EASTERN SOLENT | COASTAL PARTNERSHIP

SOUTHSEA AND NORTH PORTSEA ISLAND COASTAL FLOOD AND EROSION RISK MANAGEMENT SCHEMES

SCOPING STAGE REPORT

TECHNICAL REPORT 2: FLOOD RISK MODELLING

November 2012
Final Report

A partnership project by

Portsmouth City Council, Havant Borough Council, Royal HaskoningDHV Enhancing Society Together, Fareham Borough Council www.fareham.gov.uk, Gosport Borough Council, sponsored by Environment Agency

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1 VISION, AIMS AND OBJECTIVES

1.1 The Vision

The vision for this and subsequent phases of the Southsea and North Portsea Island Coastal Flood and Erosion Risk Management Schemes is to:

"Ensure the sustainable future of the City of Portsmouth by managing coastal flood and erosion risk."

1.2 The Aims

We will achieve this vision by:

1. Working together with our partners;
2. Providing cost effective methods for adapting to climate change;
3. Recognising the importance of communities, cultural heritage and the environment;
4. Maximising funding and contributions.

We will use this opportunity to explore and deliver broader benefits to shape the future of Portsmouth

1.3 The Objectives

The objectives of the next phase of the project are to:

- Manage the risk of flooding and coastal erosion to people and their property, now and in the future;
- Develop and prepare an adaptable flood and coastal risk management scheme to provide a safe standard of protection;
- Develop a robust business case to deliver the scheme;
- Obtain the necessary licenses, consents and approvals to deliver and manage the scheme;
- Provide a clear action and implementation plan for scheme delivery.

2 INTRODUCTION

2.1 Background to the Scoping Study

In accordance with Defra and the Environment Agency's guidance on coastal and flood risk management, the Eastern Solent Coastal Partnership completed a Strategy Appraisal Report (StAR) in 2011. The StAR identifies that the City is at significant risk of flooding with 4,211 residential, 364 commercial and 48 Ministry of Defence (MoD) properties currently at risk from a 0.5% annual exceedance probability of flooding (AEP) due to breaching of the existing coastal defences.

The StAR described the proposals for a 100 year flood and coastal erosion risk management strategy for Portsea Island, Portsmouth, Hampshire. In 2012, the Eastern Solent Coastal Partnership, in collaboration with the Environment Agency, gained formal approval to proceed with the Project Appraisal Report (PAR) development for Cells 1 and 4 of the StAR (Southsea and North Portsea Island respectively).

The coverage of Flood Cells 1 and 4 is shown in **Figure 2.1** and can be described as follows:

- Flood Cell 1: Southsea (Portsmouth Harbour Railway Station to the Royal Marine Museum);
- Flood Cell 4: North Portsea Island (The Mountbatten Centre to, and including, Milton Common).

In addition, the eastern part of the southern frontage is included within the study area to inform potential future beach management activities.

2.2 Purpose of the Scoping Study

Due to the importance of reducing flood risk to the City and due to the complexity of developing a robust scheme, that maximises benefits and funding opportunities, the Eastern Solent Coastal Partnership has scoped the work required to deliver the Southsea and North Portsea Island Coastal Flood and Erosion Risk Management Schemes (the Schemes).

This Scoping Stage guides all subsequent work towards the realisation of the Schemes, and is focused toward the next stage; the development of the PARs.

The purpose of the Scoping study is, therefore, to:

- Document the role and requirements of the PAR Stage to inform any future schemes' technical content and future approval processes such as;
    - PAR for Large Project Review Group (LPRG) approval;
    - Planning Permissions and other approvals for the Schemes by the Local Planning Authority (LPA) and other statutory regulators and/or consultees;
    - Preparation, completion and submission of an Environmental Impact Assessment (EIA) for any Schemes to support any approval processes.

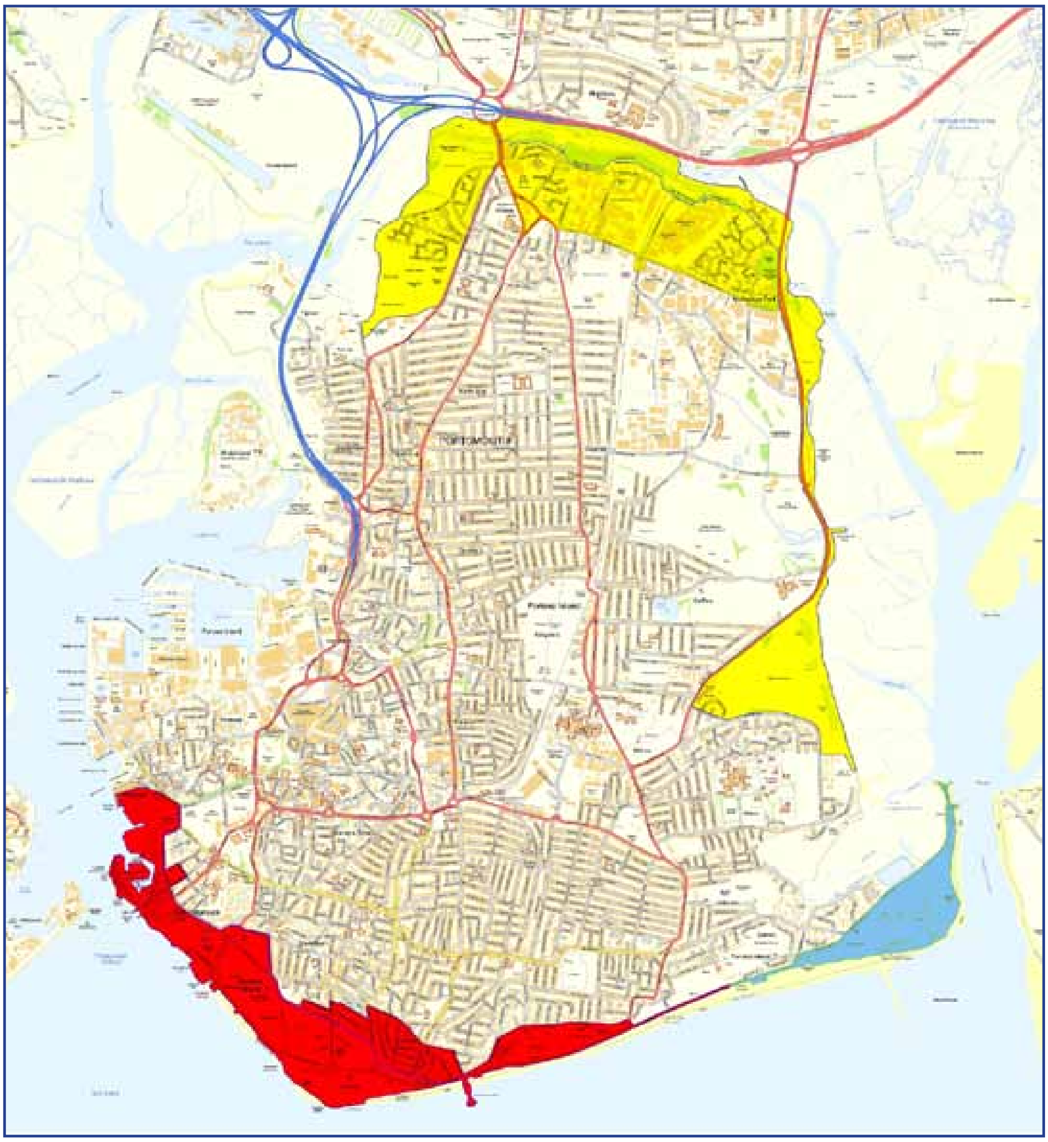


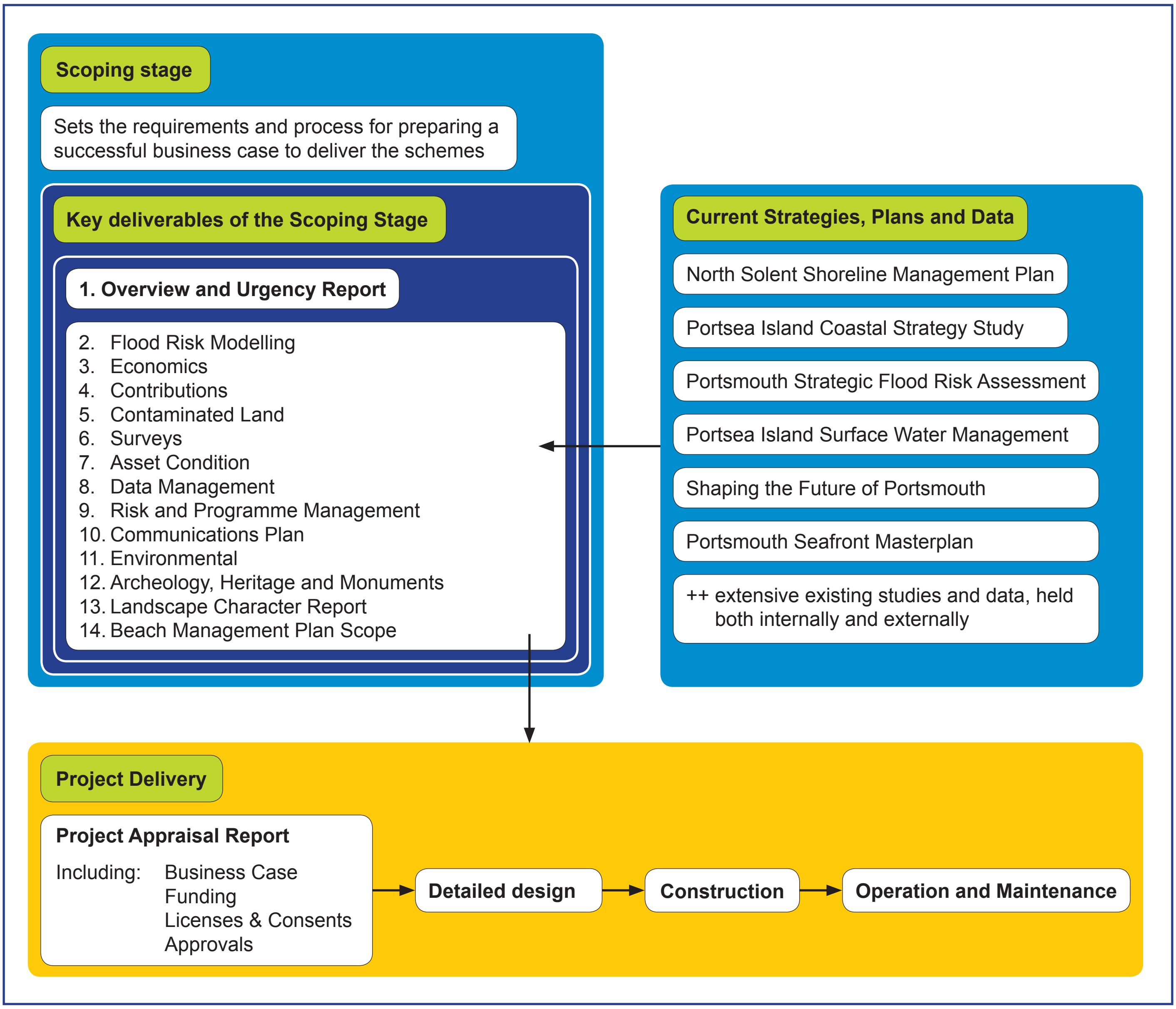
Figure 2.1: *Flood Cell 1: Southsea (shown in Red) and Flood Cell 4: North Portsea (shown in Yellow). The blue zone is included to inform potential future beach management activities.*

- Understand and identify the suitability and limitations of the existing Portsea Island Coastal Strategy Study (2002-2012) (PICSS);
- Identify the data requirements to support any scheme approval, design and construction process, including the sourcing of existing data and the identification, commissioning and collation of additional data;
- Identify a robust and resilient approach for managing data through the Scoping Stage and future scheme stages;
- Identify an engaging and proactive approach to communication within the project team, Council Members and influential internal and external stakeholders;
- Identify, share, allocate and cost project risks for managing and monitoring throughout the project;
- Generate a Project Implementation Plan;
- Produce a methodology for undertaking the PAR, and summarise this methodology in an Overview and Urgency Report.

2.3 Format of the Scoping Study

The Scoping Study comprises an Overview and Urgency Report and a number of individual assessments, which explore the requirement for delivering the PAR to achieve the necessary consents and funding to deliver an appropriate flood and coastal risk management scheme. These individual assessments are contained in the 14 Technical Reports noted in **Figure 2.2** below, with key aspects highlighted further in *Technical Report 1: Overview and Urgency*.

Figure 2.2: *Format of the Scoping Study*



3 OBJECTIVE AND FORMAT OF THE TECHNICAL REPORT

3.1 Technical Report Objective

The objective of this report is to determine what has been completed to date regarding the current and future flood risk for Flood Cell 1 Southsea and Flood Cell 4 North Portsea Island.

The assessment of flood risk is one of the key drivers for justifying coastal flood and erosion risk management schemes along the Portsea Island frontages. Flood risk modelling:

- Determines the economic damages;
- Provides information for determining optimum technical solutions for the frontages;
- Enables residual flood risk and flood warning to be assessed and planned;
- Informs the assessment of the environmental impacts.

The appropriate selection of data, methods and their interpretation to the sites around Portsea Island is important for three key reasons:

1. The flood risk extent, frequency and severity supports the process for estimating and determining economic impacts of a flood;
2. The modelling and subsequent economic assessment helps to inform, from a technical perspective, any design of options to improve flood and coastal risk. Flood modelling also supports flood and coastal risk management procedures to assets where improvements cannot be justified;
3. Robust data, methods, assumptions and mapping around flood risk underpin all other studies including economics, option design, environmental impact, planning permissions, Beach Management Plan etc.

The purpose of this report is to review the modelling undertaken to support the PICSS and determine the information that can be carried forward to any PARs.

3.2 Technical Report Format

Section 4 describes the approach used to develop this Technical Report, working in partnership with the Eastern Solent Coastal Partnership, and signposts any links to other Technical Reports produced through this Scoping Study.

Section 5 sets out the data collated through the study and available through the Eastern Solent Coastal Partnership for future use in related studies.

Section 6 describes the findings of the flood risk modelling assessment in detail and within the context of a future PAR, with Section 7 summarising the recommendations and links to the wider Technical Reports.

4 APPROACH

4.1 Working in Partnership

This Technical Report has been produced as a partnership between Royal HaskoningDHV and the Eastern Solent Coastal Partnership, with key members of the team as follows (**Table 4.1**):

Table 4.1: *Team Members*

Team member	Organisation
Hamish Hall (Author)	Royal Haskoning DHV
Julie Dunstan	Royal Haskoning DHV
Mike Walkden	Royal Haskoning DHV
Emma Moses	Royal Haskoning DHV
Bret Davies	Eastern Solent Coastal Partnership
Clive Evans	Eastern Solent Coastal Partnership
Clive Moon	Eastern Solent Coastal Partnership

4.2 Links to the Wider Scoping Stage

As part of the suite of stand-alone reports produced for this Scoping Stage, the data collated and produced and the findings from this Technical Report will contribute to the wider outputs from the Scoping Stage.

The Flood Risk Modelling Technical Report, however, is particularly key to the development of any future case to promote improved or new coastal defences for Flood Cell 1 Southsea and Flood Cell 4 North Portsea Island because it forms the basis for our understanding of the scale of flood risk to manage and in later stages the testing of approaches for managing this risk.

The Scoping Stage Technical Reports that will, therefore, directly draw on the findings presented in this Technical Report are presented in **Table 4.2**.

Table 4.2: *Wider Technical Reports with direct links to this Technical Report*

Report Number	Technical Report
1.	Overview and Urgency
3.	Economics
4.	Contributions
6.	Surveys
7.	Asset Condition
9.	Risk and Programme Management
14.	Beach Management Plan Scope

5 DATA

5.1 Project Planning Phase

The following information was identified during the Scoping Stage Project Planning Phase (November – December 2011) and used to inform the requirements for this Technical Report.

5.1.1 PICSS Review

An assessment was undertaken of four principal reports, prepared by the Halcrow Group Limited:

- PICSS: Numerical Modelling Report, June 2009;
- PICSS: Coastal Change Data, June 2009;
- PICSS: Technical Addendum to the Numerical Modelling Report (2010);
- PICSS: Coastal Defences Report June 2009.

The Partnership for Urban South Hampshire (PUSH) Strategic Flood Risk Assessment (SFRA) (2007) was also reviewed.

A detailed review of these reports was not undertaken at Project Planning Stage; however, a brief review of the following modelling parameters was undertaken, which is further developed in Section 6 of this report:

- Wave modelling;
- Wave overtopping and inland flow modelling;
- Breach Analysis.

It should be noted that there was a degree of uncertainty in the findings of the initial review owing to a lack of evidence available within the available PICSS reporting and appendices; for example details of the breach assessment and overtopping rates. Section 6 of this report furthers the flood risk modelling assessment in order to remove this element of uncertainty to reduce uncertainty and risk within future work.

5.2 Scoping Stage Data Collation and Review

The data presented in **Table 5.1** were requested for this Technical Report, with notes to record whether such data were made available to inform the Technical Report and whether it may be available for any further related studies.

Table 5.1: *Data Request at Scoping Stage and Availability*

Data	Source	Format	Procurement route	Licensing & IPR	Received (date)	Future availability and other comment
Bathymetry	Halcrow / Coastal Partnership/ CCO	Digital	N/A	TBC	29th February 2012	Only nearshore bathymetric data provided (from two of five sources used (CCO and Portsmouth City Council, PCC) within the Strategy). Royal HaskoningDHV have created a mosaic of this data.
Updated wave data	Met office, CCO	Digital	CCO website and Met Office procurement	Yes for Met Office data – PCC to purchase	N/A: decision not to purchase at Scoping Stage	To be procured from Met Office at early stage in the PAR process.
Latest Lidar	EA	Digital	EA	Yes		Filtered and unfiltered LiDAR obtained from EA Geo-store.
Halcrow wave and isis models	Halcrow	Digital	Simple handover?	TBC	Not received	Halcrow MWAVE and DAWN format means only Halcrow have the software available to access the data.
Halcrow breach assessment spreadsheet	Halcrow	Digital	Simple handover?	TBC	27 January 2012	Halcrow Overtopping spread sheet provided.
Surface Water Management Plan	PCC Highways & Halcrow	Digital	Data request to PCC Highways	TBC	14 April 2012	Available on Box in PDF format.
Old Portsmouth Coastal Strategy Study	PCC	Paper, digital (TBC)	Via PCC	N/A	January 2012	Obtained only in Hard Copy.
Portsea island TuFlow Model	Environment Agency	TuFLOW	Via PCC		5th March 2012	RH review through scoping stage suggests robust model build which could be adapted for future appropriate use. Available on Box with supporting reporting in hard copy within ESCP.

5.3 Flood Risk Modelling Assessment Method

The following approach was identified during the Project Planning Stage to undertake the Strategy flood risk modelling assessment and identify requirements for the PAR:

5.3.1 Review the Wave Modelling

- Meet with Halcrow to understand the wave modelling and get data (whole team, 5th January 2012);
- Obtain latest Met Office and recorded data (NB there will be a fee for this);
- Re-assess recorded wave climate;
- Assess impact of revised extreme sea levels on the PICSS wave climate;
- Report on the adequacy of the wave modelling (open coast, wave penetration and wind induced with the harbours) and action required for the PAR.

5.3.2 Wave Overtopping and Inland Flow Modelling

- Review joint probability assessment with new sea level data and any recommendations regarding wave climate;
- Based on current EA work, scope overtopping assessment required for the PAR with the updated and accepted wave data;
- Scope the need for additional topographic data to enable the modelling (linked to Assets Technical Report);
- Scope the requirement for 2D overland flow modelling and the opportunity to use existing model and data.

5.3.3 Breach Analysis

- Review the scoping stage review of asset condition and residual life;
- Review the overall methodology for breach assessment (why, where, when and how);
- Scope the re-assessment of breach with direct connectivity to flood risk and economics.

5.3.4 General

A working group workshop was held on 12th March 2012 to discuss the initial findings of the flood risk modelling review. Minutes of this meeting are presented in Annex 1 and attendance at this workshop comprised the following:

- Bret Davies (Coastal Partnership);
- Marc Bryan (Coastal Partnership);
- Clive Evans (Coastal Partnership);
- James Addicott (Coastal Partnership);
- John Shurvinton (PCC);
- Julie Dunstan (Royal HaskoningDHV);
- Hamish Hall (Royal HaskoningDHV);
- John O Flynn (Environment Agency);
- Ivan Parr (Environment Agency);
- Jemma Colwell (Environment Agency);
- Dominic Damarell (Minutes), Claire Short (Minutes).

6 FLOOD RISK MODELLING REVIEW AND APPROACH TO DEVELOPING ANY FUTURE PROJECT APPRAISAL REPORTS

6.1 Introduction

As stated in Section 3.1 flood risk modelling underpins flood and coastal risk economics and therefore will be fundamental to contributing to the assessment of damages, environmental impacts and the design of options for managing future risk in any future PARs developed as part of this project. Outputs of the modelling will be used by several different work streams within the PAR so it is important to maximise the benefits and opportunities arising from any modelling.

The risk of flooding from the sea is influenced by wind, waves, tides, surges, climate change, asset condition, foreshore stability, existing defence shape and threshold. All of this complex information is assessed which results in variables from which quantitative assessments of asset failure location, overtopping rates and probabilities of occurrence need to be derived.

Because of this need, it is important that the scale of the modelling is planned and defined in advance to ensure that the outputs and inputs required for the model can be clearly understood.

There are a number of models that need to be employed and numerous steps required to complete an assessment of flood risk; these have been summarised in the Flow Chart presented in Annex 2.

The following sections, using the process of the flow chart, expand upon elements of the modelling assessment to provide clarity, in the absence of specific guidance and to ensure that the correct links are made with the concurrent future PAR work streams.

6.2 Conceptual Approach

The PICSS and many similar recent projects have suffered from changing guidance and advice in relation to data and future predictions of sea level rise and extreme water levels. This has resulted in considerable delays in programmes and additional costs in developing robust business cases.

It is inevitable that there will be more changes in the standing advice on climate change and different interpretations of extremes data that could affect the outputs of the modelling. For example the Environment Agency's current advice on climate change of September 2011 notes:

"It is anticipated that over the next 12 months, wave climate projections will become available covering significant wave height, period and direction. When these are published this advice note will be updated to include that evidence."

The PAR will need to support investment over a period of years and the team recognise that there will be changes in guidance, approach or joint probability. The proposed approach aims to reduce the risks of having to re-do modelling by undertaking modelling runs at a range of levels, which can accommodate any future changes to climate change projections sea level rise guidance. This approach takes advantage of the recent improvements in computer processing power and the ability to batch models and export results automatically, but more importantly enables the modelling results to correspond to a variety of different scenarios. This is explained in more detail within the following sections, particularly Section 6.5.2 and 6.7.2 to 6.7.6.

The advantage of this approach is that many more model runs than traditionally undertaken are produced at the outset, allowing more assessments of uncertainty and the identification of cliff edge effects and other risks that could affect Portsea Island during the development of any scheme options.

6.3 Input Data

6.3.1 Bathymetry

The bathymetric data used for the PICSS and proposed for use in any future PAR development is a combination of survey data and digitised admiralty charts from several sources. Some of these data have been reviewed and appear to remain relevant to the development of any PAR.

- Gardline survey data, commissioned survey of the study area.(Data reviewed and good quality);
- Hayling data, hydrographic survey data from Havant Borough Council. (Data reviewed and good quality);
- MOD data, Detailed survey of channels in Portsmouth harbour provided by the Ministry of Defence. Not yet received;
- PCC commercial port data, data provided in hardcopy form have been digitised;
- Admiralty chart data, various areas have been digitised from charts 2045, 2625, 3148 and 2631.Not received.

The above data were combined using GIS.

The PICSS Numerical modelling report notes:

"…due to the nature of interpolation the final bathymetric data was checked against admiralty charts and corrected manually, where required, prior to use with the wave models."

Interpolated bathymetry was not received and therefore a check will be required to cross check against admiralty data and ensure no erroneous data.

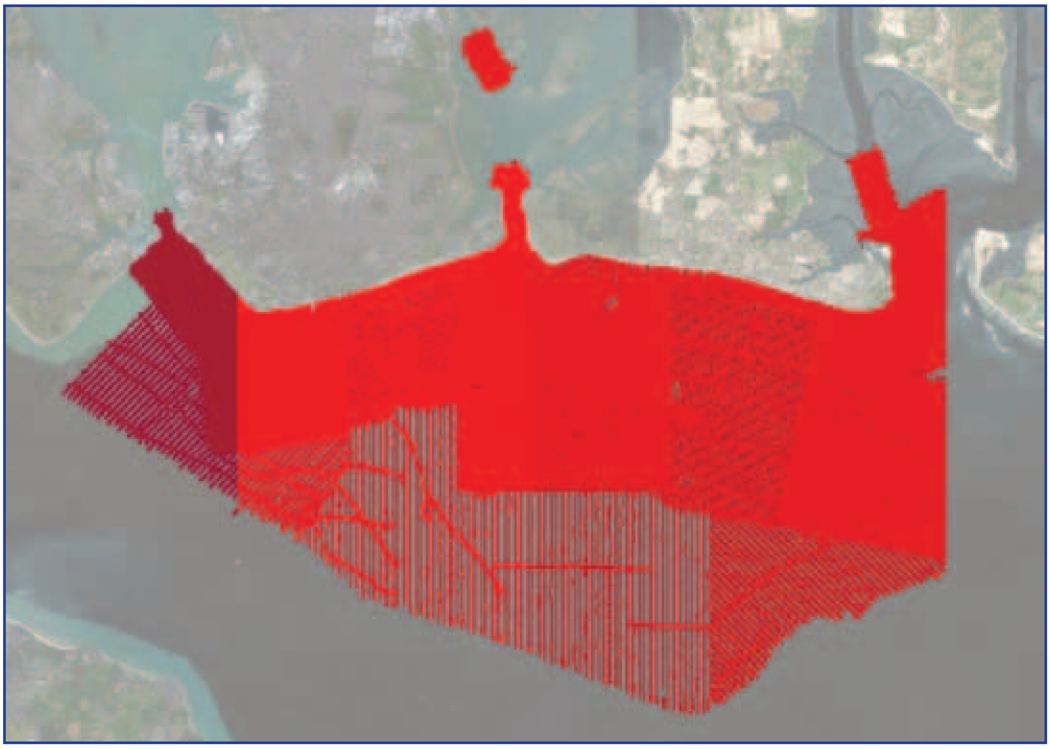


Figure 6.1: *Extent of Bathymetric data collected from CCO and Portsmouth City Council from 2004–2011.*

As can be seen from the **Figure 6.1**, there are large areas of missing bathymetry information that will need to be compiled to provide a comprehensive, detailed bathymetry close to the area of flood risk. Most notably the Harbours of Portsmouth and Langstone are not present. An opportunity to obtain further bathymetry data from the Defence Infrastructure Organisation (DIO) for Portsmouth Harbour has been identified. It is understood that the DIO have collected these data to inform the proposed Portsmouth Harbour dredge. The Eastern Solent Coastal Partnership should request this bathymetry data. Following the full collation and verification of existing data, any gaps will need to be 'filled' with the most up to date LiDAR data (which has been flown at low tide). Areas below the water level at the time of the LiDAR flight should be checked against earlier LiDAR data and then the Admiralty Chart data should be used to provide a complete bathymetry. Alternatively, additional survey could be undertaken if this is thought to be necessary. It should be noted that in Portsmouth and Langstone Harbours, the influence of bathymetry below low water is likely to be less than along the open coasts, as smaller waves are expected within the harbours.

The completed Bathymetry should be finally checked once compiled as it will be used to create the base MIKE 21 models that underpin the assessment of risk.

6.3.2 Beach Profiles and Defence Information

The latest survey, undertaken by ESCP team for the Regional Monitoring Programme, is from 2012 which is a baseline survey year, therefore complete coverage of the beach frontage with profiles available every 50m will be available. At each location any major fluctuations in form (beach) should be assessed to determine the most appropriate profile to be used in the assessment of wave run-up and overtopping. *Technical Report 7: Asset Condition* contains the proposed methodology for the assessment of condition, and builds upon the already very good set of data relating to condition. These two sets of data relating to the structures are important in both setting the present day topography for the modelling, but also in setting the baseline for assessment of future change in structure and beach profile.

6.3.3 Met Office Data

The analysis undertaken for the PICSS used wave data from 01/07/1992 to 30/06/2002; some 10 years. A longer record is now available, which could be used to improve the statistical confidence of the results. This would reduce uncertainty in the whole overtopping assessment, and so it is recommended that the longer dataset is purchased and analysed. Quotes have been obtained for these data (February/March 2012).

It is also recommended (irrespective of whether the longer dataset is purchased) that the assessment of wave conditions is revised using a more focussed or narrower directional segment, perhaps 15 or 20 degrees, rather than the 30 degrees used in the PICSS. This would result in different (potentially greater) extreme wave conditions. The usual practice of segmenting (or ‘binning’) at 30 degrees may not be appropriate in this case because of the narrow range of directions from which large waves can arrive at the Portsea coastal frontage.

The local wind climate must also be assessed in order to generate appropriate wind inputs for the wave transformation modelling. Such data could be purchased from the Met Office, but are also likely to be available locally.

Extreme wave conditions are required at return periods longer than the length of the available record. For this reason a distribution should be fitted to the observed extremes, and extrapolated to larger events. A Weibull distribution is recommended for this purpose. Wave periods must be associated with these extreme waves, and these should be estimated through extrapolation of the height/ period relationship present in the highest of the recorded data.

It should be noted that the wave data currently held describes conditions at location 50.5N, 0.86W, which is southeast of the Isle of Wight, located in a different sector and far more exposed than Portsea. Consequently the direction of the most severe waves within this data is unlikely to be the same as those at Portsea. Similarly the direction of the most severe wind may not correspond to the critical waves at the shore. During the recommended re-assessment of the Met Office data and wave climate; the PICSS assessment of the most extreme wave conditions should be reviewed again across the whole 120 to 210 degrees sector to determine if additional data are required for an alternative sector.

6.3.4 Hydrological Data

In view of the likelihood of an extreme coastal event occurring at the same time as a moderate rainfall event, it is suggested that rainfall data be obtained for the Portsmouth area. Hydrographs should be derived for the 6 month, 1 year and 5 year return periods, comprising event durations that would be likely to occur with an extreme coastal event (frontal, rather than convective rainfall).

Using the Flood Estimation Handbook (FEH), a basic assessment of residual rainfall should be made, taking account of percentage run-off (depending on land cover) and antecedent conditions (which generally can be assumed to be saturated). These data will be used to derive the direct rainfall input to the overland, two-dimensional, modelling (using TUFLOW) described later in this report.

6.3.5 Verification Data

The review of the PICSS has highlighted a degree of uncertainty in the results of previous wave modelling. In order to develop confidence in the numerical model used in any future PAR, subsequent detailed design, and possibly a flood warning system, there will need to be an element of verification. Information is required to support a verification process and whilst data are available close to the Portsea frontage, a further monitoring device (possibly attached to South Parade Pier) would be of great benefit to provide additional data. Discussions are on-going regarding the deployment of a wave recording device with the Coastal Partnership team. The sooner this is able to be deployed, the greater benefit it will have in assisting in the required verification exercises.

6.3.6 Data Checking

All data received and used in the preparation of the PAR should be reviewed by the appropriate project expert. The experts should typically check for:

- Data gaps;
- Anomalies;
- Systemic change;
- Resolution;
- Completeness of meta data;
- Evidence of uncertainty
- Mis-closure;
- Datum changes.

Where data is edited, for example to bridge gaps, this needs to be recorded and reported for auditing purposes so any future updates are straightforward. The auditing of changes will need to continue during and after the project.

6.4 Water Level Guidance

6.4.1 Regional Sea Level Extremes

Since the completion of the modelling for the PICSS, there has been a revision to Extreme Sea Levels, through the publication of the Environment Agency's Coastal Boundary Data project (2011, based on 2008 data). Inspection of these results indicates that extreme water level estimates have increased since the production of the PICSS modelling (which was based on the Old Portsmouth Strategy Study). The relevant extracts from the Coastal Boundary Data are presented in **Figure 6.2** and **Table 6.1** below:

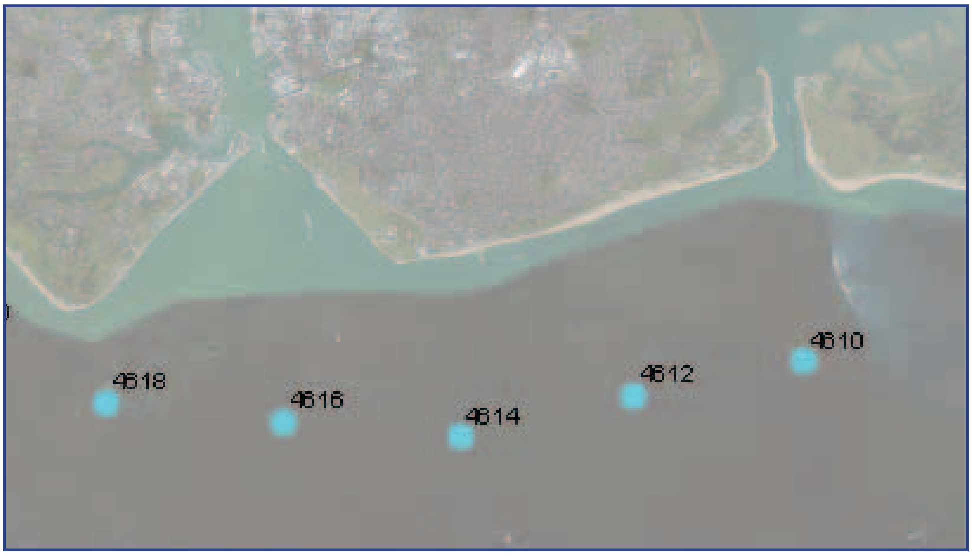


Figure 6.2: *Location points of Extreme Sea Level data*

Table 6.1: *Extreme sea level*

CHAINAGE	T1	T2	T5	T10	T20	T25	T50	T75	T100	T150	T200	T250	T300	T500	T1000	T10000
Extreme Sea Level																
4610	2.65	2.73	2.83	2.90	2.97	3.00	3.07	3.11	3.14	3.18	3.21	3.24	3.26	3.31	3.38	3.62
4612	2.62	2.70	2.80	2.87	2.94	2.97	3.04	3.08	3.11	3.15	3.18	3.20	3.22	3.27	3.35	3.58
4614	2.59	2.67	2.77	2.84	2.91	2.93	3.01	3.05	3.08	3.12	3.15	3.17	3.19	3.24	3.31	3.54
4616	2.56	2.64	2.73	2.81	2.88	2.90	2.98	3.02	3.05	3.09	3.12	3.14	3.16	3.21	3.28	3.50
4618	2.54	2.62	2.72	2.79	2.86	2.89	2.96	3.00	3.03	3.07	3.10	3.12	3.14	3.19	3.25	3.47
Confidence Interval																
4610	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6
4612	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6
4614	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6
4616	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6
4618	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6

Sea levels shown in **Table 6.1** should be used in the modelling but must be updated to present day levels (from 2008) by applying 4mm per year. Initially, it is suggested that a single set of extreme levels be adopted for modelling purposes as this will reduce the number of model runs significantly. This can be tested later with the aid of sensitivity runs and this project's proposed conceptual modelling approach (Section 6.2) which involves using increments of water levels, which can be related back to specific return periods depending on current guidance at the time, rather than modelling to specific return periods.

It is suggested that the confidence interval be only applied in exploring sensitivity and not specifically in the economic assessment or design (unless there are specific reasons to do so). This approach should be discussed further with the Environment Agency.

6.4.2 Climate Change

Sea Level Rise

In September 2011, the Environment Agency issued advice to local authorities on data and assumptions to be used in assessing the impacts of climate change on future flood risk and option design.

The purpose of this advice is to ensure that an economic appraisal considers the uncertainties associated with climate change and to support any Government investment decision.

Whilst it is recognised that this latest guidance is likely to change, the following current advice translates to the following (**Table 6.2**) for an example 50% AEP (1 in 2 year) event:

Table 6.2: *Climate Change Projections for 0.5% AEP extreme tide event at Portsmouth Harbour entrance.*

Date	Years from present day mOD (mCD)	Upper end estimate mOD (mCD)	H++ mOD (mCD)
2012	0	2.56 (5.29)	2.56 (5.29)
2025	13	2.61 (5.34)	2.64 (5.37)
2050	38	2.79 (5.52)	2.95 (5.68)
2080	68	3.12 (5.85)	3.67 (6.40)
2115	103	3.64 (6.37)	4.83 (7.56)

In accordance with the guidance, the Upper End Estimate should be used within the appraisal, but there should be knowledge of the H++ estimate for future risk management, planning and the longer term adaptive management approach for Portsea.

Change in Surge

The EA's recent report suggests the addition of the following regarding surge (**Table 6.3**):

Table 6.3: *Extract of Environment Agency's 2011 Advice to Local Authorities on Climate Change*

	Total potential change anticipated up to the 2020s	Total potential change anticipated up to the 2050s	Total potential change anticipated up to the 2080s
Upper end estimate	20cm	35cm	70cm
Change Factor	Ensure a rigorous assessment of the current coastal extreme water level has been undertaken	Ensure a rigorous assessment of the current coastal extreme water level has been undertaken	Ensure a rigorous assessment of the current coastal extreme water level has been undertaken

As recognised in the Environment Agency's report, there is considerable uncertainty in these projections. Royal HaskoningDHV has recently reviewed these projections further and believe that their use (as an addition to the extreme sea levels) may be a considerable overestimate for two key reasons:

- There is little evidence to suggest that a change in surge would be concurrent with an extreme event peak;
- With increased sea level rise, there may be less change in surge, or even a reduction in surge due to climate change in the English Channel.

It is, therefore, suggested, that a limited amount of further research is undertaken before using these data directly. We are aware that Dr Ivan Haigh of the National Oceanography Centre, Southampton, may provide some project specific advice. Given the statement above regarding the potential overestimation of climate change predictions; an assessment regarding the necessity for this further research should be made in conjunction with the economic business case as any changes could lead to a reduction in overall design heights.

Waves

At present there is no advice on a change or increase in wave climate due to climate changes, but the advice does note the following:

"It is anticipated that over the next 12 months, wave climate projections will become available covering significant wave height, period and direction. When these are published this advice note will be updated to include that evidence."

6.4.3 Joint Probability and Correlation

In 2005 the EA/Defra published Use of Joint Probability Methods in Flood Management A Guide to Best Practice R&D Technical Report FD2308/TR2. This publication is the generally accepted method for assessing joint probability and should be adopted for the PAR. Care should be taken, however, when assessing the correlation factor for the Portsea coastal frontage as due to the sheltering effect of the Isle of Wight, there may be less correlation than published. This correlation can be investigated through review of the recorded data (wave and tide height).

6.5 Wave Model

6.5.1 Selection of Modelling Package

Although a MWAVE model has already been developed through the PICSS it will be hard for any third party to review, amend or update this model. As noted previously, there is also uncertainty in the outputs of the PICSS modelling. In view of the need to update various aspects of the modelling and develop a model that will support the PAR and later design/operation it is suggested that a new Delft Swan or MIKE 21 SW (Spectral Wave) model be developed. The latter is a common and industry adopted licensed software developed and supported by DHi (Danish Hydraulics institute).

MIKE 21 SW (release 2011) is a state of the art, industry standard, third generation spectral wave model. It simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas. It accounts for the following processes (amongst others):

- Wave growth by action of wind;
- Non-linear wave-wave interaction;
- Dissipation due to white-capping;
- Dissipation due to depth-induced wave breaking;
- Refraction and shoaling due to depth variations;
- Diffraction.

MIKE21 SW holds the advantage of being relatively fast to run, which allows the exploration of a larger number of conditions than would otherwise be possible. This in turn allows better identification of critical flood conditions.

6.5.2 Input Parameter Optimisation

Having obtained a detailed bathymetry for the study area (Section 6.3.1), the MIKE21 model can be constructed. To aid run times and to reduce unnecessary computations, the grid resolution can be varied. Higher resolution will be required along all frontages and in the entrance channels to Portsmouth and Langstone Harbours.

The analysis of the Met Office wind and wave data will provide appropriate ranges of input data. The most appropriate wind and wave direction will be selected. As noted in the introduction to this section, we consider it appropriate to model a wide range of water levels and wave combinations, to reduce the risk of the need for future modelling if guidance changes.

Through this scoping assessment, we consider the offshore wave height to vary between 0m and 7m, based on an increase of the data used in the PICSS (see **Table 6.4**).

Table 6.4: *Reproduced from the PICSS Numerical Modelling Report*

Return Period	Wave Height (m)
1	5.239
5	5.698
10	5.882
20	6.060
50	6.287
100	6.452
200	6.612

Increasing the range of wave heights will allow any future change due to a reassessment of data or publication of revised climate change advice to be accommodated.

The range of water levels to be assessed should extend from the present day Mean High Water Springs (1.97mOD = 4.7mCD) to the future 1 in 1000 year + climate change (H++) level (5.7mOD = 8.43mCD).

With increased modelling capacity and computation power it is suggested that all combinations of wave and water level are run in MIKE 21. Even though many of these runs may not be used in the future, they will show potential ‘cliff edge effects’ and lead to a more resilient modelling approach as demonstrated in the example matrix of runs in **Figure 6.3** below.

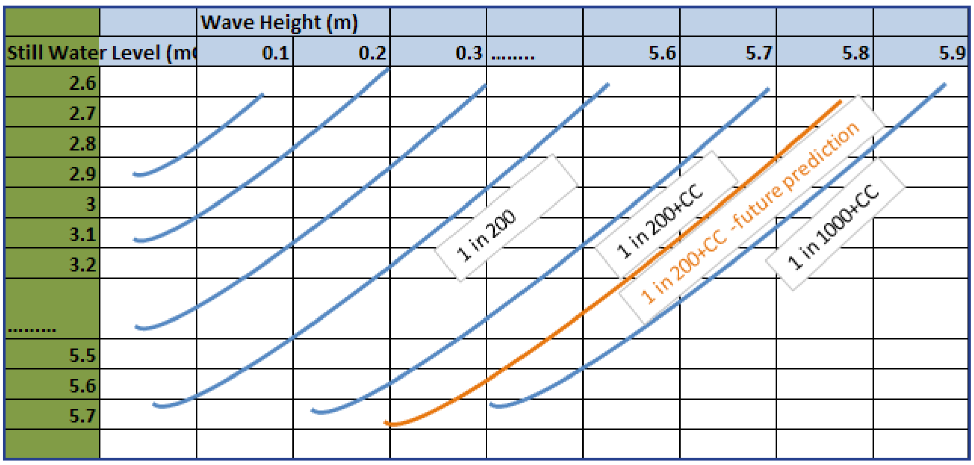


Figure 6.3: *Example Matrix of Model runs for the Exposed Locations (wave heights and still water levels truncated)*

Figure 6.3 above indicates the style of matrix suggested model runs – which at 100mm increments for both water level and wave height would require 2,600 model runs.

From this array of results it will be a simple process to define return periods across the data. This approach means that if advice regarding correlation coefficients is adopted, new lines can be plotted, without the need for additional modelling.

6.5.3 Modelling

Modelling can be batch run and data automatically extracted for points where overtopping assessments are required (Section 6.7.2).

A single wind speed and direction will be applied for the coastal frontage. For the harbours of Portsmouth and Langstone, there will need to be a range of wind directions and strengths assessed, as these are likely to be dominant, particularly in the areas sheltered from the harbour entrances.

6.6 Tidal Current Model

The PICSS modelling has already defined the changes in tide and current due to increased sea levels. It has also been used to assess peak bed shear stresses. As with the MWAVE model used in assessing the wave heights, the hydrodynamic model (DAWN) cannot be readily used by third parties to inform the PAR and the option design. Modification to this, or any, model will be needed to assess the performance of options. Improvements in bathymetric resolution and amendments to the bathymetry (for example to represent beach recharge and management structures) will be required. It is therefore suggested that the MIKE 21 model be used with the hydrodynamic (HD) module to assess currents and changes in tides.

MIKE21 HD (Hydrodynamic) (release 2011) simulates the water level variation and flow in response to a variety of forcing functions in lakes, estuaries, bays and coastal areas. The water levels and flows are resolved on a rectilinear grid, a curvilinear grid, a triangular element mesh or any combination hereof covering the area of interest. The model will be used to assess tidal flows. Spatial changes in water level along with tide curves and current velocities will be extracted for use in this assessment.

The work already undertaken in the PICSS will be invaluable in verifying the new MIKE21 HD model, as will work recently undertaken by Royal HaskoningDHV in the creation of a calibrated English Channel MIKE 21 HD Model.

The primary use of the model will be to test the options developed during the PAR in relation to beach stability through use of the peak bed shear stress outputs. The MIKE21 SW approach adopted for the wave modelling will make the further development of this hydrodynamic model relatively quick and straightforward as they rely on the same set up data.

6.7 Overtopping Assessment, Breach Risk and Inland Flood Modelling – Current situation

6.7.1 Introduction

The assessment of overtopping and the risk of breach is relatively complex, and

requires several steps and a number of iterations to better understand the overtopping and risk of breach. The PICSS adopted a simplistic approach to breach assessment, without strong evidence to support the location, physical characteristics, size or likelihood of breach. Overtopping flooding (without breach) was not modelled, which potentially ignores a significant source of flooding.

The PAR will need to have a more robust assessment of both overtopping and breach risk, as this will both inform the economic assessment and business case, but also the locations where improvements in the defences are needed to attain the desired standard of defence and structure life. The assessment will also prove useful in assessing the timing of interventions

6.7.2 Overtopping Modelling – Current Situation

The EurOtop model is the industry standard method of assessing coastal overtopping rates, and is freely available. There are a number of alternative methods of calculating overtopping volumes including Hedges and Reis (1998) overtopping model and Royal HaskoningDHV's in house model AMAZON, amongst others. Royal HaskoningDHV's recent experience on other similar projects, namely the development of North East Tidal Flood Forecasting System and the Isle of Wight Coasts and Harbours Flood Mapping project, highlighted a number of limitations of EurOtop, particularly with regard to shingle beaches. It is recommended that these limitations should be explored further by undertaking an Overtopping Pilot Study. The Pilot Overtopping Study should aim to identify the most appropriate method which gives the most realistic results in comparison with event data and anecdotal evidence for typical defences at locations across the study area. Once the Study is complete the concluded overtopping method should be applied.

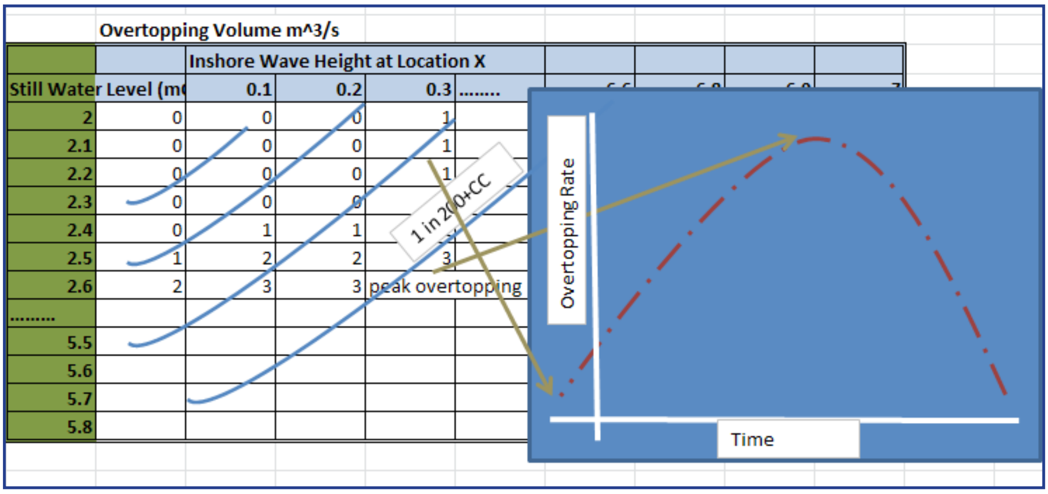
Around the whole of Southsea and North Portsea Island coastlines, a series of locations should be selected that represent:

- Changes in defence type or elevation;
- Changes in foreshore type elevation;
- Changes in exposure.

This information is readily obtained from the PICSS and the *Technical Report 7: Asset Condition*, which forms part of this suite of scoping studies. This will result in numerous sections where overtopping assessment will be required. These locations need to be identified prior to the commencement of the wave modelling to ensure that output data are automatically generated – reducing time and the risk of error.

For the range of water levels and wave heights generated at each location (as described in Section 6.3) overtopping assessment should be undertaken, using batch run and automation techniques. This will result in a further large data set with an example matrix presented in **Table 6.4** below.

Figure 6.4: *Example Use of Modelled Data to Extract Overtopping Profile Over the Tidal Cycle*



From these data, and through the Joint probability assessment relevant at the time of the assessment, peak overtopping volumes can be derived for each location (where overtopping occurs). Using the tidal curve, the lower order data can be used to define the development and decay of the overtopping; this will be the direct input into the TUFLOW overland flow modelling.

As with the wave modelling, although a large amount of data will be produced, it has several uses and removes the need for costly additional runs later. The automation of the process should also reduce the errors that often occur in transferring and manipulating data.

The outputs should be both average (to inform the flood extents) and peak (to inform the assessment of structural integrity) overtopping rates.

6.7.3 Flood Extent Modelling – Current Situation

To represent the progression of floods, and to determine depths, durations and velocities, it is proposed to undertake two dimensional surface water flow modelling, using the industry standard software, TUFLOW. TUFLOW is a 1D/2D finite difference numerical model that simulates hydrodynamic behaviours in rivers, floodplains and urban drainage environments. It is internationally recognised and used by the majority of flood risk consultants and clients in the UK. There are frequent updates to the software and the latest version of the software should be made available/used at the commencement of the study. At the time of writing this report the version operated by Royal HaskoningDHV is TUFLOW 2011-09-AF (release date 24th January 2012). Once modelling has commenced, no further updates will be accepted unless the updates refer to errors in the software. This approach is taken as there have been previous instances of changed results (with the same inputs) following software updates and a consistent platform for comparing flood depths, extents and velocities is required.

A fixed mesh grid will be adopted, with nested grids to provide details in the vicinity of the key structures.

The PAR will have the benefit of an already developed TUFLOW model for Portsmouth, held by the Environment Agency. A copy of this model is held by the Coastal Partnership and the model has been reviewed by Royal Haskoning as part of this scoping study. On the basis of this review it would appear to be a well-developed model and should provide an ideal base upon which to construct a specific model for assessing the flooding due to overtopping. The TUFLOW model would benefit from the revised wave climate, water levels and overtopping assessment. Any updates or improvements to the model during the PAR are to be fed back to the Environment Agency to ensure the continuous improvement of the understanding of flood risk.

The boundary conditions for the model will be the relevant overtopping rates for each section of frontage (described in Section 6.7.2) and a direct rainfall input (discussed in Section 6.3.4). Key sub surface drainage and the pumped system should be added to the TUFLOW model to assess the existing benefit this system provides and the consequences of a failure – or improvement.

The peak flood depths will be recorded across the grid and used as a direct input to the economic assessment (for the depth damage assessment). The velocities will be used to identify areas that could be susceptible to damage (particularly close to the overtopping locations and at constrictions). Flood progression, depth and velocities are also likely to be useful in assessing flood warning and evacuation procedures.

6.7.4 Asset Failure Assessment

The PICSS and Royal HaskoningDHV site visits and assessment undertaken for *Technical Report 7: Asset Condition* indicate that there is a high likelihood of several assets failing under a combination of high wave and water levels. This is particularly the case if overtopping occurs as the scouring effects of fast flowing water can quickly lead to failure. As noted in the introduction to this section, the PICSS did not assess the likelihood or locations of potential failure with sufficient robustness to complete the PAR or the assessment of options.

It is, therefore, suggested that the PAR adopts Environment Agency guidance *R&D Technical Report FD2318 Performance and Reliability of Flood and Coastal Defences* to assess each of the structures fragility (see **Figure 6.5**). This assessment process needs to define the location and likelihood of failure in order that the Economic Assessment can be carried out, as discussed in *Technical Report 3: Economics*.

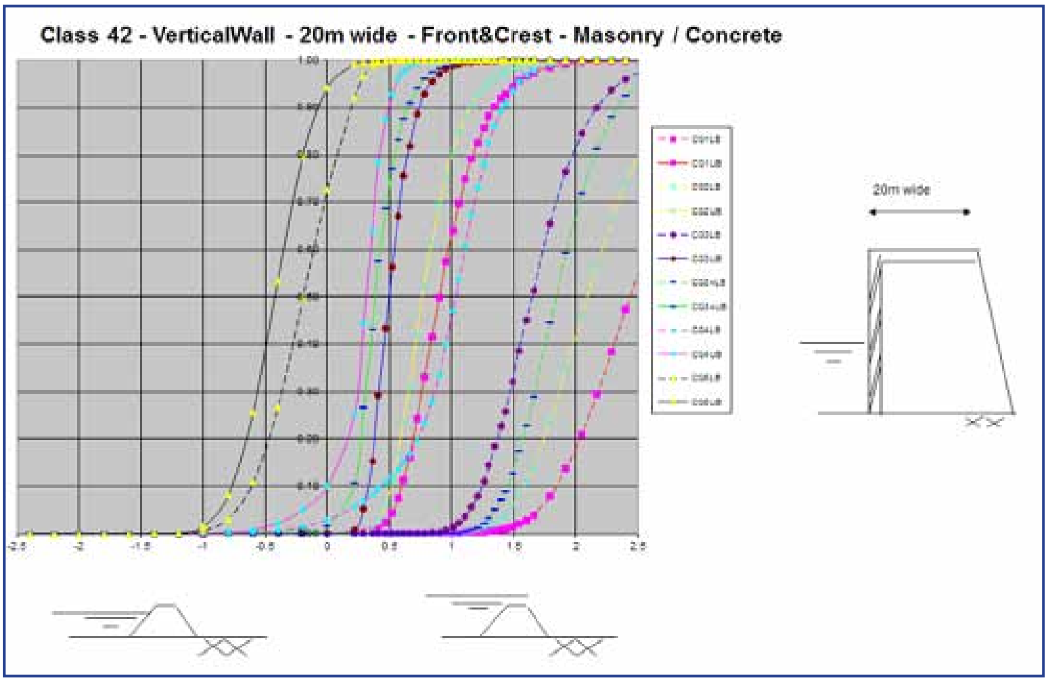


Figure 6.5: *Extract of FD2318 Performance and Reliability of Flood and Coastal Defences supporting spreadsheet*

The derivation of fragility curves for each of the structures will be based on the loading conditions (derived from the modelling), the asset conditions (from *Technical Report 7: Asset Condition*) and any structural analysis or assessment undertaken following the site investigations proposed during the PAR.

The reason for adopting fragility curves is that the modelling and condition can be linked, and failure probabilities assigned to structures. These probabilities are important in the development of the economic assessment and the do nothing flood mapping. The FD2318 spreadsheets will have to be tailored to this assessment and advice should be sought from one of the report's authors in applying the techniques.

An example assessment is enclosed in Annex 3 to describe the process.

It should be noted that the Environment Agency Evidence programme have two current pieces of work underway which may be relevant to this study. These are in relation to Phase 2 of work looking at 'SC060078 - Assessment and Measurement of Asset Deterioration Including Lifetime Costs'.

6.8 Flood Modelling – Failed/Breached Situation

The fragility assessment will indicate structures that have the potential to fail under extreme conditions, and will assign a probability to this likelihood of failure. For all structures that have the potential to fail, a series of further overtopping analyses (in the case of partial failure) or simple direct inflow assessments for full breach will need to be undertaken.

This will mean adjusting the profiles used in the original overtopping assessment to the new, failed profiles, extracting new boundary conditions and re-running the TUFLOW model. Because some structures are more likely to fail than others – several TUFLOW assessments will be required so that the correct flood envelope can be used in assessing damages. This is explained in the sketch below (**Figure 6.6**).

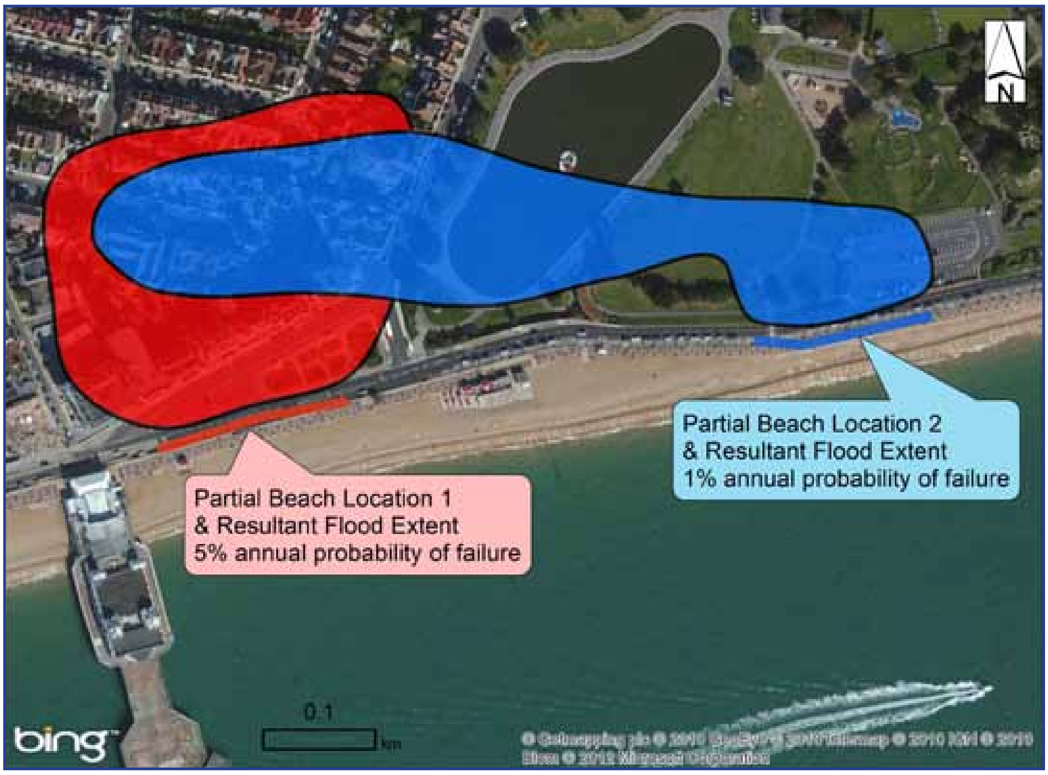


Figure 6.6: *Derivation of Flood Envelope*

In this example, the two resultant flood extents and the damages that will occur have different probabilities of occurrence. This means that the information has to be kept separate for the Economic Assessment as they will occur at different times and have different resulting economic impacts. The Economic Assessment will combine the impacts to produce the overall value in damages over 100 years, taking care not to double count properties and to write off/cap damages as appropriate (described in *Technical Report 3: Economics* that forms part of this Scoping Stage).

Combining the individual likely failures and flood extents will produce the overall flood extent map for the Do Nothing and potentially the Do Minimum scenarios.

6.9 Flood Modelling – Options

Having defined the current and Do nothing/Do Minimum scenarios, the modelling can then inform the assessment of future options. Most of Portsea's defences rely, to some extent, on the presence of a potentially mobile foreshore. This foreshore is also a valuable amenity and environmental resource, and can have an important role in proving a future enhanced defence that is capable of adapting to changing pressures. It is, therefore, suggested that the foreshore and beaches are modelled in isolation to determine their impact in isolation. A similar process is proposed for the hard assets (walls, revetments & embankments). The results of these two assessments will then be used to select a limited number of combined option model runs to define the final options that proceed to outline design and detailed PAR evaluation.

6.9.1 Flood Extent Modelling – Future Situation – Beach Management

The PICSS and *Technical Report 14: Beach Management Plan* Scope (which has been prepared alongside this report) both acknowledge the uncertainty in predicting long term future beach morphology and it is suggested that this detailed understanding is not actually necessary for the development of options.

Instead it is suggested that the modelling focuses on maximum and minimum plausible future foreshore responses, and that the impacts of these potential responses be evaluated (**Figure 6.7**). Once the impacts of these are known, then acceptable structural or management measures can be developed to ensure the presence of the foreshore.

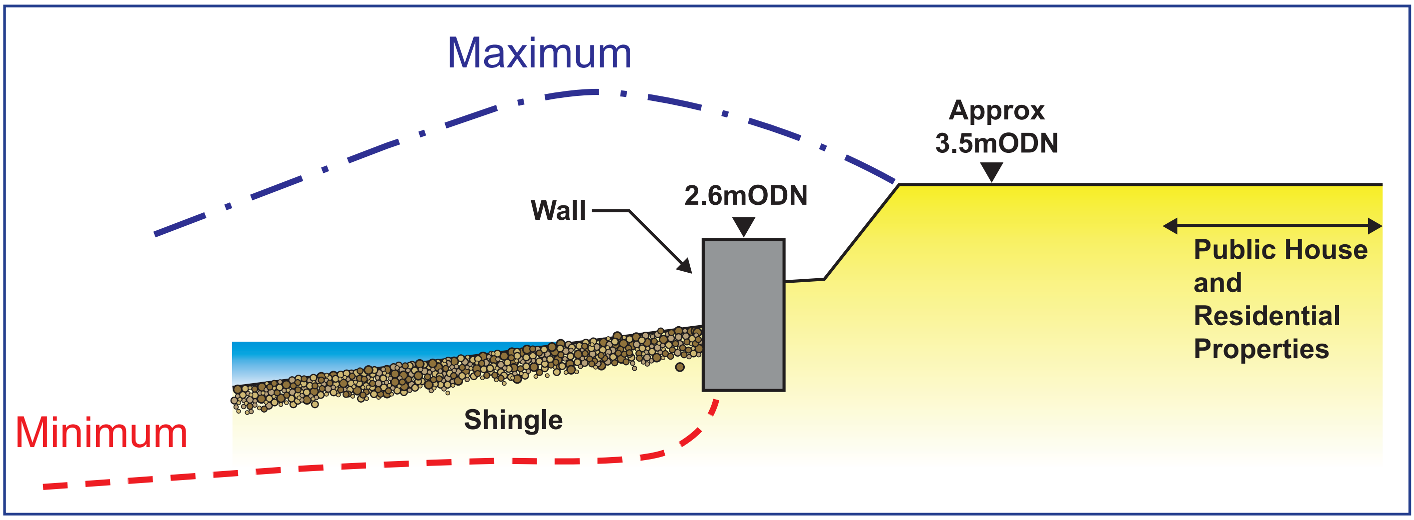


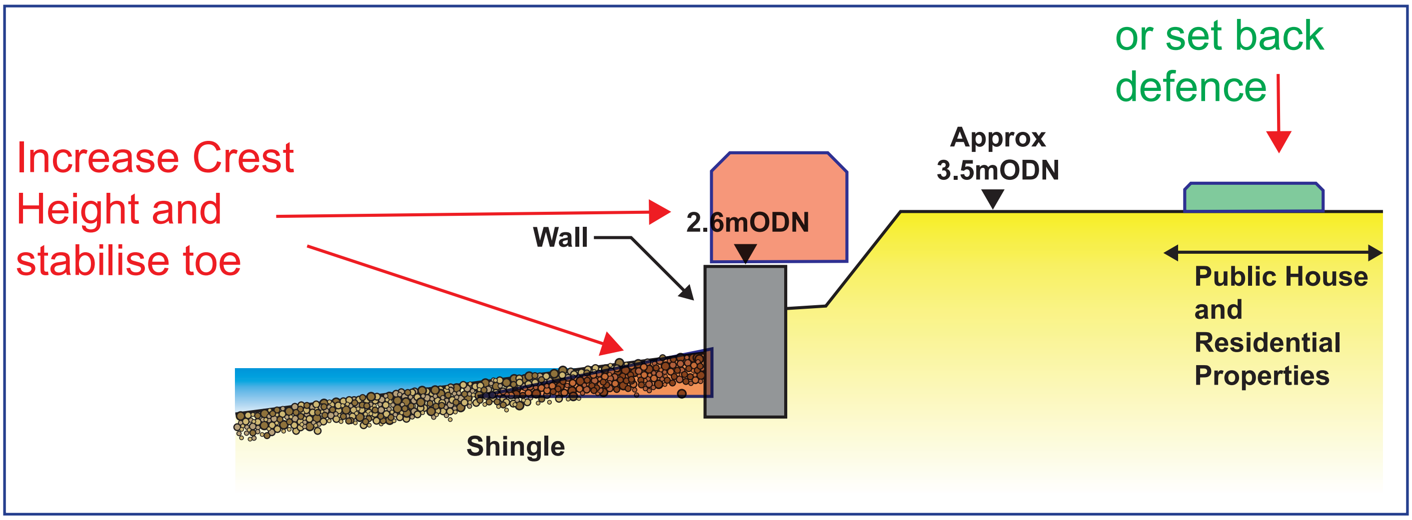
Figure 6.7: *Typical Cross-Section Through Existing Defences*

In this example there is a maximum plausible beach that could be provided (possibly through beach management, recharge or the provision of control structures). The Overtopping assessment would be undertaken again for the maximum profile to determine if there was any residual flood risk.

The minimum plausible profile would also be re-modelled to assess overtopping rates if the Beach Management Plan considered that a beach may be at risk of lowering due to a storm response or due to climate changes. If appropriate, this assessment would be fed back into the Do Nothing flood extents, particularly if the lowering in beach levels results in the failure of an asset – as would be likely in this example.

6.9.2 Flood Extent Modelling – Future Situation – Asset Management

A similar process of understanding the impact of improving or replacing the hard asset for areas at risk of failure or overtopping is suggested (**Figure 6.8** below).



Again the overtopping assessment would be re-run to either:

- Set the height of a defence to limit overtopping to the desired standard of protection (SoP); or
- To assess residual overtopping if the desired defence cannot be achieved (for example due to visual intrusion).

As appropriate, residual flood risk would then be modelled in TUFLOW to define the impact of more extreme events or the effect of H++ climate change and to inform contingency planning.

6.9.3 Option Refinement

Having reviewed the results of the beach management only and the asset management only assessment, a smaller set of combined options, appropriate to each location and taking account of costs and environmental constraints can be developed. These should again be tested with respect to overtopping and the development of a residual flood extent using TUFLOW.

Figure 6.8: *Typical Cross Section Through Existing Defences*

6.9.4 Further Option Modelling/Testing

In addition to the overtopping assessment, additional model testing is likely to be required, particularly for the options that involve beach management and/or beach control structures. For these instances it is suggested that the already proposed MIKE21 HD model and the LITPACK suite be used. LITPACK is a numerical model that simulates sediment transport for a large number of wave/current scenarios and for the combination of these simulations into predictions of the net littoral drift, developments of coastal profiles, and long-term coastline evolution. LITPACK is a DHi product and used by numerous client and consultant organisations.

The modelling should assess long term evolution of the beaches under investigation and the response to extreme, isolated events. In this way measures (structural or management) can be developed to ensure that the SoP is maintained. This modelling will also form an aspect of the Beach Management Plan that will be developed alongside the PAR. Further discussion of the beach processes and future management can be found in *Technical Report 14: Beach Management Plan* Scope, which forms part of this suite of scoping stage reports.

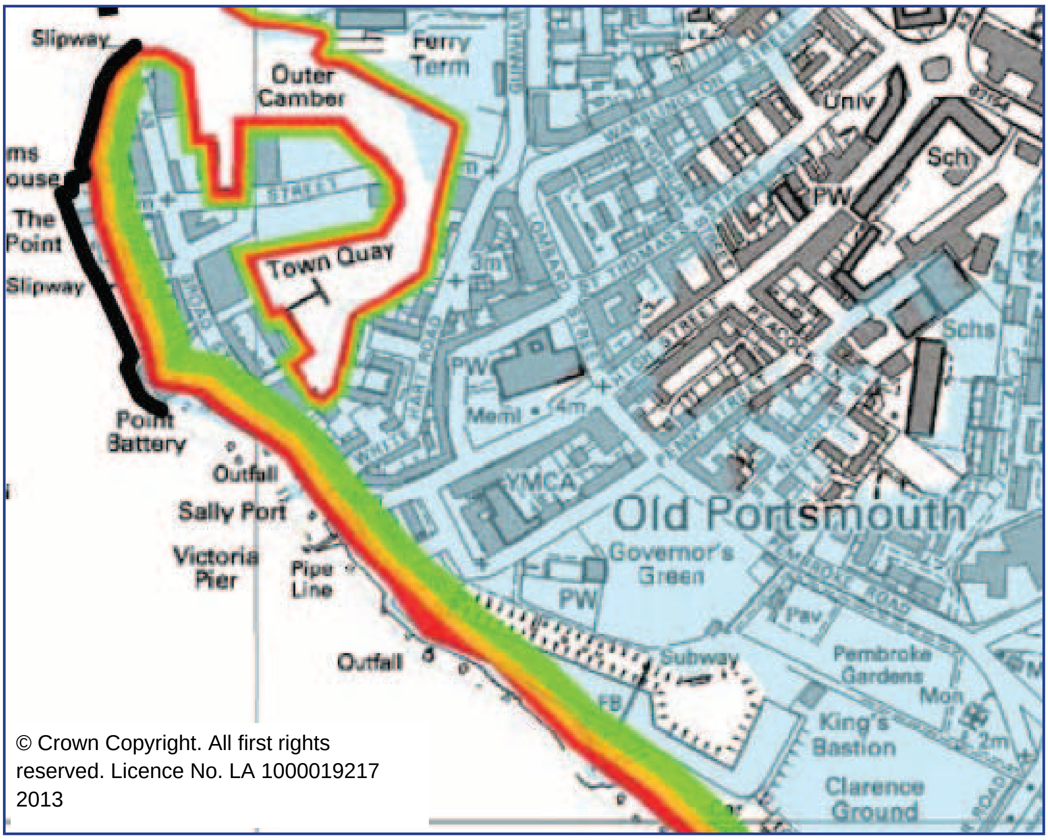
Other models may be required to size rock armour, assess pile forces and develop foundations designs.

6.10 Coastal Erosion

The PICSS did not take account of the potential losses that could occur through coastal erosion. Whilst an element of this loss is embedded in the assessment of structures' fragility, there may be areas that are not at direct risk of flooding, but that would suffer from erosion. The most up to date source of erosion information is the Shoreline Management Plan Revision (SMP2) completed in 2011. An extract of the erosion mapping is presented in **Figure 6.9** below (no active intervention).

Figure 6.9: *Extract of Erosion Mapping from SMP 2011*

- Unit boundary
- Complex coastal process
- Indicative erosion zone up to 2025
- Indicative erosion zone up to 2055
- Indicative erosion zone up to 2105
- 2115 Indicative Floodplain (1 in 200 year) provided from PUSH



For the PAR, this approach is likely to be too generic and it is suggested that suitably qualified judgement (based in the asset condition, fragility assessment and local knowledge) is used to assess future erosion potential. The resulting loss of assets and estimated timing of the loss can then be fed into the economic assessment, again taking care to ensure no double counting with written off assets due to flooding.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Future Flood Risk Modelling Recommendations

This scoping study has reviewed the work of the PICSS and recent related flood risk studies. It is clear that the understanding of the flood mechanisms is improving, but also that there is scope for refinement in our understanding – particularly the locations and impacts (including breach) of overtopping and our understanding of how these flood waters are conveyed inland.

The key recommendations for progressing the project to PAR stage and beyond are summarised below together with a timescale in brackets after each recommendation. Undertaking these recommendations will offer opportunities for creating an enhanced and robust business case and opportunities for seeking contributions towards a future flood and coastal risk management scheme for flood cells 1 and 4.

Recommendation 1: Collect together the most up to date bathymetric information (including request data from DIO), check and create a single, audited bathymetric grid for use in the modelling and the option design (next stage).

Recommendation 2: Fit a Weibull distribution to the observed extreme wave conditions, and extrapolate to larger events (next stage).

Recommendation 3: Re-assess the Met Office offshore wave data for a narrower sector, plus consider purchasing the latest data, which will improve the confidence in extreme offshore wave assessment (next stage).

Recommendation 4: Install a temporary wave recording device in the vicinity of South Parade Pier, to provide data for both future model validation and to support the option designs (now).

Recommendation 5: Accept that there will be changes in guidance and modelling outputs regarding water levels and wave heights in the future. Adopt an approach that models as many combinations as possible (using automation) to allow better exploration of the sensitivity, identify cliff edge effects and adapt to future changes in guidance, re-analysis or re-interpretation in joint probability assessments (next stage).

Recommendation 6: If deemed necessary undertake limited further research into the use of the Environment Agency's 2011 Climate Change Projections sought from Dr Ivan Haigh of the National Oceanography Centre, Southampton (next stage).

Recommendation 7: Construct a new MIKE 21 SW wave model to transform offshore waves inshore. Ensure full coverage with higher resolution in areas of risk (including the harbours). Pay particular attention to the wind strengths and directions within the harbours as these will be the greatest influence on wave heights (next stage).

Recommendation 8: Construct a MIKE 21 HD hydrodynamic model to assess current strengths, directions and, durations; ensuring that detailed bathymetry is included in the harbour entrances (next stage).

Recommendation 9: Undertake overtopping pilot study utilising tools such as EuroTop, Hedge and Reis and Amazon or similar. On conclusion of the pilot study undertake overtopping assessments for the at risk locations identified around Southsea and North Portsea Island. Perform these analyses for the current situation and a future situation with higher and lower foreshore levels. Peak and average overtopping rates will be used to inform the breach risk and flood risk (next stage).

Recommendation 10: Using the already developed Environment Agency TUFLOW model as base, assess the location, extent, depth and velocity of flooding due to overtopping and breach. Consider including coincident rainfall in the modelling (if required, rainfall data should be obtained as appropriate) (next stage).

Recommendation 11: Using existing asset information, create asset fragility curves for a range of water levels and overtopping rates to identify when and where vulnerable defences will fail (next stage).

Recommendation 12: Ensure the outputs of the TUFLOW flood modelling can be directly imported into the Economic Assessment, saving time and the risk of copying errors (next stage).

Recommendation 13: Working alongside the authors of the Beach Management Plan, assess the plausibility of using the foreshore to enhance future defences and assess the measures needed to sustain a managed foreshore. Use long shore drift and beach profile software to test local options (next stage).

Recommendation 14: Assess the erosion impacts, taking care not to double count properties at risk from flooding (next stage).

7.2 Recommendations for the Wider Technical Reports

7.2.1 Technical Report 1: Overview and Urgency

The assessment of flood risk is a key element of the delivery of a business case. The recommendations presented in Section 6 and 7.1 are potentially costly and will take time to deliver. These recommendations should be discussed in *Technical Report 1: Overview and Urgency* Report in the context of the already completed and approved PICSS (now).

7.2.2 Technical Report 3: Economics

As also noted in *Technical Report 3: Economics*, there is considerable crossover with the modelling. There are two points of significant importance that link the economics and modelling reports:

- *There will be changes in our understanding of flood risk.* This means he modelling and economics need to be commenced in the knowledge that changes will happen and the system designed to easily accept changes;
- *A large amount of information will be produced, with multiple breach and flood risk scenarios investigated.* The transfer of information to the economic assessment has to be based on as much automation as possible (to avoid errors in transposing) and a system to name, hold and audit these data should be designed and tested early in the modelling process.

7.2.3 Technical Report 4: Contributions

The assessment of flood risk will impact upon the economic assessment and may impact upon the assets affected by flood risk. This may lead to the additional opportunities for external contributions to the scheme. It is therefore, recommended that regularly analysis of the economic analysis and the assets affected is undertaken in order to identify any additional contribution sources (next stage).

7.2.4 Technical Report 6: Surveys

No additional surveys are required at this stage, although site inspection may be required to confirm details during the modelling.

7.2.5 Technical Report 7: Asset Condition Report

The assessment of asset fragility is underpinned by the current structures' condition and construction. In some instances, the modelling may indicate the need for a reassessment of an assets condition or require intrusive investigation or trial pits. It is not expected that extensive further asset condition assessment will be required (next stage).

7.2.6 Technical Report 9: Risk and Programme

As the modelling informs nearly all aspects of the PAR, any delay or problems/errors could have a significant effect on the delivery of the business case – and the provision of an improved SoP to Portsmouth.

7.2.7 Technical Report 14: Beach Management Plan

The Beach Management Plan is linked to the PAR and achieving a robust business case for investment. Therefore modelling and BMP should be undertaken in parallel so that any modelling can be designed to serve both exercises. The option development is an area where considerable links between the two studies will be of benefit to the overall project. It is recommended that these two activities are planned carefully, with all modelling carried out with the Flood Risk modelling task/activity (next stage).

ANNEX 1: FLOOD RISK MODELLING WORKING GROUP WORKSHOP MEETING MINUTES

Minutes of Meeting

Subject:	**Southsea and North Portsea Island Coastal Flood and Erosion Risk Management Schemes:** Flood Risk Modelling Working Group Workshop
Venue:	**Conference Room 3,** Havant Borough Council, Public Service Plaza, Civic Centre Road, Havant, PO9 2AX
Date:	Monday 12th March 2012
Present:	Bret Davies (Coastal Partnership),Marc Bryan (Coastal Partnership),Clive Evans (Coastal Partnership), James Addicott (Coastal Partnership), Julie Dunstan (Royal Haskoning), Hamish Hall (Royal Haskoning), Ivan Parr (Environment Agency) , Jemma Colwell (Environment Agency), John O'Flynn (Environment Agency), John Shurvinton (PCC), Claire Short (HBC) , Dom Damarell (HBC)

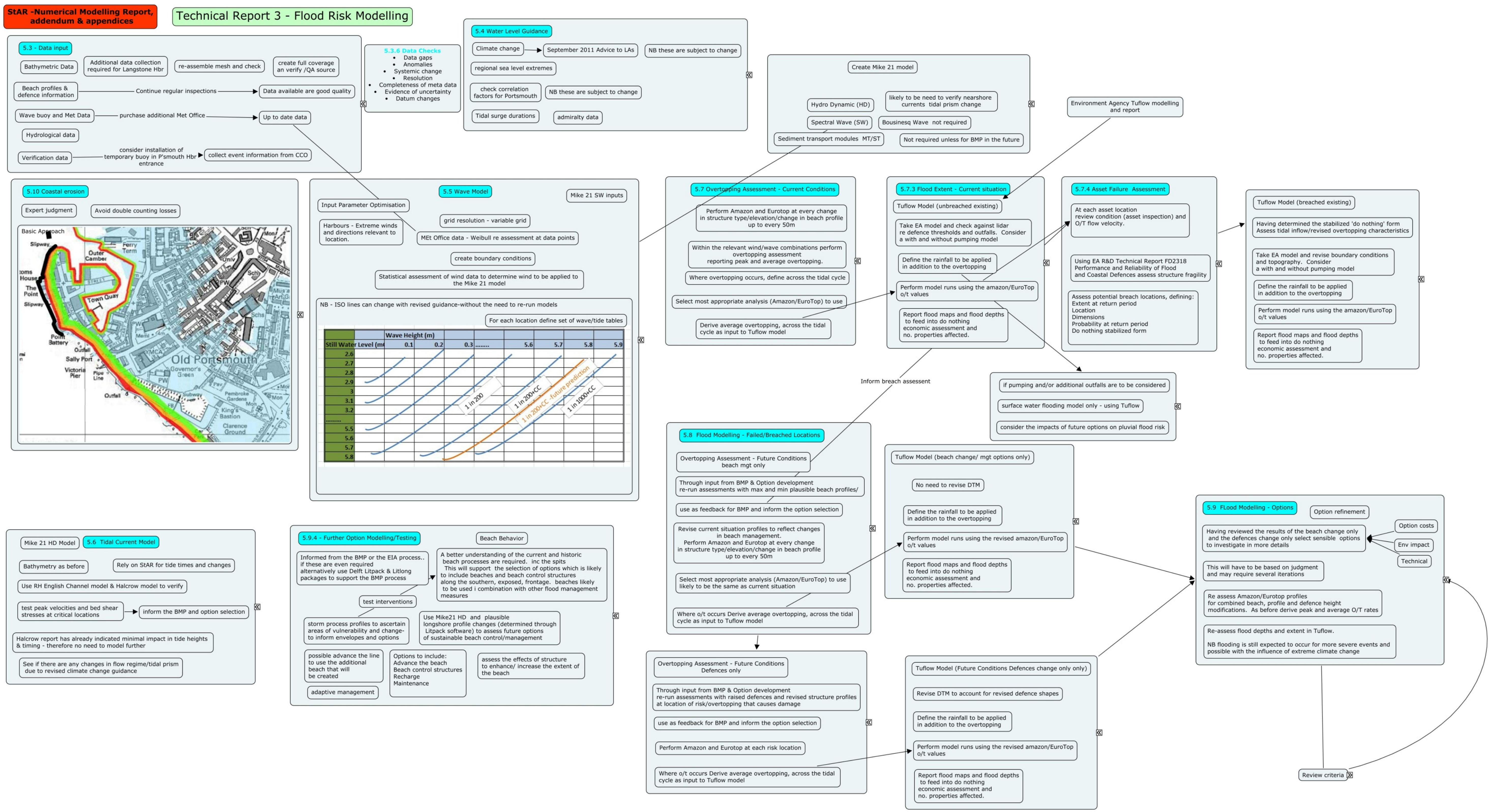
Item	***Minute***	***Action***
1	**Welcome, Introduction & Background** Introduction Presentation: given by Bret Davies	
2	**Flood Propagation Model Overview and Discussion** **EA Propagation Model** HH stated he has spent six weeks looking at data with the central theme researching flood risks and economics and stressed the flood risk has to correct. JOF said a robust model is the key element to producing a business case to acquire the appropriate funding. IP suggested the Tuflow model is the "best available information" and currently highlighted there is a Harbour/Estuary study being developed looking at transforming water levels across the harbours/estuary's to understand propagation. IP to provide the project team access to this study via Rob Luthwaite (from the EA). HH confirmed he is happy how Tuflow is set up although less confident with its breach assessment/overtopping [700m3/s] as referred to in the TuFlow report. HH asked IP about DAWN model - how were near shore waves considered? HH suggested wave data preference is to use the MIKE 21 SW model which has been used on other sites. This will be included as a recommendation in the scoping study to take forward HH stated the first step would be to have a better understanding to ascertain direction, height and period of normal and extreme waves and suggested purchasing met office data. The met office wave model supplies statistical analysis on wind and swell, HH recommended additional information is required to utilise its smaller angles. HH to clarify this data requirement with CE.	***IP*** ***HH*** ***HH***

	HH suggested there will be benefits in having many model runs CE stated there is a need for cost justification. Although there are two wave buoys in the Eastern Solent , there was not one that specifically covered the FZ 1 frontage. CE stated that there may be another wave buoy available from the Regional Monitoring Programme.. CE to discuss with CM and HH regarding an appropriate location to place the buoy. CE to also liaise with Matt Hosey regarding opportunities for sharing costs with the RMP.	***CE***
	In regard of overtopping, HH suggested using either Euro top or Amazon (Royal Haskoning's own model). HH highlighted the importance of assessing the current situation linking with structure condition (i.e. can the structure take it?) and working out where a breach would occur. HH said this probabilistic approach should also recognise that an event could happen tomorrow. CE can provide support to HH if required.	***HH***
	HH noted beach behaviour is more "woolly" and the way forward on beaches is to recognise what has happened in the past, and stated that the preparation of the beach management plan was important. The BMP will inform how to retain the beach along Southsea linking to Solent wide coastal process. HH to communicate this to the BMP project lead.	***HH***
	IP enquired about the extent of the modelling, HH confirmed it would be all around the Island. Ivan recognised it would be good as a baseline and could be used for other projects.	
	Climate Change	
	BD provided an overview on Southampton City Council (SCC) review on Climate change and sea level rise predictions	
	HH suggested small pieces of work on this issue works better and stated guidance will probably change again during this project	
	JOF stated SCC have re-run their strategy and concluded there is 200mm between the predicted extreme water levels In Year 100.	
	IP said once the Harbour and Estuary study and the model reruns are complete for Portsea, the EA's flood zone maps can be updated.	
	Mapping and Data	
	JOF enquired if other partners are involved in mapping and data. CE advised to contact the dredging contractor in regard of dredging surveys.	***CE***
	JS confirmed PCC has data on contaminated land and ancient monuments mapped. BD and JD to arrange to meet with JS to see if the data is of use. BD to arrange any data requests.	***BD & JD***
	BD confirmed more pumping stations are due to be added across Portsea Island. BD to obtain PCC's SWMP to clarify the status of this because there is an opportunity to be "on site" constructing coastal defences at the same time as Southern Water build a new pumping station.	***BD***
	BD asked the EA if the coastal defence asset reference numbers [prefix 571] are still the same? It was confirmed the numbering has remained but the system is changing to "SAMPS"	
3	**Any Other Business**	
	IP suggested the best option for Met Office Data is to use the MIKE 21 Data.	

	BD asked if the EA have Met Office Data if so in order to save project costs (approx £6k) could PCC, as a partner, use the EA's data for this project. IP to investigate.	
4	**Date of Next Meeting** No further mapping, modelling and data management meetings were arranged.	

ANNEX 2: PROJECT APPRAISAL REPORT (PAR) STAGE FLOOD RISK MODELLING PROCESS FLOW CHART

Annex 2 – Flood Risk Modelling Process Flow Chart



ANNEX 3: EXAMPLE ASSET FAILURE ASSESSMENT

Annex 3 – Example use of Fragility curves in the Assessment of flood Defence Failure.

1. Aim

Any coast protection or flood defence has the potential to fail due to poor condition, loading above capacity or scour/loss of foundation. The PAR needs to assess the location and likelihood of an asset failing in order to:

- Assess the economic damages of do nothing and do minimum option;
- Assess the costs of maintaining the current situation and affecting repairs
- Determining options for refurbishment/replacement.

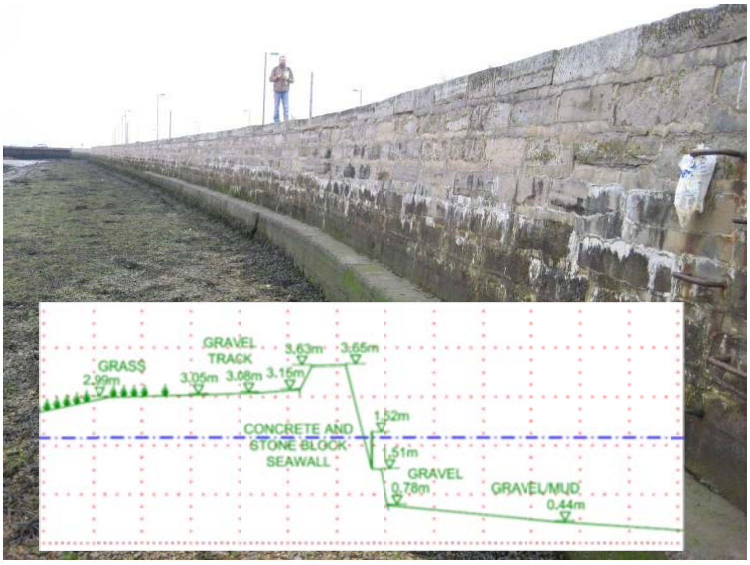
To support the PAR, and adopt an open and standard approach to asset assessment, it is suggested that the PAR adopts the Environment Agency guidance *R&D Technical Report FD2318 Performance and Reliability of Flood and Coastal Defences* to assess each of the structures fragility.

2. Example

To demonstrate the process, an example is presented which is based on a Portsea defence (taken from the Asset Report, but using fictitious data).

Frontage Length 571/3212

571/3212 - Overall condition grade, 2: Good.

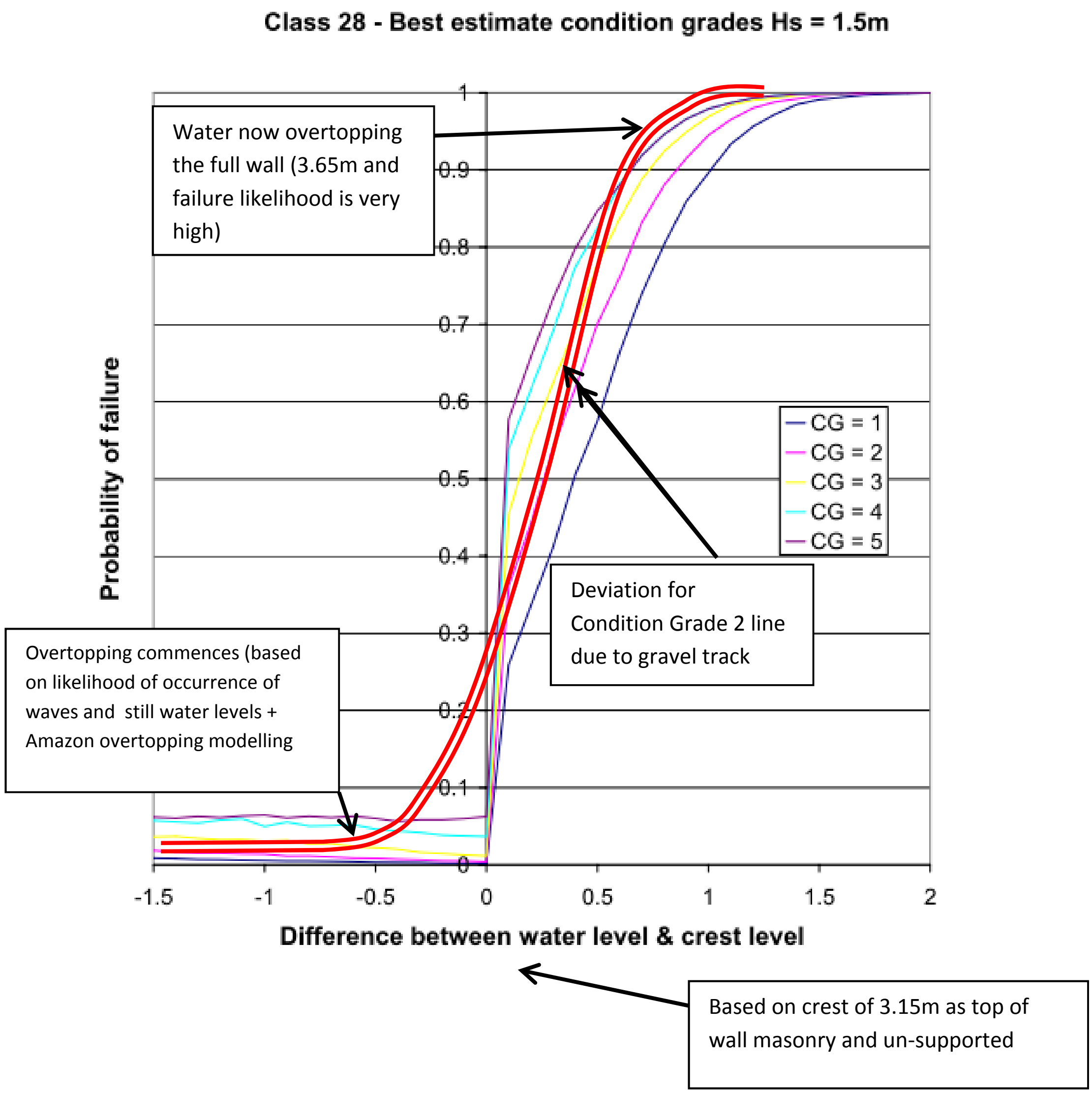


Referring to the EA R&D report, Performance and Reliability of Coastal Defences[1] there is an asset type Brick wall, for which the following probability of failure curve has been extracted.

This curve needs to be amended to take account of the narrow crest and the gravel rear to the defence –they are likely to fail sooner than noted here due to overtopping – well before the wall have been overtopped by still water level. The crest is also not substantial enough to retain water – so an effective defence height of 3.15 is chosen. This judgement would, of course, have to be evidenced.

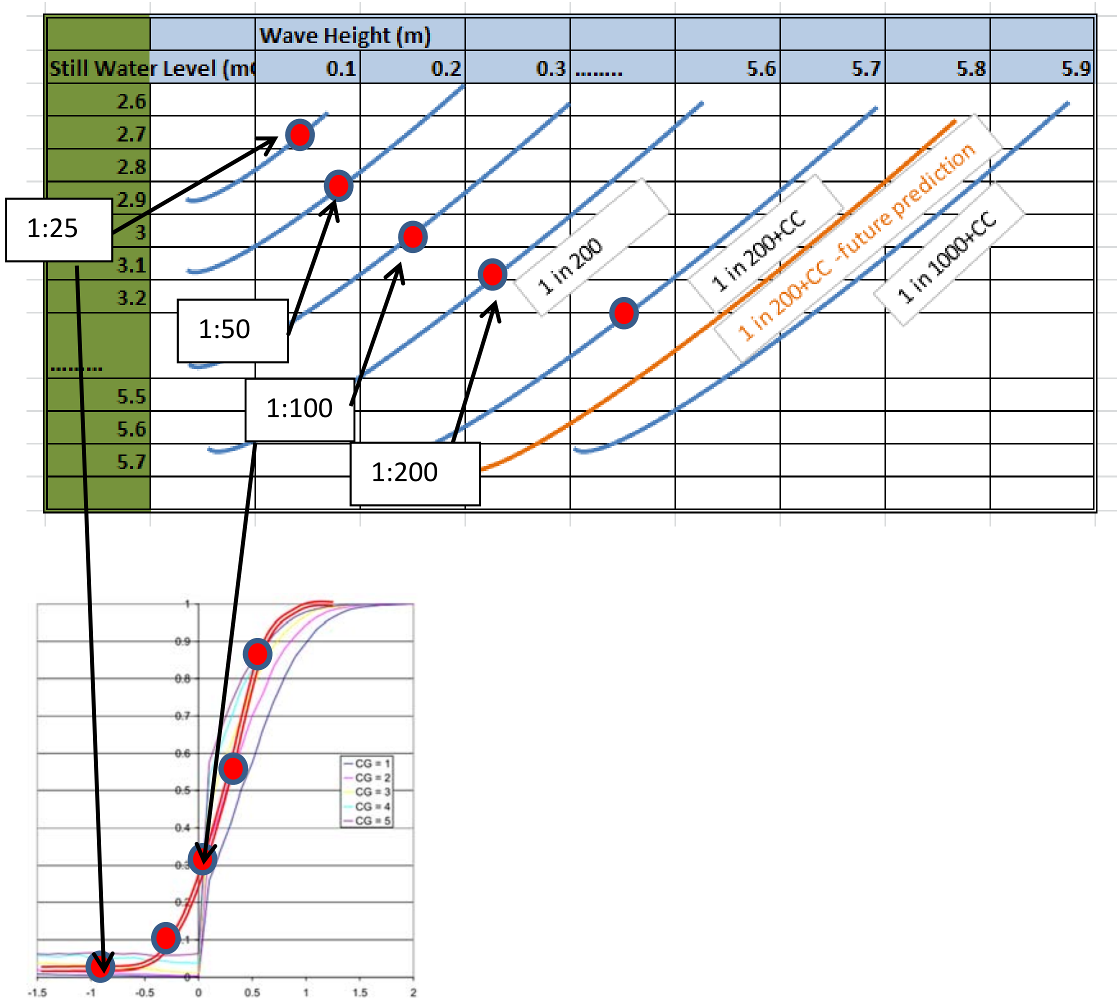
The Hs of 1.5 is probably too high but can be ignored as this curve needs to be modified.

[1] (http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/FD2318_5925_TRP_pdf.sflb.ashx),



The defence appears to be on a stable foreshore, but if it were not, a second or third line would be added based on the potential foreshore levels.

As noted in Section 5.5 of the main report, a full range of wave and swell assessments has been undertaken, from which overtopping assessments can be run. This will result in a range of events that can be ascribed similar return periods, but one event is likely to have a higher overtopping rate at this location (which will be the factor that affects structure integrity). These are represented on the diagram below by red dots.



The two diagrams can now be combined (this would be undertaken in excel), and the retun period probability of failure assessed.

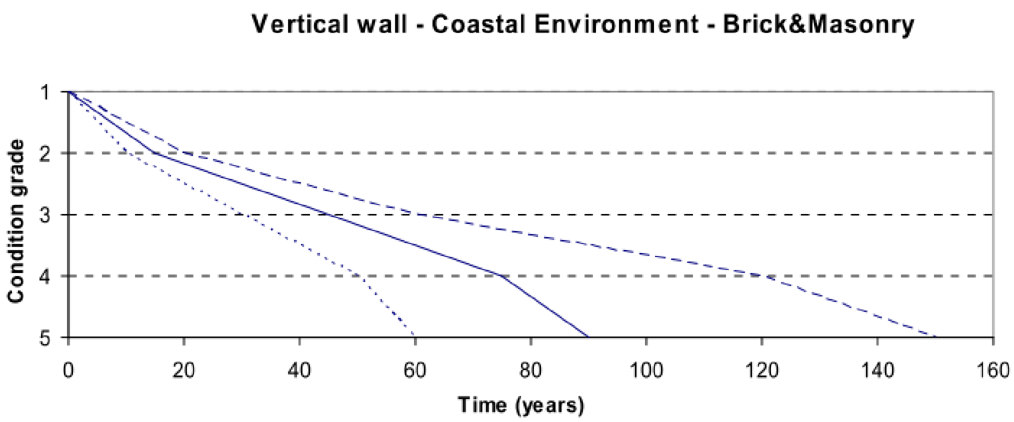
Retunr period	Probability of failure
1:1	0.01 NB Constant low risk of failure
1:10	0.01
1:25	0.01
1:50	0.10
1:100	0.30
1:200	0.55
1:1000	0.95

Taking the area under the curve, the average annual failure probability can be assessed; which is used as an input into the economic assessment:

Return Period	Probability	Failure probability	Interval (a)	Av. Probability (b)		(a)x(b) £
2	0.500	0.01				
			0.300	0.01		0.0030
5	0.200	0.01				
			0.100	0.01		0.0010
10	0.100	0.01				
			0.06	0.01		0.0006
25	0.040	0.01				
			0.02	0.06		0.0011
50	0.020	0.10				
			0.01	0.20		0.0020
100	0.010	0.30				
			0.005	0.43		0.0021
200	0.005	0.55				
			0.005	0.75		0.0038
1000	0.001	0.95				
		Annual average probability of failure				0.0136

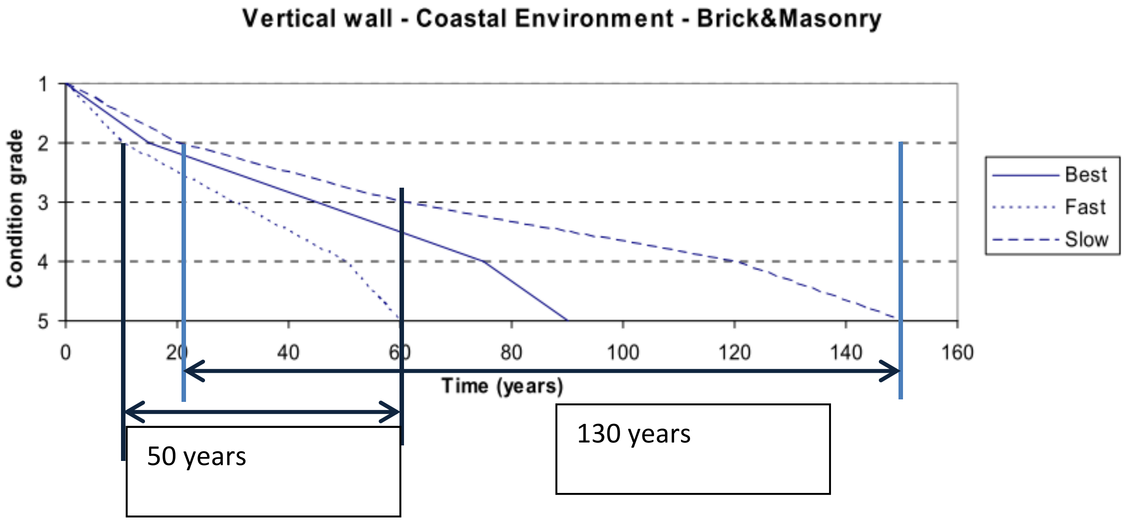
3. Estimate residual life

Based on the EA's report "Guidance on determining asset deterioration and the use of condition grade deterioration curves"[2] a brick masonry wall has the following residual life profile.



The wall being assessed has a condition of Grade 2, which means the residual life (with maintenance) can be estimated.

[2] (http://publications.environment-agency.gov.uk/PDF/SCHO0509BQAT-E-E.pdf)



Fast deterioration = 50years

Best estimate = 75 years

Slow = 130 years.

Based on the description and photograph of the defence it is likely to degrade faster (due to ad hoc pointing) under the current situation (50 years), with a faster still deterioration under the do nothing scenario (say 25 years) as the wall will rely on re-pointing to maintain integrity.

Again the estimate of residual life is used as an input into the economic assessment, and investment profile for determining expenditure for maintenance and refurbishment.