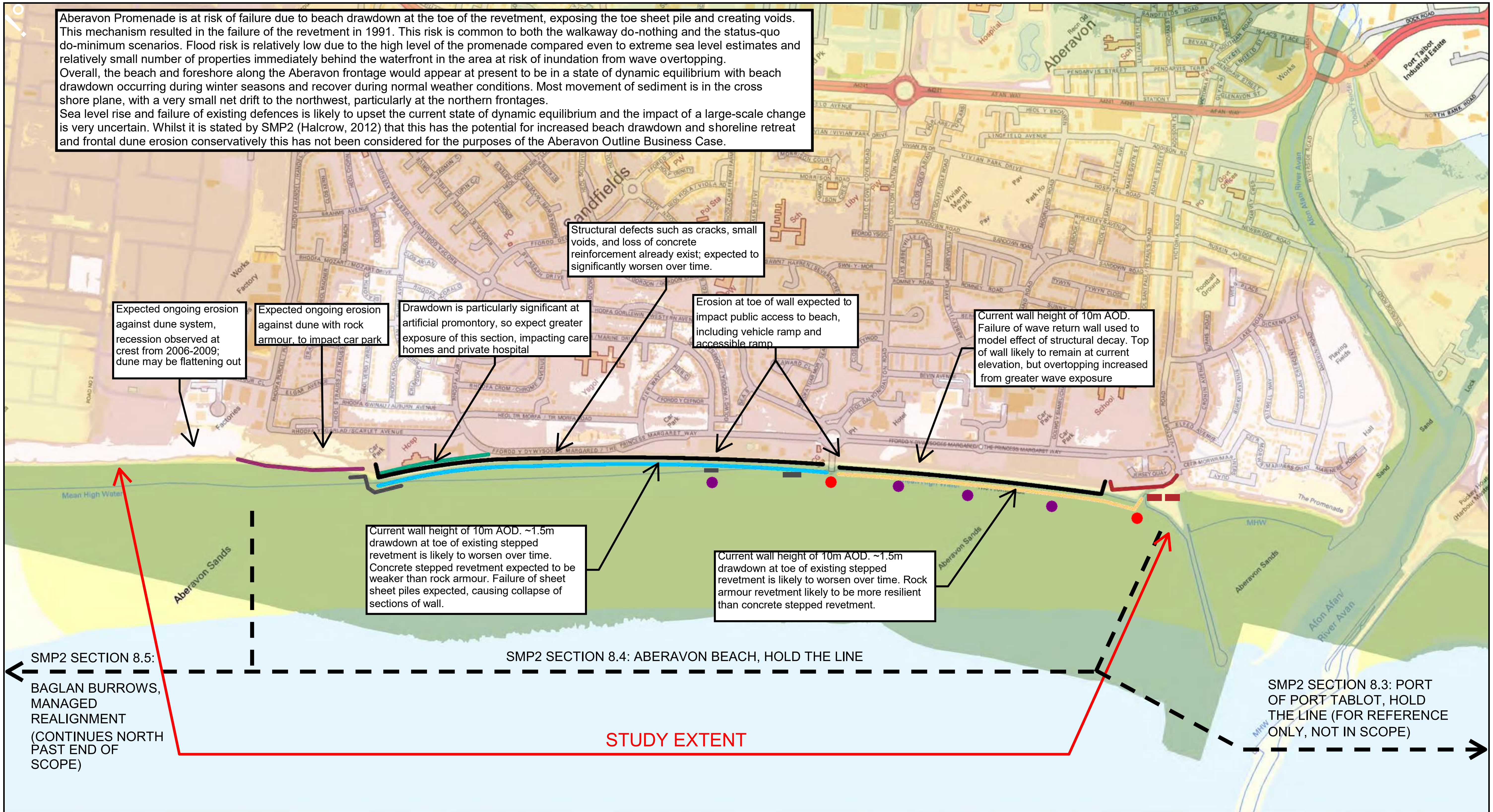
Appendix A

Site Location Plans

A1 General Arrangement: Do Nothing Scenario

A3



05/04/2012 17:41:03

Legend

LiDAR Digital Terrain Model (DTM) (m AOD)

- < 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- > 11

Wall_Type

- 2m Wave Wall
- Concrete Stepped Revetment
- Private Splash Wall
- Riprap Stone Rubble
- Rock Armour Revetment
- Rock Armour Toe Protection
- Secondary Concrete Wall

Additional Features

- Ramped vehicular access to beach
- Stepped pedestrian access to beach

Issue	Date	By	Chkd	Appd
P1	23-01-17	AC	RC	RC

ARUP

4 Pierhead Street
Cardiff CF10 4QP
Tel +44 29 2047 3727 Fax +44 29 2047 2277
www.arup.com

Metres: 0 125 250 500

Client
Neath Port Talbot County Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

Baseline Scenario "Do Nothing"

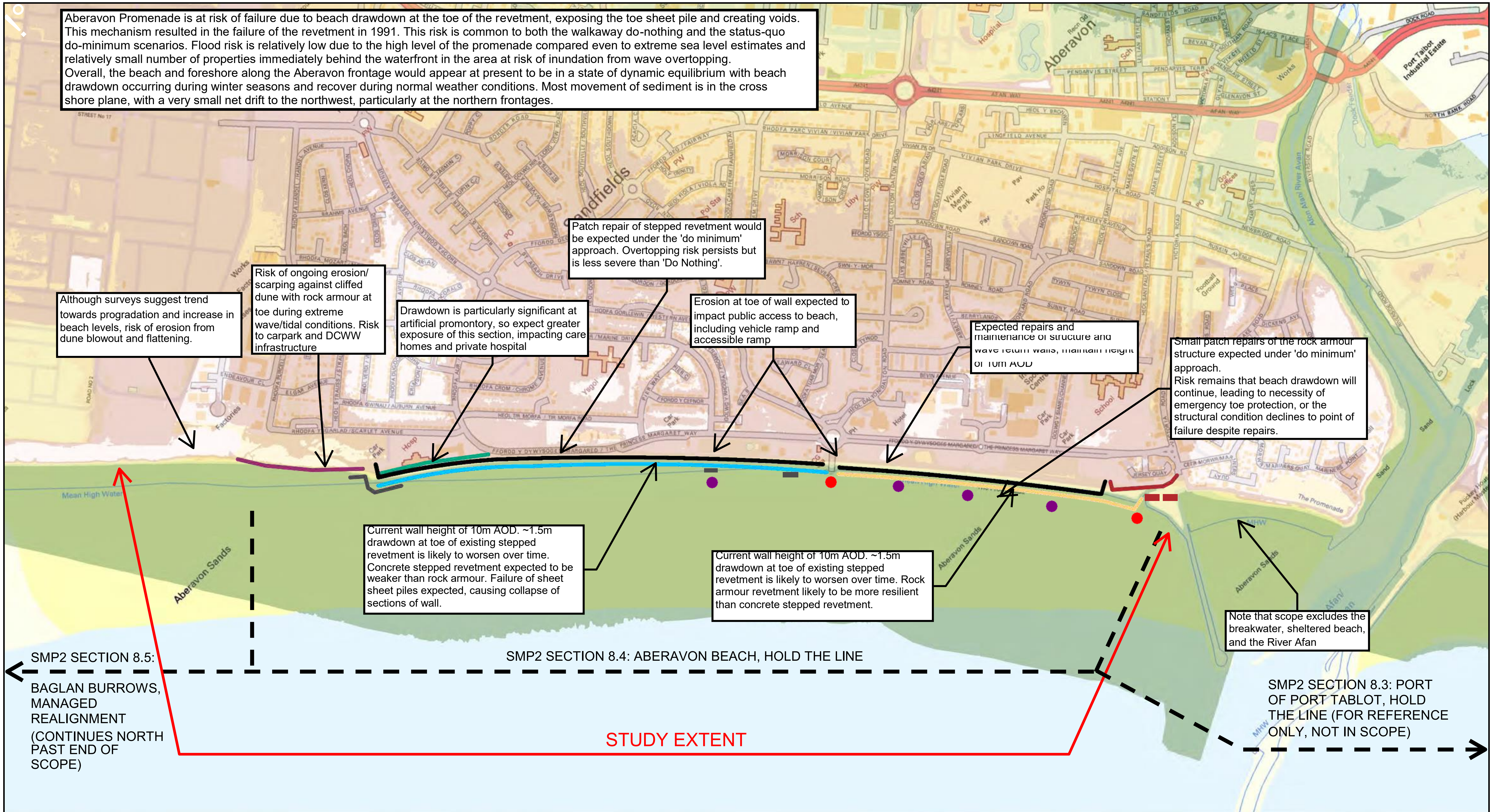
Scale at A3: **1:10,000**

Job No: **252723-00**
Drawing Status: **Preliminary**
Drawing No: **001**
Issue: **P1**

MXD Location

A2 General Arrangement: Do Minimum Scenario

A3



Legend

LiDAR Digital Terrain Model (DTM) (m AOD)

- < 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- > 11

Wall_Type

- 2m Wave Wall
- Concrete Stepped Revetment
- Private Splash Wall
- Riprap Stone Rubble
- Rock Armour Revetment
- Rock Armour Toe Protection
- Secondary Concrete Wall

Additional Features

- Ramped vehicular access to beach
- Ramped or stepped pedestrian access to beach

Issue	Date	By	Chkd	Appd
P1	23-01-17	AC	RC	RC

ARUP

4 Pierhead Street
Cardiff CF10 4QP
Tel +44 29 2047 3727 Fax +44 29 2047 2277
www.arup.com

Metres: 0, 125, 250, 500

Client
Neath Port Talbot County Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

Baseline Scenario "Do Minimum"

Scale at A3: **1:10,000**

Job No: **252723-00**

Drawing Status: **Preliminary**

Drawing No: **002**

Issue: **P1**

MXD Location

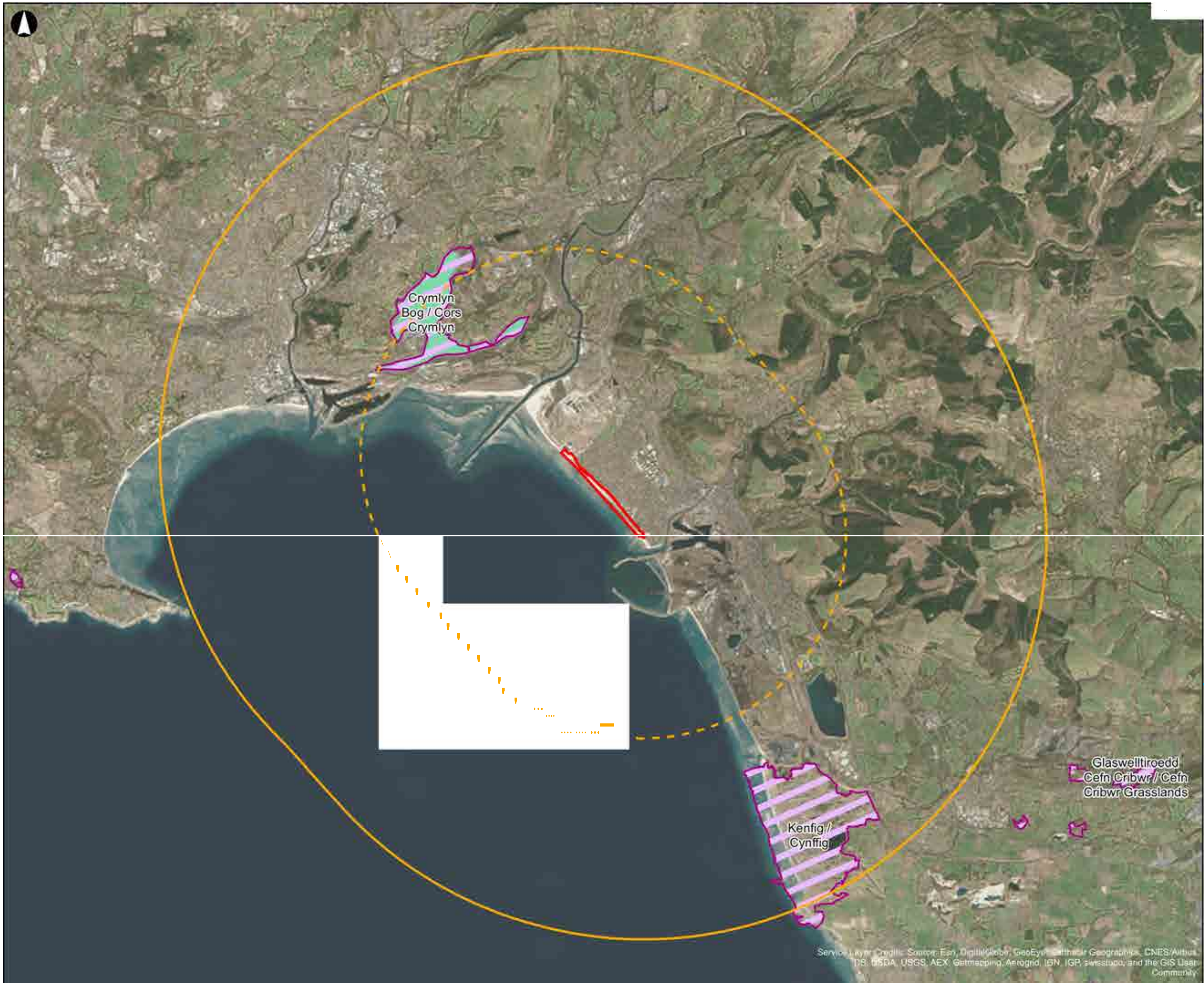
05/04/2012 17:41:03

Appendix B

Environmental Constraints Plans

B1 Regional Context

A3



Survey Boundary
10km Buffer
5km Site Buffer
Special Areas of Conservation
Ramsar

Issue	Date	By	Chkd	Appd
F1	2017-04-28	FG	AC	PW

Metres
0 1,200 2,400 4,800

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Neath Port Talbot
Castell-nedd Port Talbot
County Borough Council Cyngor Bwrdeistref Sirol

Job Title
Aberavon PAR

European Sites

Scale at A3
1:89,450

Job No
252723-00

Drawing Status
Preliminary

Drawing No
006

Issue
F1

B2 Local Context

A3

Legend

- Mean High Water Springs (MHWS)
- Listed Buildings
- Ancient Woodland
- Flood Zone C2
- Sites of Special Scientific Interest (SSSI)

Issue	Date	By	Chkd	Appd
P0	2017-01-03	FG	AC	TS

Metres

0 270 540 1,080

ARUP

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Client

Neath Port Talbot
Castell-nedd Port Talbot

Job Title

Aberavon PAR

Environmental Constraints Plan (Local Context)

Scale at A3

1:20,279

Job No	Drawing Status
252723-00	Preliminary

Drawing No	Issue
005	P0

17/01/2017 15:06:35

\\global\europe\Cardiff\Jobs\252000\252723-00\4 Internal Project Data\4-80 GIS\4-84 Map Documents\ENV_Environment\Aberavon_EnvConstraints.mxd

B3 Extended Phase 1 Habitat Survey Plans

A3

09/01/2017 12:30:24

Legend

- Target Note
- Fence
- Sea wall
- Mean High Water Springs (MHWS)
- Intertidal sand
- Shingle above high tide mark
- Coastal grassland
- Amenity grassland
- Building
- Bare ground
- Gravel and concrete
- Tarmac
- Survey Boundary

Target Note:
TN1: Buildings with bat potential
TN3: Zonation only on eastern side of outfall with highest species diversity
TN4: Coastal grassland
TN5: Sabellaria colonies recorded to existing along base of wall from here out south east

P3	2017-01-09	FG	AC	PW
Issue	Date	By	Chkd	Appd

Metres
0 30 60 120

ARUP

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Client
Neath Port Talbot
Castell-nedd Port Talbot

Job Title
Aberavon PAR

Phase 1 Habitat Survey
Page 1

Scale at A3
1:2,500

Job No	Drawing Status
252723-00	Preliminary

Drawing No	Issue
01	P3

\\Global\Europe\Cardiff\Jobs\252000\252723-00\4 Internal Project Data\4-80 GIS\4-84 Map Documents\ENV_Environment\Intertidal Phase 1.mxd

A3

Legend

- Target Note
- Sea wall
- Mean High Water Springs (MHWS)
- Intertidal sand
- Shingle above high tide mark
- Amenity grassland
- Building
- Gravel and concrete
- Tarmac
- Survey Boundary

Target Note:
TN2: Building with bat potential

Issue	Date	By	Chkd	Appd
P3	2017-01-09	FG	AC	PW

Metres
0 30 60 120

ARUP

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Client
Neath Port Talbot
Castell-nedd Port Talbot

Job Title
Aberavon PAR

Phase 1 Habitat Survey
Page 2

Scale at A3
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Job No
252723-00

Drawing Status
Preliminary

Drawing No
02

Issue
P3

09/01/2017 12:31:20

\\Global\Europe\Cardiff\Jobs\252000\252723-00\4 Internal Project Data\4-80 GIS\4-84 Map Documents\ENV_Environment\Intertidal Phase 1.mxd

A3

Legend

- Target Note
- Caravan park
- Soft cliff
- Sea wall
- Mean High Water Springs (MHWS)
- Intertidal sand
- Shingle above high tide mark
- Boulders and rocks above high tide mark
- Dune grassland
- Amenity grassland
- Building
- Tarmac
- Survey Boundary

Target Note:
TN6: 20 x sanderling recorded foraging on shore
TN7: Dune grassland and cliff with increased species diversity and potential for invertebrates, rare plants including sea stock, breeding birds and reptiles.

Issue	Date	By	Chkd	Appd
P3	2017-01-09	FG	AC	PW

Metres
0 30 60 120

ARUP

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Client
Neath Port Talbot
Castell-nedd Port Talbot
County Borough Council Cyngor Bwrdeistref Sirol

Job Title
Aberavon PAR

Phase 1 Habitat Survey
Page 3

Scale at A3
1:2,500

Job No	Drawing Status
252723-00	**Preliminary**

Drawing No	Issue
03	**P3**

09/01/2017 12:32:37

\\Global\Europe\Cardiff\Jobs\252000\252723-00\4 Internal Project Data\4-80 GIS\4-84 Map Documents\ENV_Environment\Intertidal Phase 1.mxd

A3

Legend

- Target Note
- Caravan park
- Soft cliff
- Sea wall
- Mean High Water Springs (MHWS)
- Intertidal sand
- Shingle above high tide mark
- Boulders and rocks above high tide mark
- Dune grassland
- Open dune
- Amenity grassland
- Building
- Tarmac
- Survey Boundary

Target Note:

TN6: 20 x sanderling recorded foraging on shore

TN7: Dune grassland and cliff with increased species diversity and potential for invertebrates, rare plants including sea stock, breeding birds and reptiles.

TN8: Habitat predominantly sand above high tide mark.

Issue	Date	By	Chkd	Appd
P3	2017-01-10	FG	AC	PW

Metres
0 30 60 120

ARUP

63 St. Thomas Street
Bristol BS1 6JZ
(T)+441179765432 (F)+441179765433

Client

Neath Port Talbot
Castell-nedd Port Talbot

Job Title

Aberavon PAR

Phase 1 Habitat Survey
Page 4

Scale at A3

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Job No	Drawing Status
252723-00	Preliminary

Drawing No	Issue
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10/01/2017 14:45:55

\\global\europe\Cardiff\Jobs\252000\252723-00\4 Internal Project Data\4-60 GIS\4-84 Map Documents\ENV_Environment\Intertidal Phase 1.mxd

Appendix C

Flood Risk Plans

C1


Flood Hazard Map
Do Nothing Scenario: 2018 Epoch
1 in 200 Year Flood Event
Hospital
SCARLET AVENUE
AUBURN AVENUE
RHODFA AUR / GOLDEN
SEPIA CLOSE
SEPIA CL
RHODFA CROM / CHROME AVENUE
RHODFA MOR / MARINE DRIVE
RHODFA GORLLEWIN / WESTERN AVENUE
HEOL GORDON / GORDON ROAD
CILGANT GORDON / GORDON CRESCENT
FAIRWAY
PW
HEOL VIOLA / VIOLA ROAD
Police Station
A4241
Education Facility
PIER WAY
RHODFA FFERM / FARM DRIVE
MORRISON COURT
MORRISON ROAD
Library
PO
OWENS PLACE
CRIB Y TYWOD / SANDY RIDGE
SWN-Y-MOR
HEOL COVE / COVE ROAD
FFORDD YSGOL
HEOL DALTON
LLYS ABBEYVILLE / ABBEYVILLE CT
HEOL DALTON / DALTON ROAD
HEOL BEVIN / BEVIN AVENUE
GOL WG-Y-MOR
ABBEYVILLE AVENUE
BERRYLANDS
MOORLAND ROAD
FFORDD-Y-DYWYSOGES MARGARED / THE PRINCESS MARGARET WAY
Sports/Leisure Centre
Aberavon
GOLWG Y SIANEL / CHANNEL VIEW
Sports/Leisure Centre
JERSEY QUAY

Flood Hazard Map
Do Nothing Scenario: 2118 Epoch
1 in 200 Year Flood Event

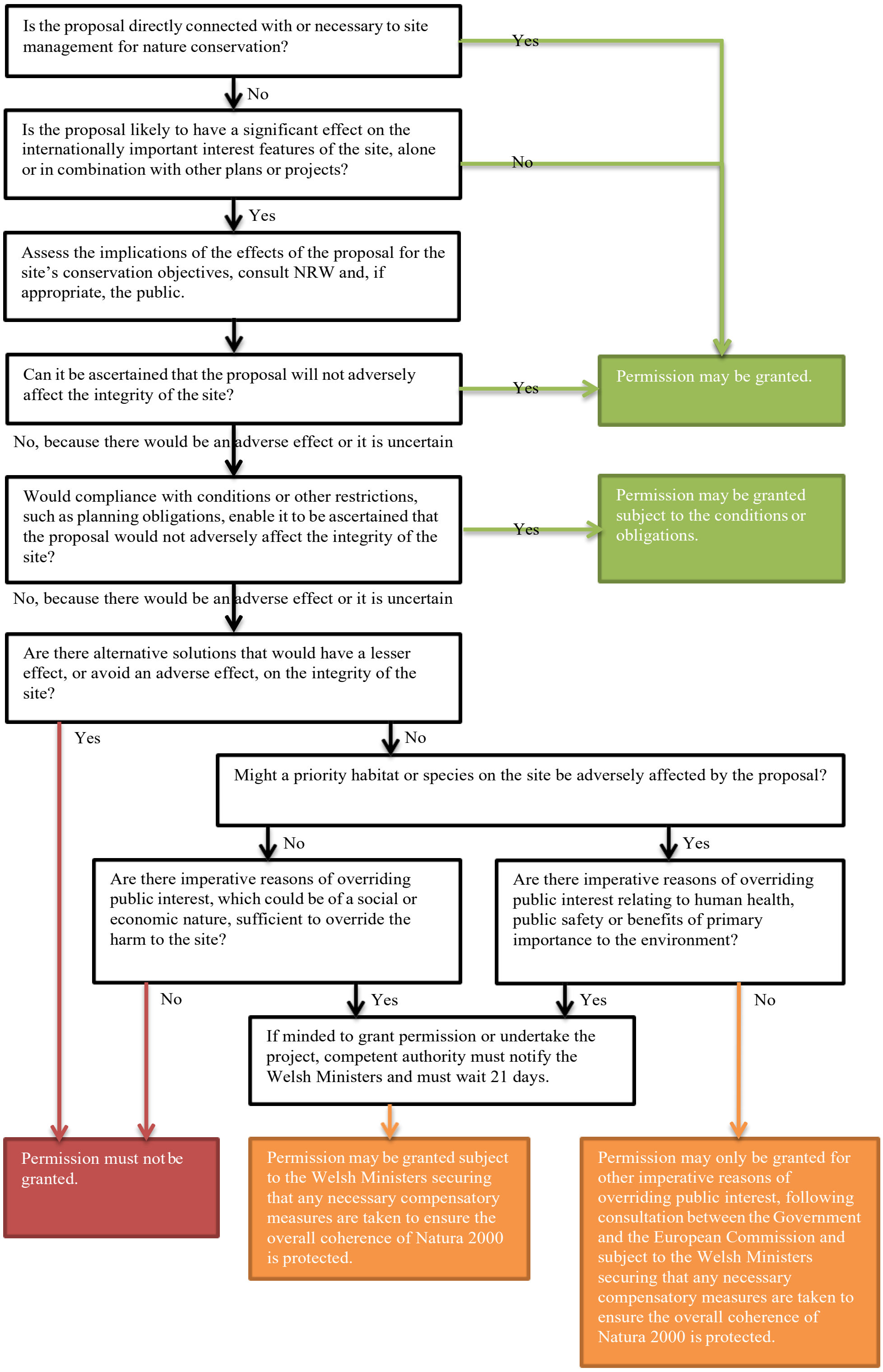
Flood Hazard Map
Do Minimum Scenario: 2018 Epoch
1 in 200 Year Flood Event


Sandfields
Aberavon
Hospital
Education Facility
Police Station
Library
Sports/Leisure Centre
PIER WAY
Flood Hazard Map
Do Minimum Scenario: 2118 Epoch
1 in 200 Year Flood Event

Appendix D

Habitats Regulations Assessment Process Outline Designs

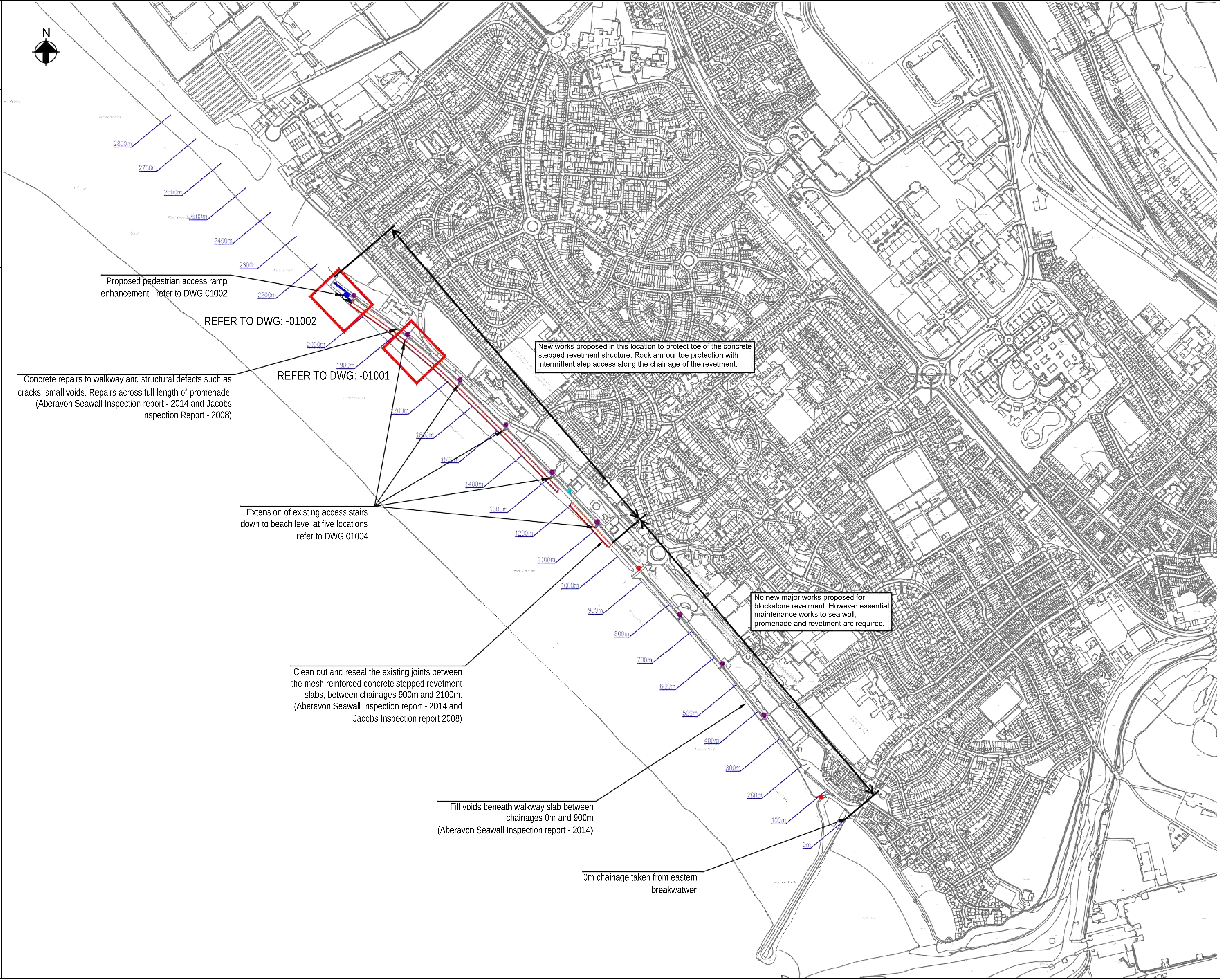
D1


Is the proposal directly connected with or necessary to site management for nature conservation?
Yes
No
Is the proposal likely to have a significant effect on the internationally important interest features of the site, alone or in combination with other plans or projects?
No
Yes
Assess the implications of the effects of the proposal for the site's conservation objectives, consult NRW and, if appropriate, the public.
Can it be ascertained that the proposal will not adversely affect the integrity of the site?
Yes
Permission may be granted.
No, because there would be an adverse effect or it is uncertain
Would compliance with conditions or other restrictions, such as planning obligations, enable it to be ascertained that the proposal would not adversely affect the integrity of the site?
Yes
Permission may be granted subject to the conditions or obligations.
No, because there would be an adverse effect or it is uncertain
Are there alternative solutions that would have a lesser effect, or avoid an adverse effect, on the integrity of the site?
Yes
No
Might a priority habitat or species on the site be adversely affected by the proposal?
No
Yes
Are there imperative reasons of overriding public interest, which could be of a social or economic nature, sufficient to override the harm to the site?
Are there imperative reasons of overriding public interest relating to human health, public safety or benefits of primary importance to the environment?
No
Yes
Yes
No
If minded to grant permission or undertake the project, competent authority must notify the Welsh Ministers and must wait 21 days.
Permission must not be granted.
Permission may be granted subject to the Welsh Ministers securing that any necessary compensatory measures are taken to ensure the overall coherence of Natura 2000 is protected.
Permission may only be granted for other imperative reasons of overriding public interest, following consultation between the Government and the European Commission and subject to the Welsh Ministers securing that any necessary compensatory measures are taken to ensure the overall coherence of Natura 2000 is protected.

Appendix E

Outline Design Drawings

E1



NOTES:

1. ALL MEASUREMENTS ARE IN METRES AND LEVELS ARE METRES AOD UNLESS NOTED OTHERWISE.
2. EXISTING CONCRETE REVETMENT DEFECTS ARE IDENTIFIED IN JACOBS REVETMENT AND SEA WALL INSPECTION REPORT, AUGUST 2008.
3. EXISTING STRUCTURE DEFECTS ARE IDENTIFIED IN ABERAVON SEAWALL INSPECTION REPORT, JANUARY/FEBRUARY 2014.
4. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT DRAWINGS. DWG:-01001 & DWG:-01002.

OUTLINE DESIGN INFORMATION FOR COSTING, TBC AT DETAILED DESIGN.

Additional Features

- Ramped vehicular access to beach
- Stepped pedestrian access to beach
- Ramped pedestrian access

0 50 100 200 Metres
Scale 1:5000

Issue	Date	By	Chkd	Appd
P0	15/03/17	JB	EA	HJR
	Issued for Information			

ARUP

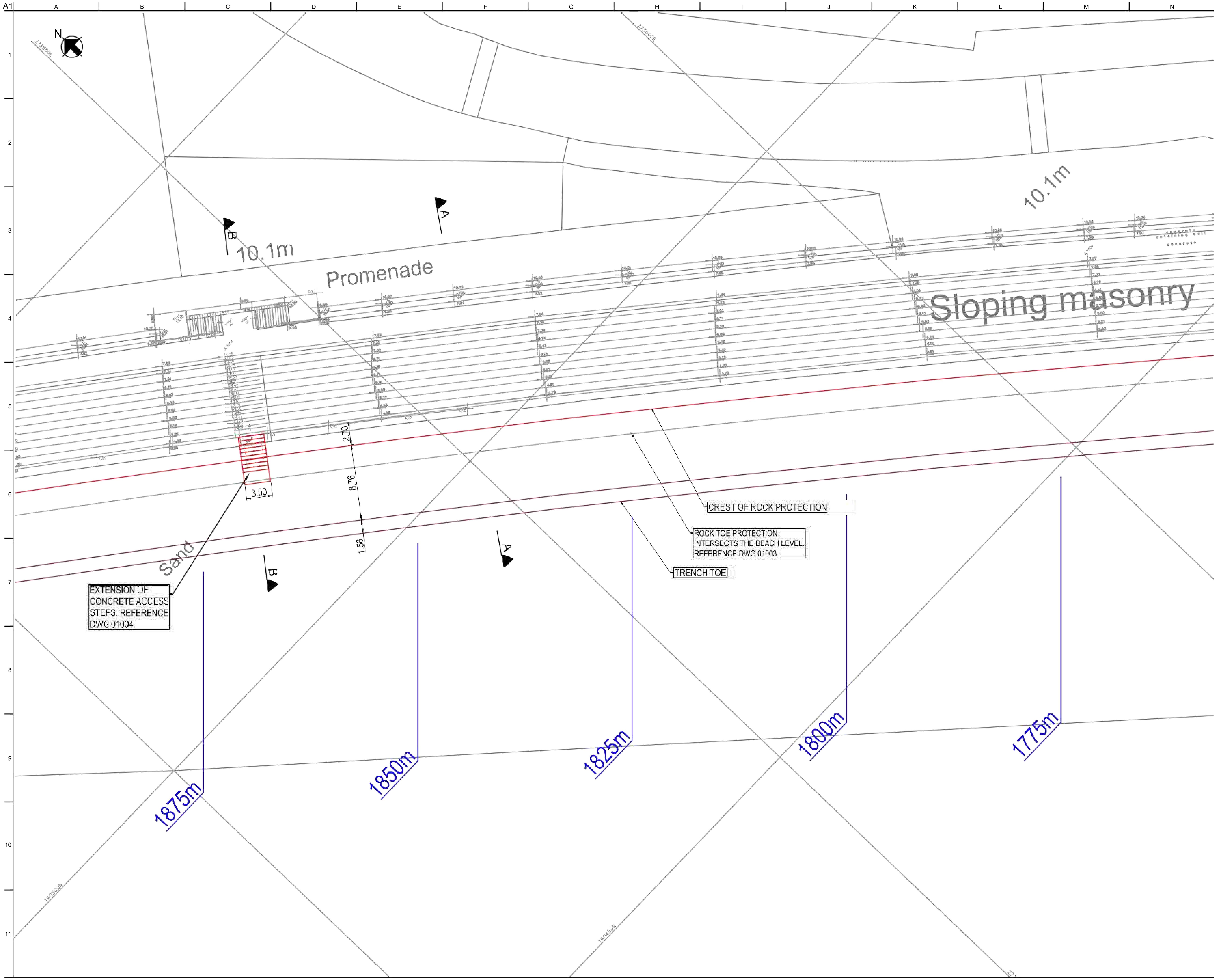
Client
Neath Port Talbot County Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

GENERAL ARRANGEMENT KEY PLAN

Scale at A1: 1:5000
Discipline: Civil
Job No: 252723-00
Drawing Status: FOR INFORMATION
Drawing No: 10001
Issue: P0

Do not scale



NOTES:

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3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT DRAWINGS.

   DWG-10001 & DWG-01002.

OUTLINE DESIGN INFORMATION FOR COSTING, TBC AT DETAILED DESIGN.

0 5 10 Metres
Scale 1:200

Issue	Date	By	Chkd	Appd
P0	14/03/17	JB	EA	HJR
	Issued for Information			

ARUP

Client
Neath Port Talbot Country Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

GENERAL ARRANGEMENT PLAN
SHEET 1 OF 2

Scale at A1: 1:200

Discipline: Civil

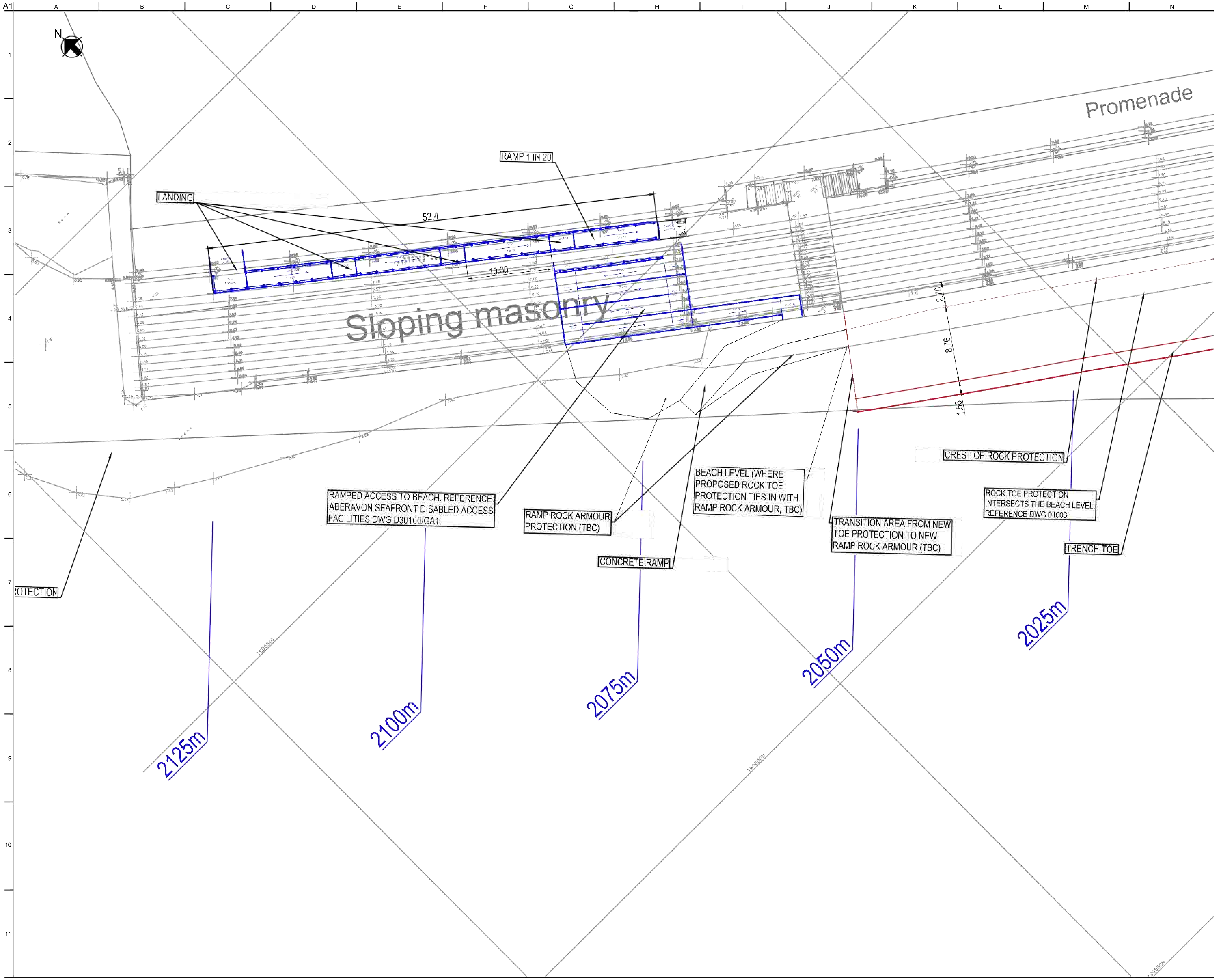
Job No: 252723-00

Drawing Status: FOR INFORMATION

Drawing No: 01001

Issue: P0

Do not scale



NOTES:

1. ALL MEASUREMENTS ARE IN METRES AND LEVELS ARE METRES AOD UNLESS NOTED OTHERWISE.
2. EXISTING CONCRETE REVETMENT DEFECTS ARE IDENTIFIED IN JACOBS REVETMENT AND SEA WALL INSPECTION REPORT, AUGUST 2008.
3. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT DRAWINGS:

DWG-10001 & DWG-01001.

OUTLINE DESIGN INFORMATION FOR COSTING, TBC AT DETAILED DESIGN.

0 5 10 Metres

Scale 1:200

Issue	Date	By	Chkd	Appd
P0	14/03/17	JB	EA	HJR
	Issued for Information			

ARUP

Client
Neath Port Talbot Country Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

GENERAL ARRANGEMENT PLAN
SHEET 2 OF 2

Scale at A1: 1:200

Discipline: Civil

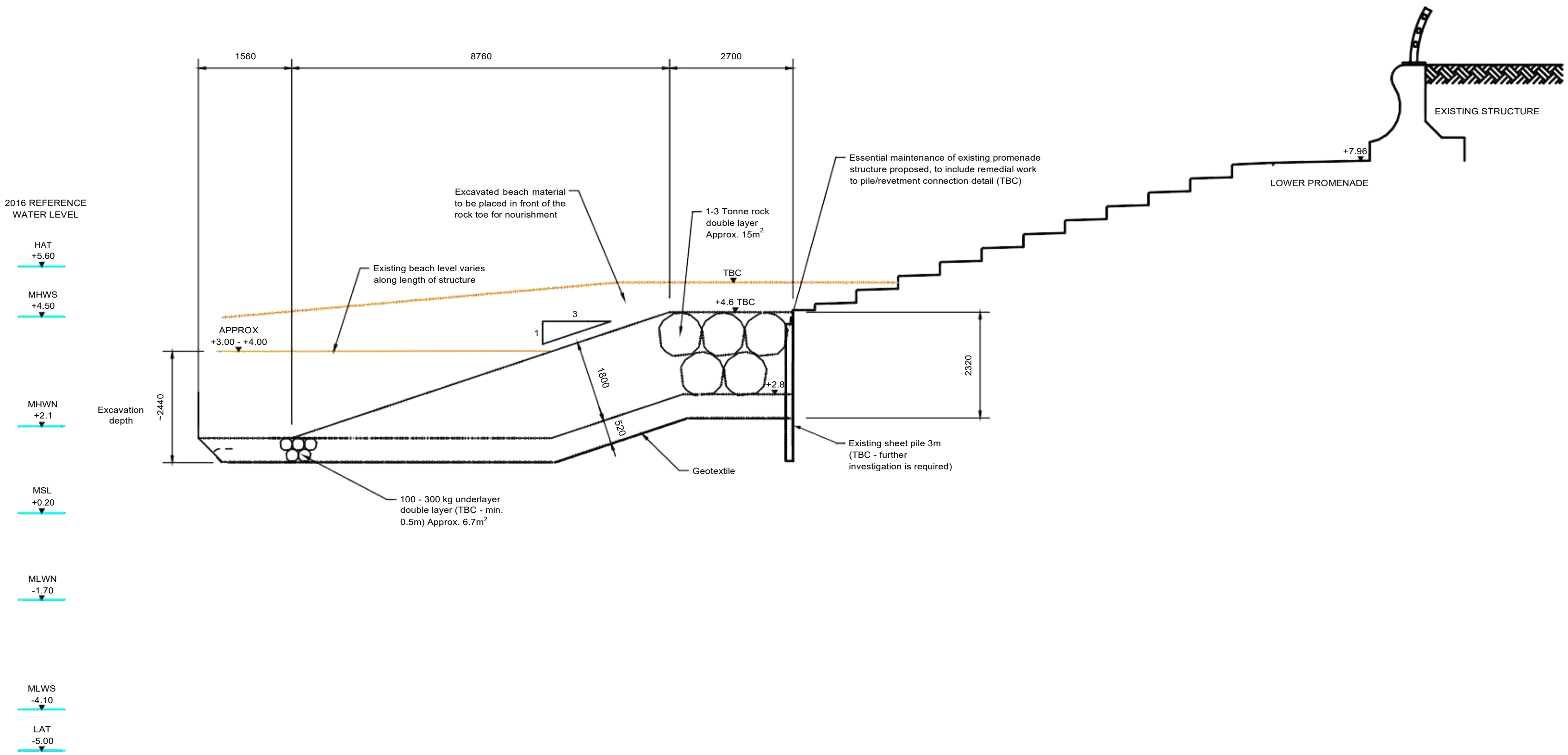
Job No: 252723

Drawing Status: FOR INFORMATION

Drawing No: 01002

Issue: P0

Do not scale



TYPICAL CROSS SECTION: TOE PROTECTION ROCK ARMOUR (1 IN 3)

SECTION A-A

NOTES:

1. ALL LEVELS ARE METRES AOD, DIMENSIONS IN MM, UNLESS NOTED OTHERWISE.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH A RELEVANT DRAWINGS.

OUTLINE DESIGN INFORMATION FOR COSTING, TBC AT DETAILED DESIGN.

Issue	Date	By	Chkd	Appd
P0	29/03/17	JB	EA	HJR
Issued for Information				

ARUP

Client
Neath Port Talbot County Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

CROSS SECTION
TOE PROTECTION (1 IN 3)
SECTION A-A

Scale at A1

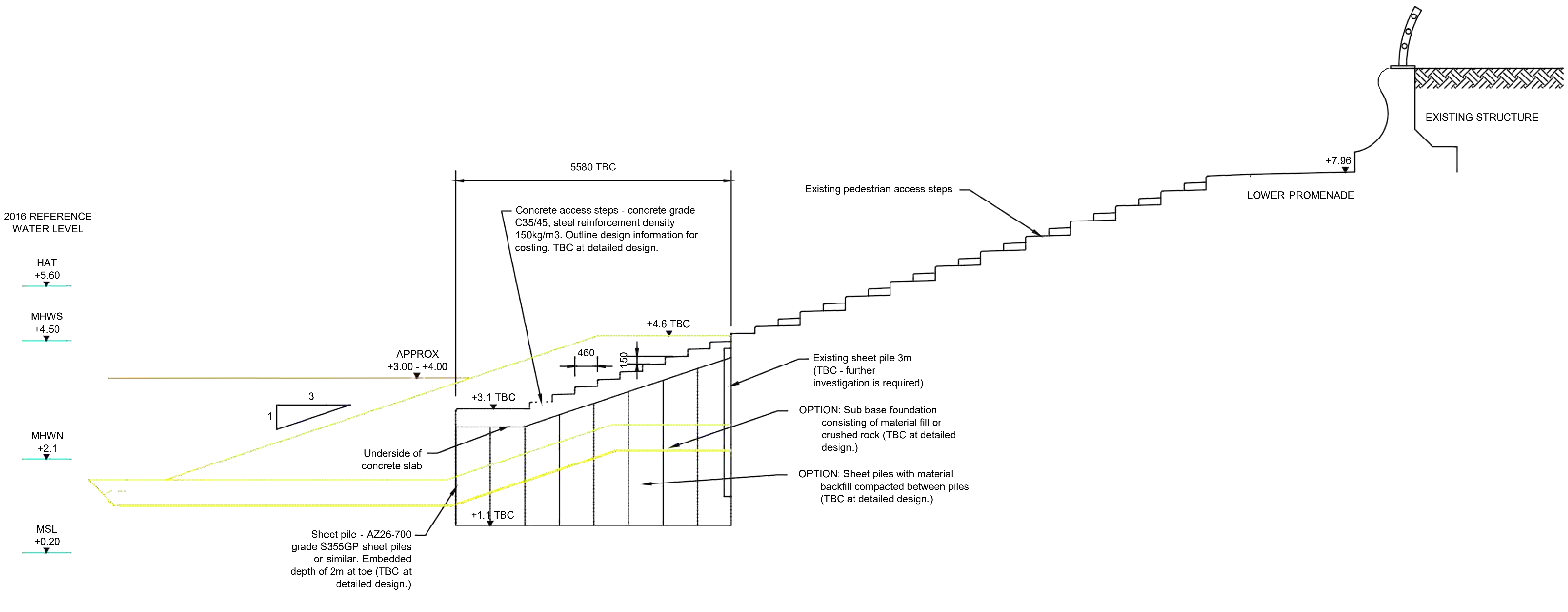
Discipline
Civil

Job No
252723-00

Drawing Status
FOR INFORMATION

Drawing No
01003

Issue
P0



Note: Access steps are located at six locations along the revetment frontage, shown in GA

TYPICAL CROSS SECTION: EXTENSION OF INTERMITTENT IN-SITU CONCRETE ACCESS STEPS

SECTION B-B

NOTES:

1. ALL LEVELS ARE METRES AOD, DIMENSIONS IN MM, UNLESS NOTED OTHERWISE.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH A RELEVANT DRAWINGS.

OUTLINE DESIGN INFORMATION FOR COSTING, TBC AT DETAILED DESIGN.

Issue	Date	By	Chkd	Appd
P0	14/03/17	JB	EA	HJR
Issued for Information				

ARUP

Client
Neath Port Talbot County Borough Council

Job Title
Aberavon Project Appraisal Report (PAR)

CROSS SECTION:
ACCESS STEPS
SECTION B-B

Scale at A1

Discipline
Civil

Job No
252723-00

Drawing Status
FOR INFORMATION

Drawing No
01004

Issue
P0

Do not scale

Appendix F

Coastal Processes Study: Aberavon Promenade Conceptual Understanding

F1

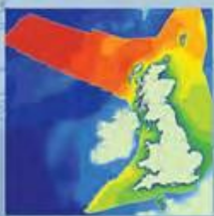
Aberavon Conceptual Understanding

Aberavon PAR

Ove Arup and Partners Limited

January 2017

Creating sustainable solutions for the marine environment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Aberavon Conceptual Understanding

Aberavon PAR

January 2017

Document Information

Document History and Authorisation		
Title	Aberavon Conceptual Understanding	
	Aberavon PAR	
Commissioned by	Ove Arup and Partners Limited	
Issue date	January 2017	
Document ref	R.2756	
Project no	R/4476/2	
Date	**Version**	**Revision Details**
11/01/2017	1	Issued for client review
30/01/2017	2	Issued for client use

Prepared (PM)	Approved (QM)	Authorised (PD)
Peter Whitehead	David Finch	Heidi Roberts
P. A. Whitehead	pp	

Suggested Citation

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A report produced by ABPmer for Ove Arup and Partners Limited, January 2017.

Acknowledgements

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Contents

Tables

Figures

1 Introduction

1.1 Study

The aim of the project for Neath Port Talbot County Borough Council (NPTCBC) is to investigate options for managing coastal flood and erosion risk and preparation of a Project Appraisal Report (PAR) at Aberavon. Improvements in the defences and flood risk are required to reduce the threat of coastal flood and erosion risk and to support existing and future amenity and regeneration in Aberavon. Proposed schemes are to be mindful of the possibility to enhance natural, historic, visual and the built environment, whilst maintaining marine activities in the most affordable and sustainable manner.

ABPmer has been commissioned by Ove Arup and Partners Limited (Arup) to review the coastal processes to determine the parameters that cause potential flood risk at Aberavon Sands. An extremes analysis has been completed to determine the volumes of wave overtopping of the defences for different return period events under existing conditions and allowing for 100 years of climate change from 2018.

This has been completed via two deliverable documents containing:

- **Process Understanding (this document):** A summary of the coastal processes affecting the defences and the conceptual understanding of the dynamics of Aberavon Sands, particularly with respect to the influence on defences and stability of the beach and foreshore.
- **Extremes Analysis (additional document):** A technical note which sets out the modelling results for the wave, water level and wave overtopping criteria for the coastal defences.

1.2 Coastal and erosion risk

Contributing factors to coastal flooding such as Sea Level Rise (SLR), storm surge levels, tidal heights, wave heights, wind speeds and existing coastal defence structures all are highly variable both spatially and temporally. Gaining a fundamental understanding of the physical process interaction with the shoreline is key to providing accurate flood risk analysis such as wave overtopping rates and inundation levels, as well as identifying the risks of coastal erosion and defence failure due to beach lowering.

Whilst coastal flooding can result from fluvial activity the highly exposed nature of Aberavon Sands to offshore waves, combined with the substantial modification of fluvial systems to the south (Port Talbot) and north (Neath estuary), fluvial flooding risk to Aberavon is much lower than that from tidal and wave inundation. The commissioned work therefore focuses on coastal flood risk, and does not include from the terrestrial or fluvial sources.

2 Site Description

2.1 Aberavon

The Aberavon frontage is a 2 km long exposed south-west facing sand beach between Port Talbot (to the south) and the River Neath (to the north) within Swansea Bay. Much of the surrounding coastline to Aberavon is heavily modified by industry. To the south of the site lies the port of Port Talbot and steel works. The structures surrounding the harbour, combined with the breakwater on the south of Aberavon sands, are likely to have a notable influence on the supply of sediment to the beach.

Aberavon Sands has a shallow beach gradient of around 1:50 from the toe of the defence to mean low water spring (MLWS) level. The beach is gradually dissipative in nature with a large breaker zone present. The breaker zone is likely to extend offshore during extreme wave conditions.

A breakwater to the south of the site extends across the upper beach around 500 m in a south-westerly direction, providing shelter to the channel entrance of the River Afan. The structure merges into the main frontage of Aberavon Sands (Figure 1) in front of the promenade.

A review of historical maps collated by Groundsure Insights (2015) shows that development has moved seaward with the construction of the promenade and associated infrastructure. The central sections of the promenade contain tourist-related businesses and runs in a northwest to southeast direction. Raised grass areas immediately behind the promenade stretch inland around 60 m before leading to a road running parallel to the sea defence. In the northern section of the beach the road cuts into the grass areas, to run directly on top of the sea defences for around 350 m before turning inland into residential properties.

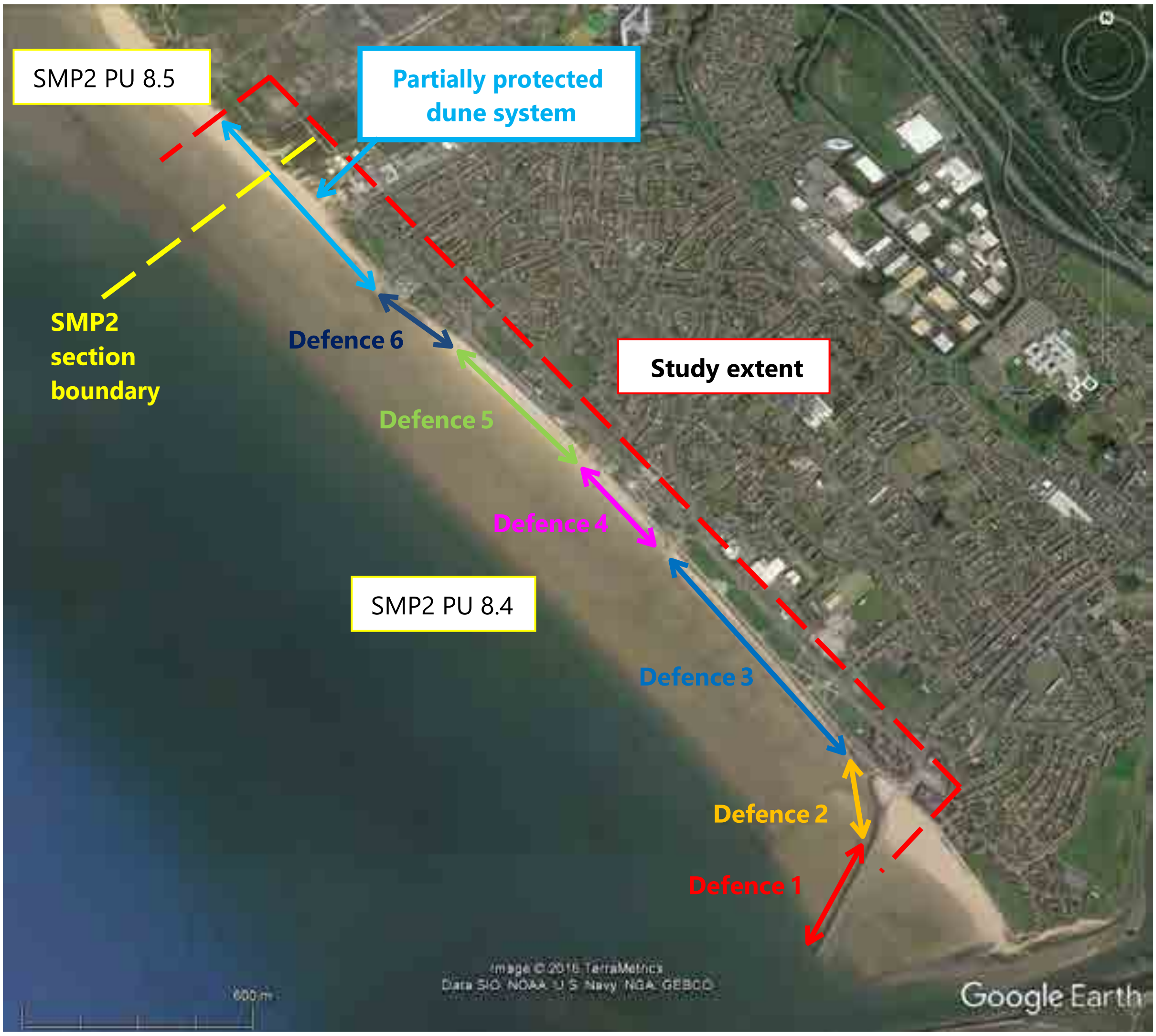
Further to the north at the end of the residential area the defence structures stop, reverting to the natural dune system in front of Baglan. Much of the industrial area behind the dunes has been closed and cleared.

2.2 Existing frontages

Aberavon is defended along the majority of its length to the dune system at Baglan. For the purpose of the conceptual understanding and the separate wave overtopping analysis, the frontage can be broadly summarised as having six different frontage types (Figure 1), namely:

- Defence 1 consists of the rubble mound breakwater, forming the eastern extent of the study area, and has potential to influence the coastal processes and sediment transport. However it was not considered for wave overtopping analysis as any inundation would fall directly onto the beach on the south side of the breakwater.
- Defence 2 is the landward extent of rubble mound breakwater, which forms a defence that provides shelter for a slipway. This defence is also not considered for wave overtopping analysis as it would not inundate infrastructure behind due to its size.
- Defence 3 is a rock armoured defence, with a recurve vertical wall at the crest with a height of 9.94 mODN at the promenade level. *Circa* 10 m back from the crest of the defence there is a setback wall of 0.5 m in height. The defence is composed of quarried stone. The defence has a facing angle of 217 degrees. Beach levels at the defence toe are around 3.47 mODN.

- Defence 4 has a stepped revetment defence, with a recurve vertical wall at the crest. The height of crest at the promenade is 9.90 mODN. The wall is composed of stepped revetment at the toe to a 2 m high recurve wave return wall. The defence has a facing angle of 222 degrees. Beach levels at the defence toe are at 3.95 mODN.
- Defence 5 has a stepped revetment defence, with a recurve vertical wall at the crest at a height of 9.98 mODN. Beach level at the defence toe are at 4.08 mODN. The defence has a facing angle of 227 degrees.
- Defence 6 has a stepped revetment defence, but with a recurve vertical wall of 2 m in height at the crest. The overall height of the crest is 9.95 mODN. Beach level at the toe is approximately 3.52 mODN. The defence has a facing angle of 236 degrees.
- The northern extent of the study site contains a partially protected dune system with maximum heights around 20 mODN backing the beach. The section adjacent to the stepped revetment appears to have ‘protecting’ layer of boulders at the toe of the dune. It is not certain whether these have been placed at the toe, or whether they are a lag deposit from historic erosion. The remaining dune is undefended with the front face natural in formation stretching to the end of the study extent.



Map data ©2016 Google. Image © 2016 Terrametrics. Data © SIO, NOAA, U.S. Navy, NGA, GEBCO

Figure 1. Aerial imagery of Aberavon Sands, containing the southern breakwater, promenade and dune system

2.3 Shoreline management policy

The study area lies within the Lavernock Point to St Anne's Head SMP (Halcrow 2012) Area 8. The SMP long term plan for Unit 8 is to 'continue to manage the risk of coastal erosion and flooding to industrial, residential, non-residential, commercial and amenity assets along the coast, whilst enabling natural evolution of the dunes. There are significant linkages and interdependencies along this frontage and its future evolution will be dependent upon future management strategies for the Port of Port Talbot, steel works and the Neath Estuary, which includes the Port of Neath and various leisure functions' (Halcrow, 2012). The specific unit policies are as follows:

- Unit 8.4: Port of Port Talbot to Baglan Burrows (Aberavon Beach). The policy is hold the line, maintaining, upgrading and replacing defences in response to future climate change/ sea level rise, subject to the availability of public funding for coastal erosion and flood risk management. There are a large number of socio-economic assets at risk from coastal erosion and flooding along this frontage along with the risk that potentially contaminated fill could be released into the coastal zone (Halcrow, 2012).
- Unit 8.5: Baglan Burrows. The policy of managed realignment will enable the dune system to function naturally, with minimal interference and monitoring, with the option to construct a secondary set back defence if there is a risk of the dunes breaching. This will minimise the risk of coastal erosion and flooding to hinterland assets, including a power station, industrial area and potentially contaminated land (Halcrow, 2012).

3 Process Understanding

This section provides a description of the marine and coastal physical processes within and around the study area. This baseline characterisation forms the basis from which assessments of potential defence options appraisal can be carried out. Of particular interest are the water levels and local wave climate which will directly interact with the coastal structures and the resulting wave overtopping (ABPmer, 2017) during extreme events. This baseline understanding also provides information for assessments of potential changes that may occur to the defence structures in the future or to help derive future defence scheme.

3.1 Offshore seabed sediment

The Bristol Channel is relatively deep, with maximum depths of approximately 60 m near its entrance. Depths decrease eastwards to about 20 m near Lavernock Point. A shallower shelf area, ranging in width from 4.5 to 20 km, extends along the northern side between the Gower Peninsula and Lavernock Point. Much of the Inner Bristol Channel sea floor lacks accumulated sediments due to the strong tidal currents. Areas of slightly muddy sands occur in northern Swansea Bay (British Geological Survey, 1986; Pantin, 1991). The thickness of sediments is generally less than 10 m (Pye & Blott, 2009).

The sediment regime of the Bristol Channel is an ebb-dominated system (Halcrow 2005). The resulting net sediment transport is westwards in the centre of the Bristol Channel with a circulation within Swansea Bay.

Out in the Bristol Channel the coarse grained sediments form low amplitude dunes and mega-ripples. The medium to fine sand exhibit either higher amplitude dunes or plane bed features. The bed morphology that occurs is dependent on the local near-bed current speeds (Collins, 1993). The principal sediment source is the reworking of Quaternary sediments in the offshore zone. Large quantities of finer sediments (mud and fine sand) are supplied to the Bristol Channel by the rivers (mainly the River Severn) and supplemented with coastal cliff erosion (Pye & Blott, 2009).

Offshore of Aberavon the seabed morphology is gently sloping, with relatively uniform depth contours leading offshore into Swansea Bay. A sandbank to the East of Mumbles Head called Outer Green Grounds reduces depths by around 3 m Chart Datum (mCD). The seabed features are shown in the Admiralty Chart provided as Figure 2 in mCD. Further detail on the local bathymetry has been provided from the ABPmer model bathymetry as shown in Figure 3 to mODN.

Source: UKHO, 1999

Figure 2. Admiralty chart data for Aberavon and Swansea Bay

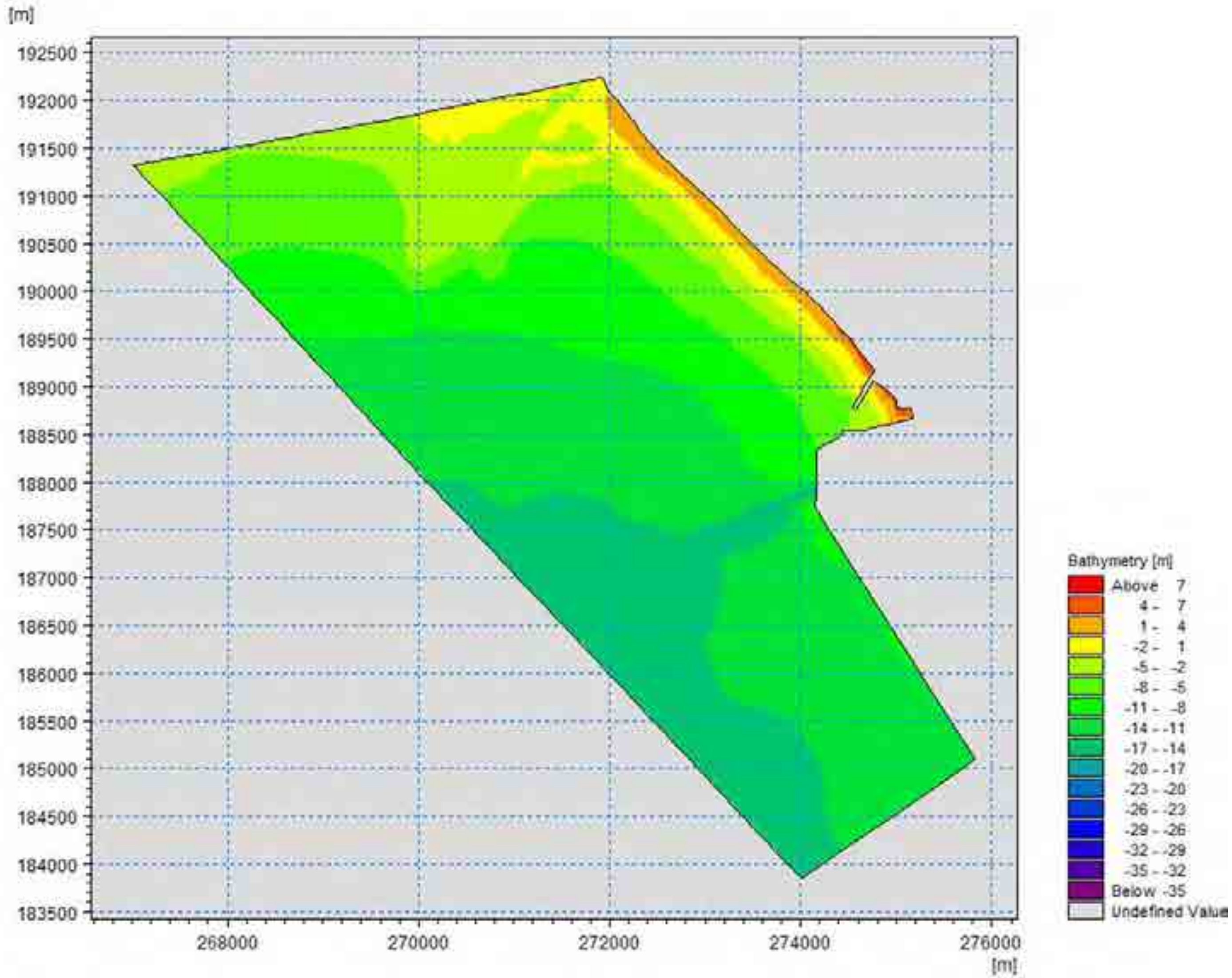


Figure 3. Local bathymetry at Aberavon (ABPmer SEASTATES bathymetry)

3.2 Coastal change

The character of the South Wales coast is controlled by resistant rock outcrops. The outcrops give rise to a series of headlands, sections of cliffed coast with intertidal shore platforms, and intervening Bays backed by sandy beaches and dunes (Pye & Blott, 2009). Although Swansea Bay is a high tidal energy area, wave processes play a very important part in transporting sediment across the sea bed throughout the Bay and around the major offshore banks (Collins *et al.*, 1980; Pattiarchi, 1985; Pattiarchi & Collins, 1988, Halcrow 2012).

Little sediment input is believed to be provided by the Rivers Tawe, Avon and Neath. The Bay, as a whole, is thought to operate as a closed sediment system (Halcrow 2012). Longshore sediment transport in offshore regions within Swansea Bay is generally to the south east, with potential re-circulation of sediment in a northerly direction due to the tidal residual (Halcrow, 2001). However transport within coastal embayment's can be modified by local eddy formations, and in general transport processes in the nearshore are dominated by wave conditions (ABP R&C 1995, 1997). Within the eastern side of the Bay sediment transport is mainly in the form of bedload transport as a result of exposure to the offshore wave climate.

Although there is limited sediment input to the coastline, there is believed to be periodic landward transfer of sand from deeper water in outer parts of Swansea Bay during storms. The SMP identifies that the system is sensitive to changes in storminess (severity and frequency) which can result in both draw-down and net accumulation. There is evidence that severe storm events are capable of moving significant quantities from deeper water in the outer parts of Swansea Bay towards the shoreline on the eastern side of the Bay, where it becomes available for re-distribution by 'normal' wave and longshore current processes. Significant quantities of sediment have accumulated in Port Talbot Outer Harbour after such events, requiring removal by dredging (Jackson & Norman, 1980). There is also a local rip current immediately to the north of the breakwater which transports sediment offshore (HR Wallingford, 1994).

The SMP analysed beach monitoring data between 1998 and 2008 (Pye & Blott 2009, Halcrow 2012). The analysis is reported to show that frontal dune accretion took place on the Baglan side of the Neath Estuary. The rest of the frontage showed a landward movement of MHWS with an overall fall in beach levels (Halcrow, 2012). Most profiles along Swansea Bay showed an overall fall in beach levels, especially in the northern and central parts of the study area at Aberavon Sands.

3.2.1 Aberavon frontage

Topographic beach profiles at the locations along the defended frontage (Figure 4 to Figure 7) surveyed between 2009 and 2013 suggest continual variation at the toe of the sea defence. Data from Pye & Blott (2013) suggest that the beach level at the toe throughout defence 4 (Profile 220) is highest in vertical height (4.5-4.8 mODN), with the lowest (3.2-3.6 mODN) throughout defence 3 (Profile 221). Sand levels at the toe of the defences vary throughout the annual profiles by 0.2-0.6 m in height. However, it is known that there is significant cyclic variability but uncertainty in the timing of each topographic survey means that a seasonal variation cannot be determined from such data. Lower beach levels remain stable, with annual variation is less than ±0.25 m below the level of MHWN (2.1 mODN).

Beach level difference between the 2011 LiDAR and a real time kinematic (RTK) topographic survey carried out during 2015 (Neath Estuary Group, 2016) suggests draw-down at the defence toe of between 0.5-1 m throughout defences 3 and 4 (Figure 8 Location A).

Within defence 5 a narrow band of no level change or slight level increase at the toe is apparent (Figure 8, Location B).

Defence 6 contains the highest magnitude of drawdown (Figure 8, Location C), with a general lowering of beach level between 0.5 and 1.5 m witnessed across the frontage width with isolated patches containing lowering greater than 1.5 m. Seaward of the toe of the defences, overall levels of the beach throughout the site appear to have lowered, with the greatest change seen at the northern and southern sections of the beach (Figure 8, Location D). Negligible level change is seen along the beach surrounding the level of MHWN (2.1 mODN).

Analysis of these profiles with reference to the mean tidal levels (Table 1) indicates that most variation in beach level against the defence toe occurs in the range of about 0.5 m around the elevation of mean high water. These profile surveys (and photographs below) tend to indicate that the beach is in dynamic equilibrium, with little evidence of net loss or gain of sediment over the whole frontage during the period of analysis. The plots indicate that most beach drawdown and recovery occur within defence widths of around 20 m in defence 3, 35 m in defence 4 and 25 m in defence 6. At times of erosion (drawdown) most of the sediment would appear to be deposited at a distance of 30-50 m from the defence toe, and is available for recovery. Over the longer term (i.e. longer than covered by the topographic surveys) anecdotal observations are that there has been an overall lowering of the beach level and foreshore. This however cannot be confirmed from the available data.

Photographs throughout defence 6 (Figure 9) and defence 4 (Figure 10) during two separate winter seasons obtained via a structural inspection report following the winter 2014 storms (Ransom & Ellis 2014) and a separate site visit in 2016 suggest a similar magnitude of drawdown at the same defence toes to that shown via the LiDAR/RTK survey comparison. It is therefore suggested that within these defence sections a similar level of drawdown occurs throughout the duration of each winter season. Stability at the defence toe within defence 5 shown in Figure 8 is also shown with similar photographs (Figure 11), with no exposure of the defence toe at the base of the concrete steps during either winter.

Recovery of beach levels at the toe of the defence throughout defence 4 is indicated via photographs taken during 2016 within a 6 month period between February and August (Figure 12). A reduction of the draw-down against the sheet piling is witnessed, along with the eradication of scour surrounding the rock armour.

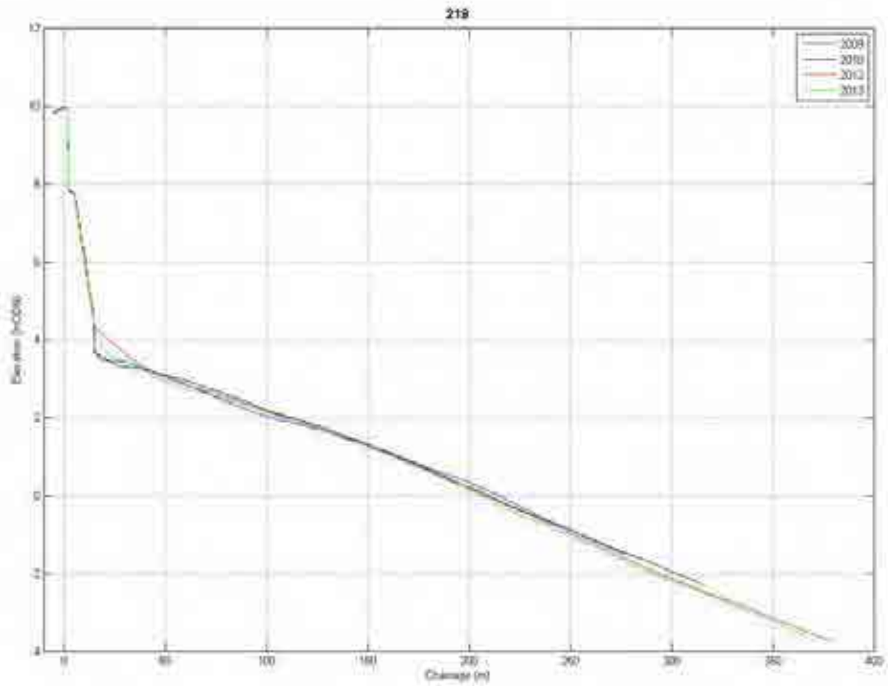
All photographs show that where the rock toe protection has been placed at both the northern and central (South) frontages, this has remained predominantly stable despite the variation in beach levels that has occurred in front or at the ends of the protection works. This indicates that the rock has been sufficient in size and profile to withstand storms conditions during the analysis period which included the large storms during the 2013/14 winter.

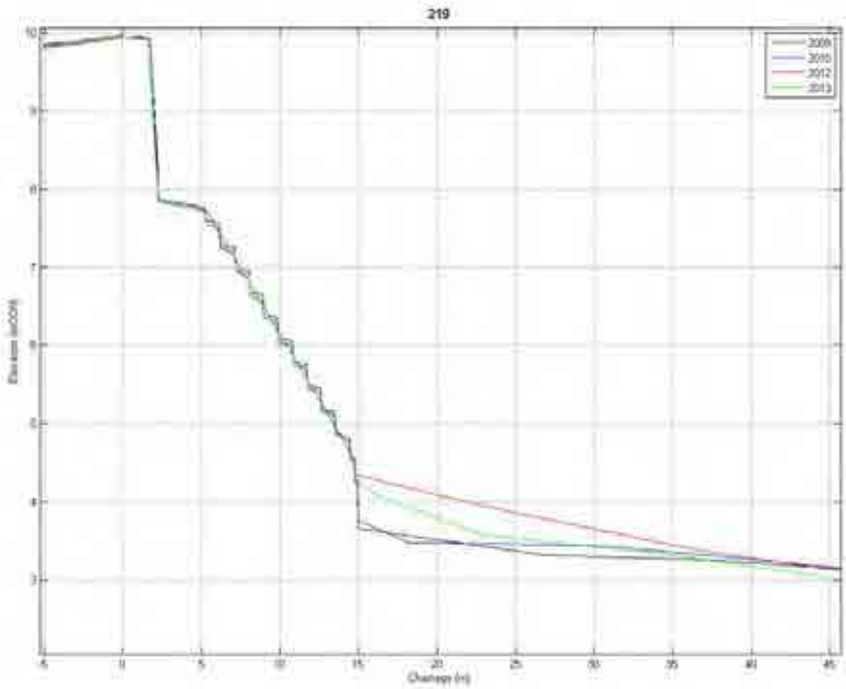
Photographic evidence exists for a failure of the existing sea defence during storms in January 1991. This showed drawdown at the defence toe and blow out of the underlying rock, but the crest of the sea defence was little affected. The SEASTATES[1] nearshore data for this period suggest a maximum wave height of about 4.5 m, around MHWS level (Table 1). The maximum water level including the wave conditions would have been around 6 mODN, i.e. still 4 m below the defence crest, and therefore no wave overtopping was likely to have occurred. Larger than normal waves occurred for a consecutive 6 day period, and the water levels throughout this period coincided approximately with the main levels of damage to the structure.

1 ABPmer SEASTATES forecast service: http://www.seastates.net/

Evidence from the photographs, LiDAR analysis and beach profiles suggests that this drawdown is limited to 20-40 m from the toe of the frontage but could be as great as 2 m immediately at the toe. The sand is deposited lower down the profile and forms the supply for beach recovery during more benign conditions.

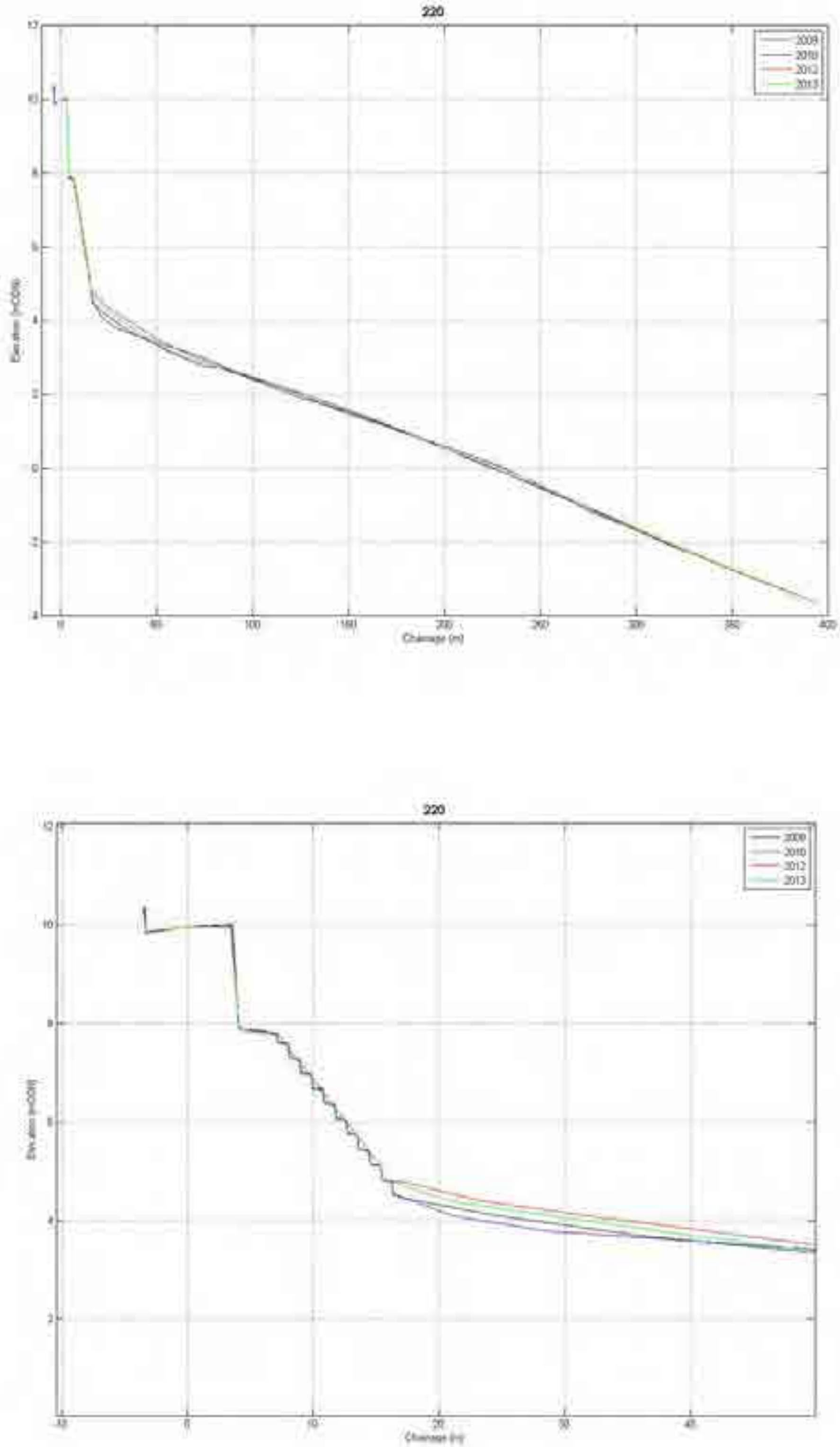
Figure 4. Beach topographic profile lines throughout Aberavon Sands





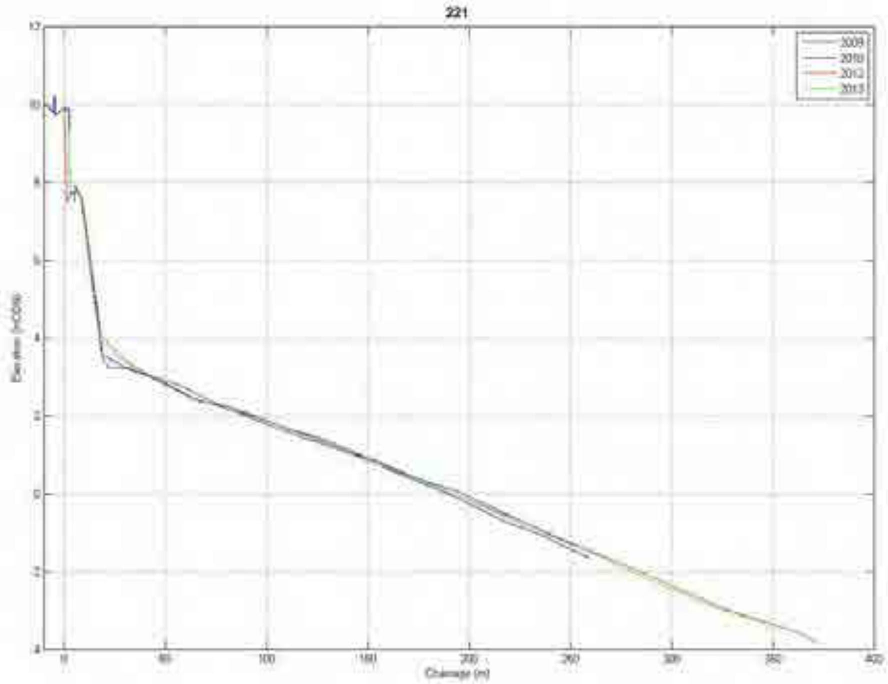
Note the reduced point resolution in 2012 survey

Figure 5. Surveys between 2009 and 2013 at Profile 219 location (defence 6)



Note the reduced point resolution in 2012 survey

Figure 6. Surveys between 2009 and 2013 at Profile 220 location (defence 4)



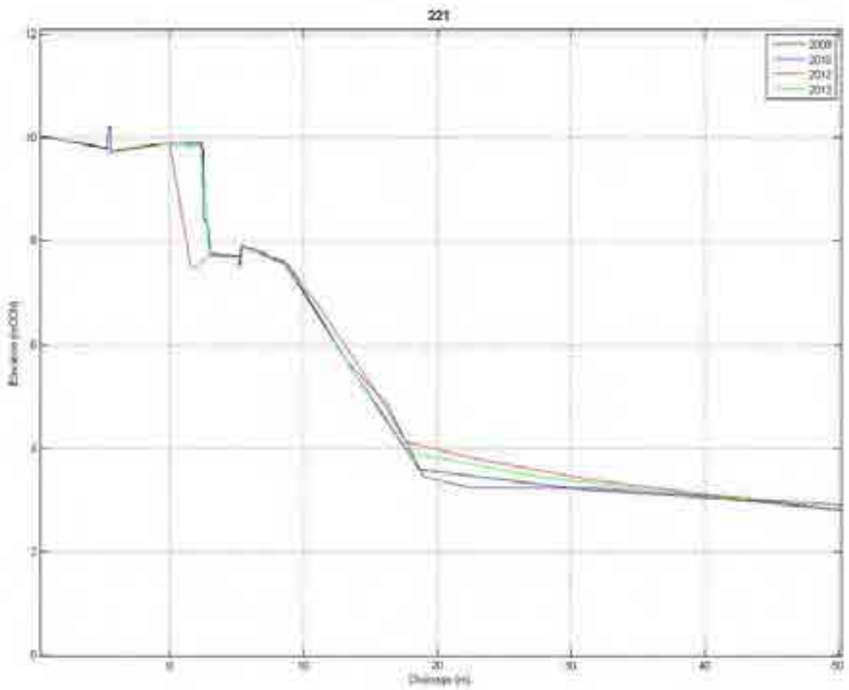
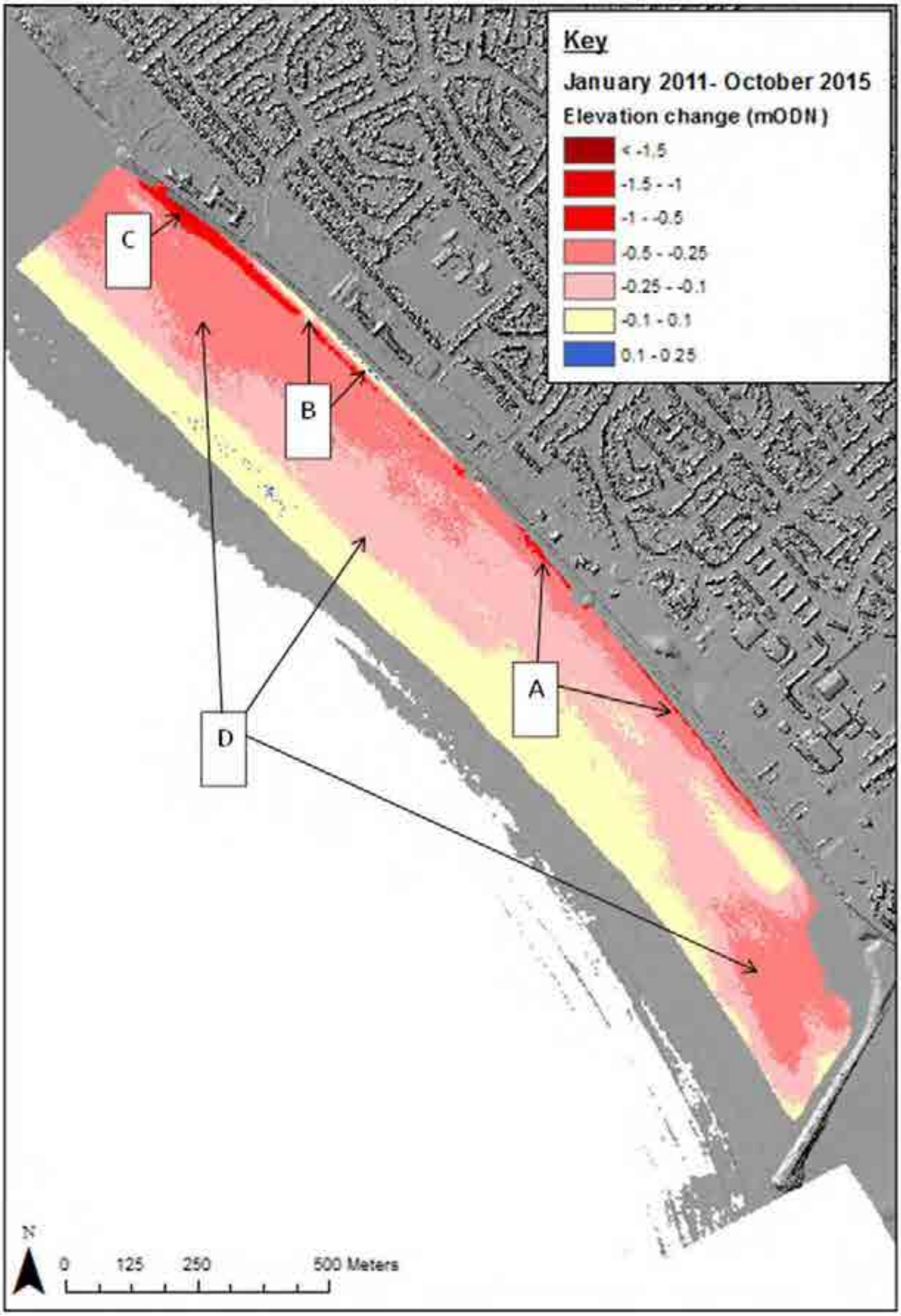


Figure 7. Surveys between 2009 and 2013 at Profile 221 location (defence 3)



Note the areas of drawn down at the defence toe, particularly throughout the northern extent.

Figure 8. Difference plot between 2011 LiDAR dataset and an RTK topographic survey carried out in 2015

Figure 9. **Defence toe drawdown throughout defence 6**

Figure 10. **Defence toe drawdown throughout defence 4**

Figure 11. **Beach levels within defence 5**

Note the reduced toe exposure and the recovery of scour around the base of the revetment in the August image

Figure 12. Photographs taken within defence 4 during winter (top) and summer (bottom) 2016

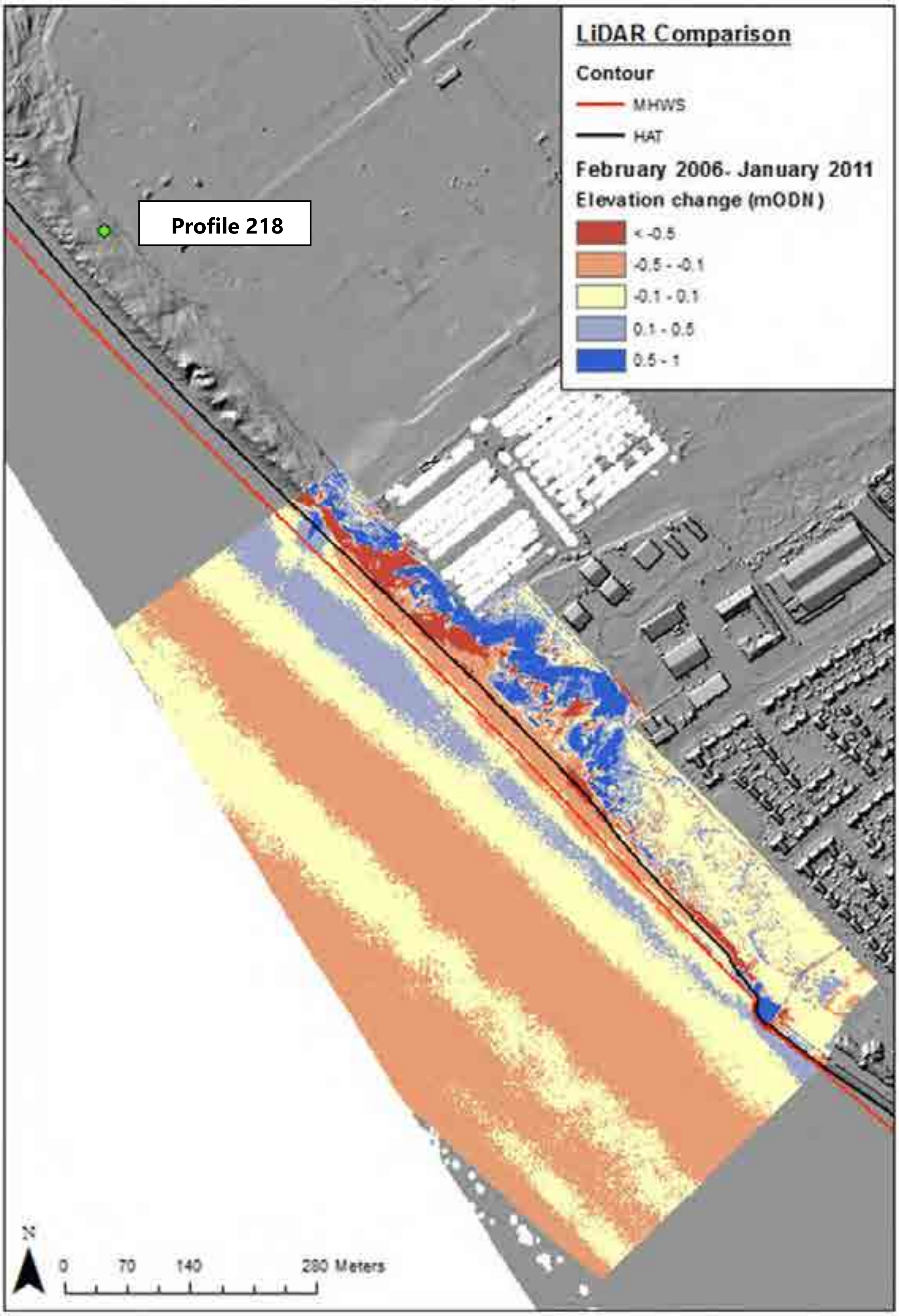
3.2.2 Undefended frontage

Stretching northwards from defence 6 towards the mouth of the River Neath a natural dune system exists, with around 2 km² of brownfield land behind the dunes containing the cleared industrial zone of Baglan petrochemical plant. Historical management of the Baglan dune system included the levelling of the pre-existing dunes, particularly within the northern sections, to raise the elevation in preparation for the construction of the petro-chemical plant in the mid-twentieth century (Pye & Blott 2014), More recently, sand accumulating in the Neath Estuary has been reported to have been recycled to the blowout areas in the dunes and possibly the beach area.

A small section of this system is contained within the present study area a section of which has some form of toe protection. The largest dunes within this section (around 20 mODN) are located immediately front the brownfield petrochemical site, and indicate a general landward recession (Figure 13) in line with the larger dune system stretching northwards outside of the study site at heights of 10-15 m above MHWS level. Evidence of dune blowout is apparent throughout this section, suggesting that the rate of recession is not entirely due to hydrodynamically induced scarping activity, but is also influenced by wind effects. Unsuccessful attempts to manage the blowouts throughout these southern dunes have been noted in previous reporting (Pye & Blott 2014).

Beach profile data between 2006 and 2009 for a cross section of dune north of the study site (Figure 14) indicates a dune recession rate (considering survey inconsistency) of 0.5-1 m/yr at the dune crest, whilst a 1-2 m/yr progradation is apparent at the dune toe. Below HAT and MHWS level (Table 1) an increase in beach level of 0.2-0.5 m is apparent. Evolution within the dunes containing the profile location has been previously suspected to be due to transport modification as a result of historical straightening and construction of the Neath channel training wall (Halcrow 2012)., Removal and spreading of sediment from the Neath channel over the adjacent beach and dune system on the Aberavon side has occurred since 2000 (Pye & Blott 2014).

Rock armour is present at the toe of the lower southern dunes that leads into defence 6. Scarping and fine sediment removal is apparent from site photos (Figure 15), providing evidence of the higher elevation cliff recession seen within the LiDAR comparison (Figure 13). Patches of recent sand subsidence can be seen, along with grass overhang. Analysing the 2011 LiDAR suggests that the toe of these dunes are 4-5 m above HAT level and therefore scarping activity is likely to only be ongoing during extreme wave and tidal surge conditions, as suggested within the SMP (Halcrow 2012).



Note the recession of the dunes, and the location of profile 218 in relation to the study area

Figure 13. Beach elevation difference between 2006 and 2011 LiDAR

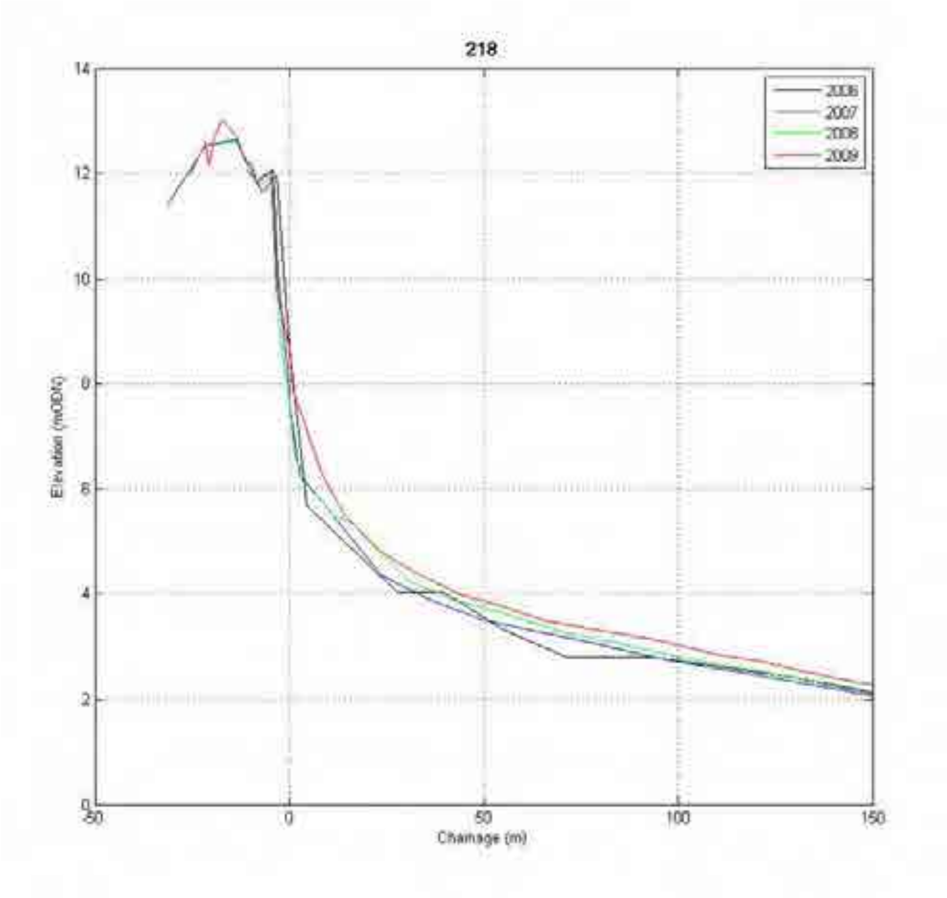


Figure 14. **Topographic profile 218 within the dune system to the north of study area**

Figure 15. **Scarping and upper beach protection of the southern dune system**

3.3 Future evolution

Under the study's do minimum scenario the revetments are anticipated to be subject to patch and repair. Beach levels are likely to remain volatile and the risk of lowering increased with SLR and storm events. Revetment sections not protected by rock armour are likely to be subject to higher levels of scour and beach drawdown. No intervention is anticipated for the dune system and recession will continue.

For the do nothing scenario predictions of the future evolution of the frontage have been reviewed against the shoreline management plan (SMP2). Due to the highly developed nature of the coastline, the natural processes have been significantly altered and therefore the future evolution will also be strongly controlled by the ongoing shoreline management activities and the presence of coastal structures, in particular the breakwaters, training walls and shoreline revetments.

The SMP2 predicts that under the do nothing scenario sea level rise will result in increased exposure and pressure on the existing defences resulting in failure in the middle epoch (20-50 years). As well as locally increasing flood and erosion risk, SMP2 predicts failure of the majority of the defences will also affect the large-scale dynamics of the Bay system. This is likely to upset the current state of dynamic equilibrium. The impact of such a large-scale change is very uncertain, but it is stated that it could result in increased tidal flows into and out of Swansea Bay, due to flooding of low-lying back barrier areas along the eastern side of the Bay (Aberavon), with the potential for increased beach drawdown and shoreline retreat. This would also result in frontal dune erosion. Failure of defences within the Neath Estuary will also allow the low water channel to evolve more naturally, affecting erosion and accretion on either side of the mouth (Halcrow 2012).

In the long term, as further defences fail, the large-scale dynamics of the Bay system will be further perturbed. There is potential for this to increase beach drawdown, with resultant shoreline retreat and frontal dune erosion. This process will be accelerated by sea level rise and unless there is a significant increase in sand supply, the net trend along the western side of the Bay will be frontal dune erosion. Along the eastern side of the Bay, failure of defences will increase erosion and flood risk to the urbanised frontages. In general, erosion of the backing promenade areas is likely to be fairly rapid initially, once defences fail, exposing assets behind (Halcrow 2012).

The dunes to the north of this study frontage will be affected by changes to the Neath Estuary and the failure of the river channel training walls. The SMP notes that there has been a recent trend of accretion along Whiteford Point. However, the ongoing accretion of the Crymlyn Burrows on the other side of the estuary may push an unconstrained channel towards the Baglan shoreline and hence increase the rate of erosion and recession.

The SMP highlights that there are, however, a number of uncertainties in predicting the future evolution of the Bay. Amongst the biggest uncertainties are the potential effects of possible changes in the bathymetry of Swansea Bay, average wind and wave conditions and the frequency and magnitude of major storms. While an increase in the frequency of moderate storm events may lead to further beach and dune erosion on exposed sections of the coast, increased incidence of major storms could increase the transfer of sandy sediment from the deeper parts of the Bay, below normal wave base, towards the coast (Halcrow, 2012).

3.4 Water levels

3.4.1 Tidal water levels

The study area is within the Bristol Channel, which is within a hyper-tidal environment, with a spring tidal range in excess of 6 m. This is due to the behaviour of the tidal wave originating in the North Atlantic and the funnelling effect of the channel, which in turn modifies the behaviour of the tidal wave. Within the study area, the tidal range is approximately 8 m during spring tides, reducing to just below 4 m during neap tides (Table 1), which is characteristic for coastal locations within the Outer Bristol Channel. The conversion from chart datum to ordnance datum (at Newlyn) for Mumbles and Port Talbot is -5.0 m and -5.3 m respectively.

Table 1. Tidal characteristics at Mumbles and Port Talbot

Location	Reference Still Water Level							Mean Range (m)	
	HAT	MHWS	MHWN	MSL	MLWN	MLWS	LAT	Spring	Neap
Mumbles (mCD)	10.5	9.5	7.2	5.2	3.3	1.1	0.1	8.4	3.9
Mumbles (mODN)	5.5	4.5	2.2	0.2	-1.7	-3.9	-4.9		
Port Talbot (mCD)	10.8	9.7	7.3	5.4	3.5	1.1	0.2	8.6	3.8
Port Talbot (mODN)	5.6	4.5	2.1	0.2	-1.7	-4.1	-5.0		

Source: UKHO 2016

The hyper-tidal range at Aberavon means that the existing frontages throughout the length of the beach are only exposed to the incident wave climate for the higher elevation periods of the tidal cycle. Reference still water levels calculated from LiDAR (Figure 16) suggest that the toe of the sea defences are in direct contact with wave conditions at Mean High Water Springs (MHWS). However at Mean High Water Neap (MHWN), Mean Sea Level (MSL) and Mean Low Water Neap (MLWN), contours are approximately 100 m, 205 m and 290 m offshore of the frontage toe, providing a wide gently shelving beach front that allows significant dissipation of wave energy towards the defences. The potential exposure to wave overtopping is suspected to be limited temporally by the tidal cycle in normal conditions. However these contours are likely to advance onshore during both surge and storm conditions, and therefore the potential for wave overtopping is enhanced. Evidence from the photographs, LiDAR analysis and beach profiles suggests that this draw down is limited to 20-40 m from the toe of the frontage but could be as great as 2 m immediately at the toe. The sand is deposited lower down the profile and forms the supply for beach recovery during more benign conditions.

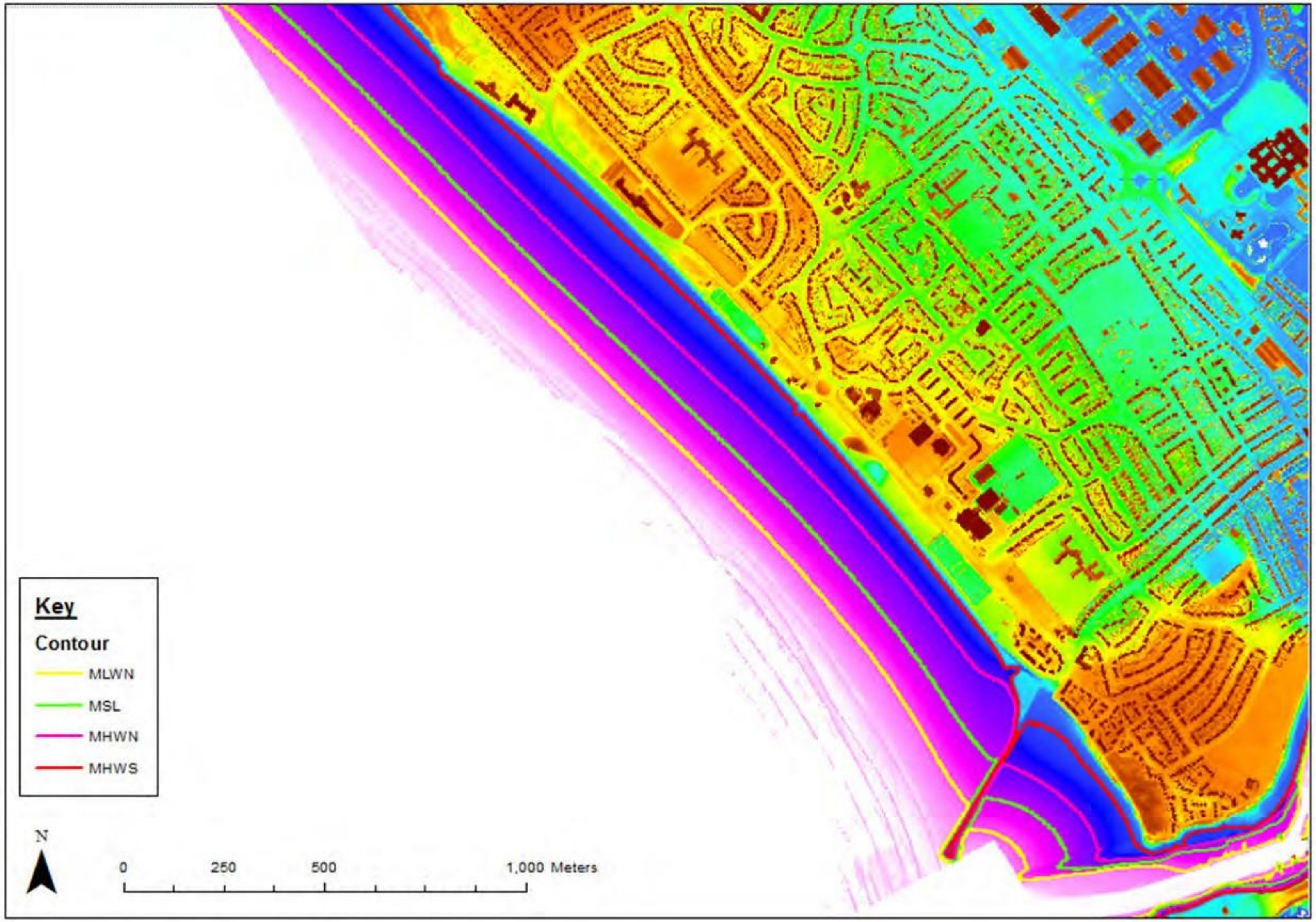


Figure 16. Relative still water levels (mODN) along Aberavon sands in respect to 2011 LiDAR

3.4.2 Surge

The Bristol Channel is affected by storm surges which are generated by the movement of Atlantic depressions across the UK. The most significant storm surges are associated with the events which track southerly across Ireland and generate strong south westerly winds. These winds force water up the Bristol Channel. The occurrence of surge events within the Bristol Channel has the potential to increase water levels by up to 2 m. At Mumbles, west of Aberavon, the largest surge height recorded at 15 minute intervals by the tide gauge between 1990 and 2014 measured approximately 1.8 m (ABPmer 2005), whilst the greatest negative surge was around -0.90 m on the 13 February 2005 (NTSLF, 2013). The highest measured water level at the Mumbles gauge over this time period was 5.63 mODN, recorded on the 8 October 2006, which relates to a relatively small positive surge of approximately 0.22 m on a very large spring tide; equivalent to 0.12 m greater than HAT.

UKCP09 predictions for future change in storm surge across the region indicate an increase in the 1 in 50-year storm surge height of up to 0.8 mm/yr (Lowe *et al*., 2009). This projected increase remains an uncertain estimate as there is inherent difficulty in predicting storm surge events due to the complicated interaction of many marine and meteorological factors.

3.4.3 Extreme water levels

The Environment Agency coastal flood boundary dataset (CFBD) provided an assessment of extreme water levels in proximity to Aberavon Sands as summarised in Table **2**. These provide the extreme water levels associated with different return periods ranging from 1 in 1 year to 1 in 1,000 years, considered accurate to one decimal place. Generally, it is the coincident occurrence of extreme surge heights with high water levels that is considered to bring about extreme water levels within the study region.

Generally, it is the coincident occurrence of extreme surge heights with high water levels that is considered to bring about extreme water levels within the study region. Observed occurrences of extreme water levels at Aberavon between 1989 and 2014 measured a height of 5.85 mODN, recorded on the on 20 February 2007. Between 1989 and 2014, there were twenty occurrences of water levels at or above HAT (Table 3).

Table 2. Extreme water levels for base year of 2008 (Environment Agency CFBD, 2011) and adjusted to include sea level rise for 2018 and 2118 epochs (EA Location Chainage 480)

Return Period (Years)	EA Chainage 480 (mODN)	Epoch 2018 (mODN)	Epoch 2118 (mODN)
1:1	5.49	5.54	6.30
1:10	5.76	5.81	6.57
1:20	5.85	5.90	6.66
1:50	5.96	6.01	6.77
1:75	6.03	6.08	6.84
1:100	6.07	6.12	6.88
1:200	6.18	6.23	6.99
1:1000	6.45	6.50	7.26
Note: Epoch values have been calculated using a linear extrapolation of the time series beyond the published data.			

Source: Environment Agency, 2011

Table 3. Water levels reaching (or above) HAT at Aberavon

Date and Time	Water Level (mODN)
20/02/2007 08:00	5.85
03/01/2014 07:00	5.78
28/09/2007 19:00	5.74
19/02/2007 07:00	5.74
08/10/2006 19:00	5.72
29/08/1992 19:00	5.72
02/03/2014 07:00	5.72
10/03/2008 08:00	5.70
09/03/1989 07:00	5.69
30/03/2006 07:00	5.69
01/02/2014 07:00	5.68
03/02/2014 09:00	5.68
29/09/2007 20:00	5.65
27/10/2007 19:00	5.65
28/10/2007 07:00	5.64
30/08/1992 20:00	5.62
21/02/2007 09:00	5.57
17/10/1997 19:00	5.56
02/02/2014 08:00	5.56
10/03/2001 07:00	5.56

Observations from Mumbles tide gauge were locally adjusted for Aberavon, with SEASTATES model filling any gaps within the time series. Red values indicate levels above HAT.

3.4.4 Relative sea level

The Bristol Channel has historically experienced changes in relative sea levels. More recently, the general trend for the southwest of the United Kingdom (UK) (as given at Newlyn, between 1916 and 1996) is of an increase in relative mean sea-level at an average rate of 0.17 ±0.012 cm per year (Woodworth, *et al*., 1999). A further analysis of the tide gauge data from Mumbles over a shorter period (between 1990 and 2010) suggests a rate of increase of 0.11 cm per year.

Future changes in relative sea level (RSL) are quoted as the net effect of geological adjustments in land levels and the projected absolute changes in mean sea level. A summary of the UKCP09 relative sea level rise projections up to 2100 and extrapolated up to 2118 for this project for the grid cell 23263 at Aberavon Sands, based on the medium emission scenario, for the range of confidence intervals are provided in Table 4.

For the climate change simulations in the study the medium emission scenario 95 percentile for an epoch *circa* 100 year in the future was calculated at 0.75 m from 2018 to 2118 using UKCP09 as per Welsh Government Adapting to Climate Change Guidance (2011[2]).

2 http://gov.wales/docs/desh/publications/111231floodingclimatechangeen.pdf

Table 4. Medium emissions scenario predicted relative sea level rise since 1990 (in m) for Aberavon

Year	Confidence Intervals 95 %ile
2000	0.044
2010	0.092
2018	0.135
2020	0.145
2030	0.203
2040	0.264
2050	0.331
2060	0.401
2070	0.476
2080	0.555
2090	0.638
2100	0.726
2118	0.888

Source: UKCP09 Grid Cell 23263

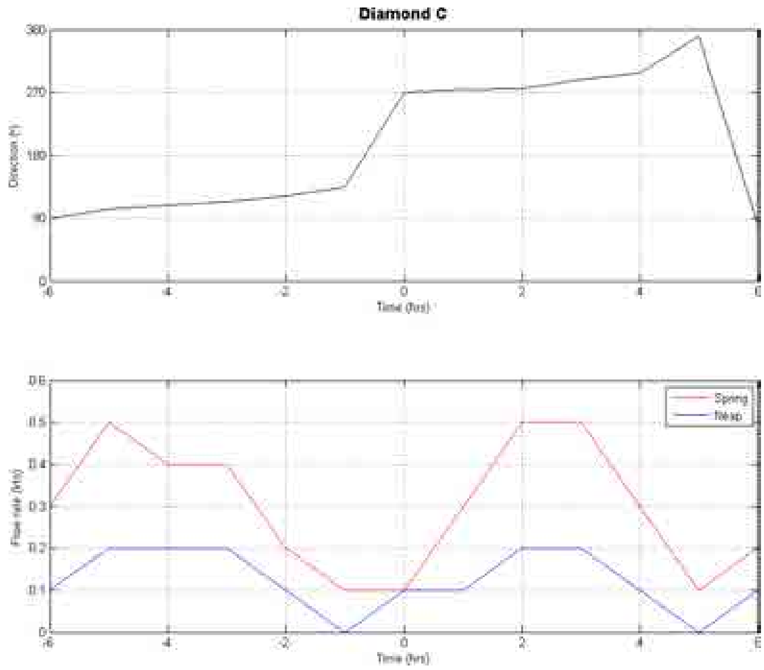
A general increase in RSL is likely to result in a number of effects, such as, displacing the high water mark towards the shoreline, enabling wave energy to move further towards the coast (exposing the shoreline to greater magnitudes and periods of wave and tidal energy) and increasing potential flood risk. The magnitude of these effects will vary depending upon the rate of predicted sea level rise and the timing relative to the 18.6 year lunar nodal cycle variations (which will impart a larger variation in amplitude over shorter timescales).

3.5 Currents

3.5.1 Tidal currents

The tidal regime within the Bristol Channel is characterised by strong tidal flows, on an east-west axis, as a result of the large tidal range and channel morphology. The current speeds vary spatially both along and across the coastline in line with channels, sandbanks and intertidal flats. The large tidal range within the Bristol Channel influences the extent to which waves interact with the seabed and able to supply additional forcing to the tidal current regime.

Tidal stream data located approximately 2 km southwest of Aberavon Sands (Figure 17) suggests peak current speeds in the nearshore are comparatively low within the study area compared with the offshore region, where maximum currents over the spring tide cycle have been observed between 1.5-2 m/s (Halcrow, 2001). Peak flow during spring tides is 1 m/s, with neap rates lowering to a maximum of 0.4 m/s. Flow is generally easterly or south-easterly in direction during the flood tide and north-westerly during the ebb.



Source: UKHO, 1999

Figure 17. Tidal stream data offshore of Port Talbot steelworks

GPS drogues deployed within the Aberavon nearshore (Neath Estuary Group, 2016) during calm conditions highlight two main points:

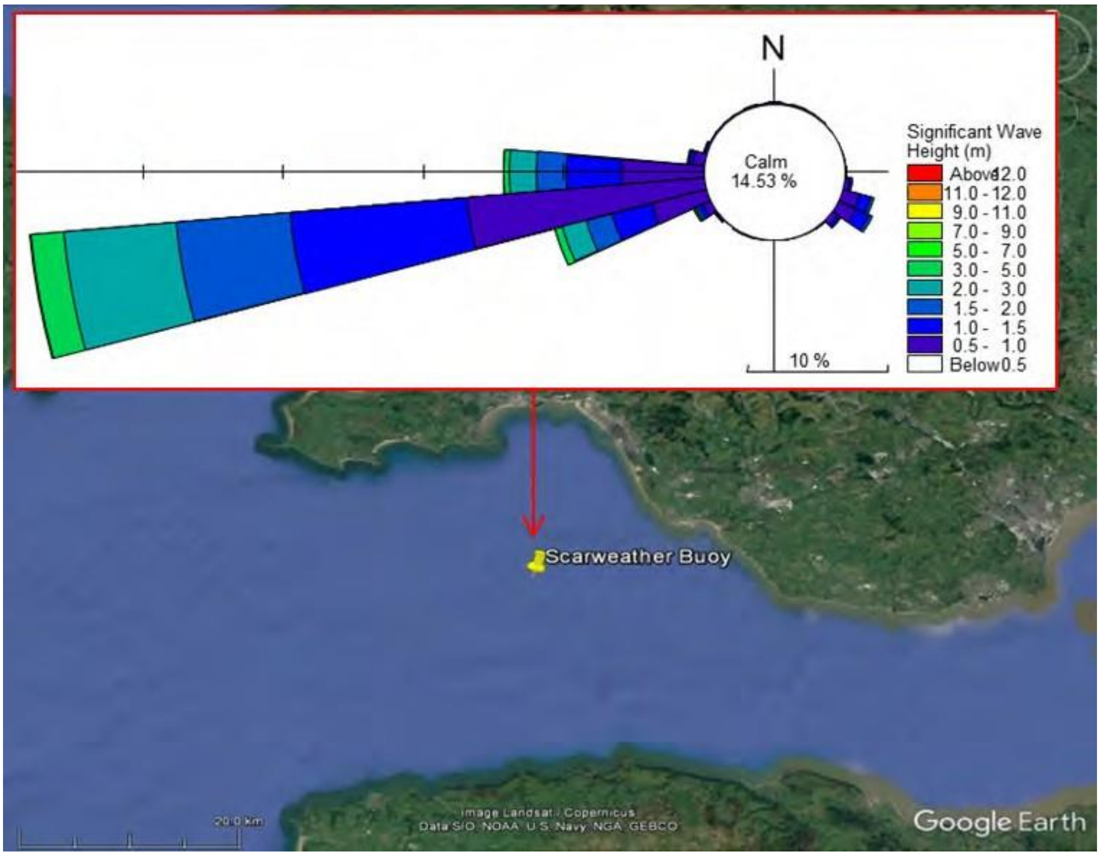
- A variance in flood tide flow orientation between spring and neap cycles. Flows at the southern end of the beach undergo a shoreward rotating curve during the neap cycle, alternating to a seaward rotation during springs. This is thought to be due to the breakwater and Port Talbot outer harbour. In the central section of the beach the opposite occurs, with a seaward flow rotation during neaps. This forms a partial rip-current system, of which is then cancelled out during springs. Rip current systems within southern sections of Aberavon Beach have been observed in previous modelling (HR Wallingford, 1994).
- During ebb tides flow of 0.02 to 0.31 m/s in magnitude run parallel to the shoreline in a north-westerly direction, beginning before predicted high water and with little directional deviation throughout the spring/neap cycle. These are similar to those seen offshore and therefore support the wider regional ebb-dominated flow schemes witnessed throughout the Bristol Channel.

3.6 Waves

3.6.1 Regional wave climate

The Bristol Channel is exposed to both long period swell waves generated in the Atlantic and shorter period wind-waves generated locally within the Channel, which are limited by wind speed and fetch length. The largest waves and most frequent direction for waves to approach the study area are from a WSW direction, with northern extents of Swansea Bay likely to experience a sheltering effect from Mumbles Point.

Data from the Scarweather WaveNet buoy located SSW of Aberavon in the Outer Bristol Channel (Latitude 51° 25'.99N, Longitude 003° 55'.99W) at 35 m water depth is used to inform the offshore wave climate. At this buoy an average significant wave height (Hs) of 1.2 m and peak wave period (Tp) of 8.6 seconds was observed for the period between July 2005 and November 2015. Waves dominantly approached from WSW for nearly 50% of the time, with significant wave heights of up to 7 m (Figure 18). The largest recorded significant wave height in the time series is 11.11 m on the 10 May 2014.



Map data ©2016 Google. Image © 2016 Terrametrics. Data © SIO, NOAA, U.S. Navy, NGA, GEBCO.

Figure 18. Significant wave height at the Scarweather WaveNet buoy between July 2005 and November 2015

3.6.2 Local wave climate

In order to accurately represent wave conditions in the nearshore of the site ABPmer has used the SEASTATES database of hindcast offshore data (ABPmer 2013, 2016). SEASTATES is a fully spectral wave model which covers the North Atlantic and European shelf seas, and is driven by the spatially and temporally varying CFSR (Climate Forecast System Reanalysis) wind fields developed by NOAA (National [American] Oceanic and Atmospheric Administration). The SEASTATES hindcast has been previously validated against 28 buoys within UK and European waters. 37 years of hindcast wave conditions are coupled with 37 years of modelled water levels to represent the complexities of the wave climate in the immediate nearshore (Table 5).

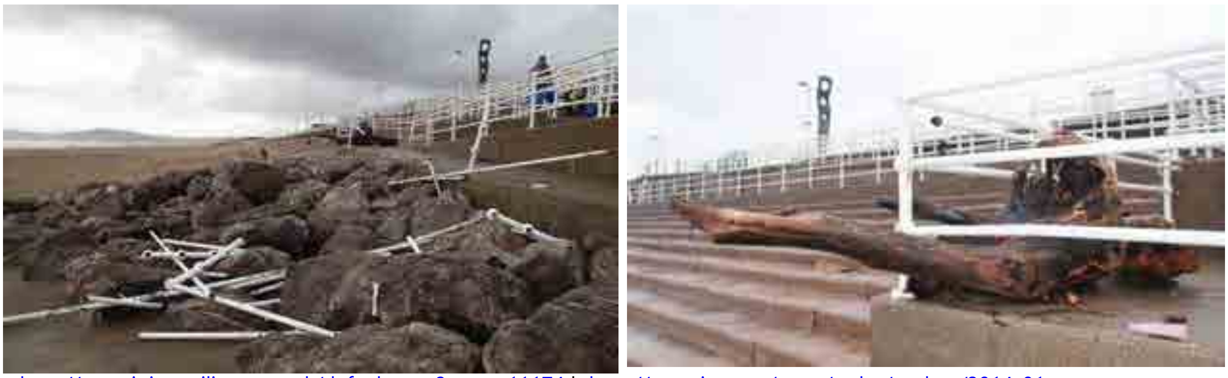
Aberavon Sands are directly exposed to the larger south-westerly wave climate, with significant wave height (Hs) ranging between 0.2 m and 1 m during normal conditions. The relatively straight beach face results in little refraction, with wave direction at the toe of the sea defence remaining south westerly throughout the extent of the beach and frontages assessed in this study. Little refraction and diffraction occurs from the breakwater to the south of the site due to its parallel orientation with the direction of the incident waves.

Table 5. Average wave statistics at the toe of frontages along Aberavon

Toe Frontage	Average Significant Wave Height Hs (m)	Average Peak Wave Period Tp (s)	Average Wave Direction (°)
1	0.42	7.1	222
2	0.53	7.4	225
4	0.47	7.4	224
6A	0.66	8.2	231
Locations are shown within (Figure 20)			

Increased wave energy is apparent towards the very south of the site, with Hs values exceeding 1 m on a more frequent basis, with Hs values over 2 m also apparent. Previous wave modelling work along this section of beach (HR Wallingford 1994) suggests similar "normal condition" Hs and Tp values to those reported here. This increased wave activity is likely to result from a small increase in beach slope towards the southern end of the site and generally deeper offshore bathymetry along the axis of wave approach. The central and northern frontages are suggested to be protected more from the shallows of the Outer Green Ground, the wider intertidal and shallower foreshore areas, which will tend to refract waves more to the west, provide greater wave dissipation and increase wave shoaling.

Evidence of structural damage to the sea defences as a result of storm wave conditions was apparent at Aberavon was throughout the 2013/14 winter (Figure 19), with crest railings removed from their foundations and significant amounts of debris scattered upon the defences.



a http://www.jointresilience.co.uk/default.aspx?page=11174 b http://www.itv.com/news/wales/update/2014-01-04/aberavon-beach-at-port-talbot-littered-with-debris/

Figure 19. Evidence of damage to the defences throughout the 2013-14 storms

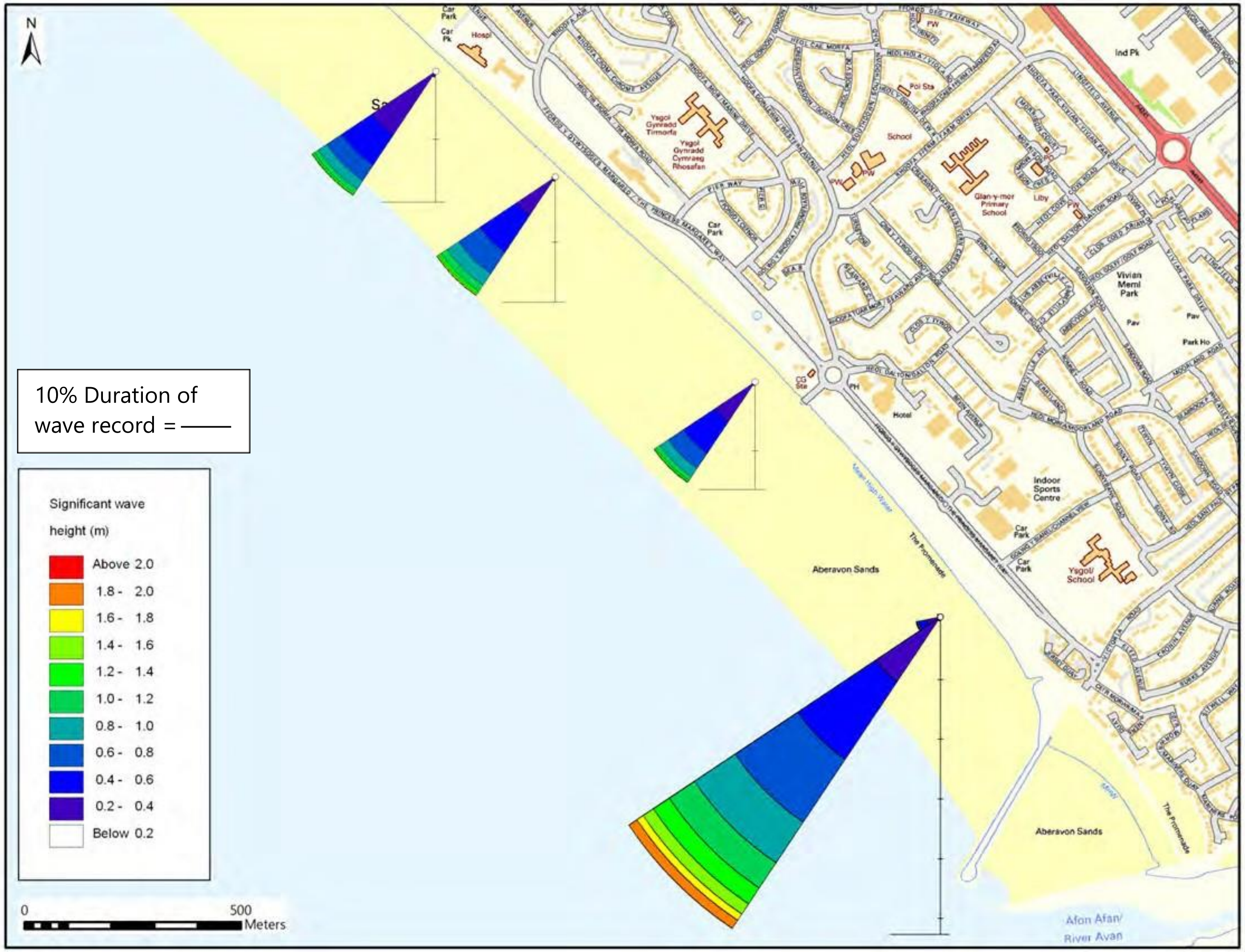


Figure 20. **ABPmer SEASTATES modelled significant wave heights at defence toe locations throughout Aberavon Sands**

3.6.3 Extreme waves

The period between mid-December 2013 and mid-February 2014 according to the Met Office, was the stormiest period of weather the UK had seen for at least 20 years, with the storms during early and mid-February being particularly severe. Subsequent analysis (Haigh *et al*. 2016) has identified that this winter season contains the largest number of extreme sea level events in any season in the last 100 years. At the offshore location of the Scarweather buoy, on 12 February 2014 (which coincided with a neap tidal period), an Hs of 8.2 m was recorded, associated with peak wave period of nearly 12 seconds (and zero-crossing wave period (Tz) of 10.3 seconds), approaching from the west-southwest. This is the direction from which maximum wave energy reaches the Aberavon frontage. Such waves however, will have attenuated significantly as they move over the shelving bathymetry towards Aberavon. The storm occurred on neap tides; therefore water depths would have been at least 3 m lower than would have been the case for spring tides. The high waves would have broken offshore reducing the impact at the defences. Despite this the photographs indicate a beach drawdown at the toe of the frontage of *circa* 2 m at certain locations. Subsequent photographs suggest that the effect may not have fully recovered by November 2016, although some partial recovery is evident. It should be noted that where frontage toe protection has been installed, the storm appears not to have affected the protection. It is also evident that if the storms had occurred on spring tides then beach drawdown could have been significantly greater and there could have been conditions conducive to failure of the base of the defences as occurred in 1991.

The Environment Agency assessment of extreme wave conditions for a coastal location in proximity to Aberavon Sands, indicated waves heights of around 3 m and above for different return periods (Table 6 and Table 7). As represented in the observed data, the largest waves generally approached from the southwest.

Table 6. Environment Agency extreme swell waves (m) for cell GL2396

Wave Approach Direction	Return periods (years)					
	1:1	1:10	1:20	1:50	1:100	1:200
Southwest	3.0	3.3	3.4	3.4	3.5	3.5
Northwest	2.3	2.8	2.9	3.0	3.1	3.2

Table 7. Environment Agency extreme swell waves period (s) for cell GL2396

Significant Wave Height (Hs, m)	Zero-crossing Wave Period (Tz, seconds)					
	<8	8 - 10	10 - 12	12 - 14	14 - 16	>16
<1	0.53	0.24	0.13	0.08	0.02	N/A
1-2	0.43	0.28	0.16	0.09	0.03	N/A
2-3	0.42	0.41	0.15	0.02	N/A	N/A
3-4	0.67	0.22	0.11	N/A	N/A	N/A
4-5	N/A	N/A	N/A	N/A	N/A	N/A
Measures relate to percentage occurrence						

The results of this analysis and the model transformation of the data to Aberavon, extreme analysis and then sea defence wave overtopping analysis is presented in ABPmer (2017). This analysis provides information for locations near the toe of the sea defence, taking account of the refraction and shoaling throughout the intertidal beach. These effects are not represented in the previous datasets described above.

4 Conceptual Understanding

Complex processes are present at Aberavon due to a combination of intense anthropogenic modification of the surrounding coastline within Swansea Bay, and variation in the forcing of overall sediment transport processes via offshore and nearshore hydrodynamics.

Low magnitude tidal currents within nearshore locations close to and throughout Aberavon beach are present compared to offshore regions within Swansea Bay. Furthermore, recent studies suggest that localised current regimes exist along the beach extent; varying in magnitude and direction throughout the spring/neap tidal cycle. As a result the majority of sediment modification and transport within the site boundaries is controlled primarily by wave conditions, although the levels of wave exposure that the defences will experience are likely to be limited temporally by the large tidal range. Aberavon Sands is directly exposed to the predominant westerly and south-westerly wave climate, with little or no modification of offshore generated waves such as those seen at Scarweather except from the shoaling bathymetry. Mumbles Head does not provide any significant sheltering from the predominant wave activity at Aberavon as it does in the west side of the Bay. The location of Aberavon in the east side of Swansea Bay means that only small levels of wave refraction occur as waves enter the nearshore, with wave direction consistently in a SW direction shoaling near parallel to the shoreline and bathymetric contours, particularly to the south-eastern frontage, In the central and northern frontages depths shallow further offshore providing more protection. This potentially explains why the beach level is lowest towards the south of the frontage and greater wave energy is seen to reach the beach and defence structures. The net littoral drift throughout the beach appears to be small and predominantly towards the northwest. This is demonstrated by a wider beach face above MHWS throughout central (north)/northern frontages and within the northern dune system.

Historically much of the shoreline modification and development at Aberavon has been built upon the existing dune system. This has prevented the natural rollback expected in an unaffected system (Halcrow 2012). Even in the dune section, roll-back is limited, with recession only occurring well above the reach of normal tides. Progradation and stability appears to be most evident since 2009. With other maritime developments in the last century such as the construction of the Neath channel training wall and Port Talbot outer harbour, sediment movement in the nearshore throughout the eastern side of Swansea Bay has been significantly modified. Evidence of large scale onshore sediment movement has been previously reported throughout the eastern side of the Bay, with single storm events transporting the equivalent of one year's volume of dredge material back into the Port Talbot channel and outer harbour (Jackson & Norman 1980).

More recently, prior to extreme winter wave conditions witnessed during the winter of 2013/14, variation in beach level at the defence toes of up to 0.5 m occurred annually. These demonstrate that variability of sediment levels within the nearshore and along Aberavon beach are not un-common, but are in fact likely to be a regular occurrence. Post 2013/14 winter, photographs throughout various defence sections provide evidence of consistent drawdown in the winter months, whilst also suggesting partial recovery throughout the summer of 2016. More evidence is required at this stage to support these photographs in proposing a seasonal variability, however considering the properties of the site, its exposure to the offshore wave climate, and the available data, it is suggested this may be the case.

Overall, the beach and foreshore along the Aberavon frontage would appear at present to be in a state of dynamic equilibrium with beach drawdown occurring during winter seasons and recover during the summer under normal weather conditions. Most movement of sediment is in the cross shore plane, with a very small net drift to the northwest, particularly at the northern frontages. There is evidence from the 2014 storms that extreme events can cause significant drawdown which may not be immediately reversible. Anecdotal observations suggest there is a net long term lowering of the beach and foreshore; however the analysis of the profiles, LiDAR datasets and photographic evidence within the last 10 years do not provide quantitative data to support this. Should a trend for long term lowering exist, then it is more likely to be a result of episodic storms events such as those in 2013/14 than from erosion during more normal events.

The considerations for future management of the coastal defences are related to managing drawdown in front of the defences, particularly in those areas where there is no scour protection. Beach levels will remain volatile and it will be beneficial for future management to include annual LiDAR surveys and monitoring of beach levels.

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6 Abbreviations/Acronyms

Arup	Ove Arup and Partners Limited
CD	Chart Datum
CFBD	Coastal Flood Boundary Dataset
CFSR	Climate Forecast System Reanalysis
GPS	Global Positioning System
HAT	Highest Astronomical Tide
Hs	Significant Wave Height
LAT	Lowest Astronomical Tide
LiDAR	Light Detection And Ranging
mCD	Metres Relative to Chart Datum
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
mODN	Metres Relative to Ordnance Datum Newlyn
MSL	Mean Sea Level
NOAA	National Oceanic and Atmospheric Administration (American)
NPTCBC	Neath Port Talbot County Borough Council
NTSLF	National Tide and Sea Level Facility
PAR	Project Appraisal Report
RSL	Relative Sea Level
RTK	Real Time Kinetic
SEASTATES	ABPmer SEASTATES forecast service
SLR	Sea Level Rise
SMP	Shoreline Management Plan
Tp	Peak Wave Period
Tz	Peak Zero Crossing Period
UK	United Kingdom
UKCP09	UK Climate Projections 09
UKHO	United Kingdom Hydrographic Office

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

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