Hunstanton Promenade and Seawall Condition Assessment

Condition Assessment Report

Environment Agency and Borough Council of King's Lynn and West Norfolk

January 2013

Final Report V3

9W5729

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Enhancing Society Together

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Appendices (On CD)

1 INTRODUCTION

1.1 Purpose of the Study

Royal HaskoningDHV (RHDHV) has been commissioned by the Environment Agency (EA) and King's Lynn and West Norfolk Borough Council (the Council) to produce a condition assessment of the seawall and the promenade at Hunstanton (the Frontage).

The condition assessment aims to identify defects and potential instability in the promenade and seawall and to understand the causes of the existing problems; thus developing clear remediation proposals that address the source of the problem.

The Study included:

- Review of available data, including previous condition assessments;
- Development of a geotechnical desk study (**Appendix i**);
- Walkover inspection undertaken by the Council and a Senior Engineer from RHDHV;
- Detailed inspection of visible structural elements and defects;
- Intrusive Geotechnical Investigation;
- Review of beach survey information, including the EA Coastal Trends Analysis and assessment of beach profiles; and
- Assessment of the current condition and residual life of the frontage.

1.2 Report Overview

The report has been set out as follows:

- **Chapter 2** describes the background and historic information on the Hunstanton Frontage.
- **Chapters 3 and 4** describe the visual inspection, the geotechnical desk study and the intrusive investigations carried out specifically for this study, as well as describing the methodology used for assessment of structural condition, stability and residual life.
- **Chapters 5 and 6** set out the methodology for assessing the vulnerability of the Frontage to beach level change, and the assessment of residual life.
- **Chapters 7 to 13 set** out the assessed condition of the seven Frontage Sections A to G based on the described investigations and methods.
- **Chapter 14** schedules the works recommended within the next five years, together with outline estimates of costs.
- **Chapter 15** summarises the above.

References are given in Chapter 16 and a glossary of abbreviations used in the reports can be found in Chapter 17.

2 BACKGROUND

2.1 Location

Hunstanton is a seaside town along the west facing coast of the Wash in Norfolk, approximately 21km north east of the town of King's Lynn (Figure 2-1). The study area comprises of approximately 1.5 km of seawall and promenade (Figure 2-2) from the southern end at the Power Boat Ramp at National Grid Reference 566750, 340000 (Chainage 0) extending northwards to the end of the seawall where the coast is protected by cliffs at National Grid Reference 567900, 342400 (Chainage 1473). The promenade and seawall provide a defence against tidal flood to the low lying developed area.

Figure 2-1 Hunstanton Location Plan

Figure 2-2 Study Extent

The promenade is a prominent tourist and amenity area with an array of attractions; hence it is well trafficked by the public. A leisure centre, an Aquarium, a small funfair and numerous kiosks are amongst the businesses that can be found along the 10m wide promenade.

2.2 History of the frontage and the defences

The Council holds an archive of data and reports about the defences along the frontage, some of which extend back to 1924. The earliest flood defences in the frontage were built in 1885. The most recent seawall structures were constructed in 1958 following storms in 1949 and 1953. In the early 2000's re-facing works were undertaken to Sections B and C of the seawall (See Figure 3-1).

The Frontage defences were designed to a 50 year return period water level with a one year return period wave height.

Over the years a number of condition assessments of the Hunstanton frontage have taken place including:

- Condition Assessment and Ground Investigation conducted by Mott MacDonald, 1996 (Mott MacDonald Investigation, 1996);
- The seawall and groynes visual survey undertaken in spring 2005 (St La Haye Ltd 2005); and
- The seawall and groynes visual survey undertaken in spring 2008 (St La Haye Ltd 2008).

2.3 Coastal Setting

An extensive area of sandy beach fronts the seawall. Some shingle material is located at high water level. The area behind the southern and central section of the seawall is generally flat and low lying with a mixture of caravan parks, funfairs and various leisure facilities. The ground then begins to rise to the east where residential streets are to be found with ground levels in the region of 10-20mAOD. Behind the northern section of the seawall the ground rises more steeply towards the exposed chalk cliffs at Hunstanton. The cliffs are between 10m and 15m high. There are no watercourses flowing through Hunstanton, the nearest river of note being the Heacham River two kilometers to the south. Further details on the geological setting of the area are provided in **Appendix i**.

Tide levels and extreme water levels are detailed in Tables 1 and 2. Tidal currents can be relatively strong in The Wash, especially in the main channels, during spring tides. This is because of its large tidal range (EA & RHDHV, 2012).

Table 1 - Tidal Levels at Hunstanton (mAOD)

HAT	MHWS	MHWN	MSL	MLWN	MLWS	LAT
	3.65	1.85		-1.25	-2.85	
Tidal range (springs): 6.50m						
Tidal range (neaps): 3.10m						

Table 2 – Extreme Water Levels for Hunstanton (Royal Haskoning, 2007)

Return Period (mAOD)							
1:1	**1:10**	**1:25**	**1:50**	**1:100**	**1:200**	**1:500**	**1:1000**
4.73	5.24	5.45	5.60	5.76	5.91	6.11	6.27

The north easterly waves from the North Sea generate the largest waves. Waves can also be generated within the Wash during periods of high winds. Local, wind generated waves are smaller and more frequent (EA & RHDHV, 2012).

2.4 Flood and Erosion Risk

Hunstanton is a regionally important commercial centre and coastal resort. As the foreshore is mainly sandy, it also presents a significant amenity and recreational value, in addition to its habitat value. The frontage also contains a number of Listed Buildings and a Conservation Area that are both nationally and regionally important historic assets (Environment Agency and RHDHV, 2012).

Based on an assessment undertaken by the on-going Wash East Coastal Management Strategy, (Environment Agency and RHDHV, 2012), the assets at risk from erosion include:

- The shelter;
- The play area with the amusement fair;
- Kiosks associated with the promenade;
- Toilet facilities;
- Pier Entertainment Centre;
- Public Car Park;
- Waterside Bar, Beach Terrace Road;
- Band Stand; and
- War Memorial.

In addition to the cost of the physical loss of the coastal defence structures, the amenity value of the frontage, and indeed the town, would also be impacted on.

3 VISUAL INSPECTION

3.1 Approach

The detailed inspection of the frontage took place on 10th and 11th May 2012 under good visibility, average temperatures of 14-15^{o}C, overcast with sunny spells and low tides (approximately -3.00mAOD). The inspection was undertaken by a coastal engineer with the aim to record the following:

- Structural defects, including: cracking, intrusive vegetation, settlement and abrasion;
- Beach Levels relative to seawall;
- Drainage locations; and
- Photographs.

The inspections and subsequent records have used the reference system established by the 1996 Mott MacDonald inspection and used in the subsequent inspections of 2005 and 2008. The frontage is divided into seven sections (A to G) based on the different types of seawall with the Sections subdivided into panels, as illustrated in Figure 3-1 overleaf.

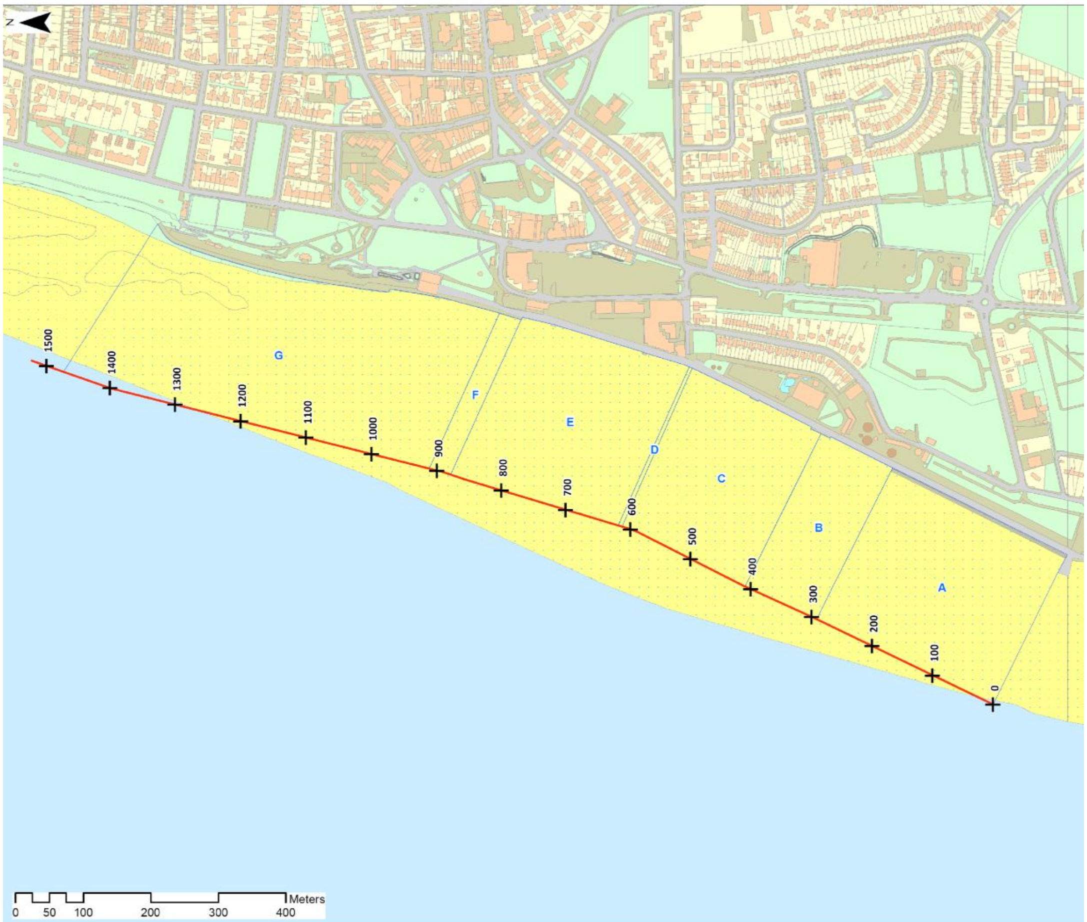

Figure 3-1 Hunstanton Frontage Chainage and Defence Sections

The sections generally comprise a seawall structure, a raised promenade and a rear wave wall. The sections and panels are distinctly separated by contraction and expansion joints. The length of seawall, promenade slab and rear wave wall panels varied in each section and did not always coincide. Table 3.1 below outlines the number of each panel type in each section.

Defence Section	Number of Panels		
	Seawall	Promenade Slab	Rear wave wall
A	68	68	68
B	33	20	20
C	60	34	34
D	1	1	1
E	46	46	46
F	4	4	4
G	92	118	118

Table 3-1 Seawall, promenade slab and rear wave wall panels

The defects and the condition of each individual panel were assessed and recorded in detail during the visual inspection. The full inspection records are contained in **Appendix ii**.

3.2 Establishing Visual Condition

The condition of each individual panel and that of the defence as a whole was established using the Environment Agency's Condition Assessment Manual 2009 (CAM 2009). This classifies the condition of structures (including those made of concrete) into 5 categories: very good, good, fair, poor and very poor; based on their general aspect, key features and specific description.

The use of CAM 2009 brings this condition assessment in-line with the national best practice. However, since the CAM 2009 does not make specific reference to the assessment of promenades, the category classification used by the Hunstanton Sea Defence Condition Survey 2005 and 2008 developed by St La Haye Limited was used, for the promenade only.

It should be noted, that for concrete seawalls, the 2005 and 2008 investigations also used CAM (or a previous version of it). Hence it can be confirmed that the visual condition methodology of this assessment is not only in-line with national guidance but it is also consistent with previous assessments of the frontage. Table 3-2 details the criteria for the visual condition assessment.

The overall condition of a particular section is determined by the condition of the majority of the panels within it. When there was relative balance of panels in different conditions a conservative approach was applied, in conjunction with sound engineering judgement.

Appendix ii presents the tables containing the detailed record of defects and condition of the individual panels within each section. A summary of the condition of the different sections within the frontage, as well as photographs and their geographical position has also been developed and is presented as **Appendix iii.**

Structure Condition	General	Key Features	Defects
Very Good	Cosmetic defects that will have no effect on performance.	No evidence of structure movement. No spalling or staining. Minor hair-line cracks or honeycombing may be present. No loss of backfill material, settlement or undermining, joints are in good condition, no sealant loss.	No significant defects. No maintenance required.
Good	Minor defects that will not reduce overall performance of the asset.	No evidence of structure movement. No slumping or heave of ground surrounding structure. Minor staining with localized spalling or appearance of small cracks. No settlement or undermining. Minor loss of backfill. Joints in good condition with minimal sealant loss.	Minor defects that can be solved by localised patching. Generally waterproof and safe for vehicles and pedestrians.

Structure Condition	General	Key Features	Defects
Fair	Defects that could reduce performance of the asset.	Minor slumping or heave of ground surrounding structure. Significant staining. Minor cracking or spalling with exposure of surface reinforcement. Minor loss of backfill. Localised undermining or settlement. Minor cracks or holes in joints due to sealant loss.	Significant defects that can only be solved by non-structural overlay. Loss of water proofing and potential hazard for vehicles and pedestrians.
Poor	Defects that would significantly reduce performance of the asset. Further investigation needed.	Minor movement of structure. Severe slumping or heave of ground surrounding structure. Minor settlement, undermining or loss of backfill material. Severe cracking or holes in joints. Severe cracking or spalling with localised areas of exposed main reinforcement.	Major defects that can only be solved with structure overlay / re-decking. Dangerous to vehicles and pedestrians. Temporary closure necessary.
Very Poor	Severe defects resulting in complete performance failure.	Evidence of severe structure movement. Severe settlement, undermining or loss of backfill material. Severe cracking or loss of concrete exposing extensive areas of main reinforcement.	Totally failed and requires reconstruction.

Table 3-2 Visual condition Assessment Categories (CAM, 2009 and St La Haye Limited, 2005)

4 INTRUSIVE GROUND INVESTIGATION

In order to determine the overall condition of the defences the visual inspection was supplemented by an intrusive ground investigation that took place on the 19th and 20th September 2012, during low tides. The intrusive investigation had the following aims:

1. To undertake further assessment of panels and sections where cracking and settlement of seawall and promenade were prominent (Sections A to E), with the aim to better understand the causes and significance of defects and uncover any hidden concerns; and
2. To provide a continuous record of the deterioration of the Frontage by investigating similar parameters at similar locations as the Mott MacDonald investigation, 1996.

Based on the visual assessment, no prominent settlement or cracks were noted in the promenade and the seawall of Sections F and G. Therefore, intrusive ground investigations were focussed on Sections A-E. The full report of the Intrusive Ground Investigation is provided as **Appendix iv**.

The intrusive ground investigation for this assessment included the extraction of concrete cores and excavation of trial pits. The concrete cores were extracted from both the promenade slab (vertical cores) and seawall (horizontal cores) to determine the concrete comprehensive strength, density, presence of voids, carbonation and grade of deterioration and settlement of underlying material. Table 4-1 presents the schedule of concrete cores. On site, the cores were taken from the same sections as specified but were not necessarily taken from the same panel. Two specified concrete cores were not taken due to them being in the same location as a new seawall, constructed in 1996. On extraction of concrete cores a video camera investigation into the exploratory holes also took place, to acquire any further evidence of settlement and deterioration within the promenade and seawall.

The trial pits were excavated in front of the seawall to expose cracks, erosion or any other signs of deterioration extending below beach level, and to confirm the depth of cover to the seawall foundation. Trial pits aimed to be taken in a similar panel location to the concrete cores. Table 4-2 presents the schedule of excavated trial pits.

Nr	Location		Quantity	Element	Orientation	Diameter (mm)	App. Depth (m)
	Section	Panel					
CC 01	A	47	1	Promenade	Vertical	100	
CC 02	A	47	1	Seawall	Horizontal	100	0.5
CC 03	Not extracted.						
CC 04	B	7	1	Promenade	Vertical	100	0.5
CC 05	Not extracted.						
CC 06	C	14	1	Promenade	Vertical	100	0.5
CC07	E	18	1	Promenade	Vertical	100	0.5
CC08	E	35	1	Promenade	Vertical	100	0.5
CC09	E	46	1	Promenade	Vertical	100	0.5

Table 4-1 Schedule of extracted concrete cores

Nr	Location		Quantity	App. Width (m)	App. Depth (m) below beach
	Section	Panel			
TP1	A	45	1	0.45	1.24
TP2	B	7	1	0.45	0.90
TP3	C	7	1	0.45	0.90
TP4	E	18	1	0.45	1.40
TP5	E	29	1	0.45	0.65

Table 4-2 Schedule of excavated trial pits

Figure 4-1 below illustrates the location of the excavated concrete cores and trial pits.

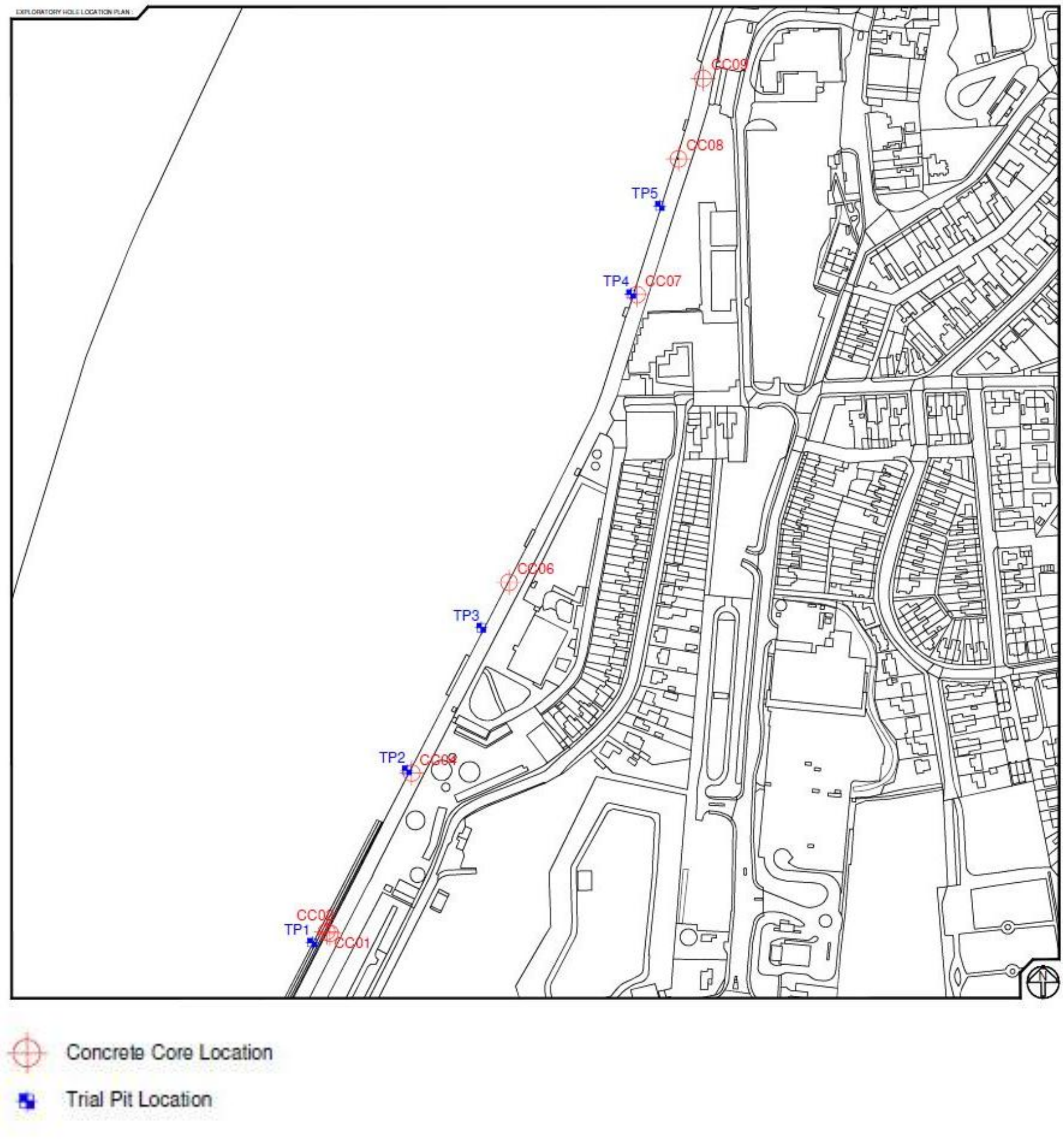

Figure 4-1 Location of Concrete Cores and Trial Pits

4.1 General Findings

The results give a good indication of the overall condition of the panels. Direct comparison with the 1996 Mott MacDonald investigation could not be undertaken due to the slightly differing core locations of the present investigation. However, the locations were generally the same to enable an overview of change to be derived.

Overall, it was found that the thickness of the concrete and the fill material type varied considerably along the length of the survey area. No significant defects were found at any of the survey locations. Sections 7-11, which detail the condition assessment for each area A-E, provides further information and interpretation of the intrusive ground investigation results, in the context of the overall condition of the sections.

5 BEACH LEVEL ASSESSMENT

5.1 Coastal Trend Analysis

The Shoreline Monitoring Group, as part of the Anglian Coastal Monitoring Programme has been undertaking annual beach topographic surveys since 1991. Profiles are surveyed at every kilometre and in The Wash they extend from Gibraltar Point to Old Hunstanton Figure 5-1. The monitoring profile relevant to the frontage is N1D1 which is located in Section A (See Figure 5-2, below).

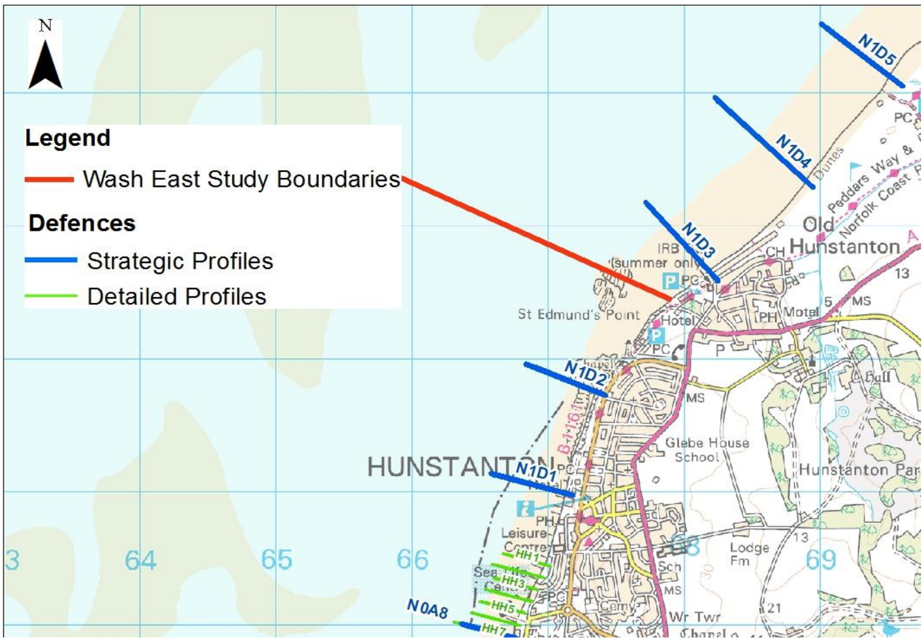

Figure 5-1 Anglian Region Monitoring Programme beach profiles

The N1D1 beach profile data from 1991 to 2006, presented in the Coastal Trends Analysis (EA, 2007), has been assessed for this condition assessment. Figure 5-2 presents a summary figure for this profile. Horizontal erosion trends of around 1.5myr^{-1} are shown on the upper foreshore, with horizontal accretion at approximately mean sea level. This indicates a trend of profile flattening. Conversely, the lower sand and mud flat show a strong vertical accretion of approximately 0.4myr^{-1} over this time period.

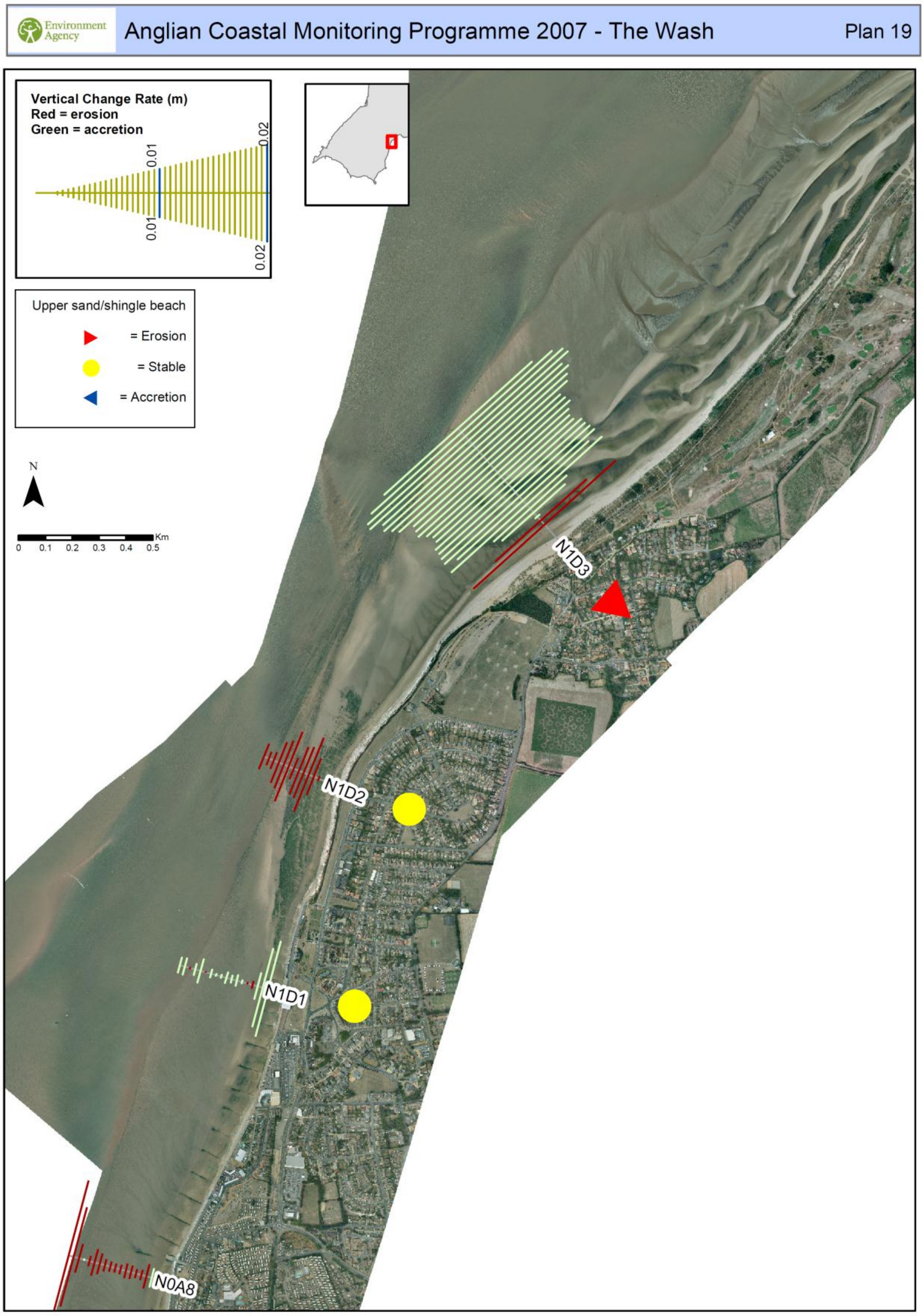

Figure 5-2 Coastal trend analysis of profile N1D1

5.2 Defence Toe Assessment

For the performance and residual life of the defence the most important beach level parameter is the beach level at the toe of the structure. This level affects the stability of the seawall and determines the degree of toe undermining. Analysis of beach levels in front of the seawall was undertaken and shows that beach levels directly in front of the seawall vary. Between January 1992 and May 2011 beach levels varied from approximately 3.5 to 3.75mODN at their highest down to approximately 2.25mODN at their lowest, giving rise to a variation in beach levels of up to 1.5 metres (Figure 5-3). This change has occurred over a 2 to 2.5 year timescale. The value of 5.59mODN, seen in 1995 is extremely high and would indicate that the beach levels were high enough to almost reach the crest of the defences at section A-E. Since there are no records of such conditions this value can be excluded from the analysis. The largest variations in any one year, around 1m, can be observed in 1996, 2002 and 2008. This overall variability indicates that the beach has a relatively high response to the wave environment, but the overall trend is one of no movement.

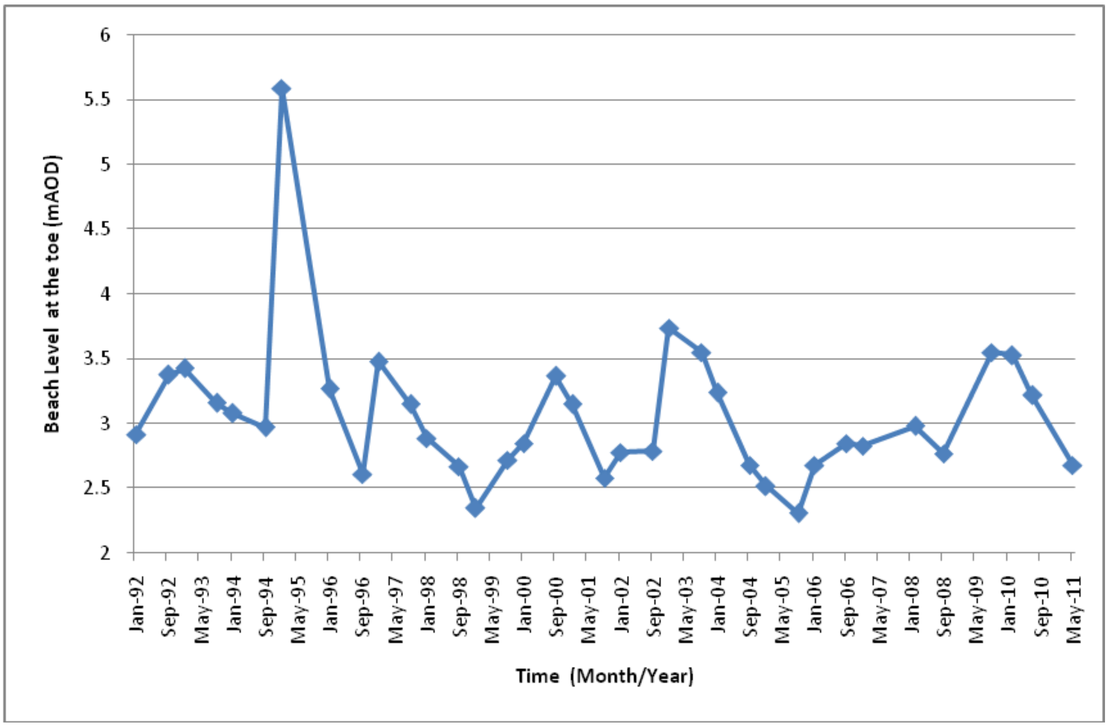

Figure 5-3 Beach variability at the toe of the defence, profile N1D1

5.3 Critical Beach Levels

In Chapters 7 to 13 a critical beach level has been identified for each defence section, taking into consideration its toe foundation level. The beach level assessment carried out in this Chapter has been used to establish the vulnerability of the defences in relation to their critical beach level.

6 RESIDUAL LIFE ASSESSMENT

The following factors have been considered in determining the residual life of the Frontage:

- **Age –** the defences were first constructed in 1958, with some re-facing of the seawall in sections B and C in recent years (between 1996 and 2005).
- **Visual condition –** the visual condition helps identify the degree of deterioration that the frontage has incurred through its life span. Its remaining residual life is largely dependent on its current condition. As discussed in Chapter **3**, the visual condition has been classified into five condition grade categories ranging from very good to very poor.
- **Deterioration curves** –EA developed guidance (2009) on the assessment of the residual life of seawalls for different condition grades. This guidance has been used, and Table 6-1, which is an extract from the EA guidance, sets out the estimated time (years) for concrete vertical walls to deteriorate to the relevant condition grade. Three rates of deterioration are given, and the effects of regular maintenance are also included.

Time to progress to next Condition Grade (years)		Best Estimate					Fastest Estimate					Slowest Estimate				
Condition grades		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Concrete Vertical Sea Wall	Not Maintained	0	10	30	60	75	0	5	15	25	30	0	20	60	120	150
	Maintained	0	10	30	65	80	0	5	15	30	35	0	20	60	120	150

Table 6-1 Deterioration time (years) for different condition grades, for concrete vertical walls in the coastal environment
1 – Very Good, 2- Good, 3 – Fair, 4 – Poor and 5 – Very Poor

A residual life range based on the Best and Fastest rates of deterioration been used. The slow rate is not considered appropriate for the Hunstanton frontage, given that the defences have required refurbishment to sustain them since they were first constructed just over 50 years ago. Accordingly, a maintained concrete seawall is considered to have a life to failure of between 35 (fastest) and 80 (best) years. Where the current structure condition has been assessed as grade 3, then the current residual life will therefore be between 20 (fastest) and 50 (best) years.

- **Engineering judgement.**

  Following attribution of this preliminary residual life range, other information such as critical beach levels, stability and engineering judgement have been used to determine the residual life range. The residual life of each defence section is presented in Chapters 7 – 13.

7 SECTION A ASSESSMENT

7.1 Cross-section Description

Section A extends for approximately 292m, from Chainage 0 to Chainage 292. The structure in this section consists of a reinforced concrete stepped apron with a steel sheet pile downstand, a reinforced concrete promenade slab and a recurve wave wall to the rear (Figure 7-1). The underlying foundation material is chalk fill (Mott MacDonald, 1996). At the time of the inspection the beach level was relatively high with nine steps exposed (level). The seawall, promenade slab and recurve wave wall panels were 4.25m long.

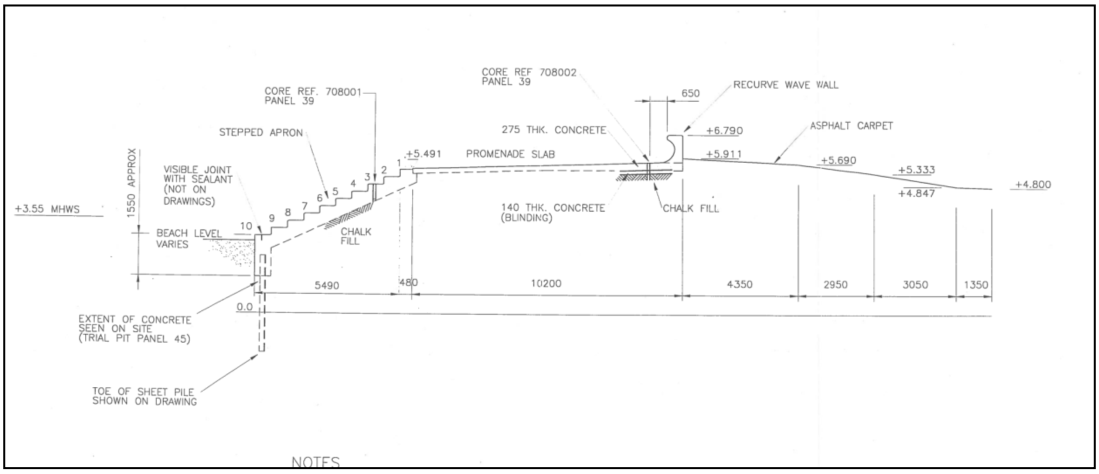

Figure 7-1 Section A cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all level are in metres relative to Ordnance Datum.

7.2 Visual Inspection

7.2.1 Seawall – Stepped Apron

The stepped apron is overall in fair condition with only 3% of panels rated as poor condition. Panel 68, the last Section A panel, had a 3m crack exceeding 5mm width (Figure 7-2). Repairs to the crack are required to avoid further widening and subsequent loss of material as well as saline intrusion into the chalk fill foundation material. Other defects observed include widespread concrete abrasion and some sealant loss.

Figure 7-2 Significant crack across the seawall panel 68 of the Section A

7.2.2 Promenade Slab

The promenade slab is in fair condition (84% of panels) with some 10% of panels in good condition as well as 3% of panels in very good condition and 3% of panels in poor condition. The most considerable areas of settlement extend from panels 33 to 42 (approximately 40m length) with a maximum settlement of 40mm of the promenade in relation to the seawall (Figure 7-3). Overall the defects observed were concrete abrasion, some sealant loss and concrete spalling. Sealant replacement and concrete patching of areas with abrasion is recommended.

Figure 7-3 Panel 64 cracking and sealant loss (left) and 40mm settlement (right)

7.2.3 Rear Wave Wall

The recurve wave wall is in very good condition (87% of panels) with some 13% of panels in good condition. Hair-line vertical cracks and some localised patch repairs were observed. The Mott MacDonald investigation (1996) concluded that such hair-line cracks were the result of thermal shrinkage, did not affect the main strength of the recurve wave wall and therefore were not serious. The visual inspection found no evidence to indicate that there has been a significant deterioration of these cracks.

Three panels (64, 65 and 66) have suffered some sealant loss and a horizontal crack along the crest of the recurve can be observed. Replacement of lost sealant is recommended as well as the continued monitoring of the cracks.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this section.

7.3 Intrusive Ground Investigation

7.3.1 Concrete Cores

Concrete cores CC01 and CC02 were taken through Section A, from the seawall and promenade, respectively. The findings are summarised in Table 7-1.

Ref	Structure	Orientation	Concrete depth	Fill	Compressive Strength	Void	Notes
CC01	Promenade	Vertical	160mm 100mm	Chalk	$39.0N/mm^2$	None	Two slabs of concrete present.
CC02	Seawall	Horizontal	600mm	Chalk	$33.0N/mm^2$	None	N/A

Table 7-1: Section A concrete core results

7.3.2 Trial Pit

A cross section of the trial pit TP1 is shown in Figure 7-4.

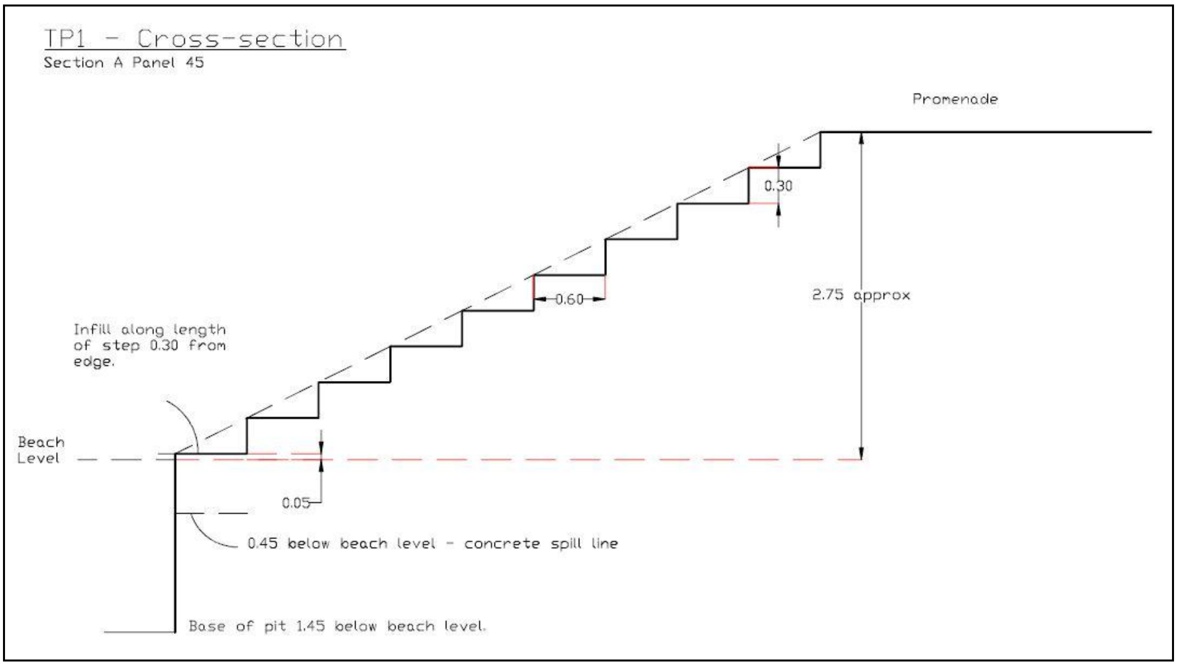

Figure 7-4: Trial Pit Cross Section

The trial pit was excavated to 1.45m below beach level. A possible hard surface was found at this location, but was partially obscured by pit side collapse. It is possible that the seawall might extend to deeper than this, but this was not verified. No defects were visible below beach level.

7.3.3 Overview

Overall, the seawall and promenade in this area are in good condition. The overall strength of the concrete is good. No voids were observed in this location, reducing the potential for settlement in the future. The two slabs of concrete forming the promenade will increase the overall strength of the structure.

7.4 Beach Levels

The concrete stepped apron toe is set at +1.4mAOD and the defence sheet pile toe is set at -1.5mAOD. If the beach levels were to drop to +1.4mAOD the toe of the concrete stepped apron would become exposed and there would also be an unsafe drop for pedestrians from the stepped apron onto the beach (approximately 1.60m). Toe undermining is a major cause of defence failure (Environment Agency, May 2009).

In addition, exposure of the vertical piles is likely to accelerate erosion in the area immediately adjacent to the piles. Once scour starts taking place the steel pile toe would become exposed and start to degrade. At -1.5mAOD it is expected that the defence will lose stability, due to lack of beach material in front of the structure which stops it from sliding. At this point the probability of overturning and collapsing, due to loss of foundation material, is also high. The rate at which these failure mechanisms may take place cannot herewith be predicted.

Based on the discussion above, **+1.4mAOD is the critical trigger level**. If the beach regularly reaches this level (i.e. if it is seen in two to three records over five years) monitoring of the condition of the toe and its degradation is required to establish if remedial works or reinforcement is necessary. Furthermore, if beach levels records regularly fall below +1.4mAOD it would mean that the sheet pile toe is becoming exposed regularly, therefore, monitoring its condition is necessary to establish if intervention is required.

As discussed in Chapter 5 the beach levels vary approximately +/-1.5m over a 2.5 years cycle covering five beach level surveys (including summer and winter profiles). Hence a level observed on two to three survey records over five years can be considered a regular occurrence.

7.5 Residual Life Assessment

The overall residual life and condition of the frontage is dependent on the condition of the seawall, the potential for settlement or movement based on ground condition, deterioration due to ageing, beach levels and associated potential for failure.

The intrusive investigation revealed the absence of significant vertical or horizontal voids, hence very little potential of movement through settlement or rotation. The concrete strength is generally good. Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, and therefore no significant risk failure due to beach lowering and toe exposure. At +2.31mAOD, the lowest beach level on record is well above the critical beach level +1.5mAOD. The seawall is generally in fair condition.

Based on the structure deterioration and critical beach levels, a residual life of **30 to 50 years** can be attributed (see Chapter 6), provided that maintenance works to the frontage continue and the beach levels remain stable.

7.6 Recommended Works

The recommended works for defence Section A are as follows:

- Local beach monitoring;
- Sealant replacement; and
- Patch repair at cracks and significantly abraded panels.

Chapter 14 presents the details and costs of recommended remedial works.

8 SECTION B ASSESSMENT

8.1 Cross-section Description

Section B extends for approximately 117m, from Chainage 292 to Chainage 409. The structure at this section consists of a concrete seawall which has been refaced recently (around 2000) with a new smooth finish concrete skin over the previous mass concrete wall. It is not known if the new concrete face has any reinforcement. The promenade slab is lightly reinforced and the recurve wave wall placed at the rear. Sand fill is the foundation material (Figure 8-1).

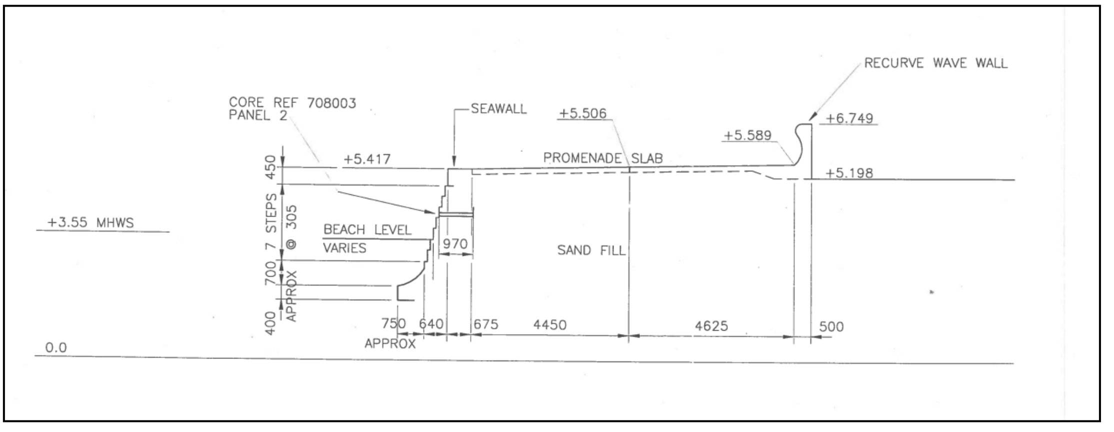

Figure 8-1 Section B cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all levels are in metres relative to Ordnance Datum. Re-facing works conducted in 2000 not included

8.2 Visual Inspection

8.2.1 Seawall

The seawall is in very good condition (79% of panels). 15% of panels are in good condition, 3% of panels in fair condition and 3% of panels are in poor condition. In Panel 1, a horizontal 2.7m long crack with a width smaller than 5mm was found below an outfall pipe and spanning between vertical joints. There was some indication of forward rotation of the top part of the seawall panel and the crack has now spread to the adjacent panel (Figure 8-2). This crack has propagated since the 2008 condition survey.

 

Figure 8-2 Section B, large crack observed in panel 1

8.2.2 Promenade slab

The promenade slab is generally in fair condition (70% of panels) with some 20% of panels in good condition. 5% of panels are in very good condition with just 5% in poor condition. Panel 4 is in poor condition hence localised patch repairs are required. Some of the defects observed on the slabs include concrete abrasion, sealant loss and spalling spots.

8.2.3 Recurve wave wall

The recurve wave wall is in very good condition (70% of panels). 25% of panels are in good condition and 5% of panels are in fair condition. There are no panels in poor condition. No immediate repairs or maintenance activities are recommended.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this Section.

8.3 Intrusive Ground Investigation

8.3.1 Concrete Cores

It was decided that location CC03 should not be sampled due to the construction of a new seawall in 1996. CC04 was a vertical core through the promenade concrete slab. The findings are summarised in Table 8-1.

Ref	Structure	Orientation	Concrete depth	Fill	Compressive Strength	Void	Notes
CC03	Not surveyed						
CC04	Promenade	vertical	169mm over another slab (unknown thickness)	Sandy gravel (30mm)	37.5N/mm^2	None	Fill sandwiched between two slabs.

Table 8-1: Section B concrete core results

8.3.2 Trial Pit

A cross section of the trial pit TP2 is shown in Figure 8-3.

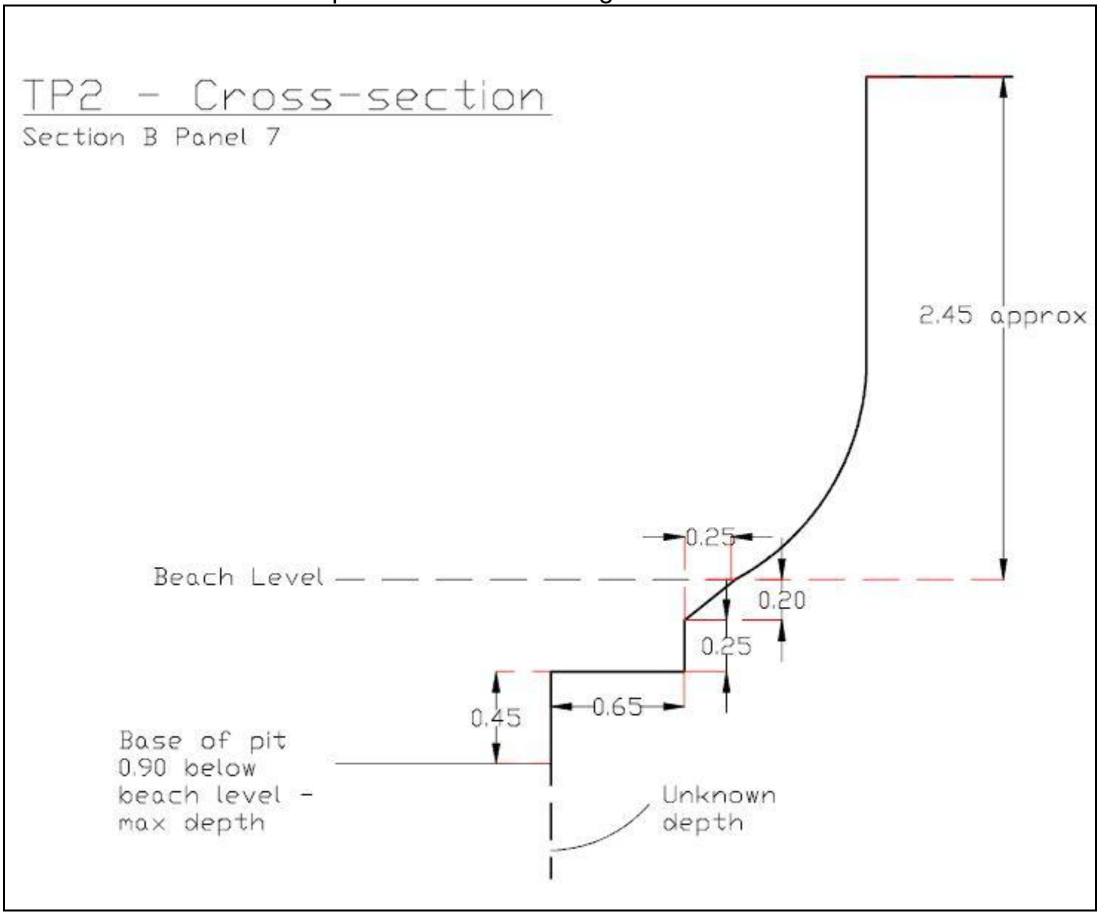

Figure 8-3: Trial pit TP2 cross section

The trial pit was excavated to 0.90m below beach level, in front of Panel 7. This was the maximum depth. Water ingress occurred from 0.45m. The seawall toe foundation depth was unknown. No defects were visible below beach level and the seawall was in reasonable condition.

8.3.3 Overview

Overall the intrusive ground investigations showed that the seawall and promenade is in good condition. The promenade concrete slab is 170mm thick and is overlaid on another concrete slab of unknown thickness. This will increase the strength of the promenade. At 37.5N/mm^2 the concrete is of sufficient strength. No voids were present which reduces the potential for settlement in the future. The depth of the toe in relation to beach levels was unknown. The area of cracking in Panel 1 and the apparent rotation of the upper part of the seawall should be monitored to detect any deterioration.

8.4 Beach Levels

As previously discussed in the section, works have been undertaken post 1996 and the new toe of the concrete wall is set at +2.20mAOD. However the old toe was set at approximately +1.70mOAD and the old foundations also contribute towards the stability of the structure against beach levels. If the beach levels were to drop to +1.70mAOD the toe would become undermined due to scouring. It is expected that the defence would start to lose stability, due to the lack of beach material in front of the structure which currently stops it from sliding. At this point the probability of overturning and collapsing, due to loss of foundation material, also becomes higher. The rate at which these failure mechanisms may take place cannot herewith be predicted.

Based on the discussion above, **+1.70mAOD is the critical trigger level.** If the beach regularly falls below this level (i.e. if it is seen in two to three records over five years) monitoring of the condition of the toe and its degradation is required to establish if remedial works or reinforcement are necessary.

8.5 Residual Life and Condition Assessment

The intrusive investigation revealed the absence of significant voids (vertical or horizontal) hence very little potential of movement through settlement or rotation. The concrete strength is generally good. Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD is well above the critical beach level +1.70mAOD. The seawall is generally in very good condition.

Based on its very good condition and critical beach levels, a residual life of **30 to 50 years** can be attributed (see Chapter 6), provided that maintenance works to the frontage continues and the beach levels remain stable.

8.6 Recommended Works

The recommended works for defence Section B are as follows:

- Local beach monitoring;
- Seawall sealant replacement;
- Promenade patch repair at cracks and significantly abraded panels; and
- Monitor crack in Panel 1.

Chapter 14 presents the details and costs of recommended remedial works.

9 **SECTION C ASSESSMENT**

9.1 Cross-section Description

Section C extends for approximately 204m, from Chainage 409 to Chainage 613. The structure at this section consists of a concrete seawall which has been refaced recently (around 2000) with a new smooth finish concrete skin over the previous mass concrete wall. It is not known if the new face was reinforced. The promenade slab is lightly reinforced and the recurve wave wall placed at the rear over a sandy clay foundation material (Figure 9-1).

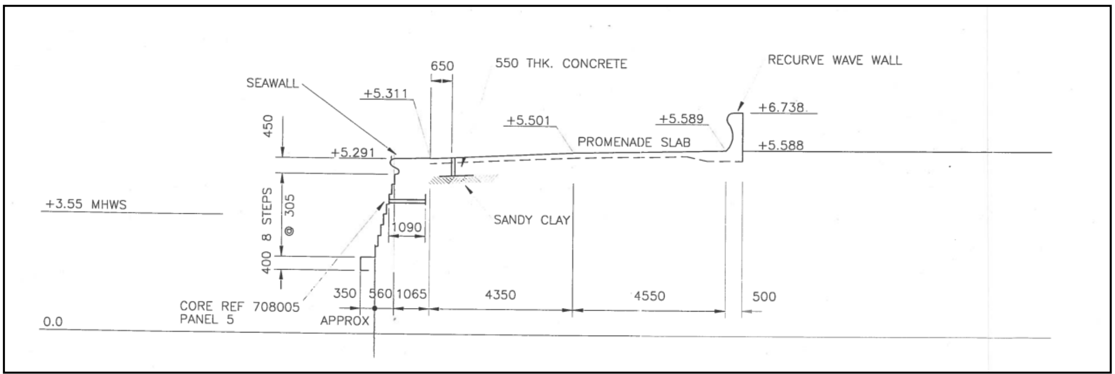

Figure 9-1 Section C cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all levels are in metres relative to Ordnance Datum. Re-facing works conducted in 2000 not included

9.2 Visual Inspection

9.2.1 Seawall

The newly refaced seawall is in very good condition (76% of panels). Some 22% of panels are in good condition and 2% of panels are in fair condition. Minimal concrete abrasion and some hair-line cracking were observed in 24% of panels.

9.2.2 Promenade slab

The promenade slab is generally in fair condition (64% of panels). Some 36% of the panels are in good condition. Defects observed include concrete spalling, sealant loss, cracking and settlement. Areas for which previous patch repairs have taken place were also observed (Figure 9-2). Sealant replacement and patch repairs of cracks are recommended.

Figure 9-2 Promenade slab with heavy patch repairs

9.2.3 Recurve wave wall

The recurve wave wall is generally in good condition. 50% of panels are in very good condition. However, 44% of panels are in good condition and 6% of panels are in fair condition. There were no panels in poor condition. Hair-line cracking was widely observed. No immediate repairs or maintenance activities are recommended.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this section.

9.3 Intrusive Ground Investigation

9.3.1 Concrete Core

It was decided that location CC05 should not be sampled due to the construction of a new seawall in 1996. CC06 was a vertical core through the promenade concrete slab. The findings are summarised in Table 9-1.

Ref.	Structure	Orientation	Concrete depth	Fill	Compressive Strength	Void	Notes
CC05	Not surveyed						
CC06	Promenade	Vertical	700mm	Sandy clay	34.0N/mm^2	None	Newer concrete. Surface of slab subsided ~20mm

Table 9-1: Section C concrete core results

9.3.2 Trial Pit

A cross section of TP3 is shown in Figure 9-3.

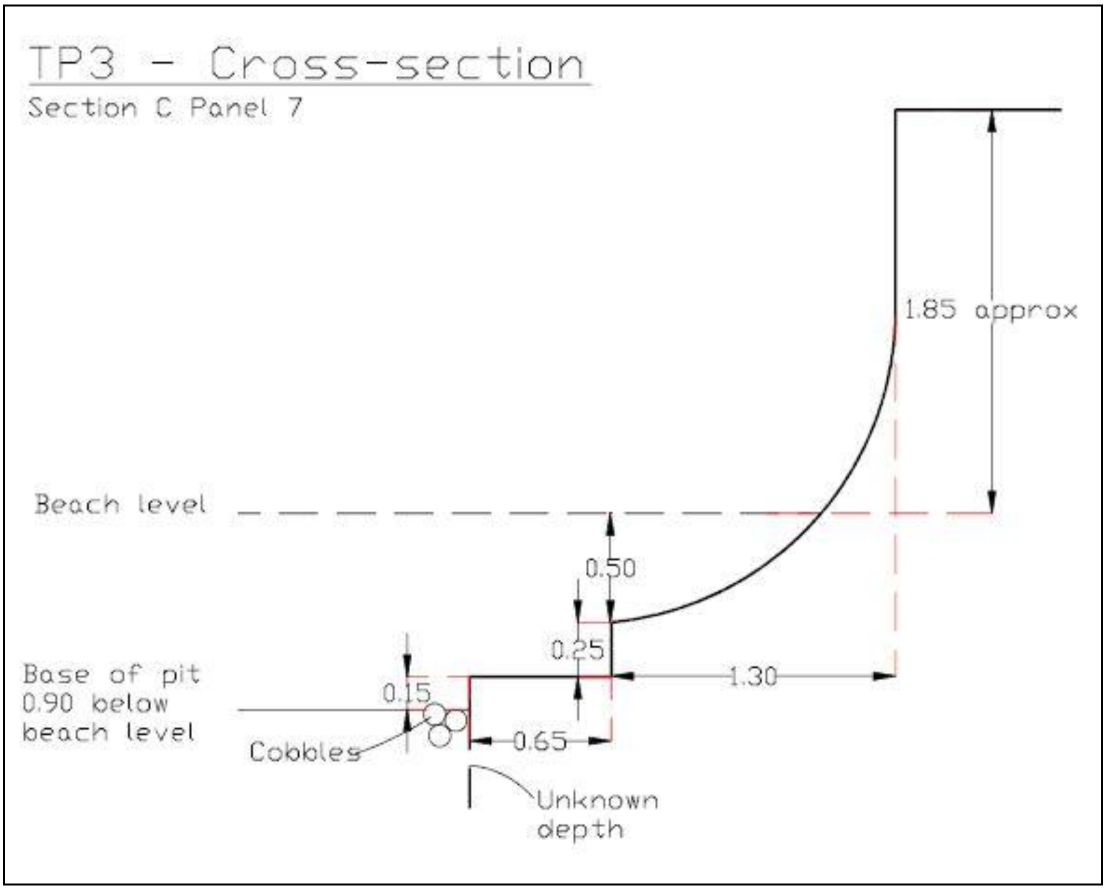

Figure 9-3: Section C Panel 7 trial pit cross section

The trial pit was excavated to 0.90m below beach level, in front of Panel 7. Water ingress occurred from 0.60m. The seawall toe foundation depth was unknown. Cobbles of dimensions 80mm x 100mm x 100mm were present at the base of the pit. No defects were visible below beach level and the seawall was in reasonable condition.

9.3.3 Overview

Overall the intrusive ground investigations showed that the seawall and promenade is in good condition. At 700mm the promenade concrete slab is of a significant thickness. 20mm settlement was noted although it was not clear if this was as a result of poorly compacted fill beneath. The condition of the slab is fair overall. The compressive strength of the concrete is sufficient at 34.0N/m2. No voids were present which reduces the potential for settlement in the future. The depth of the toe in relation to beach levels was unknown following excavation of the trial pit.

9.4 Beach Levels

As previously discussed, in the section works have been undertaken post 1996 and the new toe of the concrete wall is set at +2.20mAOD. However the old toe was set at approximately +1.80mOAD and the old foundations also contribute towards the stability of the structure against beach levels. If the beach levels were to drop to +1.80mAOD the toe would become undermined due to scouring. It is expected that the defence would start to lose stability due to the lack of beach material in front of the structure which currently stops it from sliding. At this point the probability of overturning and collapsing, due to loss of foundation material, becomes higher. The rate at which these failure mechanisms may take place cannot herewith be predicted.

Based on the discussion above, **+1.80mAOD is the critical trigger level**. If the beach regularly falls below this level (i.e. if it is seen in two to three records over five years) monitoring of the condition of the toe and its degradation is required to establish if remedial works or reinforcement are necessary.

9.5 Residual Life and Condition Assessment

The intrusive investigation revealed the absence of significant vertical or horizontal voids and therefore very little potential of movement through settlement or rotation. The concrete strength is generally good. Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk of failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD is well above the critical beach level +1.80mAOD. The seawall is generally in very good condition.

Based on its very good condition and critical beach levels, a residual life of **30 to 50 years** can be attributed (see Section 6), provided that maintenance works to the frontage continues and the beach levels remain stable.

9.6 Recommended Works

The recommended works for section C are as follows:

- Local beach monitoring;
- Seawall sealant replacement; and
- Promenade patch repair at cracks.

Chapter 14 presents the details and costs of recommended remedial works.

10 SECTION D ASSESSMENT

10.1 Cross-section Description

Section D extends for approximately 6m from Chainage 613 to Chainage 619. The structure at this section consists of a concrete promenade slab to the rear of the existing seawall (Figure 10-1).

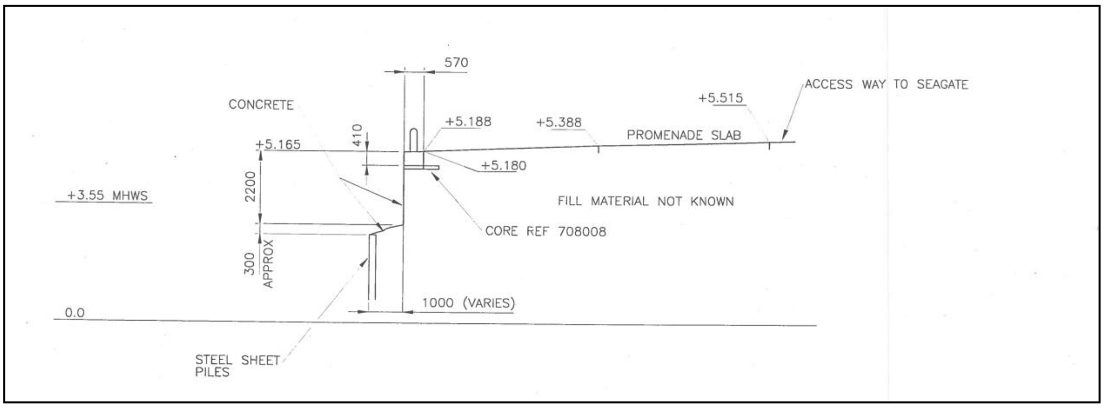

Figure 10-1 Section D cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all level are in metres relative to Ordnance Datum.

10.2 Visual Inspection

Section D comprises only one panel with both the seawall and promenade in fair condition with some sealant loss and patch repairs.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this section.

10.3 Intrusive Investigation

No intrusive investigation was undertaken at defence Section D.

10.4 Beach Levels

At this section the end of the concrete toe is set at approximately +2.60mAOD. Below this level a sheet pile toe has been placed for which the depth remains unknown but it exceeds +2.15mAOD (end of the trial pit, 2012). If the beach levels were to drop below +2.60mAOD the steel pile toe would become exposed and start to degrade. Loss of the sheet pile would lead to the loss of foundation material and consequently a higher likelihood of overturning and collapsing failures to occur. Furthermore, as the beach in front of the defence reduces, sliding also becomes more likely.

Based on the discussion above, **+2.60mAOD is the critical trigger level.** If the beach regularly falls below this level (i.e. if it is seen in two to three records over five years) monitoring of condition of the sheet pile toe and its degradation is required to establish if remedial works or reinforcement are necessary.

10.5 Residual Life and Condition Assessment

Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk of failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD has in the past breached the critical beach level +2.60mAOD, hence this frontage is more likely to be impacted by the existing beach variability. Monitoring of beach levels at Section D is more critical than sections A, B and C. The seawall is generally in fair condition.

Based on critical beach levels, a residual life of **10 to 20 years** can be attributed (see Section 6), provided that maintenance works to the frontage continues and the beach levels remain stable.

10.6 Recommended Works

The recommended works for Section D are as follows:

- Local beach monitoring;
- Seawall sealant replacement; and
- Promenade patch repair at cracks and significantly abraded panels.

Chapter 14 presents the details and costs of recommended remedial works.

11 SECTION E ASSESSMENT

11.1 Cross-section Description

Section E extends for 260m from Chainage 619 to Chainage 879. The structure at this section consists of a concrete promenade slab and recurve wall to the rear of a concrete block work seawall (Figure 11-1). In 1979 the promenade slab was observed to be sinking, and as a result in 1980 holes were drilled into the face of the seawall and grout injected. It is understood that this operation was unsuccessful as the grout was washed out by the sea.

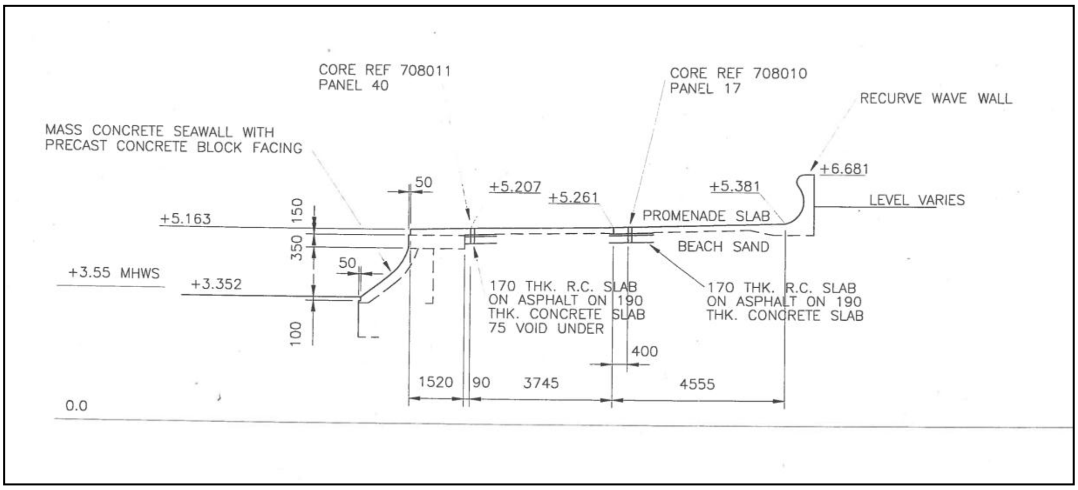

Figure 11-1 Section E cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all level are in metres relative to Ordnance Datum

11.2 Visual Inspection

11.2.1 Mass Concrete Seawall with precast concrete block facing

The mass concrete seawall is in fair condition (91% of panels) with 5% panels in poor condition, 2% of panels in good condition and 2% of panels in very good condition. Concrete abrasion (particularly at the edge of blocks), sealant loss and cracking of blocks were the most noticeable and frequent defects. Sealant loss and cracking are likely to lead to saline intrusion, further concrete abrasion and concrete spalling as well as loss of material from the foundation of the promenade. Several outlet points can be found throughout the seawall and they are likely to contribute towards the deterioration of the seawall (Figure 11-2).

Figure 11-2 Outfall at panel 5 and seawall panel in poor condition (left), typical seawall panel condition (right)

11.2.2 Promenade slab

The promenade slab in Defence Section E is generally in fair condition (69% of panels), with 20% of panels in good condition, 4% of panels in very good condition and 7% in poor condition. Typical defects observed include significant cracks, spalling spots and patch repairs. A 35m long crack was observed on the promenade extending from panels 37 to 43 (Figure 11-3). Since the Mott MacDonald investigation (1996) this crack has propagated an additional 3m. There has been 10mm settlement at the central line between the rear and front section of Panel 39. This may be evidence of ground movement between the panels.

Figure 11-3 35.4m long crack spanning between planes 37 to 43

11.2.3 Recurve wave wall

The recurve wave wall was generally in good condition (41% of panels) with 39% of panels in very good condition. It should be noted that inspection of 20% of panels was not possible as they were obstructed by kiosks. There were no panels in poor condition. Some hairline cracking was observed in 30% of the panels. These were mostly minor in nature.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this report.

11.3 Intrusive Ground Investigation

11.3.1 Concrete Core

CC07, CC08 and CC09 were vertical cores taken through the promenade slab. The results are presented in Table 11-1.

Ref	Structure	Orientation	Concrete depth	Fill	Compressive Strength	Void	Notes
CC07	Promenade	Vertical	190mm	Bitumen coated gravel.	36.5N/mm^2	50mm void between two concrete slabs. Lateral extent unknown.	Void filled with loose bitumen coated gravel.
CC08	Promenade	Vertical	340mm delamin-ation at 265mm depth	Well compacted gravel.	28.0N/mm^2	30mm void between slab and fill material. Void extended south. Lateral extent unknown.	
CC09	Promenade	Vertical	267mm	Well compacted gravel.	39.0N/mm^2	20mm deep void extending south and east. Lateral extent unknown.	

Table 11-1: Section D concrete core results

11.3.2 Trial Pit

A cross section of Trial Pits TP4 and TP5 are shown in Figure 11-4 and Figure 11-5, respectively.

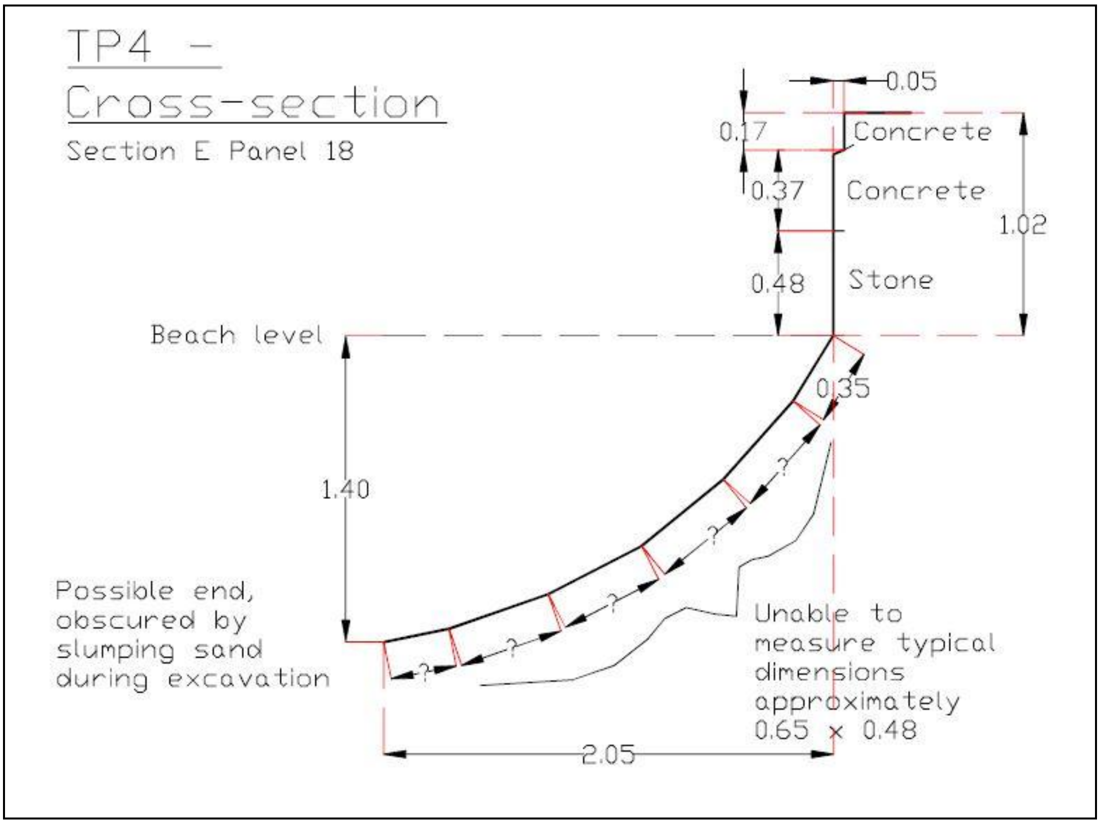

Figure 11-4: Trial Pit TP4 Cross Section

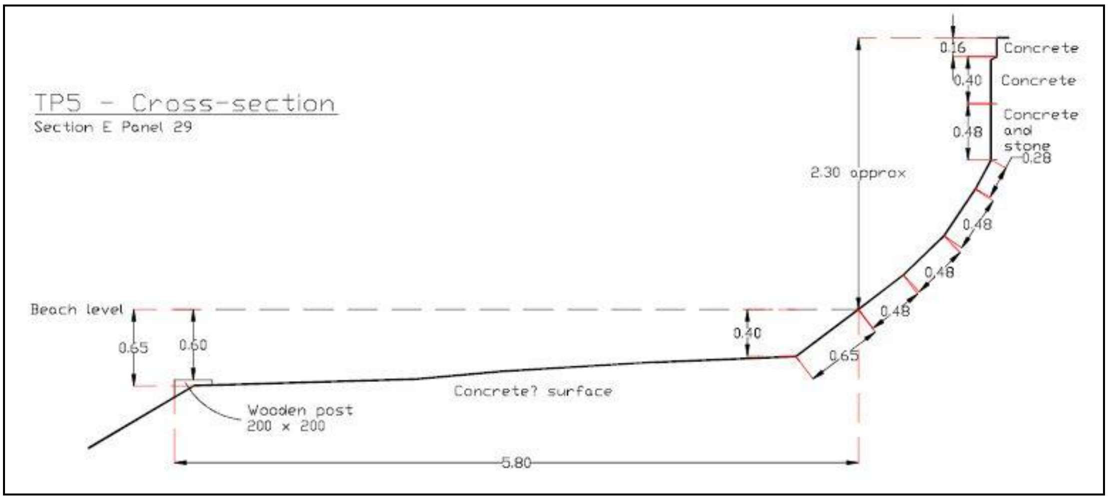

Figure 11-5: Trial Pit TP5 Cross Section

Trial pit TP4 was excavated to 1.40m beneath beach level at Panel 18. A maximum six slabs were observed down to this depth. After this depth, sand slumped into the pit, obscuring further slabs. Overall the slabs showed some wear, with cracked surfaces at the joints. Some infill had occurred at the joints. Water Seepage was visible from 0.60m below beach level.

A second trial pit (TP5) was excavated in Section C to 0.65m beneath beach level in front of Panel 29. A concrete apron was uncovered to 5.80m distance from the last slab of the seawall. A wooden post was located at this point offshore, and the concrete surface dropped off after this. Water obscured measurements of the depth of the concrete here. Some flaking and dimpling was observed on the face of the stone, on the seawall. Some seepage was observed at around 0.35m below beach level.

11.3.3 Overview

Overall the intrusive ground investigations showed that the seawall and promenade is in variable condition. At 190mm the promenade concrete slab is of reasonable thickness. The compressive strength of the concrete varied between 39.0N/mm^2 to 28N/mm^2. The presence of the void suggests that settlement could continue to occur at this location. The depth of the toe in relation to beach levels was unknown following excavation of the trial pit but it was possible that the sixth slab marked the toe of the wall at the location of TP04. At TP05 the offshore measurement of the concrete apron was unknown but its presence increases the overall stability of this structure. The presence of bitumen coated aggregate in the void suggests that a second slab was laid over a bitumen surface.

11.3.4 Beach Levels

At this section the concrete toe is set at approximately +2.30mOAD. If the beach levels were to drop to +2.30mAOD the toe would become undermined due to scouring. It is expected that the defence would start to lose stability, due to a lack of beach material in front of the structure which currently stops it from sliding. At this point the probability of overturning and collapsing, due to loss of foundation material, becomes higher. The rate at which these failure mechanisms may take place cannot herewith be predicted.

Based on the discussion above, **+2.30mAOD is the critical trigger level.** If the beach regularly falls below this level (i.e. if it is seen in two to three records over five years) monitoring of the condition of the toe and its degradation is required to establish if remedial works or reinforcement are necessary.

11.4 Residual Life and Condition Assessment

Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk of failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD has more or less reached the critical beach level +2.30mAOD. The seawall is generally in fair condition.

Based on the structure deterioration but more importantly the critical beach level, a residual life of **10 to 20 years** can be attributed (see Section 6), provided that maintenance works to the frontage continue and the beach levels remain stable.

11.5 Recommended Works

The recommended works for section E are as follows:

- Local beach monitoring;
- Patch repair of seawall and promenade cracks and significantly abraded panels.

Chapter 14 presents the details and costs of recommended remedial works.

12 SECTION F ASSESSMENT

12.1 Cross-section Description

Section F extends for 33m from Chainage 879 to Chainage 912. The structure at this section consists of a mass concrete seawall with a smooth battered face and a promenade paved with tarmacadam and a recurve wave wall at the rear (Figure 12-1). The foundation material is sand.

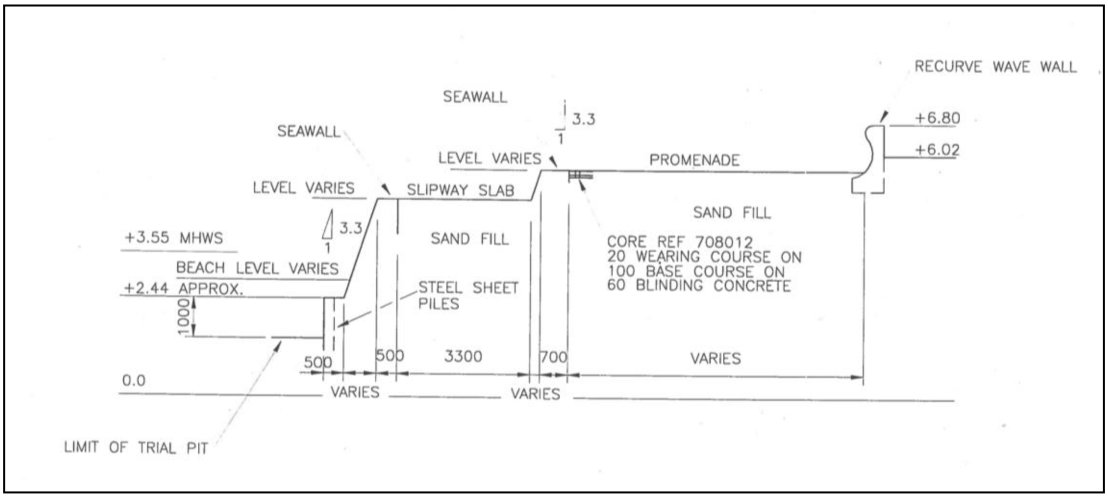

Figure 12-1 Section F cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all levels are in metres relative to Ordnance Datum

12.2 Visual Inspection

12.2.1 Seawall

In defence Section F there are two sets of seawall panels, some supporting the slipway and some supporting the promenade. Overall the seawall panels are in fair condition (88% of panels). Panel 3 supporting the seawall is in poor condition due to the presence of a horizontal 3m crack with a maximum width of 20mm (Figure 12-2). Sealant loss was apparent between the slipway slab and the seawall section underneath. There was also sealant loss between vertical joints of the panels exposing underlying material. Concrete abrasion and hairline cracking was also prominent.

Figure 12-2 Crack at seawall panel 3.

12.2.2 Slipway and promenade slab

Three slipway slabs are in fair condition and one slipway slab is in fair condition due to previous patch repairs. The promenade slabs are generally in good condition (three panels) and one panel in fair condition.

12.2.3 Recurve Wave Wall

The recurve wave wall was generally in good condition (three panels) and one panel in fair condition.

For further detail of the Condition Assessment see tables presented in **Appendix ii**. **Appendix iii** presents a summary sheet of this report.

12.3 Intrusive Investigation

No intrusive investigation was conducted at defence Section F.

12.4 Beach Levels

At this section the end of the concrete toe is set at approximately +2.40mAOD. Below this level a sheet pile toe has been placed for which the depth remains unknown but it exceeds +1.40mAOD (end of the trial pit, 1996). If the beach levels were to drop below +2.40mAOD the steel pile toe would become exposed and start to degrade. Loss of the sheet pile would lead to loss of foundation material and consequently a higher likelihood of overturning and collapsing failures occurring. Furthermore, as beach levels in front of the defences lower, sliding also becomes more likely.

Based on the discussion above, **+2.40mAOD is the critical trigger level.** If the beach regularly falls below this level (i.e. if it is seen in two to three records over five years) monitoring of the condition of the sheet pile toe and its degradation is required to establish if remedial works or reinforcement is necessary.

12.5 Residual Life and Condition Assessment

Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk of failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD has in the past been below the critical beach level +2.40mAOD. Therefore, this frontage is more vulnerable to the existing beach variability. Monitoring of beach level at section F is more critical than sections A, B, C and E. The seawall is generally in fair condition.

Based on the structure deterioration and more importantly critical beach levels, a residual life of **10 to 20 years** can be attributed (see Section 6), provided that maintenance works to the frontage continue and the beach levels remain stable.

12.6 Recommended Works

The recommended works for defence Section F are as follows:

- Local beach monitoring;
- Placement of sealant joint;
- Patch repair of seawall cracks.

Chapter 14 presents the details and costs of recommended remedial works.

13 SECTION G ASSESSMENT

13.1 Cross-section Description

Section G extends for 561m from Chainage 912 to Chainage 1473. The structure at this section consists of a mass concrete gravity wall structure with recurve profile with a concrete promenade to the rear of the wall (Figure 13-1).

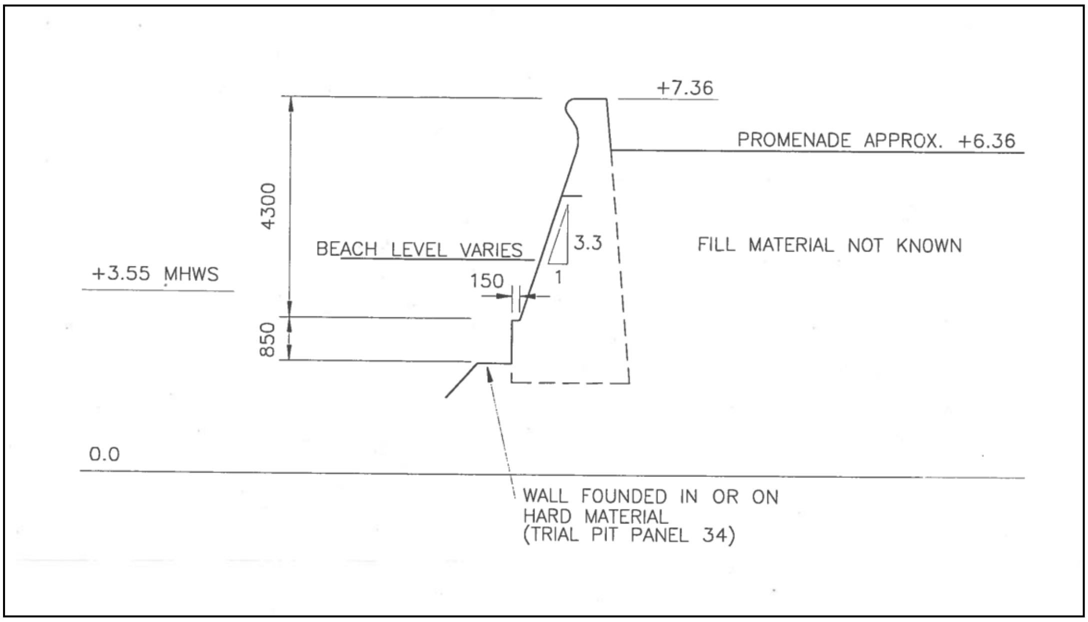

Figure 13-1 Section G cross-section, extracted from Mott MacDonald Investigation (1996). All dimensions in mm and all level are in metres relative to Ordnance Datum

13.2 Visual Inspection

13.2.1 Seawall

The mass gravity seawall is generally in fair condition (93% of panels) with 5% of panels in poor condition and 2% of panels in good condition. Vertical joints in the seawall are alternate construction/contraction joints (no sealant) and expansion joints (filler and sealant). Horizontal joints are all construction joints. Concrete abrasion and cracking to loss of concrete was observed in many locations particularly at the junction of vertical and horizontal joints. Repairs involving replacement of lost concrete had been undertaken in a number of locations (approximately under 30% of the panels), but had de-bonded in many instances. Seepage through joints was observed in a number of locations particularly adjacent to jammed flap gates.

13.2.2 Promenade slab

The promenade slab in defence Section G is in very good condition (88% of panels) with some 12% of panels in good condition. The main defect observed was cracking of the slab (Figure 13-2).

Figure 13-2 Section G seawall panel with cracking at joints and loss of concrete

13.2.3 Upstand Recurve wave wall

The upstand recurve wave wall is in very good condition (73% of panels) with 27% of panels in fair condition. The main defect observed was cracking across the length of the upstand recurve wave wall at the locations with surface water outlet points (Figure 13-3).

Figure 13-3 Recurve wave wall upstand with cracking at an outlet point

13.3 Intrusive Ground Investigation

No intrusive investigation was conducted at defence Section G.

13.4 Beach Levels

At this section the gravity seawall is founded in or on hard material at +2.10mAOD. The nature of the hard material is unknown but is likely to be local Carstone (**Appendix ii**). Hence is difficult to ascertain at what level we can expect the onset of problems related to beach levels. Nevertheless +**2.10mAOD** can still be taken as the critical trigger level with the premise that if beach levels regularly fall below +2.10mAOD, further monitoring and investigations are required to understand the foundation of the structure and establish if remedial works or reinforcements are necessary.

13.5 Residual Life and Condition Assessment

Apart from some seasonal variation the beach levels have remained stable over the last 20 years and there is no discernible erosional trend, hence no significant risk of failure due to beach lowering and toe exposure. The lowest beach level on record +2.31mAOD has been close to the critical beach level +2.10mAOD. The seawall is generally in fair condition.

Based on the structure deterioration and, more importantly, critical beach levels, a residual life of **10 to 20 years** can be attributed (see Chapter 6), provided that maintenance works to the frontage continue and the beach levels remain stable.

13.6 Recommended Works

The recommended works for defence Section E are as follows:

- Local beach monitoring;
- Monitor and repair cracks at the upstand wall;
- Patch repair of seawall.

14 REMEDIAL WORKS

14.1 Works Required

The detailed visual inspection determined the overall condition of each panel, based on the CAM guidance and the St La Haye Limited classifications. Specific defects were recorded in the defence (**Appendix ii**). The types of defects seen were used to determine the works required. A summary of the works is provided in Table 14-1.

Defect	Works
Sealant loss	Clear out of remaining sealant. Wash-down cleared area (to remove salt water and loose material). Re-seal with sealant and level off.
Cracking	Cut out cracked area, to remove loose concrete. Treat any exposed reinforcement bar. Make good with patch repair mortar. Re-seal any joints as necessary.
Concrete abrasion	Cut out any loose concrete. Treat any exposed reinforcement bar. Make good with patch repair.

Table 14-1: type of remedial works required

14.2 Cost Estimate

An estimate of the cost of the required works is provided as part of this condition survey report. A daily rate of **£2,500** was derived for a working gang, based on the type of works required. The daily rate was estimated based on experience of similar works and includes:

- labour
- overheads; and
- materials.

The duration of the works has been broken down per panel, including seawall, promenade and recurve wave wall. The estimated duration was also based on experience of similar works. The final cost of the works, per panel was therefore calculated by multiplying the daily rate with the expected duration of the works.
A contingency of 30% has been added to allow for cost and work extent variation.

14.3 Year of intervention

The categories of the visual condition assessment were used to determine the year of intervention of maintenance works. This report considers maintenance works that are required over the next five years. Where a panel was categorised as "poor" remedial works are required in the first year. Panels categorised as "Fair" but with specific defects, such as sealant loss, are considered to require maintenance works in the next two to five years. Panels categorised as having "Good" condition, or "Fair" condition with no specific defects, are not considered to require works over the next five years.

14.4 Summary of works

The works identified as being necessary within the next year are summarised in Table 14-1. **Appendix ii** provides further information for works required in the next two to five years.

Section	Reference	Details	Works required	Section Total*
A	Seawall Panel 45	Significant abrasion of concrete.	Patch repair	
	Seawall Panel 68	Concrete abrasion. Sealant loss.	Patch repair. Sealant replacement	
	Promenade Slab 36	Several patch repairs present.	Sealant replacement	
	Promenade Slab 64	Minimal concrete abrasion, patch repair required.	Patch repair	**£21,000**
B	Seawall Panel 1	Outfall present. Lengthy crack.	Sealant replacement	
	Promenade Slab 4	Patch repair required.	Patch repair	**£9,000**
C & D	N/A	N/A	N/A	N/A
E	Seawall Panel 3	Sealant loss. Concrete abrasion. Various cracking. Parts of concrete have come away.	Patch repair	
	Seawall Panel 5	Outfall present. Sealant loss. Concrete abrasion. Various cracking. Parts of concrete have come away.	Patch repair	
	Promenade Slab 25	Several patch repairs	Sealant replacement	
	Promenade Slab 28	Some sealant loss	Sealant replacement	
	Promenade Slab 36	Serious crack. Spalling spots. Various minor patch repairs present.	Sealant replacement	**£16,000**
F	Seawall Panel 2	Sealant loss. Concrete abrasion. Hair-line cracking.	Sealant replacement	**£3,000**
G	Seawall Panel 33	Sealant loss. Concrete abrasion. Cracking face. 2 outfalls present. Access Ramp.	Patch repair	
	Seawall Panel 52	Sealant loss. Concrete abrasion. Severe edge cracking. Outfall present.	Patch repair	
	Seawall Panel 54	Sealant loss. Concrete abrasion. Severe edge cracking. Outfall present.	Patch repair	**£19,000**
			Total (year one) with contingency (£21k)	**£89,000**

*Numbers are rounded to nearest **£000.**

Table 14-1: Recommended remedial works in Year 1

The cost of the works required in years two to five are summarised in Table 14-1-2.

Year works needed	Sea wall	Promenade	Recurve wall	Total (with contingency)
Year 1	£48,750	£18,750	£0	**£89,000**
Year 2-5	£117,500	£40,625	£1,250	**£207,000**
				£296,000

Table 14-1-2: Summary of recommended remedial works

14.5 Overview

Overall, no significant defects were observed and the seawall and promenade do not require any significant structural works in the next five years. The works outlined above will have immediate benefit in that they will increase the public safety of the structures. In the medium term, patch and repair works will maintain the integrity of the structures and will ensure that the structures remain safe for public access.

14.6 Beach Monitoring

A critical limiting factor in the assessment of defence residual life was found to be the variation of beach levels. For defence Sections D-E the residual life was lowered because there was evidence to show that beach levels had, in the past, dropped lower than the critical beach level for these sections. An important thing to note, however, is that this assessment was based on one of the Environment Agency's Anglian Coastal Monitoring Programme profiles. It was assumed that this profile represented the whole frontage.

In the future it is recommended that more beach profiles are taken along this frontage, at a higher spatial-frequency, to build a more comprehensive picture of beach change. Considering that this is the most important factor affecting the defences at Hunstanton, this information would significantly benefit future defence assessments.

15 SUMMARY

This condition assessment has collated previous information about the seawall and promenade at Hunstanton, and combined it with a detailed visual inspection and ground investigation of the structures and beach levels. This information has been used to define the estimated residual life of the defences.

A summary of the results of the assessment is provided in Table 15-1.

Section	Residual Life (years)	Limiting Factor/Reason
A	30-50	Defence Structure
B	30-50	Defence Structure
C	30-50	Defence Structure
D	10-20	Beach levels
E	10-20	Beach levels
F	10-20	Beach levels
G	10-20	Beach levels

Table 15-1: Summary of defence residual life

Minor remedial works are required to sustain these defences. It is estimated that these works amount to **£89,000** in Year 1 and a further **£207,000** across Years 2-5. These values include 30% contingency, and cover estimated costs of labour, overheads and materials.

It is recognised that this value is not insignificant. However, these works will, in the long term, maintain the integrity of the defences and will maintain public health and safety. Critically, beach levels were found to be the most important factor affecting defence residual life. As well as the remedial works outlined in Chapter 14, it is also recommended that monitoring of the beach levels, particularly at the toe of the defences, occurs. This monitoring should include profiles taken through Sections A to G defined in this assessment, to improve the understanding of beach behaviour along the frontage and better inform beach level assessments.

The Wash East Coastal Management Strategy, currently in development, has so far outlined the expectation and need for a sea defence with a promenade. It has been agreed that this needs to be maintained. The recommended remedial works outlined in this report are considered to meet this expectation and need.

The Strategy will aim to develop an efficient way to implement this maintenance and to support the BCKLWN’s future planning and funding strategy.

16 REFERENCES

Wash East Coastal Management Strategy – Task 1&2 – Baseline Coastal Processes, Environment Agency and Royal HaskoningDHV June 2012

Guidance on determining asset deterioration and the use of condition grade deterioration curves, Environment Agency May 2009

Coastal Trend Analysis, The Wash – Gibraltar Point to Old Hunstanton. Anglian Coastal Monitoring Programme. Shoreline Management Group. March 2007

Managing Flood Risk Condition Assessment Manual, Environment Agency

17 GLOSSARY

Glossary	
AOD	Above Ordnance datum
BCKLWN	Borough Council of Kings Lynn and West Norfolk
EA	Environment Agency
OND	Ordnance Datum Newlyn
LAT	Lowest Astronomical Tide
MHW	Mean High Water
MHWS	Mean High Water Spring
MHWN	Mean High Water Neap
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MSL	Mean Sea Level
RHDHV	Royal HaskoningDHV (formerly Royal Haskoning)

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