

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
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Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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Drawing Number
MOBC-ACM-XX-00-DR-CE-01124

Rev
P2

Plot Date : 5/11/2018 11:46 AM
File Name : SCOUR PROTECTION CONCRETE CANVAS

NOTES

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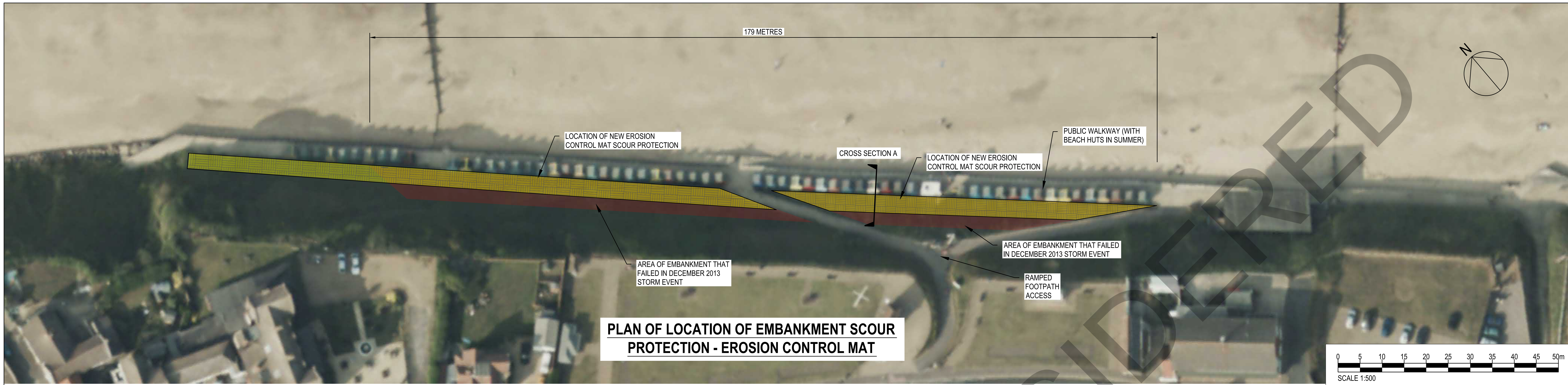
5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.



PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - EROSION CONTROL MAT

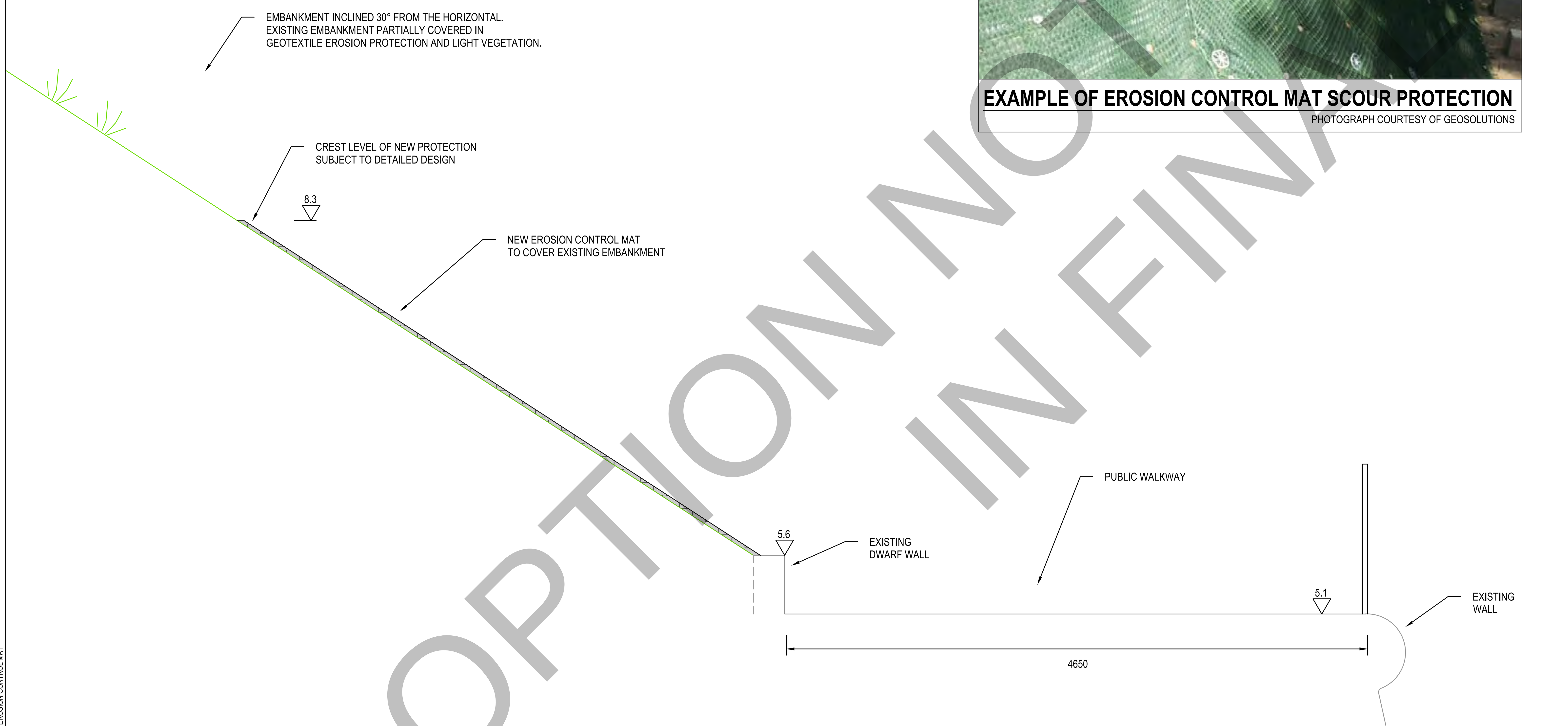
LEGEND

- AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2013 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.
- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

EXAMPLE OF EROSION CONTROL MAT SCOUR PROTECTION

PHOTOGRAPH COURTESY OF GEOSOLUTIONS



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - EROSION CONTROL MAT

0 0.5 1.0 1.5 2.0 2.5m
SCALE 1:25

PHOTOGRAPH OF EXISTING EMBANKMENT
(NOTE EXISTING GEOTEXTILE EROSION PROTECTION UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

Revision Details	By	Check	Date	Suffix
SHORTLIST ISSUE	BO	DG	21/04/17	P2
DRAFT ISSUE	BO	DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 12
EMBANKMENT SCOUR PROTECTION - EROSION CONTROL MAT
Tensar Vmax

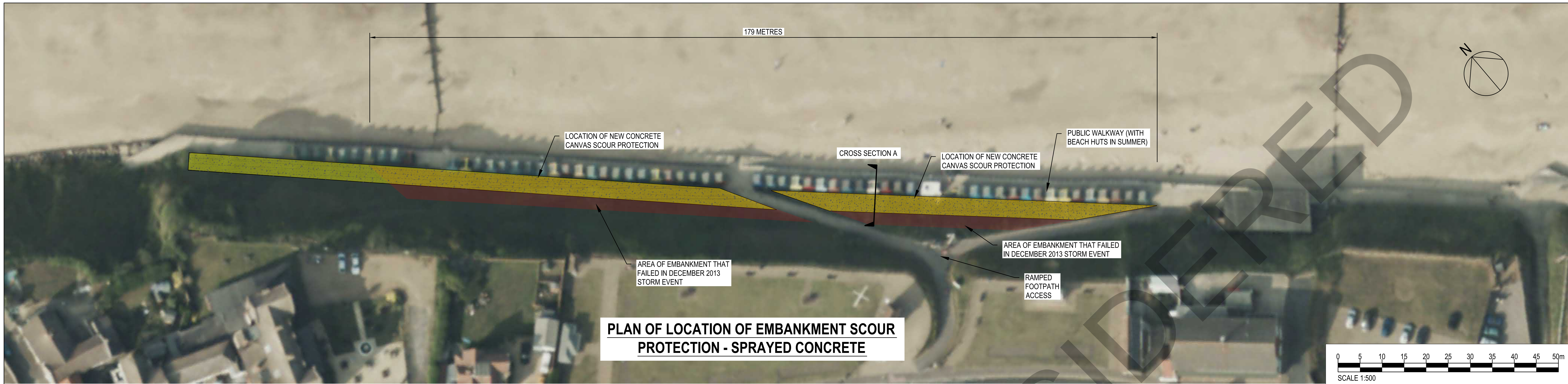
Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	**Zone**
1:50 / 1:500	-

AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
www.aecom.com

Drawing Number: MOBC-ACM-XX-00-DR-CE-01125
Rev: P2

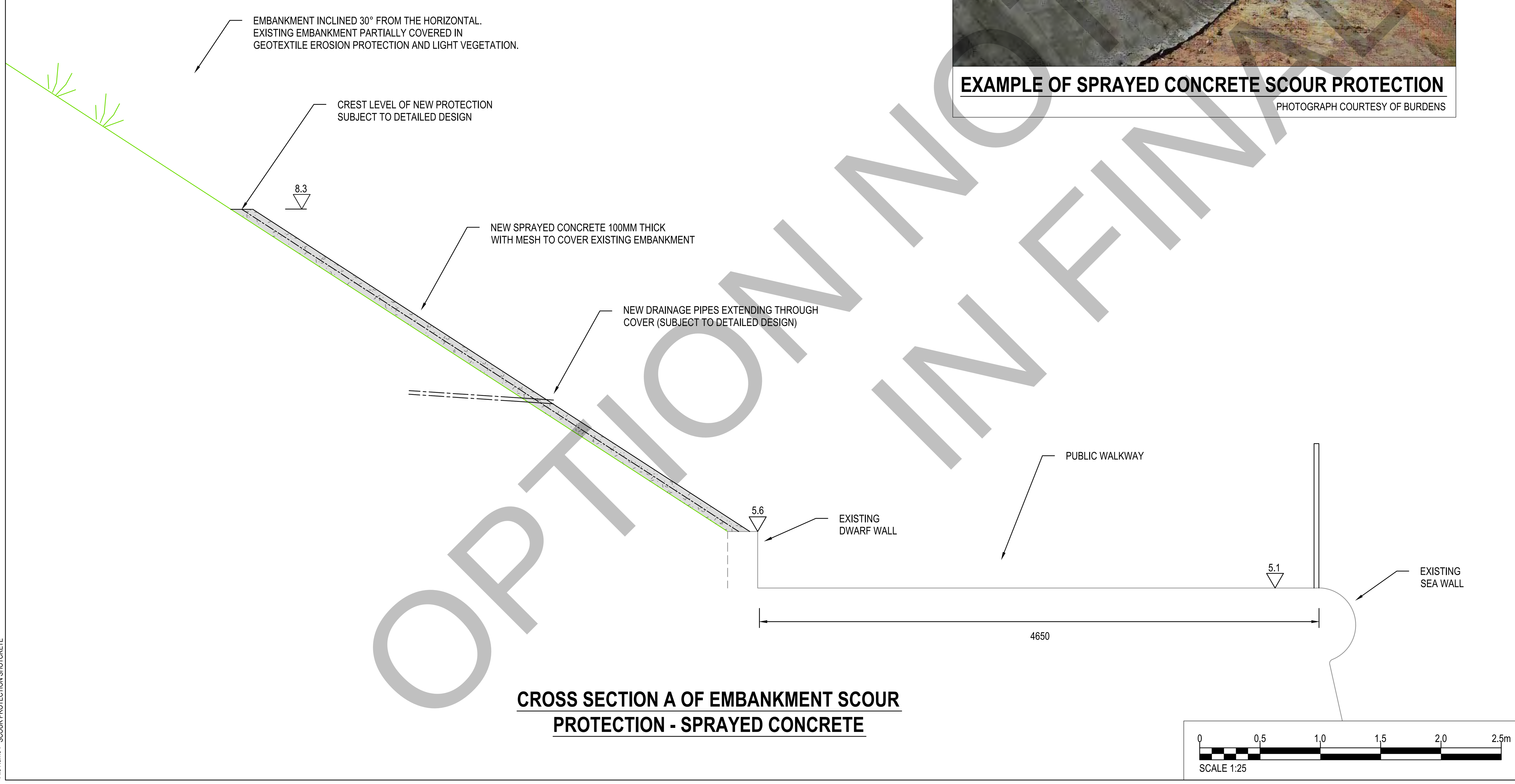
Plot Date : 5/11/2018 11:48 AM
File Name : SCOUR PROTECTION EROSION CONTROL MAT



PLAN OF LOCATION OF EMBANKMENT SCOUR PROTECTION - SPRAYED CONCRETE

EXAMPLE OF SPRAYED CONCRETE SCOUR PROTECTION

PHOTOGRAPH COURTESY OF BURDENS



CROSS SECTION A OF EMBANKMENT SCOUR PROTECTION - SPRAYED CONCRETE

PHOTOGRAPH OF EXISTING EMBANKMENT

(NOTE EXISTING GEOTEXTILE EROSION PROTECTION UNDERTAKEN IN 2014)

PHOTOGRAPH COURTESY OF NNDC, APRIL 2014

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5. DIMENSIONS/ARRANGEMENT OF NEW STRUCTURES ARE SUBJECT TO DETAILED DESIGN.

LEGEND

- AREA OF EMBANKMENT THAT FAILED DUE TO SCOUR IN DECEMBER 2013 STORM EVENT. REPAIRS UNDERTAKEN IN APRIL 2014.
- LOCATION OF NEW SCOUR PROTECTION (BASED ON DEFENDING AREAS THAT FAILED IN 2013 STORM EVENT).

AERIAL IMAGERY DATA (2013) COURTESY OF CHANNEL COASTAL OBSERVATORY

Revision Details	By / Check	Date	Suffix
LONGLIST ISSUE	BO / DG	21/04/17	P2
DRAFT ISSUE	BO / DG	23/03/17	P1

Purpose of issue

FOR OPTION APPRAISAL

Client

NORTH NORFOLK DISTRICT COUNCIL

Project Title

MUNDESLEY
OUTLINE BUSINESS CASE

Drawing Title

OPTION 12
EMBANKMENT SCOUR
PROTECTION - SPRAYED CONCRETE

Designed	Drawn	Checked	Approved	Date
GB	GB	DG	PN	23/03/17

AECOM Internal Project No.	Suitability
60519091	S2
Scale @ A1	Zone
1:50 / 1:500	-

AECOM Infrastructure & Environment UK Limited
Scott House
Alencon Link
Hampshire, RG21 7PP
Tel:+44 (0)1256 310 200
Fax:+44 (0)1256 310 201
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Drawing Number	Rev
MOBC-ACM-XX-00-DR-CE-01126	P2

Plot Date: 5/11/2018 11:51 AM
File Name: SCOUR PROTECTION SHOTCRETE

Appendix C – Economic Assessment Report

Please refer to the Economic Assessment Report appended to the OBC submission

Appendix D – Costing Report

Please refer to the Costing report appended to the OBC submission

Appendix E – Partnership Funding Calculator

Please refer to the Partnership Funding Calculator appended to the OBC submission

Appendix F – Shortlist Option Drawings

Please refer to the Shortlist Option Drawings appended to the OBC submission

Appendix G – Preferred Option Overview Plan

Please refer to the Preferred Option Overview Plan appended to the OBC submission

	Efficiency	Summary	Potential Value Estimation (indicative)	Timing of Realisation	Likelihood	Comment
	1. Controlling Project Scope					
	2. Reducing Future Maintenance					
2A	Timber groynes	Addition of rock protection around most vulnerable sections, reduced maintenance costs	-£13,538	Operation and Maintenance	High	Savings increase overtime
2B	Seawall	Addition of rock protection around most vulnerable sections, reduced maintenance costs	£72,308	Operation and Maintenance	High	Savings increase overtime
	3. Economies of Scale					
3A	Rock purchase	Bulk purchase of rock and saving for future use	£392,000	Operation and Maintenance	High	Savings increase overtime
	4. Innovation & Value Engineering					
4A	Steel framed structures - rock protection	Through placement of rock protection, the steel framed structures can be left in situ without posing an increased risk to public when they fail	£116,000	Operation and Maintenance	Med	
4B	Use of tropical timbers	Opting to use tropical timbers over locally sourced oak	£24,000	Construction	High	Savings in maintenanc costs
4C	Avoidance of detailed design for complex structures	Opting to use rock protection avoids need for detailed design of complex steel framed or timber structures	£35,000	Appraisal	High	Initial saving
	5. Packaging & Programming					
5A	Tendering process	Undertake a competitive tendering process with the aim of reducing overall project costs.	£35,000	Appraisal	High	Initial saving
5B	Tendering process	Utilising existing framework agreements reduces procurement costs	£35,000	Appraisal	High	Initial saving
5C	Tendering process	Utilising existing framework agreements, the scheme will benefit from cheaper rates and agreed terms and conditions previously negotiated	£70,000	Appraisal	High	Savings throughout project
	6. Contracting Approach					
	7. Streamlined Process					
	8. Operational Productivity					
8A	Land access	Local landowner allows use of beach access as a contribution	£35,000	Construction	High	Assumes 6 months construction
8B	Site compounds	Local landowner supplied land compounds as a contribution	£35,000	Construction	High	Assumes 6 months construction

Total £835,770.00

Project name	Mundesley OBC
Date last updated	07/03/2018
Version number	Rev 1

Information to help you assign scale of probability and impact based on threshold ranges set on Sheet 3 (Prioritisation)

Cost
£ 2,497,000.00

	Probability	Cost	Time	
H	51 to 70%	£250.7k to £374.55k	3 to 4 wks	374.55
L	11 to 30%	£63.425k to £124.85k	1 to 1 wks	124.85
M	31 to 50%	£125.85k to £249.7k	1 to 3 wks	249.7
VH	71 to 100%	£375.55k to £624.25k	4 to 7 wks	624.25
VL	0 to 10%	£0k to £62.425k	0 to 1 wks	62.425

Risk ID	Risk description		Response Action		Qualitative Ranking (After Response Action)						Assumptions in baseline cost	Scheme Max Cost impact (£m)	Scheme Risk Sum £m (cost x probability)	Scheme % item contribution of Total Risk Sum
	Source of risk	Consequence on project	Action / Mitigation	Action owner	Residual probability (%)	Probability scale	Cost impact	Time impact	Cost+time impact	Priority				
1	Variation in material prices (particularly rock & timber)	Variability in markets for major component of the material cost for the scheme	Optimism bias of 30% has been applied to all estimated costs. NNDC will seek to bulk purchase most materials with beneficial prices & store locally.	NNDC	30%	M	M	VL	M	M		0.25	0.07	11.8
2	Fluctuations in currency market (Value of £)	Variability in the value of the pound will impact on the cost of any imported materials for the scheme	Optimism bias, seek to bulk purchase with beneficial prices & store locally.	NNDC	30%	M	M	VL	M	M		0.25	0.07	11.8
3	Unforeseen specific technical issues (i.e. soft ground conditions) identified during detailed design leading to redesign of sections of work	Redesign leading to programme delays and increased costs	Designer's risk assessment to be undertaken during the detailed design process by suitably experienced personnel. Optimism Bias of 30% has also been applied to all cost estimates to cover all unforeseen risks. Detailed ground investigation following Eurocode standards prior to completion of detailed design.	NNDC	20%	L	H	M	H	M		0.37	0.07	11.8
4	Funding changes in delivery period due to multiple sources of contributions and third party funding either being delayed or not materialising.	Adds inflation to the scheme, risk of additional mob/demob costs	Early engagement with potential third party funders has been on-going and written funding commitments have been obtained from NNCD, Mundesley Parish Council and Anglian Water. Continued engagement will ensure that legal agreements are completed and the funding arrives in a timely manner. Possible re-profiling of contributions with updates on the scheme.	NNDC	20%	L	H	L	H	M		0.37	0.07	11.8
5	Funding shortfall due to overspends	Failure to complete the scheme due to lack of money	The scheme has been designed to be affordable, if unforeseen costs arise they will either be met by NNDC or the scope of works will be reduced, therefore works will be scheduled in order of priority.	NNDC	20%	L	H	L	H	M		0.37	0.07	11.8
6	Potential for damage to properties during construction	Vibration during works (particularly beach access) cause damage to nearby buildings	Condition survey of buildings prior to construction, monitoring during construction, avoiding potentially sensitive locations.	Contractor	10%	VL	L	L	L	L		0.12	0.01	2.0
7	Delays or objections in obtaining the required consents and approvals	Project delayed due to delays or objections in obtaining consents and approvals from the various approval authorities.	Early and on-going engagement with the relevant approval authorities will identify any potential issues early in the detailed design process. Adequate time will also be allowed in the programme to obtain all the required consents.	NNDC	20%	L	L	M	M	M		0.12	0.02	3.9
8	Change of landowners/uses along the frontage	Impact on design with additional cost & time requirements	Continued engagement throughout detailed design & construction to work with landowners/operators to identify potential changes as early as possible	NNDC	10%	VL	L	L	L	L		0.12	0.01	2.0
9	Unexploded Ordnance	Discovery of UXO during construction works	Detailed UXO search will be undertaken during the detailed design process, and if required potential mitigation measures such as watching brief or probing can be adopted during construction. In addition the construction programme will be designed to be flexible to minimise downtime on discovery of a UXO.	NNDC	20%	L	H	M	H	M		0.37	0.07	11.8
10	Changes in guidance or legislation	Changes in legislation could impact on mitigation required during construction	Major changes not foreseen, sensitivity analysis undertaken which demonstrates that the scheme is robust against a reasonable range of uncertainty	NNDC	30%	M	L	M	M	M		0.12	0.04	5.9
11	Unforeseen buried services	Discovery of buried services during construction works. Potential impact on cost and time	Desktop services search will be undertaken with latest service records. In addition, the construction programme will be designed to be flexible to minimise downtime on discovery of buried services.	NNDC	10%	VL	L	L	L	L		0.12	0.01	2.0
12	Poor weather or adverse sea levels, waves, currents and other climatic factors	Risk of programme delays due to periods of bad weather where construction is not possible	Construction will be designed to be flexible to minimise downtime due to inclement weather. Intertidal works planned for summer months.	NNDC	30%	M	M	M	M	M		0.25	0.07	11.8
13	Risk of contaminated land	Risk of either encountering, or creating environmental contamination and/or pollution during construction	Desktop contaminated land survey and mitigation measures will be incorporated into the design to limit potential impacts	NNDC	10%	VL	L	VL	L	L		0.12	0.01	2.0
14	Availability of rock	Key material not available causing delays to programme	Early engagement with a supplier, bulk purchasing power (and potentially an early purchase) will mitigate suply risks.	NNDC	20%	L	M	M	M	M		0.25	0.05	7.8
15	Deterioration of existing defences	Defences fail faster than expected changing the programme of works. The adaptive solution may have to be topped up with rocks sooner than expected	Works all commence early in the programme (Year 1) and continuous monitoring of the existing defences will take place	NNDC	20%	L	L	L	L	L		0.12	0.02	3.9
											Sum	£ 3.00	£ 0.64	100.0 All %

Safety In Design – Designers Health & Safety Audit Form

Project:	Mundesley OBC – Initial Designer's Risk Assessment								Distribution: North Norfolk District Council									
Job No:	60519091								Rev									
Client:	North Norfolk District Council								Date									
	Initial	Rev1	Rev2	Rev3	Rev4	Rev5	Rev6	Rev7	Rev8	Client								
Date	April 17	Oct 17	Jun18							Architect								
By	GB	GB	GB							M & E								
Checked	DG	DG	DG							CDM-C								
Approved	-	-	PN							QS								

Design Notes / Statement:

The preferred option outlined in the Mundesley OBC includes a combination of rock works, scour protection, timber groynes and seawall / apron refurbishments. It is assumed that all works will be undertaken by a competent contractor working to a method statement.

The following acronyms have been used to assign hazards to the various different parts of the preferred option;

- RW; rock works
- SP; scour protection
- TG; timber groynes
- SW; seawall and apron
- ALL; all defence works

(1)	(2)	(4)	(5)
Feature, element, process or work activity e.g., construction of retaining walls, installing dry risers, constructing manholes It is important to state the method of construction you have assumed [if relevant to the provision for safety - see column (4)]	**Significant hazards identified** Significant hazard = a hazard that is: 1. Not obvious to a competent contractor or other designers, or 2. Unusual, or 3. Difficult to manage	Where the hazard cannot be eliminated **Provisions designed in to make the residual hazards easier to manage** (thus reducing the risks from the hazard) At construction, operation, maintenance and decommission stages	**Consequence assessment of measures proposed** Analysis of consequences should include an assessment of: 1. Costs; 2. Whether safety depends on strict site control, e.g., PPE; 3. Whether proposal leads to creation of other more serious hazards;

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 1	Slips, trips and falls causing injury to public and site staff.	Working at the top of the beach where there is more shingle/ deposited material (Uneven beach) and various buried structures. (ALL).	Const.	Care to be taken while accessing locations required to undertake the works.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	Monitor	
			Maint.	As Construction and Maintenance	
			Decom.	As Construction and Maintenance	
		Working surface on top of the seawall can get wet leading to a greater slip potential. (SP, SW)	Const.	Care to be taken while accessing locations required to undertake the work.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	Monitor	
			Maint.	As Construction and Maintenance	
			Decom.	As Construction and Maintenance	
		Storage of materials on the promenade will limit space and increase the potential for slips, trips and falls. (SW, SP).	Const.	All materials to be stored until required in dedicated storage area and not kept on the promenade.	Safety depends on: Contractor implementing a plan with adequate site storage and suitable working procedures to be approved and adhered to.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 2	Construction vehicles and plant traveling through Mundesley town to site.	Vehicles and plant accessing the site and moving about on site. The site access to the beach is owned by and in close proximity to a small number of 3rd party properties. Potential to damage 3rd party property and injury the public (ALL)	Const.	Only use agreed access routes identified on drawings, with segregated pedestrian walkways wherever possible. Surveys of 3rd party properties will be required.	Safety depends on: Use appropriately trained banksman for all reversing within site compound and all access and egress to public roads. Ensure all plant operatives have the appropriate training / licence. Impose appropriate site speed limit. Keep landowners/occupiers informed of arrangements concerning traffic management. Clear and appropriate signage to warn of hazards.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
		Distance material has to travel to get to site (tropical hardwood), resulting in increased pollution (TG)	Const.	Only use agreed access routes identified on drawings.	Safety depends on: Use appropriately trained personnel for transport of material from source location and from UK port to Mundesley.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	N/A	
Item 3	Construction vehicles and plant moving around on site	Vehicles or plant causing injuring or death to personnel on site. (ALL)	Const.	Designed so a minimum amount of construction vehicles are required on site. Wherever possible pedestrian segregation will be adopted.	Safety depends on: Use appropriately trained banksman. Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 4	Materials travelling to site via sea	Site access via sea involves travelling and working on water. Serious hazards that can occur while on water may occur during storm conditions or during deposition of material on site. Risk of injury to public, workers or damage to properties and plant (RW).	Const.	Pre-planning of journey, monitoring of weather, tidal and sea-state conditions. Public/ pedestrian segregation on the beach.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	N/A	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 5	Transporting materials to site	Material falling out of a road vehicle and injuring or causing death of personal. Especially when traveling down steep access ramps (SP, TG, SW)	Const.	Pre-planning of journey, using the appropriate vehicle and having the specified amount of material in the vehicle.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 6	Working with hand tools	Personnel using hand tools on site for fixing of steel elements. Risk of injury if not operated correctly (SP, TG, SW)	Const.	Where possible breaking or compaction work to be undertaking using excavators/suitable mechanical equipment instead of handheld tools Use of hand tools in line with safety standards. Operation of hand tools by appropriately trained personnel only.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place Residual risk remains if handheld tools are used, but risks are reduced by selecting experienced, trained and competent contractors.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 7	Lifting of materials / equipment causing injury to site staff (manual handling)	Manual lifting of materials presents a risk of injury to site personnel. Heavy materials are to be lifted into place using lifting equipment and this process if incorrectly managed could cause injury to site staff (ALL).	Const.	Manual handling is designed out wherever possible and by using mechanical lifting aids where it is not possible to be avoided	Safety depends on: Contractor to implement a lifting plan, produced by a trained and competent person. All heavy materials/equipment to be lifted using suitable plant. Site personnel to be well clear of lifted materials/equipment at all times. Manual handling remains an inevitable activity, but risks are reduced by selecting experienced, trained and competent contractors.
			Operat.	N/A	
			Maint.	As Construction	

			Decom.	As Construction	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 8	Working at height.	Risk of falling from height when working on top of the sea wall and above excavations (SW, SP)	Const.	Ensure construction personnel are appropriately trained to work at height. Ensure working at height safety procedures are followed. Work from the base of the seawall where possible to limit working at height requirements.	Safety depends on: contractor to ensure a safe working method is established before work commences on site. Residual risk remains
			Operat.	Handrail will be installed as part of these works.	
			Maint.	As construction	
			Decom.	As construction	
Item 9	All the proposed works are on a public beach or promenade.	Risk that the public will enter the site causing injury or death. (ALL)	Const.	Site boundaries and fencing erected. Clear markings so public doesn't access the site when works are taking place or when site is not in use (i.e. overnight or weekends). Site boundary, vehicle and pedestrian access routes and compound areas to be included on detailed design drawings	Safety depends on: Site boundary to be clearly defined. Site fencing to be erected to prevent public gaining access to site, in conjunction with adequate warning signs and consider site security.
			Operat.	Monitor changes	
			Maint.	As Construction	
			Decom.	As Operation	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 10	Work with the existing structure such as encasing and doweling into the seawall and apron	Existing structures are old and there is a risk of movement / collapse during construction (SW)	Const.	Personnel to be aware of the potential risks of working around the existing structure. Condition of existing defences to be relied upon to be confirmed at detailed design. Undertake investigations to assess risk of existing defence collapse prior to construction. Halt works if unstable. Drawings incorporate details ordinance levels of the top of the seawall and apron	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place. Use appropriately trained banksman for moving or handling materials in proximity to existing structures. Ensure all plant operatives have the appropriate training / licence.
			Operat.	Monitor	
			Maint.	As Construction	
			Decom.	As Construction	
		Personnel working around rusted bolts and nails (TG). Risk of injury.	Const.	Designs account for the existing structure in drawings from historic drawings. Personnel to wear appropriate safety clothing to reduce risk of injury from existing structure.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	Monitor changes	
			Maint.	Assessment of original existing structure, as changes may be required.	
			Decom.	As Maintenance	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 11	Unstable cliff face	Digging/excavation of beach potentially leading to undermining of cliff (ALL). Vibrations during construction potentially increasing instability of cliff face (ALL).	Const.	Cliff stability to be considered in safe working plans and method statements and suitable mitigation / safety measures adhered to throughout construction. Regular cliff inspections to be undertaken prior to starting construction on the beach to determine cliff stability. Halt work immediately if cliff becomes unstable. Restricted area to be set up at cliff base for personnel, plant and vehicles to avoid getting too close to the cliff in case of failure (appropriate size of restricted area to be determined by contractor). Excavation following the slope of the cliff – detailed in the designs Extra care to be taken around the cliff at all times.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place. All site personnel to be made aware of danger of cliff instability and to follow the safety rules set out by the contractor in Method statements.
			Operat.	Monitor and restrict access accordingly	
			Maint.	As Construction	
			Decom.	As Construction	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 12	Working near water in a tidal environment with changing water levels and wave action. .	Risk of hypothermia and drowning and damage to plant and materials. Also potentially unfavourable conditions negatively impacting construction (ALL)	Const.	Wherever possible the design will limit the need to work in close proximity to water. Pre-planning of works so work is undertaken in consideration of the tide. Method statements to set out working near water safety procedures. Appropriate training for working near water for all site staff. Working near water safety procedures to be followed by all site staff.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place. All site personnel to be made aware of danger of working near water and to follow the safety rules set out by the contractor in Method statements. Residual risk remains
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 13	Excavations, ground conditions and buried services	Potential to excavate during construction. Potentially causing injury to site personnel, general public and monetary damages. Risk of collapse or striking buried services. Risk of excavations being infilled by high tides or surface water flooding (TG, SW)	Const.	Design to limit excavations into made ground wherever possible. All excavations to be designed with sufficient space to avoid steep slopes. Tidal and weather information will be provided All excavations should be infilled overnight and at weekends. Excavations will be limited - contractor to establish limits on length of open excavation appropriate to the ground conditions encountered, weather conditions and tidal changes. Further ground investigations to be undertaken at detailed design stage including a detailed service search.	Safety depends on: contractor to satisfy themselves that services are not in the area of works prior to commencement of works, consider use of cable avoidance tool. Safety depends on: contractor using suitable excavation / construction techniques for the ground conditions Safety depends on: appointment of competent contractor with experience of working with excavations. Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 14	Contamination and Pollution	Risk of either encountering, or creating environmental contamination and/or pollution during construction. There is a marine conservation zone located in the waterbody fronting the site (ALL).	Const.	Residual risk of spillage remains.	Safety depends on: site personnel aware of environmental risks. Regular maintenance and checks on all plant and machinery to ensure full working condition. Incorporate environmental management considerations into method statements.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
		Water runoff from concrete works (SW).	Const.	If possible collect water run-off and dispose of suitably to limit environmental impact	Safety depends on: site personnel aware of environmental risks. Regular maintenance and checks on all plant and machinery to ensure full working condition. Incorporate environmental management considerations into method statements.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 15	Steep slope surface	Concrete mattress to be placed on a steep slope so personnel working on the slope may slip or trip, fall or be crushed (SP).	Const.	Suitably trained personnel and safety equipment to be used. Personnel to not be present on slope when mattress is being lifted into position. Pedestrian segregation zone preventing personnel from standing beneath any object (i.e. materials / equipment) in case it falls.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place. Contractor to implement a plan for setting out the concrete mattress by a competent person. All heavy materials/equipment to be lifted using suitable plant. Site personnel to be well clear of lifted materials/equipment at all times. Residual risk remains.
			Operat.	N/A	
			Maint.	As construction	
			Decom.	As construction	

	Feature, element, process or work activity	Significant hazards identified	Provisions designed in to make the residual hazards easier to manage		Consequence assessment of measures proposed
Item 16	Site access	Access points for various defence works could be hazardous – i.e. for concrete mattress via the beach to get onto the promenade. (ALL).	Const.	Access points to site to be clearly marked and made safe for site personnel.	Safety depends on: Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As construction	
			Decom.	As construction	
Item 17	Unexploded Ordnance (UXO) strike causing explosion	Potential for explosion causing asset damage, injury or death to site workers and general public (ALL).	Const.	Undertake UXO desktop survey to confirm risk rating of areas from historic records Undertake site investigations with suitable UXO sensors (magnetometer) prior to construction Safe removal and disposal of UXO's prior to construction	Safety depends on: Undertaking suitable UXO surveys and investigations. Contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As construction	
			Decom.	As construction	
Item 18	Noise and vibration. Dust	Noise and vibration from construction activities risks to human and property receptors. Dust from construction works have the potential to act as a skin, eyes and respiratory irritant to site staff and public. In extreme circumstances, dust may lead to long term or even fatal illnesses / condition (ALL).	Const.	Works to be designed to limit noise and vibration wherever possible. Where unavoidable mitigation will be included. Where possible, dust creating activities will be removed or limited within the design.	Safety depends on: contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	
Item 19	Inclement weather	Risk of accident or injury increased due to bad weather (ALL).	Const.	Stop work during periods of bad weather which is increasing risk of incident	Safety depends on: contractor to establish suitable working procedures through Method Statements, to be approved prior to activity taking place.
			Operat.	N/A	
			Maint.	As Construction	
			Decom.	As Construction	